



## From The Chief Editor's Desk



Dear Readers,

It is again that time of the year, while keeping with our tradition; we present to you the latest edition of the Agriculture Today Year Book. The sixth edition of the year book is the result of the unfaltering support, constant encouragement and faith reposed on us by our loyal readers. Our readers have been the reason for the unparalleled presence of the magazine, Agriculture Today, in the Indian scene for more than a decade. The magazine, over the years, has become the platform to discuss and debate topics of agricultural relevance.

Agriculture Today Year Book of 2013 features articles penned by some of the most eminent persons in Indian agriculture. These articles represent different facets of Indian agriculture, introduce many new concepts and initiatives and also have identified several areas of concern to Indian farming. The year book, has thus tried to strike a right balance with combination of data, analysis and information.

I would like to thank all the eminent writers for their valuable contribution for the Year Book 2013. Their timely and appropriate contributions were influential in making this year book a reality. I trust that the Year Book will serve as a useful guide and reference to all those related to the agriculture sector, including government officials, policy makers, scientists, agribusiness companies, NGOs, institutions, agri researchers, professionals, planners, students etc. We have put our best efforts to create this year book. Nonetheless, there is further scope for improvement which we promise to refine in the next edition of 2014. I request all our esteemed readers to impart their valuable support by sending in comments and suggestions.

I take this opportunity to express our gratitude to Prof. MS Swaminathan, Chairman and all the members of the organizing committee of the Agriculture Leadership Summit 2013 for their valuable guidance. I am also thankful to my colleagues specifically Ms. Anjana Nair and Abdul Rehman for their untiring efforts in compiling and editing the Agriculture Year Book 2013.

A handwritten signature in black ink, appearing to read 'MJ Khan', written in a cursive style.

Dr. MJ Khan



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# Achieving the Goal of Sustainable Food Security



**A**ugust 15, 1947, marked the fulfilment of our freedom struggle, which was a unique one in human history because of Mahatma Gandhi's leadership in launching a non-violent, non-cooperation movement. Jawaharlal Nehru talked on that day about "India's Tryst with Destiny". On the same day, our newspapers expressed not only great happiness at the successful outcome of India's freedom struggle, but also painted a grim picture of impending food famine. There was fear that unless our agricultural production goes up, famines of the Bengal Famine type (1943) may recur. It is in this context Jawaharlal Nehru said "everything else can wait, but not agriculture". Today, 66 years later, the Government of India is launching the largest social protection measure against hunger ever attempted in human history. The Food Security Bill currently before Parliament confers a legal right to food to nearly seventy percent of our population with home grown food.

How did our agricultural destiny change? There were three major contributing factors. First was scientific research resulting in high yielding varieties of major food plants supported by appropriate agronomic

practices. Second, services which could take the technology to small and marginal farmers were organised. Finally, Government offered a remunerative price and also purchased all the grains of farmers at that price. Thus, mutually reinforcing packages of technology, services and public policies were put in place in the 1960s. International collaboration, like getting dwarf wheat seeds from Norman Borlaug from Mexico helped us to purchase time in the struggle for balancing human numbers and the human capacity to produce the needed food.

I wish to refer to an important development in the field of agricultural science and education in the 1960s. 2013 marks the 150th anniversary of the signing of the Morrill Act in USA by President Abraham Lincoln. This Act led to the creation of a System of Land Grant Colleges. India adopted this system following Jawaharlal Nehru's visit to USA in the 1950s. In 1958, we started our own Land Grant Universities initially with the GB Pant University of Agriculture and Technology at Pantnagar, Uttarakhand. Today, there are over fifty such universities covering all fields of agriculture, horticulture, animal husbandry and fisheries. These universities are playing an important role in the development of location specific technologies and services.

For the first time, research, education and extension education were brought together into an integrated system.

The existence of such a system enabled us to test and identify high yield technologies speedily. For example, we received seeds of semi-dwarf varieties of wheat from Mexico, through the kind help of Dr Borlaug in September 1963. In July 1968, the then Prime Minister India Gandhi released a special stamp titled "The Wheat Revolution". Wheat cultivation in India started in the days of Mohenjo-daro, now in Sind, Pakistan, over four thousand years ago. Between 1964-68, the progress made in improving wheat production exceeded the progress made during the preceding four thousand years of wheat cultivation. This is why the progress is referred to as a revolution and not an incremental evolution. The dwarf plant stature in the Mexican varieties developed by Dr. Borlaug as well as by others came from the Norin dwarfing gene identified by Dr. Gonzirolnazuka of the Norin Experiment Station, Japan. The Norin 10 dwarfing gene is also known in scientific literature as Reduced height (Rht) gene which may either be dominant or semi-dominant. Studies have shown that mutations in dwarfing genes lead to reduced sensitivity to the endogenous growth regulatory hormone gibberellins. The 'Green revolution' genes had a transformational effect in the area of yield enhancement. In addition to Dr. Borlaug, Dr. Orville Vogel of Washington State, US used the Rht gene effectively to breed the winter wheat Gaines, which held for a long time the world record for yield in wheat.

In early 1960s, a similar transformational gene also became available in rice first from Taiwan and later the International Rice Research Institute, the Philippines. Thus, the 1960s witnessed great progress in achieving a yield revolution in wheat and rice as well as in maize, jowar and bajra. In the latter three crops, the technique used was the exploitation of hybrid vigour. This helped the Government of India to launch in 1966 a high yielding varieties programme in these five crops. By breaking the barrier to high yields, it became possible to convert a small government programme into a mass movement. Our farmers disproved the prophets



of doom wrong. This has been the most exciting chapter in India's agricultural history, paving the way to enabling government fifty years later to confer a legal right to food to large segments of our population.

The inclusion in the Food Security Legislation of nutri-cereals like bajra, jowar, ragi, madua etc in the food basket, from the point of view of access to highly subsidised food grains, has been a wise step. Unfortunately, government and media are still referring to such nutrition-rich climate resilient cereals as "coarse" cereals. This terminology created in colonial times should now be discarded. Enlarging the food basket has also the advantage

that we can supply grains instead of cash in the Public Distribution System even in a drought year. Indian farmers can easily produce over 100 million tonnes of wheat, 150 million tonnes of rice and over 100 million tonnes of nutri-cereals by 2020. Therefore, there should be no difficulty in honouring the commitment made under the Food Security Act. The National Commission on Farmers in their five reports submitted between 2004 and 2006 has provided an implementable strategy for converting the green revolution into an evergreen revolution leading to the enhancement of productivity in perpetuity without ecological harm. Unfortunately, the government is yet to implement the recommendations of the National Commission on Farmers.

This indifference will affect our agricultural progress and consequently our ability to fulfil the legal commitment made in the Food Security Act. Even a simple suggestion like re-designating the Ministry of Agriculture as the Ministry of Agriculture and Farmers' Welfare has not been adopted. We wanted a mind-set change in Krishi Bhawan, leading to the recognition that farmers' wellbeing alone can ensure a steady supply of food grains to the Public Distribution System. The rationale for Krishi Bhawan's existence is the wellbeing of our farm families and thereby the health of our farming enterprise. Unfortunately, the officers in Krishi Bhawan consider farmers as not saviours and custodians of our Food Security System, but as beneficiaries of a few government programmes. This mindset will have to be changed if we are to

avoid moving away from the ecstasy of 2013 to the agony of the Bengal Famine days of 1943.

**FEEDING AND FUELLING THE FUTURE**

“Feed the Future” is a programme of the US Government designed to assist developing countries, particularly in Africa, to produce food for their current and future populations in an ecologically sustainable manner. The World Committee on Food Security (CFS) was restructured in 2010 for the purpose of promoting global, regional and national policies and partnerships, designed to achieve the goal of food for all and forever. To assist them with credible scientific advice, CFS established a High Level Panel of Experts (HLPE), guided by an International Steering Committee comprising 15 experts serving in their personal capacity and without any financial compensation. I have been serving as Chairman of the Steering Committee from its inception in 2010.

The purpose of HLPE and its Steering Committee is to provide CFS with science-based analysis and recommendations on topics considered by CFS as important to its mandate. Thus, the following demand-driven reports have been submitted : (a) Price Volatility and Food Security, and Land Tenure and International Investments in Agriculture (2011), (b) Food Security and Climate Change, and Social Protection for Food Security (2012). In July 2013, we presented the following two reports to the CFS Bureau: Investing in Smallholder Agriculture for Food Security, and Biofuels and Food Security. All these reports are available at HLPE’s website (<http://www.fao.org/cfs/cfs-hlpe/en/>).

Our Report on smallholder agriculture calls for a New Deal

for farmers cultivating small farms (about 2 ha in size). The New Deal is to provide in an integrated manner appropriate packages of technology, services and public policies. Public policies related to the conservation of prime farm land for food production and to providing small holders opportunities for assured and remunerative marketing are particularly important. These reports are relevant to our country, since we are now enacting legislation which makes access to low cost food a legal right for over two thirds of our population. The sustainable implementation of this legislation will depend upon both land use policies and the efforts made to convert the slogan “Jai Kisan” into reality.

FAO’s most recent estimates indicate that 12.5 per cent of the world population (868 million people) are under-nourished in terms of energy intake. Nearly 1/3 of such undernourished children, women and men are in India. Therefore, the National Food Security Bill is timely and we can be proud of the fact that ours will be the largest social protection measure against hunger in the world.

In recent years, particularly after



the very steep escalation in the cost of fossil fuels in 2008, there is a debate about the potential impact of biofuels on food security. How do we develop policies for making efforts in the areas of food and energy security mutually reinforcing and not antagonistic? Food versus fuel is not an option, since we need both. I would like to summarise briefly our recommendation for achieving the twin goals of sustainable food and energy security.

World Biofuel production increased from about 20 billion litres/ year in 2001 to over 100 billion litres / year in 2011. The steepest rise in biofuel production occurred in 2007/2008, when a sharp rise in food commodity prices occurred. In the evolution of biofuels, the first few efforts were in the field of utilizing crop plants. For example, Brazil started a large programme with sugarcane as the feedstock. Public policies like investment subsidies, mandatory installment of ethanol pumps, and taxation of gasoline led to biofuel production reaching 12 billion litres/ year within a decade. Similarly in the US, the ethanol production grew substantially following the enactment of the Energy Tax Act of 1978. Maize producing states like Iowa started diverting a high proportion of maize for ethanol production. In European Union also, public policies stimulated the production of biodiesel. The second generation biofuels are largely from agricultural crop residues and biomass utilization. Rice straw and other crop biomass are being increasingly used for ethanol production. Jatropha curcas became the preferred non-edible oil crop for biodiesel manufacture. The third generation biofuels will come from microorganisms and from genetically engineered bacteria. Thus, biofuels



are providing important new opportunities for scientific research and for income and employment generation.

The future of biofuels will depend upon the development of new technologies. At present, ethanol production is largely from sugar beet, maize, sugarcane and cassava. Biodiesel production is from rapeseed, soybean, palm, and jatropha, while biomethane production is from anaerobic digestion mainly in maize. The government of India announced a National Policy for Biofuels in 2009. Under this policy, the target for 20 percent for all biofuels was set for 2017. Progress in achieving the goals of this policy has been slow largely because there was exaggerated expectations from Jatropha. Nevertheless, the four main objectives of our National Policy on Biofuels continue to be relevant.

- i) Meet energy needs of India's vast rural population, stimulating rural development and creating employment opportunities
- ii) Address global concerns with emission reductions through environmentally friendly biofuels
- iii) Derive biofuels from non-edible feedstock on degraded soils or

wastelands unsuited to food or feed, thus avoiding a possible conflict between food and fuel;

- iv) Optimum development of indigenous biomass and promotion of next generation biofuels.

There is however apprehension that diversion of prime farm land for fuel production would have an adverse impact on food security. Therefore Food Security policies and biofuel policies must be complementary. This will call for a Coordinated National Food and Energy Security Strategy. For this purpose, the following guidelines will be useful:

- i. The prior existence of technical, social and environmental zoning to delimit "available land" and accompanying resources;
- ii. The prior existence of "responsible land investment" practices;
- iii. The prior existence of mechanisms to ensure the capacity to react quickly to food price spikes and problems of food availability (price triggers, waivers, "minimum" levels of food stocks);
- iv. The prior evaluation of the

implications for the origin of feedstock provision (domestic/imported); and for trade;

- v. A prior evaluation of the implications of the policy for domestic and international food security.

Developing and implementing an Integrated National Food and Energy Security strategy is the pathway for achieving food security coupled with the production and utilization of the quantity of biofuels needed for meeting energy needs.

The Food Security Bill provides for substituting cash in the place of grains. While this provision may be necessary under conditions of severe drought and fall in production, giving cash and not grain should be an exception and should not become the rule. If cash is given, the incentive for procurement at the minimum support price will go down. If procurement goes down, production will go down. Also, according to the legislation, the senior woman in the household will be given the Entitlements Card. This is in recognition of the pivotal role played by women in managing and ensuring household food security. According to the law, it will become obligatory to give the cash to the woman handling the Entitlements Card. It is very likely that this situation could enhance possibilities for domestic violence, since the male preference for the use of the money may sometimes be for the purchase of alcoholic drinks. Therefore both in the interest of agricultural production and domestic harmony, it is important to avoid taking the route of paying cash instead of grain.

The Food Security Act is a historic document and it is our duty to ensure that the act becomes a powerful tool for ensuring food with dignity for all and forever. ♦

# How do we feed a growing world population?

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Get more from existing farmland

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# *Major Concerns*



**RAHUL DHANUKA**  
Director (Marketing)  
Dhanuka Agritech  
Limited

# Farm or home, water needs to be conserved

**W**ater has different meanings for different people. For a scientist it is H<sub>2</sub>O, for a child it is something to play with, for someone feeling hot it is most soothing liquid to splash in, for a thirsty person it is something to quench thirst with but for all living beings, grass and trees it is life.

Water is available in nature in liquid, solid and gaseous forms. Its melting point is 0.0°C and boiling point is 99.98°C or approximately 100°C. Its density is 1,000 kg per m<sup>3</sup>. It is virtually the reference point for the scientists. Water has greater significance for those connected with agriculture, as agriculture is the single largest segment consuming water - accounting for about 70 per cent of water consumption. Like all other natural resources water is also not uniformly divided among the countries across the globe. The balance is tilted against African and Asian countries. Also, availability of water is gradually getting tilted in favour of the rich who can afford it.

## THE SITUATION IS GRIM!

Half a century back, when world population was less than half of what it is today, water was available for everyone in plenty. Now, it is inadequate in most countries, and it will be scarce for more than half the population of the world in the next 25 years. Unless we wake-up to this reality, staring into our faces, our coming generation will face a severe crisis for water!

Natural water is the best for agriculture and humans. This fact is particularly visible during the rainy season, when plain rain water produces so much greenery and thick growth of vegetation which even heavy doses of fertilizers and irrigation through best of sprinkler systems cannot produce. Therefore, it is essential for us that we do not allow even a small quantity of rain water to run off and go waste.

## CONSERVE WATER

We may follow any method of water conservation depending on various environmental and other factors prevailing in our region. At present, we come across many cases where this precious resource is wasted in public places like parks, market places, housing societies where any individual is not answerable for its use and for bearing its cost.

Farmer and the rural community form the largest vote bank, but at the same time it is these groups which hold the largest potential for a revolution. As a country we need a revolution in water management and water conservation. Starting with mass awareness at village and farm level about the importance of water and its availability, now and in the future we can move on to the importance of not wasting this precious resource and methods of its conservation and management.

## CROP CHOICE

Awareness can be brought about by using mass visual, audio and print media for campaigning, and once the farmers know that water is not an unlimited resource, they can be given information on water consumption in different crops for possible shift to crops which require less water. For example, it takes 10,000 liters of water to produce 20 kg Basmati rice, whereas ordinary rice requires 77,510 liters; wheat 30,240 liters and maize 21,924 liters. A dozen roses consume 120 liters water and just one apple consumes 99 liters water to produce.

***'Khet ka paani khet mein  
aur gaon ka paani gaon mein'***

Training on increasing the water table by leveling the fields for uniform absorption of available water by lower strata of the soil is another effective method of water conservation. Similarly, making contours in the fields where the land is sloppy ensures retention of water in the fields. The biggest



benefit can accrue through water conservation by digging ponds in farms and lining them with PVC sheets for conserving rain water for use during dry spells. Re-charging of wells by diverting rain water not only results in improving water table in the area, but also improves the taste of water where it is otherwise saline.

Mulching i.e., covering the fields with leaves, grain husk, fodder and crop remnants, ensures retention of moisture in the field which ultimately results in conservation of water. As an alternative, sowing of broad leaf crops protects the soil from direct rain drops falling on the soil surface resulting in lesser soil erosion and absorption of water by the soil. Protection of soil from direct sun reduces evaporation of water. This technique works best where the land has relevant slope.

Construction of bunds in the fields results in retention of water and moisture in the fields. Another effective method of water conservation is 'ridge and furrow method' which entails digging deep drain after 2-3 rows of crops which provides water to these rows in the event of less rain fall. In case of heavy downpour it works as drainage for surplus water. Accordingly, ridge and furrow technique is beneficial both in the event of less or excess rainfall.

### IN OUR HOMES

The rainwater which falls on the roofs of houses is often collected using roof guttering leading through a pipe to a storage tank. Water collected in this manner can be used for gardening, cleaning and washing purposes. This system requires minimal recurring costs and effort. In our daily routine one can avoid use of running water



while brushing teeth, shaving, washing vegetables, fruits, utensils and clothes for avoiding wastage of water. While taking bath, use of mug and bucket instead of shower, saves water. Washing machines users can avoid half-loads as full loads consume less water. One can also remain alert in re-cycling water. Gardening, car washing etc. can be done with water earlier used for washing vegetables and fruits and clothes. Keeping fields and gardens free of weeds saves water and soil nutrients.

Nowadays, water saving flushing systems are available, where the consumption of water is much less than the consumption in conventional systems. Using automatic switches for stopping the motor when the over-head tank becomes full, is a wise decision. These are quite reliable, trouble free and affordable tools. Leaky taps is another avoidable wastage of water. The actual wastage is much more than one can imagine as visible wastage is of only drops of water.

### ON INDUSTRIAL FRONT...

Industries are the second biggest consumers of water, and most of the

big industrial units have treatment plants for their effluents in place. However, some of the units discharge effluents in rivers and streams and make usable water unusable and, at times, even harmful to humans, animals and plants. It is imperative that industries properly handle pollutants for discharging our duty as responsible citizens and not just for avoiding penal action. While using water for industrial purposes, water should be re-cycled where possible, wells recharged and water conservation and management in industry encouraged.

### GLOBAL PERSPECTIVE:

On the international front, export of water by sea from Europe to the Middle East has started on a large scale, as desalination plants in Middle East are not able to keep pace with the ever growing demand for water. Water has gained so much significance and criticality in the Middle East that Israel has warned of military action against countries which try to stop water flowing to it.

Desalination of sea water for making it potable presently is prohibitively expensive. Similarly, artificial rain does not appear to be viable solution because of its cost. Next world war will definitely be over water, if timely steps are not taken for proper conservation of rain water and water management. It is time that the private sector, students, families and civil society at large come forward to supplement the efforts of state and central governments for spreading awareness, and supporting schemes for water conservation and management to protect the future of coming generations. We all know and need to put in practice that we can't create water but can certainly save it. Let's do it. ♦

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# India's Shattering Pulses Economy

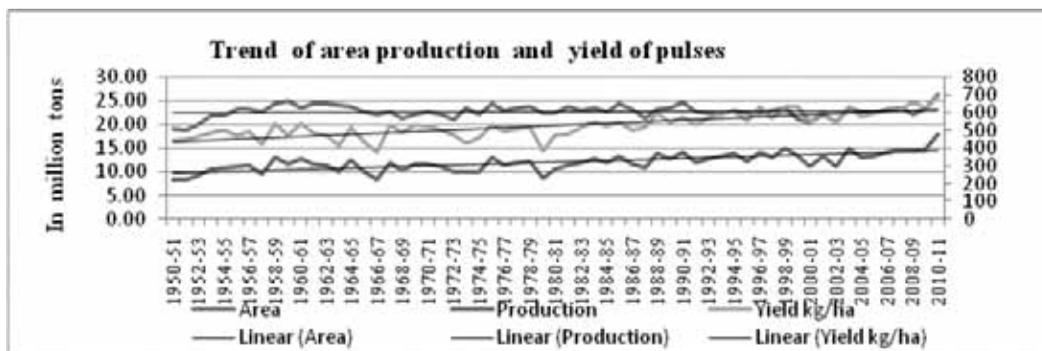


**P**ulses constitute an essential part of the Indian diet. Pulses are nutritionally important food crops due to their high protein and essential amino acid content. Like many leguminous crops, pulses play a key role in improving soil fertility through biological nitrogen fixation with the help of rhizobium bacteria found in their root nodules. They thus play an important role in ushering sustainable agriculture development. Pulses can contribute significantly in achieving the twin objectives of increasing productivity and improving the sustainability of the rice and wheat-based cropping system. While the traditional cropping pattern almost always included a pulse crop either as a mixed crop or in rotation, the commercialization of agriculture has encouraged the practice of sole-cropping. The latest pulses production is quite encouraging, which makes India the largest producer in the World.

India produces a quarter of the world's

pulses accounting for largest share in the world production, both in quantity and variety. The major pulses grown in India are chickpea (33 percent in area and 50 percent in production), pigeon pea (15 percent in area and 17 per cent in production) and lentil (6 per cent in area and 6 per cent in production) during TE 2010 (agri-coop.nic.in). Thus the poor production of pulses have not only created an imbalance in the demand and supply, but also resulted in soaring import bills, unpredictable price rises and low net profit compared to competing crops. The demand- supply gap and shortfall in pulses have been attributed to a number of factors, major ones being the increasing population, rising income of the people, geographical shift, abrupt climate change, complex disease – pest syndrome, socio- economic policies and input constraints.

Pulses are highly susceptible to insect pests and diseases. Climate changes like increasing humidity and cloudy weather found more in-



Source: Agriculture at a glance 2011, Ministry of Agriculture, GOI.

### Analysis of ACGR of Area, Production and Yield of different pulses and total food grain Crops (Base: T.E.1981-82=100)

A - Area, P - Production, Y - Yield ACGR – Annual compound Growth rate in percent

Crop	1980-81 to 1989-90			1990-91 to 1999-00			2000-01 to 2010-11		
	A	P	Y	A	P	Y	A	P	Y
Chick pea	-1.41	-0.81	0.61	1.26	2.96	1.68	4.61	6.32	1.64
Pigeon pea	2.30	2.87	0.56	-0.66	0.89	1.55	1.18	2.05	0.87
Lentil	1.99	5.49	3.43	2.33	2.44	0.09	-0.31	0.04	0.40
Other Pulses	0.02	3.05	3.03	-1.61	-1.58	0.04	0.03	0.96	0.94
Total Pulses	-0.09	1.52	1.61	-0.60	0.59	0.93	1.62	3.35	1.90
Total Food grains	-0.23	2.85	2.74	-0.07	2.02	1.52	0.37	2.12	2.89

Source: Agriculture at a glance 2011, Ministry of Agriculture, GOI.

cidences of pests and diseases. In the past, gram pod borer (*Helicoverpa armigera*) has been a major pest of pigeon pea in most parts of the country and presently pod fly (*Melanogromyza abtusa*) is emerging as a serious pest of pigeon pea in central and south India. *H. armigera* is a key pest of pigeon pea, inflicting 80-90 per cent yield loss. It causes considerable yield loss of 2.5 lakh tons of grains/annum worth more than Rs.3750 million per year. The pulses are also sensitive abiotic like climatic factor i.e. heavy rains, flood, frost and drought as compared to cereals. Some pulses are long duration as well as low yielders like pigeon pea which takes one year while farmer wants to take more than 3 crops in a year.

#### PRESENT STATUS OF PULSES INDIA

The area and production growth of pulses have been steady but not commensurate with that of other food grains. Productivity increased from 441 kg/ha during 1950-51 to 688 kg/ha during 2010-11 over six decades whereas food grain productivity increased about 4 times from 522 kg/hectare during 1950-51 to 1921 kg /hectare during 2010-11. The area of pulses ranged from 18.78 to 26.28 million hectares during 6 decades and the linear trend line showed slightly upper side. Farm-

ers have shifted their area to more remunerative crops like cereals, vegetables and other commercial crops. Therefore, we need to improve productivity of pulses.

#### Analysis of ACGR of area, production and yield of different pulses and food grain

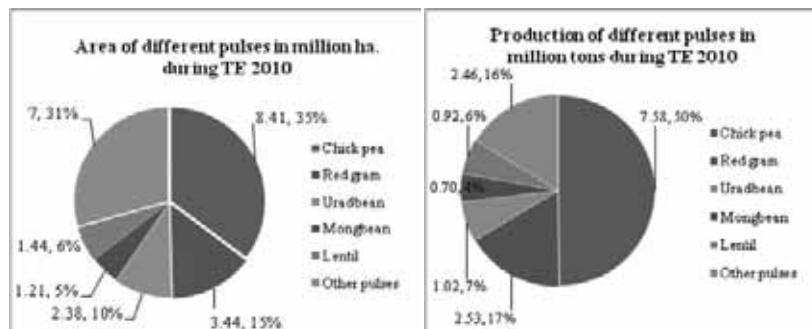
The annual compound growth

of chickpea recorded the highest growth rate in area (4.61 percent), production 6.32 (percent) and in yield 1.64 (percent) during 2001 to 2010-11 followed by 1.26, 2.96, and 1.68 per cent in area production and yield during 1990-91 to 1999-00. In case of Pigeon pea, accelerated growth rate in area and production was 2.30 percent and 2.89 percent respectively but in productivity it recorded 0.56 percent during 80s followed by 1.18, 2.05 and 0.87 per cent during 90s. In the case of lentil, the highest growth rate reported was 5.49 percent, 1.99 percent and 3.43 percent in production, area and productivity respectively during 80s followed by 2.33 percent and 2.44 percent in area and production during 90s. However, negligible growth was reported during 2000s. The growth rate of other pulses was reported more than 3

#### State wise transition in area and production over the decades

State	Area in ( 000 hectare)		(% Change over the decades	Production in (000 Tons )		(% Change over the decades
	2000-01	2010-11		2000-01	2010-11	
Rajasthan	2374.8	4754.8	100.22	731.5	3259.7	345.62
Jharkhand	116.3	426.2	266.45	96.0	329.6	243.38
Gujarat	635.1	890.0	40.14	190.7	723.0	279.13
Chhattisgarh	668.5	861.4	28.86	267.5	537.5	100.94
Orissa	604.3	879.0	45.46	212.7	426.9	100.71
Maharashtra	3557.3	4038.0	13.51	1637.4	3099.8	89.31
Karnataka	2046.7	2792.0	36.41	956.2	1565.0	63.67
Haryana	159.9	176.4	10.32	99.4	158.5	59.46
Madhya Pradesh	3554.2	5161.8	45.23	2275.4	3386.2	48.82
Andhra Pradesh	1902.2	2131.8	12.07	1054.2	1440.0	36.60
Assam	111.5	126.4	13.35	62.3	70.1	12.52
Uttar Pradesh	2691.7	2449.0	-9.02	2160.3	2037.0	-5.71
Bihar	717.2	612.3	-14.62	620.7	537.8	-13.36
Tamil Nadu	687.9	636.8	-7.43	312.7	246.0	-21.34
All India	20348.1	26401.7	29.75	11075.4	18240.9	64.70

**Share of area and production of major pulses in major states of India**



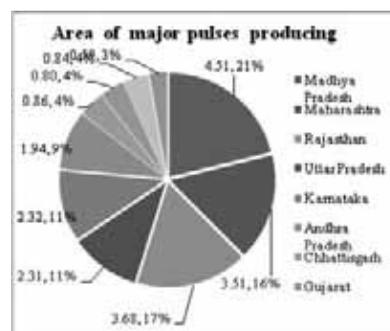
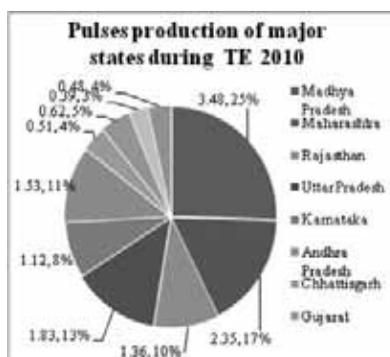
percent in production during 1980s, however 1990s and 2000s reported below normal growth rate. The annual compound growth in area and production of total pulses in India was low during 1980-81 to 1989-90. However, growth rate of area, production and yield of total pulses were

**State wise transition in area, production and yield of total pulses**

There was enormous interstate variation seen in area, production of total pulses. The emerging Jharkhand increased 266.45 percent area while production jumped 243.38 percent followed Rajasthan 100 percent area contributed 345 percent production and the Gujarat increased area 40 percent provide 279.13 percent production over the 2000-01 to 2010-11 while national average increase 29.75 percent area and production 64.70 percent. However, the Madhya Pradesh is the highest pulses producing state occupied area 5161 thousand hectare contributed 3386 thousand tons of total pulses during 2010-11 followed by Rajasthan 4754.8 thousand hectare, production 3260 thousand tons and Maharashtra 4038 thousand hectare, production 3099 thousand tons during 2010-11. The few states like Bihar decreases area -14.62 percent and production -13 percent followed by Tamil Nadu area -7 percent and production -21 percent over the 2000-01 (see table 2).

**Share of major states in area, production, yield of pulses and growth pattern**

The major pulses producing state i.e., Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka and Andhra Pradesh occupied 18.27 million hectares (80.30 percent) area, which contributed 11.67 million tons (80.60 percent) in production. Madhya Pradesh is the highest pulses producing state with 21.22 percent of area of total pulses area contributing 29.36 percent of total pulses production. MP occupies first position in chick pea production with 37.77 percent of total area contributing

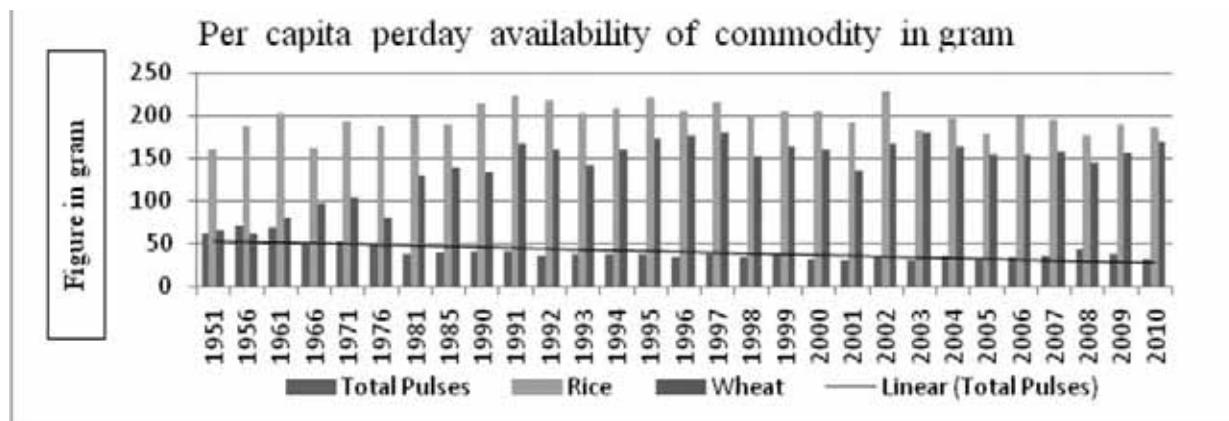


44.20 percent production. In case of pigeon pea, 10.44 and 12.49 percent of area and production respectively is the state's share and the state remained second in pigeon pea production during 2009-10. The annual compound growth rate of total pulses was recorded at 1.58, 2.64 and 2.82 percent. The same trend followed in chick pea production at 2.38 percent, 5.27 percent and 4.47 percent during 1980s, 1990s and 2000s respectively. However, pigeon pea recorded positive growth rate at 2.72 and 2.36 during 1980s and 2000s.

Maharashtra is the second largest pulses producing state occupying 14.50 percent of total pulse area contributing 16.16 percent of total pulses production. In the first position is pigeon pea with 31.53 percent area and 37.28 percent production during 2009-10. Second position is occupied by chick pea with 15.80 percent of total area contributing 14.90 percent production. Maharashtra recorded the highest annual compound growth rate of 7.15, 4.69 and 4.63 percent for total pulses during 1980s, 1990s and 2000s respectively. Chick pea production recorded 9.10, 5.74 and 13.92 percent where as pigeon pea recorded accelerated growth rate of 6.19 and 6.71 and 2.19 percent during three decades - 80s, 90s and 2000s.

Rajasthan is the third important pulses growing state according to area (16 percent of total pulses area) contributing to 9 percent production during TE 2010; however the average yield recorded was 497 kg /hectare during 2008-09 due to the unfavorable climate and biotic abiotic stresses. Rajasthan is an important state for pulses as per area (3.67 and 3.5 million hectares during 2008-09 and 2009-10 respectively and irrigated area 15 percent). Climate of Rajast-

### Per capita per day availability of pulses and other cereals



Data Source: Agriculture at a glance 2011, Ministry of Agriculture, GOI.

han is suited to pulses, which need less water requirement as compared to other cereals. Uttar Pradesh, Karnataka and Andhra Pradesh are also in terms of pulses production (13 percent, 11 percent and 8 percent) while area occupied is 10.15 percent, 10.18 percent and 9 percent during TE 2010. Uttar Pradesh, Karnataka and Andhra Pradesh are more diversified and have more crop competition during Kharif and Rabi season. Chhattisgarh, Orissa and Gujarat have also performed better in pulses production.

#### State wise productivity

In case of state wise productivity there are lot of variation with minimum range of 339 kg /ha in Tamil Nadu and the highest in Bihar at 814 kg /ha followed by Uttar Pradesh 791 kg /ha, Andhra Pradesh 787 kg /ha and Madhya Pradesh 771 kg /ha. However, the national average was recorded at 637 kg /ha during TE 2010. The highest productivity of chickpea was recorded at 1412 kg /ha during 2008-09 and slightly lower, 1308 kg/ha during 2009-10 in Andhra Pradesh and followed by 1071 kg/ha in Madhya Pradesh and 863 kg/ha in Maharashtra and the national average 915 kg/ha during 2009-10. In case of Pigeon Pea, state wise the highest



productivity was recorded at 989 kg /ha during 2008-09 and slightly lower at 906 kg/ha during 2009-10 in Gujarat, followed by 870 Jharkhand and 850 kg/ha in Madhya Pradesh and national average recorded at 711 kg/ha. However, Andhra Pradesh recorded the lowest yield of 438kg/ha during 2009-10.

#### Per capita per day availability of pulses and other cereals

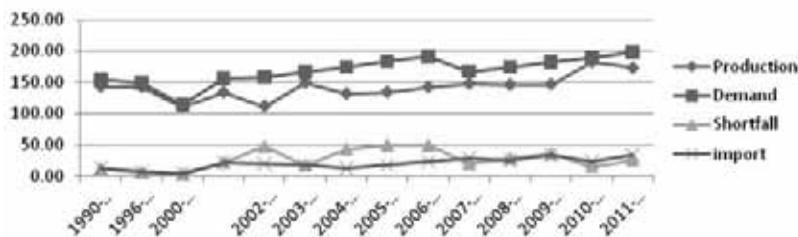
The scenario of net per capita per day availability of pulses has fallen drastically from 61 gram to 41 gram during 1951 to 1990, while rice has increased from 159 gram to 212 gram and wheat 66 gram to 133 gram during the same period. The wheat net per capita per day availability has

increased more than double during four decades. The Indian Council of Medical Research (ICMR) has recommended 65 grams of pulses per capita per day. The NSSO data revealed that per capita consumption of pulses has been shrinking during that the last few decades as domestic production had been lagging behind consumption requirement and imports are not adequate to bridge the supply – demand gap. This shortfall has serious nutritional implications especially to children and women in rural areas.

#### Reasons for stagnation in area under pulses

The main reason for stagnation in area under pulses has been differential impact of technology and

**Total Pulses production, Demand and Import (In lakh tons)**



Data Source: Agriculture at a glance 2011, Ministry of Agriculture, GOI.

relative profitability leading to shifting of area under pulses to more remunerative crops. The relative price disadvantages for each pulse crop in its major regions and expansion of irrigation are other factors. Uncontrolled water flows common in canal systems is incompatible with large scale area under pulses.

The second factor influencing area allocation is risk in productivity and farm income. There is a significant decline in instability of yield of paddy and wheat from the onset of Green Revolution. Instability in productivity of gram remained much higher than of wheat as well as in chickpea much higher than paddy. Pulses grown mostly under unirrigated or rainfed situation, in marginal lands suffered instability.

Though India is the largest producer of most of the pulses its productivity levels are generally low. India do not figure in major technological breakthroughs like Canada and others achieving averages of around two tonnes per hectare in pulses productivity. Technology breakthroughs in difficult regions and adverse farming conditions (rainfed regions, the ghats and hill regions) are absent on a large scale.

**DEMAND SUPPLY GAP IN PULSES**

The domestic production ranged from 14.26 to 14.66 million tones during 1990-91 to 2009-10

The Indian population's current

growth rate is 1.76 percent, while that of pulses was only 0.59 percent during 1990s and 3.35 percent currently. To bridge the gap between demand and supply of pulses the requisite annual growth rate of pulses production is a minimum 4 percent.

The domestic demand of pulses varied from 155 lakh tons during the period 1990-91 to 2011-12 while production was less during the same period. The gap between domestic demand and production of pulses in the country has been widening (10 to 50 lakh million tons) during aforesaid period. To bridge this demand, Indian imports of pulses during 2011-12 (Apr-Mar) were 3.4 million tons. Lack of assured market is one factor responsible for the stagnation in pulse production.

The minimum support price announced by the government does not benefit farmers in absence of procurement mechanism. Moreover, all pulse crops are not covered under the minimum support price. Therefore, procurement policy for pulses needs to be strengthened immediately and reasonable buffer stock needs to be built up to meet the contingencies. Appropriate market intervention and promotion of post harvest technology are also necessary to encourage farmers to invest more in pulses production. Distribution of pulses through PDS may improve access to pulses and help in stabilization of cost of pulses.

**Constraints of pulses production and productivity**

Despite many best efforts for increasing pulses productivity, there wasn't any revolutionary change in pulses production scenario. There are many constraints in area, production and productivity of pulses in India. The area of pulses did not increase significantly as compared to wheat and rice. Non availability of seeds of improved variety, lack of knowledge of package of practices, lack of irrigation facilities and minimal use of fertilizers were some of the reasons. Also the low input nature of pulses, growing pulses as residual / alternative crops on marginal lands and giving more preference to staple food / income needs from high productivity – high input crops like paddy and wheat by the most of farmers have been affecting the production of pulses in India. Pulses in most parts of the country are grown as rain fed crops with little or no modern yield enhancing inputs. The low priority accorded to pulses crops may be related to their relatively low status in the cropping system in many of the farmer's crop management scheme. In addition to this, these crops are adversely affected by biotic and abiotic stress which are not managed properly. Marketing facilities, prices, minimum support price and policy should reform from time to time, which should be beneficial to pulses growers.

**STRATEGIES FOR ATTAINING SELF SUFFICIENCY IN INDIA**

To achieve self-sufficiency in pulses, the projected requirement is estimated at 26.5 Mt by the year 2050. To meet this requirement, productivity needs to be enhanced to about 1000 kg/ha, and an additional area of about 3.0 M ha has to be brought under pulses besides reducing post-

harvest losses. This uphill task has to be accomplished under more severe production constraints, especially abiotic stresses, abrupt climatic changes, emerging insect-pests, and fertilizers & micronutrient deficiency and lifesaving irrigation in rabi / summer pulses. This requires a proactive strategy from researchers, planners, policy-makers, extension workers, market forces and farmers aiming not only at boosting the per unit productivity of land, but also at reduction in the production costs.

Research efforts to develop drought tolerant high yielding varieties of pulses with pest resistance should be undertaken for Rajasthan, Haryana, Uttar Pradesh and Madhya Pradesh. High yielding and short duration pulse crops like black gram needs to be incorporated in the cropping system to make the different production systems profitable and improve soil health. Production system needs to be intensified through popularizing summer green gram cultivation during spring/ summer season under irrigated conditions to adopt crop pattern potato - green gram in northern India i.e. Uttar Pradesh, West Bengal and Bihar.

Easy and timely availability of critical inputs like quality seeds, fertilizer and nutrients and insecticides and pesticides at nearby market is important. Creation of informal seed village system will ensure farmer to farmer seed production and distribution

chain for easy availability of quality seeds. Production of quality seeds of improved pulse varieties by private agencies needs to be encouraged to meet the demand of the farmers. Improved seeds should be made available to the farmers at his doorstep at reasonable rate.

Transfer of technology in relation to pulses should be strengthened in farmer participatory mode with active involvement of multidisciplinary team of scientists. Effective IPM module to control insect pest and dis-



eases to avoid losses in field and during post-harvest and storage is also important.

#### POLICY ISSUES

The National Food Security Mission (NFSM), launched in 2007, is a crop development scheme that aims at additional production of 2 million tons of pulses by the end of 2011-12. The scheme was approved with an outlay of Rs.4,883 crore for the period from 2007-08 to 2011-12. A sum of about Rs.3,381 crore has been spent till 31 March 2011. The Mission interventions consist of a judicious mix of

proven technological components covering seeds of improved variety, soil ameliorants, plant nutrients, farm machines/implements and plant protection measures. In addition, a special initiative to Accelerated Pulses Production Programme was initiated in 2010 to boost the production of pulses by active promotion of technologies in 1,000 clusters of 1,000 ha each. Considerable achievements under the NFSM have been recorded during the course of implementation of the programme such as new farm practices, distribution of seeds of high yielding varieties of pulses and treating area with soil ameliorants to restore soil fertility for higher productivity. Through targeted interventions, the mission has already achieved, a year in advance, 25 MT of additional production of food grains exceeding the target of 20 MT of production set for the terminal year 2011-12, of the Eleventh Year Plan.

Pulses contribute significantly in increasing productivity and improving the sustainability in agriculture, but it has been ineffective in increasing production and productivity and farm income. Efforts will have to be made to fill up productivity gaps of the existing technologies and their scaling up through proper extension mechanisms through supply of inputs, institutions and proper governance. Problems of Indian pulses economy can be solved with the increase in the sources of production. Effective and continuous efforts are needed to increase the area under cultivation as well as the productivity of pulses. ♦



**Suresh P Prabhu**  
Ex Union Minister

# Soil Management for Sustainable Agriculture

**T**he agriculture development issues are multi-dimensional; some are within the realm of agriculture, and some beyond.

The Indian population, which increased from 683 million in 1981 to 1,210 million in 2011, is estimated to reach 1,412 million in 2025 and to 1,475 million in 2030. To feed the projected population of 1.48 billion by 2030, country needs to produce 350 million tonnes of food grains (FAO, 2006). The expanded food needs of future must be met through intensive agriculture without much expansion in the arable land. The per capita arable land decreased from 0.34 ha in 1950-51 to 0.15 ha in 2000-01, and is expected to shrink to 0.08 ha in 2025 and to 0.07 ha in 2030.

The total factor productivity is used as an important measure to evaluate the performance of production system and sustainability of its growth pattern. The partial factor productivity of fertilizers during the last three and half decades showed a declining trend from 15 kg food grains/kg NPK fertilizer in 1970 to 5 kg food grains/kg NPK fertilizer in 2005. In urgency for higher production, no serious attention was given to the long-term soil quality, and sustained high productivity. As a consequence, the annual compound growth rate of major crops has declined from 3.36 per cent in 1981-85 to 0.11 per cent in 2001-05. The inputs use efficiency, particularly nutrient use efficiency, is now quite low; 30-50 per cent in case of Nitrogen, 15-20 per cent in case of Phosphorous, 8-12 per cent in case of Sulphur, 2-5 per cent in case of Zinc and 1-2 per cent in case of Iron and Copper.

## ISSUES

There are many issues of soil management, but the major reasons identified for soil quality deterioration are:

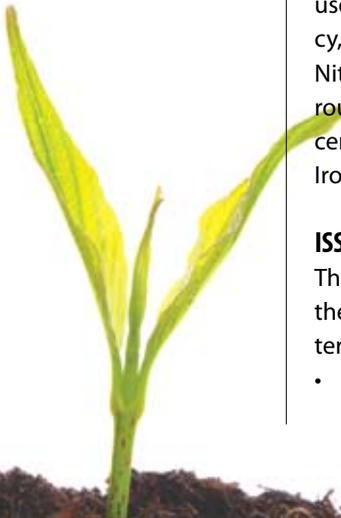
- Nutrient mining: Wide nutrient gap be-

- tween nutrient demand and supply
- High nutrient turn over in soil-plant system
- Low and imbalanced fertilizer use,
- Emerging deficiencies of secondary and micronutrients in soils,
- Soil acidity and soil salinization and sodification etc.
- Nutrient leaching in sandy soils,
- Nutrient fixation in red, laterite and clayey soils,
- Impeded drainage in swell-shrink soils.

## STRATEGIES

Restoration of soil health is crucial for sustaining future agricultural productivity. Avoiding and rectifying physical degradation, managing soil organic matter and soil biological condition, soil testing, synchronized fertilization techniques, integrated plant nutrient management, conservation agriculture, balanced fertilization of crops, integrated plant nutrient supply, enhancing nutrient use efficiency, manipulation of soil biota and selection of appropriate cropping systems are some important soil management technologies that have been evolved with the objective of increasing and sustaining high agricultural productivity. Further, in the context of growing concerns on food quality - ground water quality, green house gases (GHG) emissions, climate change, soil biodiversity etc. - are some of the important issues for reorientation/integration of different soil management technologies so that all the basic functions of soils are improved and sustained in future. The following strategies are, therefore, recommended for consideration by policy makers:

- Soil management for sustainable agriculture is a burning issue and very much related to agenda item of 12th Five Year Plan.
- Soil testing and advisories for nutrient application as per soil testing of values is the most important part of soil management.





- There is a lack of awareness of soil testing among the farmers. About 74 per cent farmers do not now know the importance of soil testing and nutrients deficiency in their fields.
- There is shortage of soil testing facility in the country. Laboratory building, equipments and trained staff are prime requirement for soil testing facility.
- Latest technologies like remote sensing and GIS should be used to generate soil nutrient content data region wise. Soil nutrient mapping for entire area of the country and geo-referencing to generate site-specific fertilizer recommendations should be developed.
- Site-specific fertilizer recommendations developed by various centres of All India Coordinated Research Project on Soil Test Crop Response (AICRP-STCR) for 65 crops should be made available to the farmers through proper and timely advisories by trained extension workers. These recommendations should be made available online in a user-friendly local language.
- Soil test recommendations should take into account farmer's resources and expectations.
- There is a weak linkage between soil test research and service leading to poor validation of soil test values and fertilizer recommendation.
- The soil test should not be limited

to NPK alone. Due to multi-nutrient deficiencies, it should also cover all the secondary and micro-nutrients.

- Apart from soil testing, farmers and extension workers should be trained for taking proper soil sample.
- There should be a programme of sample exchange between soil testing laboratories for verification of soil testing values and regular monitoring of quality of analysis.
- Each soil testing laboratory should adopt some villages in its jurisdiction for awareness, proper soil sampling, regular monitoring of soil health and take up, front-line demonstrations to show the importance of soil testing and efficient and timely delivery of advisories.
- Till further extension of soil testing facilities, the number of soil sampling may be restricted to 20 per village as it is not possible to analyze the soil of each farmer with current soil testing facilities. The fields of a village may be categorized into very low, low, average, medium, high and very high productive field after survey of condition of crops by GIS technology and 3-4 samples from each category may be analyzed for all nutrients rather than analyzing a large number of samples for one or two nutrients from a village. Such recommendations of a village may be replicated in other identical villages.
- Investment on soil testing facility

will not only increase the agriculture production of the country, but will also address the problem of nutrient imbalance, soil degradation and saving of fertilizers.

- Supply of different fertilizers to a cluster of villages should be based on soil test values of that cluster. In fact, the development of a customized fertilizer for a region and a crop should also be based on soil test values and fertilizer recommendation for a particular crop.
- The success of soil test based recommendations depends on the access of recommended nutrients to the farmers. So, government should develop a strategy to ensure adequate and timely availability of nutrients at the door step of the farmers.
- For improving soil health, Integrated Plant Nutrient System (IPNS) should be promoted on a large scale - legumes in cropping systems and incorporation of their residue, development of technologies for composting, crop residue in-situ composting and use of bio fertilizers should be a part of IPNS as a whole.
- IFFCO Model of Soil Rejuvenation and Sustainable Agriculture should be adopted by other fertilizer industries and should be spread from length to breadth of the country.
- Work done by IFFCO Foundation for promoting dual purpose summer mungbean offers an applicable strategy for increasing pulse production, reducing nitrogen requirement of a cropping system, improving soil health, improving income and livelihood of farmers and improving nutritional security for the consumers.
- We should promote cooperative, Public and Private Partnership (PPP) model for promoting sustainable agriculture.
- We should develop a resource based farming system for different agro-climatic regions. ♦



**Animesh Banerjee**  
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## The Welfare Subsidy : Is it a Sustainable Tool For Socio-Economic Development?

**T**he welfare subsidies were introduced following the French revolution, to entice their subjects by the European rulers. Such welfare subsidies did not adversely affect the European economy, since there had been easy flow of capitals, predominately generated from their captive markets in the erstwhile colonies. Similarly, following antiapartheid movement in USA, social sector schemes were mooted to appease its socially backwards communities, largely black habitants.

After Second World War, the decolonisation process gradually set in, and with the passage of time, the European colonies waned out. Thus, they not only lost their captive markets, but also easy access to cheaper inputs like labour and materials from their erstwhile colonies! Besides, these countries following globalisation had faced stiffer competition from the third world nations! With the shifting scenario, it became necessary for most of these nations to revisit their welfare policies, especially to prune the unsustainable social development programs!

In contrast, India is increasingly overburdening its economy with the unsustainable welfare

schemes, especially using it as a political tool for gaining election mileages. It may not be out of place to mention here that the welfare scheme was rooted in India during the post independent era, at the initial plan periods. But the core socio-economic objectives progressively got distorted into politically-motivated apparatuses, especially with the hurling of 'Garibi Hatao Scheme'! Following governments continued with such slogan oriented social development programmes primarily to lure their voters, as a part of competitive vote-bank politics!

While most of these social sector schemes have attracted severe criticism for its repeated failures to deliver the contemplated benefits to the targeted groups, a grandiose welfare scheme named as 'National Food Security bill' is under consideration in the parliament. The National Food Security program contemplates to provide 5kg of subsidised food grains per person per month covering two third of country's population. It would cost the exchequer around Rs 1, 24,747 Crores, at the very first year. This program has raised several doubts, amongst the notable economists and professionals, both in the country & abroad, about the rightness of spending such a huge amount, out of the exchequer, especially at a time when country's economy is at its lower ebb!

India's growth trajectory is presently snaking due to increasing gaps between the government's annual revenue income and expenditure. India's present growth reversal has raised several doubts on the venerability of such policy initiatives of the government. According to Professor Deepak Lal of James S Coleman Professor Emeritus, USA, the growth rate has slipped in India, due to the diminishing tax revenues on which the enlarged spending especially politically-motivated unsustainable welfare schemes are based. According to Prof Lal, the "Trickle-down" from rapid growth cannot redress Indian poverty; it showed a shocking failure to recognise the outcomes of the



recent period of rapid growth in reducing poverty, in India.

Ashok Gulati, Chairman, Commission for Agricultural Costs and Prices, Ministry of Agriculture, Government of India, in an interview had stated that the country has largely followed a 'price policy approach' to achieve essentially what are the equity ends. It has subsidized food and agricultural inputs, so that poor consumers and small farmers can have economic access to these. But the ground evidence suggests that this may not be the best way to achieve equity objectives. It has led to major distortions in markets, besides high costs in handling food grains over and above diversions to non-targeted groups. These have resulted in large 'efficiency losses' without achieving commensurate results on equity front. Literature on best practices around the world too shows that 'income policy' approach rather than 'price policy' is more efficient in achieving equity ends, and this has been successfully adopted by many countries across the world. Specific criticisms of subsidy schemes are corruption and mismanagement, besides posing heavy burden on the government budgets. It has been amply proved that the poverty and food insecurity exists due to lack of access to education, health care and most significantly gainful employment!

This very 'income policy approach' in achieving equity, has already been very skilfully demonstrated in India, with the success of the well-known 'Anand Model' of dairy development. It is therefore more prudent to revisit this model, especially in the present

context of the proposed 'Food Security Scheme! While dwelling on the food security vis-a-vis 'Anand Model', it would be worthwhile to spool back the erstwhile 'Food Aid Program' of the UNO. The objectives underpinned in the food aid program were, to a certain extent, similar to that proposed in the 'Food Security Bill' of India. The UNO program was contemplated to provide food security to the third world nations by evolving



a distribution model. The program distributed the accumulated surplus food commodities with the donors in the developed world. UNO Food Aid Programme, however, came under severe criticism for its misapplications, besides using the food aid as a tool for expansion of the commodity trade in the third world markets, by the donor nations! Thus the critics continued to tag the Program as an Aid followed by Trade program!

Most of the third world nations whilst hemmed in food aid dependency, India succeeded to monetise the aided commodity to generate fund for fostering indigenous growth. This was classic example in which UNO's food distribution model was converted into a growth model, in India. It became popularly known, world over, as 'Operation Flood Program', which ushered milk sufficiency, in India! This rare testimony would not have happened, had a visionary leader, late Dr Varghese Kurien, not been there

to evolve an appropriate growth oriented delivery model. His model had successfully demonstrated as to how a food aid can be used for creation of self-sufficiency, besides gainful employment to the millions of destitute cum unprivileged, in India!

There are several other welfare programs that exist to wane out of continued dependency on grants or gratis. Most notable was the 'Grammine Bank Model', developed by the noble laureate, Dr Mohamed Yunies, in our neighbouring country, Bangladesh. His model too demonstrated, how to become self-reliant by creating access to gainful employment for the 'have-nots'. He also advocated an exclusive business model, stressing on higher social cost benefit compared to economic benefit. Dr A P J Abdul Kalam, an eminent scientist cum thought leader, and our past president, also versioned a socio-economic development model, 'PURA'. It is a unique concept of providing all urban facilities for skill development in the rural areas so as to create an easy access for rural youths for gainful employment.

Arguably, no civil society can ill afford its sizable section to be allowed continually out of the legacies of any growth process. There are several developmental models already available or newer one could be developed, underpinning 'income policy' approach to enhance the purchasing power for the unprivileged to become self-reliant, rather than continue them to be dependent on doles in form of food aids or welfare gratis. The Laws of Manu (Manusmriti) states, "depend not on another, but lean instead on the self. True happiness is born of self-reliance"! ♦

**DR. NAWAB ALI**  
Former DDG  
(Engg.), ICAR

# CLIMATE CHANGE AND AGRICULTURE

## Mitigation Measures for Sustainable Food Security

**A**gricultural and allied activities cause rise in concentration of atmospheric green house gases (GHG) and this result in climate change and global warming. The present global agricultural production and food availability of about 4000 Mt is enough to provide about 2300 kcal of dietary energy per day to every one of 7500 million people of the world, provided every one has an equal physical and financial access to it. But, as of now, it is not so. It, therefore, requires policy and programmes that ensure this equality for food and nutritional security for every individual on the planet earth. The present, right to food policy of India, is a step forward in this direction

In India, agriculture sector contributes about 28per cent of the total GHG emissions which are primarily due to methane emission from rice-fields, enteric fermentation in ruminants, and nitrous oxides from application of



manures and fertilizers to agricultural soils. The emissions from Indian agriculture are likely to increase significantly in future as India needs more food for its increasing population.

### IMPACT OF GLOBAL WARMING ON AGRICULTURE

The generic impacts of rise in temperature would be on all aspects of agriculture. These changes could affect food production, supply and access through their direct and indirect effects on crops, soil, livestock and pests. In general, increase in temperature can reduce crop duration, increase crop respiration rates, affect the equilibrium between crops and pests, hasten nutrient mineralization in soils, decrease fertilizer use efficiencies, and increase evapotranspiration.

Increase in CO<sub>2</sub> is however, beneficial for several crops such as wheat, rice, legumes, and oilseeds, but crops like maize, sorghum, pearl millets and sugarcane may not benefit from increased CO<sub>2</sub>. It is estimated that 10- 40per cent loss in crop production in India may occur by 2080-2100 AD on account of temperature rise. Recent studies done at IARI, New Delhi indicated the possibility of loss of five per cent (4-5 million tonnes) in wheat production, with every rise of 1oC temperature throughout the growing period even after considering carbon fertilization. The 1oC increase in temperature in India would approximately coincide with 2010-2030. Photosynthesis of several crops increases as atmospheric CO<sub>2</sub> increases. Such carbon fertilization effects are important for crops such as rice, wheat and pulses. The yields of these crops, in general, increase by 10-15per cent as CO<sub>2</sub> goes up from the present level of 370 ppm to 550 ppm. Simple adaptations such as change in planting dates and crop varieties could help in reducing impact of climate change to some extent. For example, IARI reported that losses in wheat production can be reduced from 4-5 million to 1-2 million tonnes, if a large percentage of farmers could change to timely planting and better adapted varieties.

### Sector Wise contribution to climate change in India (GHG Emissions)

Sector(s)	Emission of GHG, per cent	Remarks
• Energy	61	Fossil fuel used in agriculture considered in energy sector
• Agriculture	28	
• Industrial process	1	
• Wastes	2	
• Land use changes	1	

**Contribution of agriculture in India to climate change (GHG Emission)**

Agriculture sector	Emission of GHG, per cent	Remark
• Enteric fermentation	59	• Methane emission from enteric fermentation of ruminant animals and rice fields.
• Wetland Rice cultivation	23	
• Soil	12	• Nitrous oxides from manure and fertilizers applied to soil.
• Manure management	5	
• Crop residue	1	



Global warming, in short-term, is likely to favour agricultural production in temperate regions (north Europe and North America), and negatively impact tropical crop production (south Asia and Africa). This is likely to have consequences on international food prices and trade. Small changes in temperature and rainfall could have significant effect on quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants with resultant implications on their prices and trade. Pathogens and insect populations are strongly dependent upon temperature and humidity. Increase in these parameters will change their population dynamics resulting in yield loss.

Global warming could increase water, shelter and energy requirements of livestock for meeting the projected milk and meat demands. Climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performances, and

perhaps reduce the total area where high yielding dairy cattle can be economically reared. The increase in sea and river water temperature is likely to affect fish breeding, migration and harvest. Coral reefs in the Indian seas are predicted to decline from 2040.

Measures like changes in land use and management, use of resource conservation technology, risk management through early warning system and crop insurance and nutritional strategies for managing heat stress in dairy animals help in mitigating the impact of climate change

RESOURCE CONSERVATION MEASURES
• Low Tillage
• Integrated Farming System
• Crop cover and Rotation
• Residue Incorporation
• Interculture and Weed Control
Tools and Equipment are needed for timeliness in operation, placement of inputs and comforts to workers

and global warming.

It is estimated that globally, 30per cent of Earth's species could disappear, if temperature rise 4.5°F (2.2°C) and upto 70per cent, if temperature rise 6.3°F (3°C). The hardest hit will be plants and animals in colder climates or at highest elevations and those with limited ranges or little tolerance for temperature change. The carbon dioxide (CO<sup>2</sup>) emissions that are a leading cause of global warming also turn oceans more acidic, killing coral reefs, and the microscopic plankton that blue whales and other marine mammals depend on for food. In the long run every species will be affected.

During the past few years, prices of basic grains (wheat & corn) and oilseeds (soybean) have soared up. Feed grains for meat, dairy and poultry production, and the extra demand for grains to make biofuel have pushed prices higher.

Farmers benefit from higher prices. Upto a point, investors in ethanol refineries also gain from the mandated use of their output. Although global biofuel production has increased, it still account for less than 5per cent of world wise transportation fuel. Biofuels have now become politically fashionable because they combine benefits for farmers with popular cause, increase energy security and curb global warming. The eco-gain and fuel savings are meager as the substitution of corn based ethanol for petrol-gasoline results in little reduction in GHG. Indeed, ethanol for biofuels encourages deforestation in the developing countries. Forests also absorb CO<sup>2</sup>, a green house gas.

In India, it is expected to run all cars on ethanol blended fuel. Ethanol is made from molasses, a byproduct in sugar industry. It is also regarded as a green fuel. The GOI has set a

<b>RESOURCE CONSERVATION EQUIPMENT &amp; TECHNOLOGY</b>	
• Laser land leveler	• 30-50per cent savings in water
• Rotavator	• 50per cent fuel saving and better quality seed bed
• Zero till drill/minimum till drill/ multipurpose tool bar/ raised bed planter	• 5-10per cent increase in yield and savings of Rs. 2000-3000/ha (US\$ 50-60 / ha)
• Pressurized irrigation	• 20-30per cent savings in water
• Rotary power weeder	• 20-30per cent savings in time and labour
• Vertical conveyor reaper/ combine	• Timely harvesting, more yield
• Multi-crop thresher	• 50per cent savings in labour and time and 54per cent savings in cost of threshing
• Straw combine	• Recovers 50per cent straw and also 70-100 kg grain/ha resulting into an average saving of Rs. 1250/ha (US\$ 25-30 / ha)
• Straw baler	• Makes bales and checks environmental pollution
• Straw cutter-cum-spreader	• Cuts and spreads the straw evenly and helps in sowing by zero till drill.
• Improved manual harvester for mango & kinnow	• No damage to fruit and higher capacity

deadline for oil firms to begin selling 10per cent blended fuel, also known as E10. There are several roadblocks in meeting the GOI deadline. One, oil firms are unlikely to have an adequate supply of ethanol. Indeed, they have been struggling to meet the blending requirement of five per cent ethanol, which is now mandated in some states. The big sugar companies have the capacity to meet the increased requirement of ethanol. Increasing ethanol production would require major investment by sugar companies, which may not happen overnight. There is an urgent need to look at other alternatives for producing biofuels such as *Jatropha* and agricultural wastes. These are still in a nascent stage. The government needs to dramatically speed up R&D in these areas, if it hopes to switch to biofuels.

### **MITIGATING THE GLOBAL WARMING` Carbon Sequestration**

Concerns about rising atmospheric CO<sub>2</sub> levels have generated interest in recent years regarding the sink potential of soil organic carbon (SOC). The world's soils are estimated to contain 1500 Gt of SOC, roughly double the amount of carbon in the atmosphere, while the world's oceans

have about 38000 Gt of carbon. This, the earth and its atmosphere have about 40,250 Gt of carbon.

Though fossil fuels, petroleum and coal have been the major causes of increasing CO<sub>2</sub> in the atmosphere, land modifications such as tillage have been a significant contributor. It has been estimated that in USA many soils have lost 30-50per cent of the carbon that they contained prior to cultivation. Much of this loss of carbon has been assigned to the practice of ploughing the soil and the tilled soils are viewed by many as a depleted carbon reservoir that can be refilled. It is reported that the croplands in USA have lost 5 Gt carbon, an average of 36t/ha, and suggested

that much of this can be restored over a period of 50 years with the appropriate management. The primary practice suggested was that of conservation tillage, broadly defined as any tillage method that leave sufficient crop residue in place to cover at least 30per cent of the soil surface after planting. It is believed that wide adoption of conservation tillage could sequester 25-40 Mt of carbon/year in the USA.

It is also projected that conversion of all the global croplands to conservation tillage could sequester 25 Gt carbon over a period of 50 years, marking it as one of the key global strategies for stabilizing atmospheric CO<sub>2</sub> concentrations. This



*Laser Land Leveler*

has attained general acceptance, to the extent that some farmers now receive payment from coal-burning utilities in emission-trading arrangement brokered through the Chicago Climate Exchange, in return for practicing conservation tillage. Payments are based on the premise that conservation tillage sequesters the equivalent of 1.25t of CO<sub>2</sub>-e/ha/year or 0.3t carbon/ha/year.

However, some studies on the role of tillage in sequestration of carbon have shown that both, conservation & conventional tillages help in SOC sequestration. SOC concentration, in conventional tillage, is more in deeper layers (> 30cm) and SOC concentration is near the surface 5-10 cm deep and its distribution is not uniform throughout the seed-bed extending upto 20cm. This contrasting result may be due to tillage induced differences in thermal and physical conditions that affect root growth and distribution.

There are many other good reasons for conservation tillage. It protects soil against erosion and reduces the cost of cultivation by saving energy (fossil) and labour. These benefits have been well documented, and are in themselves sufficient to justify the promotion of conservation tillage strategy to stabilize CO<sub>2</sub> concentration in the atmosphere.

However, the wider belief that conservation tillage also favours carbon sequestration may simply be an artifact of sampling methodology. There is reason to believe that the shallow (5-20 cm depth) sampling employed in most studies introduce a bias. Studies that have involved deeper (30 cm or more) sampling generally show no carbon sequestration advantage for conservation tillage, and in fact often show more carbon in conventionally tilled systems.



**RAISED BED PLANTING**

Raised bed planting has shown saving of 55per cent, 42per cent and 44per cent in time, energy and cost of operation, over conventional system on fresh beds. On permanent beds, these are 63per cent, 56per cent and 57per cent, respectively.

tem. It may be desirable to have more research on tillage based carbon sequestration involving long-term gas exchange measurements and deeper soil sampling, to clarify the issue. Until then, it is premature to predict the carbon sequestration potential of agricultural systems on the basis of projected changes in tillage practices, or to stimulate such changes with policies or marketing instruments designed to sequester carbon.

**USE OF BIO-ENERGY**

Bioenergy is derived from biomass that traps and transforms nature's solar energy into chemical energy

which is subsequently harnessed and utilized for various purposes. The similarity between fossil fuels and biofuels comes from the fact that fossil fuels are hydrocarbons formed during the fossilization of carbohydrates in biomass. However, as compared to fossil fuels, biofuels significantly reduce or eliminate nearly all forms of air pollution, from air toxins like carbon monoxide (CO) to particulates and hydrocarbons that cause respiratory illnesses and cancer, to sulfur that causes acid rain.

Rising prices of fossil fuels and environmental pollution associated with their use have resulted in a worldwide interest in the production and use of biofuels and other sources of renewable energy. Bioenergy is the most widely used form of renewable energy in every country of the world for centuries and at present it provides over 15per cent of the world's total energy supply. Upto 2010, there was 35 GW of globally installed bio-

**Impact of Zero till drill adaptation**

<b>BENEFITS</b>	<b>POTENTIAL</b>
<ul style="list-style-type: none"> <li>• 50 to 65per cent savings in time in land preparation and sowing.</li> <li>• 40-65per cent reduction in cost of operation</li> <li>• Yield increase by 5per cent</li> <li>• Saving in fuel by 30 per cent</li> </ul>	<ul style="list-style-type: none"> <li>• Total wheat area =26 Mha</li> <li>• If only 11Mha is sown by zero till, total saving expected is Rs.2200-3300 crore.</li> <li>• Average Field capacity is 3ha/day (sowing time=20 days)</li> <li>• Number of drills needed=0.18 million</li> <li>• Funds needed = Rs. 360 crores</li> <li>• Saving in cost of production =Rs.2200 crores</li> <li>• Increase in wheat production= 2 Mt.</li> </ul>

**GHG REDUCTION BY BIOFUELS RELATIVE TO GASOLINE**

Biofuel Sources	Feedstock	GHG Reduction, per cent
• Sugar	Sugarcane, sweet sorghum	100
• Starch	Maize	41-66
• Cellulose	Maize and sorghum stalk, crop residues, grasses	13-53
• Oil	Oilpalm, soybean, rapeseed	50-100

energy capacity of electricity generation, of which 7GW was in the USA.

Bioenergy can provide livelihood activities to millions of house-holds with employment and income in growing, harvesting, handling, transportation, storage and processing operations. Local farmers have the ability to improve returns as marginal crops become viable as bioenergy feedstock. Several energy crops can be cultivated on degraded or marginal land with the added benefit of preventing erosion, restoring nutrients to depleted soil and arresting desertification. There are some agricultural commodities which are specially grown for biofuel such as corn and soybean in USA; sugarcane in Brazil; rapeseed, wheat, sugarbean in Europe; Palm in Southeast Asia; sor-

ghum and cassava in China; and Jatropha and Sweet Sorghum in India.

The use of bioenergy from biomass contributes to waste management as well as energy security, and help to prevent or slow down climate change and global warming. Bio-Energy Council of India (BECI) promotes development and deployment of bioenergy as a clean and sustainable energy source and also helps in combating climate change and global warming. The need is to explore and promote new value chain in bioenergy using the latest and upgraded technology to maximize fuel crop yields for energy generations.

In 2010, the global biofuel production was about 105 billion litres and it provided 2.7per cent of the world's fuels for road transport,

through ethanol and biodiesel. Global ethanol production was 86 billion litres, and that of biodiesel was 19 billion litres. As of 2011, mandates for blending biofuel with fossil fuels exist in 31 countries. Biofuels have the potential to meet more than 25per cent of world demand for transportation fuel by 2050.

Globally, Brazil and the U.S.A., account for 90 per cent of bioethanol production from sugarcane and maize grain, respectively. European countries have so far been the leading producers of biodiesel from oilseed, which accounts for about 10per cent of total biofuels production. International trade in biofuels has been limited. The diversion of maize grain to bioethanol production and the good investment climate have driven up maize prices, which has flowed over to price increase for other cereals and generally food stuffs as well, in many countries. However, the production, consumption, and trade situation could change dramatically in the coming years. In Asian region, both China and India are gearing up for substantial investments in biofuels.



**SOME OF THE MAJOR BIOFUEL SOURCES OF THE WORLD**

Biofuel Source	A brief description
• Corn	• It is the dominant feed-stock for ethanol in the USA. Production is concentrated in the mid-west, the corn-belt.
• Sugar cane	• Brazil, the world’s foremost integrated biofuel economy, has the available land resources and tropical climate for large scale sugarcane based ethanol production.
• Wheat	• Wheat is a favoured feedstock for bioethanol in northern climate. Growing wheat for fuel has also attracted controversy.
• Sunflower	• Sunflower seed is used for biodiesel production in southern European countries such as Spain.
• Rapeseed	• The second most important feedstock currently used for biodiesel production, rapeseed (also known as canola) grows in temperate climate.
• Soya	• Soya, which can be grown in many parts of the world, is currently the most important biodiesel feedstock, accounting for an estimated 43per cent of total world biodiesel production.
• Palm Oil	• A high yielding tropical biodiesel feedstock. Palm planting has been criticized for encroaching on the environment. The use of palm, a staple food-stuff, in fuel is also controversial.
• Jatropha	• It is lower yielder than palm but also a tropical plant, Jatropha can grow on less fertile land and, since it is not an edible oil, it avoids food or fuel issue.

Malaysia and Indonesia are investing heavily in oil palm plantations for biodiesel production.

Cellulosic ethanol is likely to gain an increasingly large market share in the near future. As of now, sugarcane remains by far the most economically viable ethanol feedstock. Cost of sugarcane ethanol is 30-50 per cent of petrol and that from corn is 60-80 per cent.

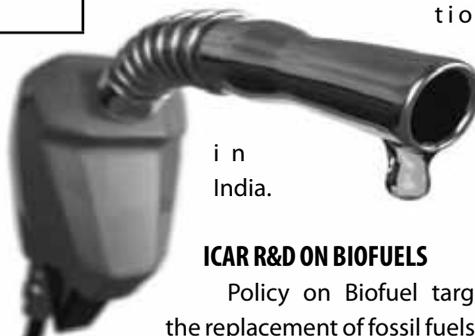
Bioenergy from biomass and other renewable energy sources, such as solar, wind, hydro, geothermal and tidal are being promoted as a substitute to the conventional fossil fuels and expected to replace it substantially by 2050. Fossil fuels invariably accompanied with environmental problems of local and global dimensions. Biofuels, including wood, charcoal, biogas, ethanol, energy crops, agricultural residues and processing products are clean and green energy source having potential to facilitate the development of a greener globe

for better living. The liquid biofuel, usually in the form of alcohol, can be produced from plant carbohydrates after enzymatic hydrolysis and fermentation. Similarly, biodiesel can be produced from vegetable oil and animal fats.

Ethanol from Agri-Resources: Agriculture produces about 800 million tonnes of crop residue annually and processing byproducts. About 150 million tonnes of it is considered surplus for conversion into biofuels. Non-edible oilseeds could also be converted into biofuels. Ethanol productivity can be calculated for the higher yielding locations/districts of important crops and such calculations show that sugarcane has the highest ethanol potential of 12000 l/ha as against 10000 l/ha for cassava and 1800-3500 l of ethanol / ha for cereals and potato.

Biodiesel Crops: It is a potential

replacement for a portion of fossil fuel based diesel used in transportation. It can be produced from both, used kitchen oil and new vegetable oils and animal fats. It is renewable resource, reduce HC, CO and CO2 exhaust emission, and is non-toxic and biodegradable. There are many oil-yielding crops such as jatropha, soybean, rapeseed, oil palm, cotton seed, rubber seed, sunflower, safflower, coconut, etc. that can be used for biodiesel production. Among these, jatropha oil is a non-edible oil and has a good potential and known for more than 50 years. A large project has been launched by the Government of India for its plantation. Jatropha oil has been used as a substitute in many countries and it is being tested and promoted by a number of R&D and commercial organizations



in India.

**ICAR R&D ON BIOFUELS**

Policy on Biofuel targets the replacement of fossil fuels by biofuel to the extent of 5per cent by 2012, 10per cent by 2017 and above 10per cent, beyond 2017. Biofuels are generally referred to liquid or gaseous fuels produced from biomass which are biodegradable products obtained from agriculture, forestry and related industries. The major biofuels are bioethanol, biodiesel, biogas and producer gas. GOI is giving more emphasis on biodiesel production through Jatropha curcas and Pongamia pinnata plantations on degraded lands and its subsequent processing and utilization.

The ICAR R&D activities on biofuels are being conducted at eight cen-

ters of All India Coordinated Research Project on Agro Forestry (AICRPAF); seven centers of the Network Project on Tree Born Oilseeds; four centers of AICRP on Renewable Energy Sources (AICRP-RES) and the Centre of Excellence on Biofuels at TNAU, Coimbatore.

The major activities of AICRP on Agroforestry in respect of jatropha, started in 2003, and focused on collection of germplasm; evaluation trials for growth; seed yield and oil content; hybridization; reproductive biology; agri-silvicultural trails; molecular characterization; biochemical activities and farmers training. Based on the information available, it can be stated that for a 4-5 years old plantations, 1-1.5 kg seed/plant could be obtained under rainfed conditions whereas 2-3 kg seed/plant is possible under irrigated conditions.

The main focus of AICRP on Renewable Energy sources (RES) is to develop technology and pilot plants for the production of biodiesel from non-edible oils such as jatropha, karanj and mahua for use in stationary IC-Engines for power and in tractors. It also focuses on development of technology for use of byproducts of biodiesel production such as husk, oilcake and glycerol.

The Centre of Excellence on Biofuels at TNAU, Coimbatore is focusing on breeding of high yielding varieties and hybrids for biofuels production from jatropha, karanj, sweet sorghum and sugarbeet; afforestation of wastelands through energy planta-

tion; biofuel production technology; byproducts utilization, popularization of biofuels and human resources development.

The current R&D activities are focused upon development and evaluation of a decentralized system for production and utilization of biodiesel in selected production catchments; use of Jatropha oilcake as a substrate for biogas and manure production; and use of straight Jatropha oil, as HSD extender. There is a need



for development and standardization of technology and system(s) for production, collection, shelling, hulling, seeds storage, and oil extraction and byproducts utilization at village or Panchayat level. It would also require development and evaluation of biodiesel plant for decentralized fuel production, storage and distribution.

#### **RECOMMENDATIONS AND SUGGESTIONS**

- Policy on biofuel should protect competition between food and fuel and identify a complimentary approach that benefits both the sectors.
- The social and environmental im-

pacts of biofuel technologies and its use need to be assessed.

- Different biofuel feed stocks for energy efficiency must be evaluated and greenhouses gases mitigated.
- Development of gene banks and molecular breeding programmes for biofuel crops having high photosynthesis and metabolism and low lignin with easy breakdown for biofuel conversion and standardize technology for post-harvest management, biofuel processing/bioconversion and byproducts utilization.
  - Utilization of crop residues for bioenergy using an appropriate thermal and/or bioconversion technology and levels of residue retention for feed and as soil amendment for sustainable land use under different cropping systems.
  - Utilization of agricultural soil as carbon sink using appropriate technology.

The major solutions for climate change and global warming in the near future for India are carbon sequestration and trading and efficient use of alternate and renewable energy sources and biomass based decentralized power generation and use, specially in the rural sector. All these would help in mitigating the impact of climate change and global warming on account of agriculture and allied activities and facilitating sustainable higher agricultural production and productivity, to meet the ever rising demand of food, feed and fuel. ♦

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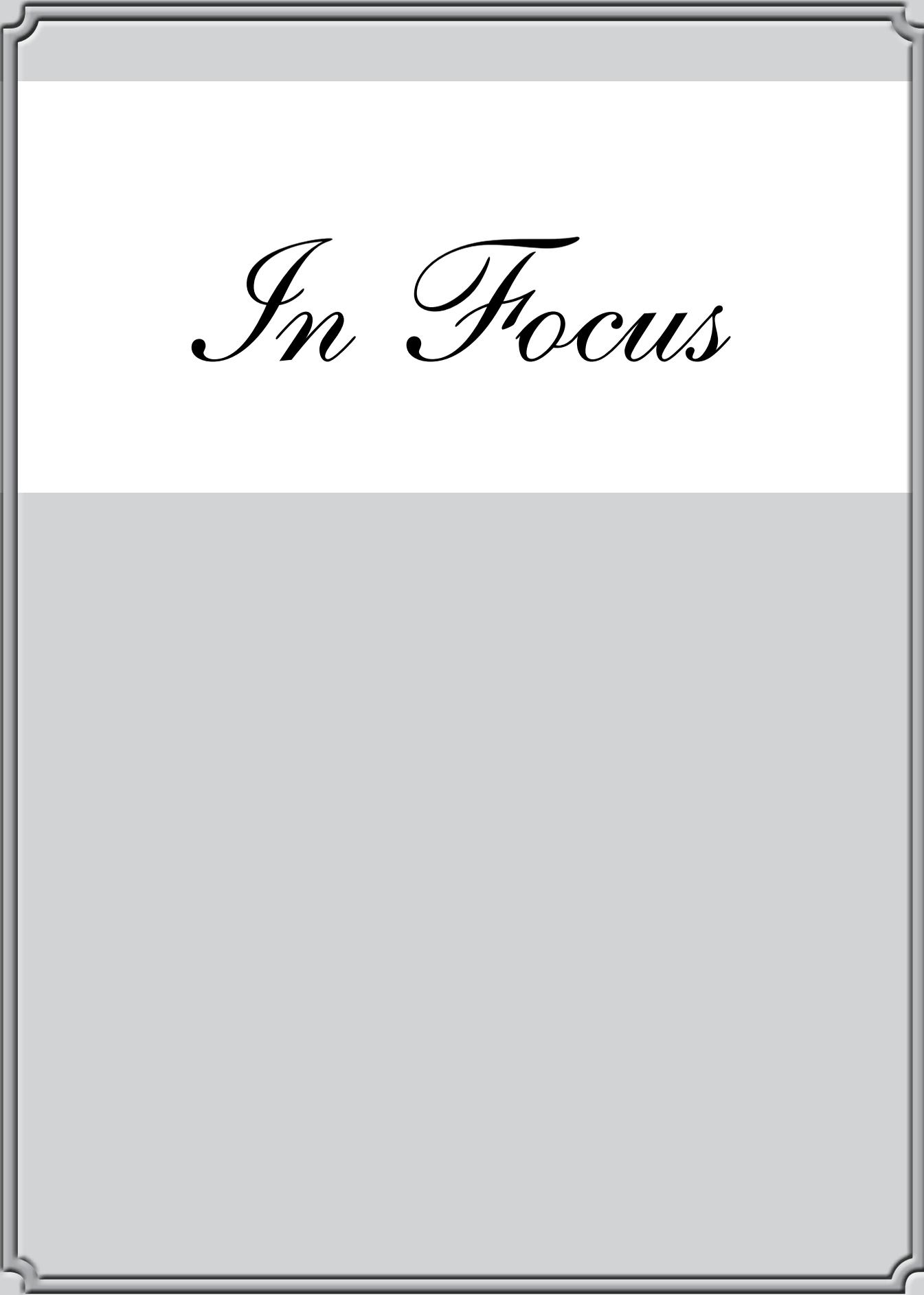


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# *In Focus*

**Raj Paroda**  
Executive Secretary,  
Asia-Pacific Association  
on Agricultural Research  
Institutions (APAARI)

## CLIMATE SMART AGRICULTURE FOR IMPROVING LIVELIHOODS OF SMALL HOLDER FARMERS

**T**he Asia-Pacific is an agriculturally vibrant region. With 38 per cent of total agricultural land, it houses 80 per cent small holder farmers supporting 74 per cent of world's agricultural population.

The region encompasses 39 countries, including 19 commonwealth members with two world's most populous countries, China (1.3 billion) and India (1.1 billion). With 3.5 billion people, the region accounts for about 58 per cent of the world's population. Agriculture (crops, livestock, fishery, forestry, and the associated natural resources endowments) is the main source of livelihood for nearly 2 billion people. The region is the largest supplier of the world's food and agricultural products. The Green Revolution was brought out by a science-led synergistic approach capitalizing genetic potential, irrigation, fertilizer, appropriate policies and farmers' hard work. It led to an unprecedented transformation in food security and rural development in the region. Since mid-sixties, the Asian cereal production has almost doubled – reaching nearly 1 billion tonnes, recording an annual growth rate of 3 per cent. The increased agricultural productivity, rapid industrial growth and expansion of the non-formal rural economy resulted in quadrupling

per caput GDP, thus halving also the level of poverty in the region. However, continuing to secure such gains is becoming a major challenge, especially in the context of declining natural resources as well as global climate change.

### THE CHALLENGES AHEAD

Food insecurity and poverty, accounting for two-third of the world's hungry and poor, exacerbated by the soaring food and fuel prices, global economic downturn, volatile markets and climate change-induced vulnerability, have surfaced as major development concerns in the region. The problem has further been intensified with sharp rise in the cost of food and energy, depleting water resources, diversion of human capital from agriculture, shrinking farm size, soil degradation, indiscriminate and imbalanced use of chemical inputs and overarching effects of changing climate. The per caput land availability for agriculture in the region (0.3 ha) is almost one-fifth of that in the rest of the world (1.4 ha). The region's agrarian landscape is dominated by smallholder farmers (~80 per cent of the world's small and marginal farmers). Now more than 650 million people, half of the world's poor (income <US\$ 1/day), are



getting hungrier and poorer day by day. It is estimated that by 2020, food grain requirement in the Asia-Pacific region would be between 30-50 per cent more than the current demand. A low investment in agricultural research for development further complicates the problem. The region currently accounts for ~26 per cent of global carbon dioxide (CO<sub>2</sub>) emissions, and its share is projected to increase to nearly 50 per cent by 2030, accelerating GHG emissions and further contributing to global climate change. The future dependence on imported fossil fuels raises concern about price volatility and shocks, and supply disruptions in agriculture production. Therefore, ensuring the availability of and economic access to food, in both quantity and quality (nutrition), for the poorest of the poor in the developing countries of the region remains a daunting challenge. In this direction, the 'GCARD Road Map' developed through interaction of diverse stakeholders in 2010 highlights the urgent changes required in Agricultural Research for Development (AR4D) globally, especially to address the needs of resource-poor smallholder farmers and consumers. It envisages major thrust on "Innovations for greater impacts on small holder farmers". In general, improving efficiency and resilience of agriculture around the farming systems would be of prime importance.

### POVERTY AND MALNOURISHMENT

According to FAO, the number of undernourished people in the world has increased during the last decade, and the number of hungry for the first time has crossed the 1 billion mark. Almost two-third of the world's hungry (642 million) and



67 per cent of the world's poor have their homes in this region. The gains made in the 1980s and early 1990s in reducing chronic hunger have been lost, and the hunger reduction target of 50 per cent by 2015 under MDG now remains elusive. Despite the fall in international food and fuel prices since late 2008, the prices in domestic markets have remained 15- 25 per cent higher in real terms than the trend level-resulting in further distress for the poor. The region is home to 70 per cent of the world's undernourished children and women. These numbers have remained stubbornly high, and have even increased lately. During the past one year, the number of hungry in the region has increased by 10.5 per cent, thus derailing the progress further. Lack of economic access, not the physical access, is thus a major challenge before the policy makers of the region.

### NATURAL RESOURCE DEGRADATION

The ever increasing population growth is interlinked with fast declining and degrading land, water, biodiversity, environment and other natural resources which are 3-5 times more stressed due to population, economic and political pressures in

the Asia-Pacific compared to the rest of the world. The region has already reached the limits of land available for agriculture and hence no further scope exists for horizontal expansion. Inefficient use and mismanagement of production resources, especially land, water, energy and agro-chemicals, has vastly reduced fertility and damaged our soil health. To a greater extent, lack of political will and appeasement policies to provide free or cheap food as well as water, energy etc., have further increased the problem.

Moreover, while maintaining a steady pace of development, the region will also have to reduce its environmental footprint from agriculture. The reduction in water availability and increase in animal and plant diseases will primarily affect poor countries and the small island states that have limited capacity to respond and adapt against such negative impacts. Regrettably, man-made disasters in some countries (like Aral Sea in Central Asia) could even exacerbate the natural ones.

### STRATEGIES TO ENSURE FOOD AND NUTRITIONAL SECURITY

#### Using Rich Biodiversity Resources

Agricultural biodiversity is a key resource for achieving food and nutritional security. The Asia-Pacific region has rich diversity of fauna and flora including agroforestry species and is the centre of origin of many important crops, livestock and forest tree species. This rich genetic resource serves as a mine of genes for specific/ unique traits for use in germplasm improvement, through breeding and biotechnology applications, in order to develop varieties possessing high productivity, better

nutritional quality, resistance to biotic (diseases and insect pests) and abiotic (drought, frost, flood, salinity) stresses and high adaptation to climatic variations.

Accordingly, germplasm conservation through use can significantly help in achieving both sustainable agricultural growth and development. It is, therefore, necessary that each country has an effective national system, including Gene Bank, to conserve valuable genetic resources for posterity and also to use them for increased productivity.

### **OUTSCALING INNOVATION FOR RESILIENCE**

One of the main causes of slow growth in agriculture is the poor dissemination of new technologies relevant to the needs of smallholder farmers. Innovations in agriculture must be to meet the challenge of increasing resource scarcity and the structural transformation in the socio-economic context. Therefore, in liberating from hunger and poverty, while sustaining the natural resources base, the policy makers will have to ensure renewed thrust and funding support on agricultural research for development.

Some new innovations such as: hybrid technology in maize, rice and other crops, Bt Cotton, GM corn etc. need to be replicated. Best practices such as conservation agriculture would contribute considerably in arresting natural resource degradation, help in climate change adaptation and mitigation as well as increasing farm profitability. One such successful example in the region is of conservation agriculture (CA) in the Indo-Gangatic Plains, led by NARS (Bangladesh, India, Nepal and Pakistan) and facilitated by CIMMYT,

has led to a cost benefit ratio of 1:19 (investments of US\$ 3.5 million led to an output equivalent of US\$ 64 million) through adoption of zero tillage for planting wheat over 2.5 million ha. The area under CA could be increased by almost four fold (10 million ha).

Efforts should be made to capture farmer led innovations on climate smart agricultural practices and blend them with modern science. For addressing the issues of resource fatigue and bridging the existing yield gaps, the recommendation domains of the best-bet management technologies, resource mapping and characterization using new tools and techniques like remote sensing and GIS, would help considerably. Documenting success stories of potential climate smart technologies like stress tolerant genotypes/hybrids, better feeding management of local livestock breeds, conservation agriculture, laser land levelling, micro-irrigation systems, use of customized fertilizer nutrients etc. and replicating them in the homologous ecologies, production systems and farmer conditions through effective regional networks receive high priority.

### **MAKING GREY AREAS GREEN**

In order to combat the twin problem of meeting food, nutrition and energy needs on one hand and increasing population and depleting natural resources on the other, there seems to be an urgency now to attain Evergreen Revolution. Special emphasis needs to be given to rainfed agriculture, which is critical for sustainability, improved livelihood and enhanced income of resource poor farmers. For better risk management, diversified agriculture- such as silvipastoral approach through crop-livestock integration, agri-horticulture and

agro-forestry has to be adopted. Accordingly, a paradigm shift is needed now in rainfed agriculture towards integrated natural resource management (INRM). Establishment of Rainfed Area Development Authorities, on lines similar to that in India, will help in making gray areas green.

### **EMPOWERING WOMEN FOR INCLUSIVE GROWTH IN AGRICULTURE**

It is now well recognized that women empowerment is important for building the nations. Late Prime Minister of India, Pandit Jawaharlal Nehru had said that "in order to awaken the people, it is the women who have to be awakened. Once she is on move, the family moves, the village moves, and the nation moves". Globally, about 43 per cent are women in agriculture. In India, 60 per cent of farming operations are performed by women. Therefore, agriculture can be a primary driver for the empowerment of women and vice versa. Innovations and opportunities at the village level will not only meet the multiple needs of women and their families, but also make their lives healthy, satisfying and meaningful. However, women in agriculture are faced with specific limitations such as: access to agricultural land, credit, technology, opportunities and market related services. All these adversely impact their livelihood and performance. The State of Food and Agriculture 2010-11 Report of the FAO has already indicated that reducing the gender gap between male and female farmers could raise yields on farms operated by women by 20- 30 per cent. As a consequence, it is estimated that this would result in a reduction of undernourished people in the world by 12- 17 per cent, which translates into 100-150 million



fewer people living in hunger. In this endeavor, both APAARI and Indian Council of Agricultural Research (ICAR) had recently organized the first Global Conference on Women in Agriculture (GCWA) involving over 750 participants across 50 countries, and defined a clear roadmap for greater empowerment of women in agriculture for food, nutritional and livelihood security.

### **STRENGTHENING COLLABORATION AND PARTNERSHIPS**

Regional and global networks and partnerships for knowledge sharing and enhanced capacity development of different stakeholders is a must for outscaling of innovations in similar ecologies. It has been increasingly realized that under the changing scenario of production to consumption, the linear approach in technology development and deployment will not serve the purpose to address Millennium Development Goals (MDGs). Therefore, for inclusive growth in agriculture through large scale uptake of new technologies, a major shift in our approach from R&D to R4D, involving greater participation of different stakeholders, will be

the key factor for future success. The past experiences from the regional organizations/programs like APAARI, SAARC, ASEAN, Rice Wheat Consortium (RWC), and Cereal System Initiative in South Asia (CSISA) reveal that regional partnership is important to catalyse adoption of new technologies and sharing knowledge for mutual benefits.

The Asia-Pacific Association of Agricultural Research Institutions (APAARI) has been instrumental in promoting regional cooperation for agricultural research and has organized a series of expert consultations on emerging issues vis-à-vis agricultural research for development (AR4D) such as: food crisis and bio-fuel; biotechnology and biosafety; post-harvest management; resource conservation technologies; climate change etc.

### **KNOWLEDGE SHARING AND CAPACITY BUILDING**

APAARI has been supporting a major program known as Asia Pacific Agricultural research Information System (APARIS) under which more than 40 success stories from the Region have been published and

disseminated widely. We need to learn from each other's success as well as failures so as to not reinvent the wheel but take advantage of innovations that have already made large scale impact.

APAARI has also come out with some important declarations such as: Tsukuba Declaration on Climate Change, Suwon Framework on Agrobiodiversity, Bangkok Declaration on Strengthening Agriculture Research for Development etc.

### **THE WAY FORWARD**

Agriculture in the Asia-Pacific must liberate the region from the twin scourges of hunger and poverty and that of malnutrition of children and women. The region must continue to feed the world with adequate food supply. Accelerated science and innovation-led agricultural growth must be inclusive and should address the needs and aspirations of resource-poor smallholders in the Asia-Pacific region. Under the growing challenges of resource degradation, escalating input crisis and costs with overarching effects of global climate change, the major gains in food grain production would largely depend in future on a paradigm shift from integrated germplasm improvement to that of integrated natural resource management. The future AR4D efforts by NARS be reoriented towards farming system's approach. More importantly, it must bridge the income divide between farmers and non-farmers and benefit equally the consumers. Developing countries in the Asia-Pacific region would have to triple their investments in AR4D, so as to address future challenges effectively and to ensure food, nutrition and environment security in the region. ♦

**R. R. HANCHINAL  
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 AND DIPAL ROY  
 CHOUDHURY**  
 Protection of Plant  
 Varieties and Farm-  
 ers' Rights Authority,  
 New Delhi

# Protection of Plant Varieties and Farmers' Rights Act: The Way Forward

**E**nforcement of Intellectual Property Rights (IPRs) in agriculture, led to the 'Plant Patent Act, 1930' in USA and formation of the Union Internationale pour la Protection des Obtentions Végétales (UPOV) or the International Union for the Protection of New Varieties of Plants in 1961 in the Europe. Plant variety protection through Plant Breeder's Rights was brought into major focus by the General Agreement on Tariffs and Trade (GATT), a multilateral instrument governing international trade. GATT negotiations in Uruguay Round led to the establishment of World Trade Organisation (WTO) in 1995. Article 27(3) b of Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) under WTO provides that members shall provide for the protection of plant varieties, either by patents or by an effective sui generis system or by any combination thereof. India, having ratified TRIPs, passed the 'Protection of Plant Varieties and Farmers' Rights Act' in 2001 to establish an effective system of protection of plant varieties and farmers' rights in harmonisation of the UPOV system of Novelty, Distinctness, Uniformity and Stability, which is an unique sui generis system of protection of plant varieties.

## OBJECTIVES OF PPV & FR AUTHORITY

The PPV&FR Authority was established on 11th Nov, 2005 with the following objectives:

- To provide an effective system for protection of plant varieties (in compliance of TRIPs agreement Art. 27(3)b, Part II) and rights of farmers and plant breeders.
- To recognise the farmers in respect of their contribution made at conserving, improving and making available plant genetic resources (in light of FAO and CBD Agenda 21) for development of new plant varieties.
- To protect plant breeders' rights to stimulate investment for R&D and develop new varieties (essence of UPOV convention).
- To facilitate the growth of seed industry to ensure production and availability of high



quality seeds and planting materials.

## REGISTRATION OF PLANT VARIETIES

Registration of plant varieties was initiated with twelve crop species in 2007 which was later on extended to another 45 crop species making a total of 57 crop species open for registration and protection of plant varieties by Aug 2013. The crop species notified includes eight cereals, seven grain legumes, six fibres, eleven oilseeds, sugarcane, eight vegetables, five flowers, four of spices and condiments, one fruit, five medicinal and aromatic plants and one plantation crop. During XIth Plan period, guidelines for more than 40 species was being finalised for DUS descriptors. Some of the prioritized crops include apple, pear, peach, walnut, citrus, banana, pomegranate, grapes, ber; forestry & commercial plantation species like tea, eucalyptus, casuarinas; vegetables like chilli, cucurbits, melons; flowers like carnation, bougainvillea, jasmine, tuberose and other crops including minor millets, betel vine etc.

## Classes of varieties that can be protected under the Act

As per Section 14, three classes of varieties can be registered: (a) new varieties, (b) extant varieties, and (c) farmers' varieties. For new varieties, the genera and the species, which can be registered is being notified by the Central Gov-

ernment. A new variety shall be registered for breeder's right, if it conforms to the criteria of Novelty [not been sold or otherwise disposed of in India, earlier than one year and outside India (in case of trees and vines earlier than six years, or, in any other case, earlier than four years)]; Distinctiveness (different for at least one essential character from all varieties of common knowledge), Uniformity (sufficiently uniform in essential characters) and Stability (if the essential characteristics remain unchanged after repeated propagation) or in short distinctiveness, uniformity and stability (DUS) parameters. The variety should have a denomination which is not a trademark/emblem or geographical indicator.

Extant varieties have been classified as the following: (a) varieties notified under the Seeds Act, 1966, (b) farmer varieties and (c) varieties about which there is a common knowledge or (d) any other variety that is in the public domain. Farmers' varieties, have been defined as (i) varieties that have been traditionally cultivated and evolved by farmers in their fields and (ii) a wild relative of a variety about which farmers possess common knowledge. The Act also makes a provision for registration of an essentially derived variety (EDV).

#### REQUIREMENTS FOR THE APPLICATION FOR REGISTRATION

Applicants are required to provide information i) about the origin of the genetic/parental material for the development of the variety and it is lawfully acquired, ii) not using the 'Terminator Technology' (GURT Affidavit), iii) complete passport data and distinct characters (Technical Questionnaire), iv) contribution of any community/others in the breeding/evolution or development of

the variety, v) photographs of the distinct characters, vi) authorisation by the breeder in case of an institutional application (PV-1) and proof of right to make application (PV-2). Applications can be made in English/Hindi, and shall be submitted in triplicate along with registration and DUS test fee (if applicable) and required quantity of seeds/planting material. However, in case of farmers' variety, application is required to be endorsed by concerned Chairperson/Secretary of the Biodiversity Management Committee/District Agricultural Officer/District Tribal Development Officer or Director of Research (State Agricultural University).

#### SEED SUBMISSION AND NATIONAL GENE BANK

Seeds/planting materials and parental lines having prescribed seed quality parameters shall be deposited to the National Gene Bank (Sec 27). Seed/planting material should not be subjected to any chemical or bio-physical treatment. The seed samples conserved in the National Gene Bank at medium term condition for the duration of protection will aid in solving disputes such as infringement of plant breeders rights etc. Field Gene Banks have been established at Ranchi, Dapoli, Mashobra for asexually propagated/perennial crop species.



#### SEED RELATED OTHER PROVISIONS

- As per rule 22(6), any public or private institution, community or individual involved in the production and use of seed of any varieties shall be required to submit the information on its characteristics or/and a true sample of seed of such variety.
- The authority shall keep a record of the production and sale of seed of all registered varieties.
- It is also necessary for all breeders of registered varieties to supply certified figures on annual seed production and sales to the Authority

#### DUS TESTING AND CENTERS

Distinctiveness, Uniformity and Stability (DUS) test can characterize and generate an official description of a variety seeking plant breeders' rights to identify the distinct characters. To ascertain distinctiveness in the field based test, a comparison of the candidate variety with morphologically similar reference varieties of common knowledge is generally done. These varieties of common knowledge can include extant varieties, VCKs/registered variety/Farmers' varieties. Provisions are as follows,

- (i) New variety: a new variety is tested in a replicated trial in comparison with suitable reference varieties of common knowledge over two similar growing seasons at two locations to determine DUS.
  - (ii) Varieties of common knowledge: similar test but for one season
  - (iii) Farmers' variety: Grow out test for one season at two locations
- Trees and vines: The testing shall be field and multi-location for at least two similar crop seasons and there is an option for on-site testing. In case field based DUS testing fails to resolve distinctiveness, 'Spe-

cial Tests' (which can be on physical, biochemical, molecular, response and organoleptic parameters) can be undertaken. Guidelines for testing each crop species are notified in the Plant Varieties Journal of India for locations, descriptors, plot size, replication, plant population, manner of data recording etc. Authority developed DUS infrastructure in more than 68 centers at ICAR institutes/SAUs/other research organisations since 10th Plan, developed crop specific guidelines and entrusted these centres to characterize reference/example varieties.

### REGISTRATION AND BENEFIT SHARING

Trees and vines can be protected upto eighteen years, whereas others can be protected up to fifteen years, but for extant varieties notified under Seeds Act, 1966, the duration will be effective from the date of notification. Breeders, agents or licensee of a protected variety are required to pay annual and renewal fee, to maintain legal protection. Annual fee shall be determined on the basis of declaration given by the breeder for the net sale value and royalty received for the registered variety and will be deposited in the 'National Gene Fund' under Sec 45. Details of the registration certificate shall be published in the PVJ inviting claims for benefit sharing that can be made within six months. Any person(s)/group/others can submit the claim for benefit sharing for their contributions made in selecting, conserving and providing the genetic material with substantive proof.

### RIGHTS OF BREEDERS

Breeders will have exclusive rights to produce, sell, market, distribute, import or export the protected variety, and can appoint agent/licensee, seek civil remedy in case of infringement of right. However authorisation is re-

quired if an EDV is produced from a farmers' variety.

### PROVISIONS FOR FARMERS

The Act gives definition of a farmer that means any person who cultivates crops by cultivating the land himself; or cultivates crops by directly supervising the cultivation of land through any other person; or conserves and preserves any wild species or traditional varieties, or adds value to such wild species or traditional varieties through selection and identification of their useful properties.

### FARMERS' RIGHTS: SEVERAL UNIQUE PROVISIONS ARE LAID OUT

- Farmers' right on seed: To save their own seed from their crop and use it for sowing, re-sowing, exchanging, sharing with and selling to other farmers provided that farmer is not entitled to sell branded seed of a protected variety.
- Farmers' right to register traditional or farmer bred varieties.
- Farmers' right for reward and recognition for community conservation.
- Farmers' right for benefit sharing, receiving compensation for undisclosed use of traditional/farmers' varieties; receiving compensation, if a registered variety can't perform under given conditions.
- Farmers right for protection against infringement and receiving free services and exemption from paying any fee.
- Compulsory licensing: If the seeds of the protected variety are not available or costly, compulsory license can be given.

Farmer's variety application must be made with respect to a variety and need not to be accompanied with GURT affidavit, any declaration that parental material has been acquired

lawfully, and passport data of parental lines. Farmers/communities can apply in newly prescribed format; give ownership details, some characters of the farmers' variety, send seed samples. State Agricultural Universities/ICAR institutes/ KVKs/ NGOs can help and endorse in filing of applications. Farmers can also be trained in training cum awareness camps conducted by the Authority. Farmers' varieties will be tested in PPV&FRA centers for one season grow out test and no testing fee is required.

### AWARDS AND REWARDS TO FARMERS

Keeping in view of the 'past, present and future' contributions towards agro-biodiversity conservation, there are provisions made for, viz., (i) "Plant Genome Saviour Community Award" of Rs.10 lakh in cash, which has already been given to ten farming communities since 2009-10; (ii) Reward of Rs.1 lakh in cash that has been given to ten farmers and (iii) Recognition certificates that were given to twenty nine farmers/communities. During 2013, the Authority published advertisement(s) in major national dailies inviting applications/nominations for the award for which the last date will be Sep 30, 2013. The awards/rewards are selected by a duly constituted committee followed by on site verification, if necessary.

Till 2013, the authority has rewarded ten farming communities with PGSC Award; ten farmers with Farmer award, and recognised twenty nine farmers/communities for their conservation work.

### REGISTRATION OF FARMERS' VARIETY

So far, the authority has registered fourteen farmers' varieties in rice and wheat, which belong to different agro-geographical regions ranging from Uttarakhand, Kerala, HP, Punjab, Maharashtra and UP, and many



farmers' varieties from all over India are in the process of testing and registration. Keeping in view of the popularity of these varieties, it is expected that concerted efforts will be undertaken for wider adoption and commercial multiplication.

### NATIONAL GENE FUND

PPV&FR Act, 2001, also provides for the "National Gene Fund" under Sec 45 and the manner of applying the Gene Fund were prescribed under Rule 70(2) for supporting and rewarding farmers, community of farmers, the tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas of agro biodiversity hotspots. This fund can also be utilised for benefit sharing, compensation and related matters.

### OTHER PROVISIONS

Researchers can use registered variety to create any variability in breeding programme but repeated use as parental line(s) requires permission of the original breeder. Any person/community/organisation can claim contribution of village or local communities in the evolution of a variety for which compensation can be determined by authority and deposited in Gene Fund (Sec 41). Any person/group of persons/governmental or non-governmental organization, on behalf of any village/local community in India, can file in any notified centre,

claim for contribution in the evolution of any variety and in that case the authority can direct breeder to deposit compensation (arrear of land revenue) to the Gene Fund. Section 47 provides that after 3 years of issue of certificate of registration, in case of inadequate seed supply, high price of a registered variety, compulsory license can be granted to undertake production, distribution and sale of seed/propagating material.

### NATIONAL REGISTER OF PLANT VARIETIES

The authority is maintaining the 'National Register of Plant Varieties'; under Sec 13, a ledger having details of the registered varieties which is an authentication of the plant breeders rights granted to the applicant.

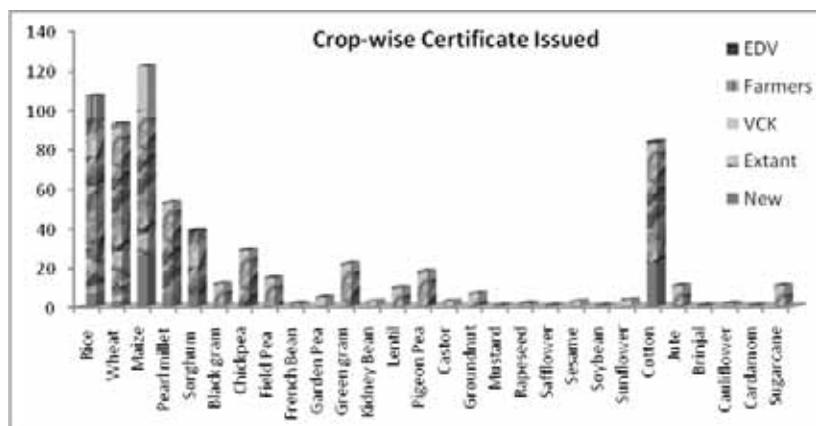
### PLANT VARIETIES PROTECTION APPELLATE TRIBUNAL (PVPAT)

An appeal can be made to Tribunal as per Plant Varieties Protection Appellate Tribunal (Application and Appeals) Rules, 2010, against the order/decision of the Authority/ Registrar for registration of a variety, registration of an agent/license, claim for benefit sharing, revocation/modification of compulsory license, payment

of compensation. There is a transitory provision by which it is provided that till the PVPAT is established, the IPAB will exercise the jurisdiction of PVPAT. The decisions of the PVPAT can be challenged in High Court. The Tribunal shall dispose of the appeal within one year.

### PROGRESS OF THE AUTHORITY

Till 14th of August, 2013, the authority has received 4,738 applications seeking protection of plant varieties under different categories (1873 under extant, 1456 under farmers', 1347 under new and 62 under EDV category); maximum number of applications were received for rice (1808), followed by cotton (953), maize (346), pearl millet (211), brinjal (213), bread wheat (141), sorghum (183) etc; plant variety registration certificates were issued for 662 crop varieties (555 extant notified, 22 VCK, 70 new and 14 farmers', 1 EDV), database development and DUS testing and development of DUS test guidelines for economically important crops. Authority has initiated several training cum awareness programme in ICAR institutes/SAUs/research institutes/other organisations; participated in several forums for exchanging and interacting with various stakeholders. Two databases, viz., NORV (Notified and Released Varieties) and IINDUS



Indian Information System for DUS) has also been developed.

### **BENEFITS OF PLANT VARIETY PROTECTION IN OTHER COUNTRIES**

As on date, majority of the developed and developing nations has ratified the UPOV convention and harmonized the domestic plant variety protection (PVP) law. Introduction of PVP system increases investments in plant breeding, research infrastructure and licensing arrangements, availability of better quality seeds and genetic material, though sometimes, seed costs increase slightly (e.g., in Canada, seed costs for cereals and oilseed industry increased upto 8.6 per cent between 1990-1999) to cover the cost of IP protection, trials and royalties. Simultaneously, public sector such as Universities and Agriculture and Agri-Food in Canada had been receiving royalties of more than \$ 2.9 million per year. According to an UPOV Report on the Impact of Plant Variety Protection, published in 2005, after China became a member of UPOV in 1999, several improved and protected varieties for major staple crops (e.g. rice, maize, wheat), horticultural crops (e.g. rose, chinese cabbage, pear), including traditional flowers (e.g. peony, magnolia, camellia) and forest trees (e.g. poplar) were available for farmers; in Argentina, during 1982 till 1991, the average annual number of titles granted to domestic breeders were 26, which doubled to 70 (267 per cent) during 1992-2001, certified seed production of protected varieties of wheat and soybean were increased; in Kenya, increased introduction of foreign horticultural varieties contributed to the diversification of the horticultural sector (for example the emergence of the flower industry) and supported



the competitiveness of Kenyan products (cut flowers, vegetables and industrial crops) in global markets; in Republic of Korea, membership of the UPOV convention in 2002 not only increased the number of genera and species under protection, it also stimulated participatory plant breeding in rice and other crops. In summary, the benefits of PVP are as follows:

- Increased breeding activity and encouraged new types of breeders, such as private breeders, researchers and farmer breeders
- Developed partnerships, including public-private cooperation
- Developed new, protected varieties leading to improvements for farmers, growers, industry and consumers, with overall economic benefit, competitiveness in markets and development of the rural economy

### **WAY FORWARD**

An effective plant variety protection system will reward innovations in plant breeding making available seeds of superior varieties which the farmers can use for increasing productivity and to face global

challenges. Indian legislation is framed to ensure 'equity' and level playing field among the plant breeders and millions of farmers who nurture 'agro-biodiversity' in centres of diversity of many crops like rice, millets, vegetables, citrus, mango, spices etc. There is a need to register more number of farmers' varieties/land races, promote in situ, on farm conservation; license and commercialize superior parental/inbred lines for exploitation of hybrid vigour which will be instrumental in benefit sharing when such varieties are utilised in commercial plant breeding programme for which ICAR/SAUs/NGOs have significant role in handholding. India, being the leading country to legislate an unique plant variety protection system with farmers' rights, which is otherwise neglected in developed economies, is required to demonstrate convergence with PPV & FR Act, 2001 for purpose in similar legislations including the proposed 'Seed Bill, 2010' and 'Biodiversity Act, 2002' for promoting innovation, stimulating investment for R&D in agricultural research for plant breeding and in ensuring farmers' rights. ♦



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# Growth Performance and Transfer of Technology in Indian Agriculture

## GROWTH PERFORMANCE OF AGRICULTURAL AND ALLIED SECTORS

Agriculture accounts for 14 per cent of GDP, about 11 per cent of total exports, remains main source of raw materials for a large number of industries, and provides employment to 57.4 per cent of work force in rural areas. However, its GDP contribution has declined from 23.4 per cent in IXth Plan to 19 per cent in the Xth to 14.2 per cent at the end of XIth Plan, and average annual growth of the agriculture was reported as 2.5 per cent, 2.4 per cent and 3.3 per cent in these plans respectively, which fell short of the targeted growth rate of 4 per cent in the eleventh five year plan. The crop sector has recorded average growth of about 1.8 to 2 per cent, however, allied sectors like horticulture, animal husbandry and fisheries have registered output growth of 4.5 to 6 per cent. Targeted Growth rate during XIIth Plan is 4 per cent. The dependence of the population on Agriculture for self-employment remained unchanged over the decade (2000-2010). Therefore, it calls for adequate coverage of small, marginal and farmers from weaker sections to obtain more inclusive and faster growth that has been prominently reflected in the Approach Paper to the XIIth Plan.

## STATE WISE GROWTH TRENDS

State wise growth trends calculated from CSO data showed that despite usual explanations for low growth like changing climate, soil degradation, stress on water resources, technology slowdown and policy constraints, some states have done exceedingly well, recording average annual growth of 4 per cent and above during XIth Plan. The major States falling in this category are: Jharkhand (7.94 per cent), Rajasthan (7.67 per cent), Chhattisgarh (6.74 per cent), Andhra Pradesh (5.38 per cent), Assam (4.81 per cent), Gujarat (4.11 per cent), Maharashtra (6.63 per cent), Karnataka (5.74 per cent), Madhya Pradesh (5.43 per cent), and other NE States like Mizoram (9.45 per cent), Manipur (8.33 per cent), Tripura (5.76 per cent), Arunachal (5.56 per cent) and Sikkim (4.83 per cent). The next category recorded average annual growth rate of 2-4 per cent - Haryana (3.44 per cent), Orissa (3.35 per cent), Meghalaya (3.34 per cent), Uttar Pradesh (3 per cent), Nagaland (2.85 per cent), West Bengal (2.76 per cent) and Uttarakhand (2.47 per cent). The third category of the states recorded low growth rate of less than 2 per cent. They are: Punjab (1.71 per cent), Bihar (1.19 per cent), Tamil Nadu (1.08 per cent), Himachal Pradesh



(1.07), Goa (1.03 per cent), Jammu & Kashmir (0.68 per cent) and Kerala (-0.4 per cent).

It showed that action at state level matters a lot in determining performance of agriculture in a state. The slow moving states are required to give adequate focus on key growth drivers like - technology, inputs, management of natural resources, investments, agricultural infrastructure, markets/price incentives, convergence and programme delivery and inclusive approach. There is a need to learn from better performing states, and replicate relevant experience in low growth/ states particularly those with high potential. Agriculture diversification towards high value agricultural commodities like fruits and vegetables hold vast potential to accelerate growth and improve farm income in the country. Harnessing full benefit of diversification requires new institutional and contractual arrangements for production / marketing, and ensuring that smallholders are not excluded from the process. Considering the costs and constraints of resources such as water, nutrients and energy, the genetic enhancement of productivity should be coupled with input use efficiency.

### **SECTORAL CHALLENGES AND OPPORTUNITIES**

#### **SHRINKING LAND HOLDINGS AND NATURAL RESOURCE BASE**

Predominance of smallholders in Indian agriculture is continuing to rise. Average size of land holding has reduced to 1.30 hectare. Small and marginal farmers now hold 83 per cent of total land holdings and they occupy about 41 per cent of area under all operational holdings. These farms have to be focussed for agricultural development for their own sake, for future growth of farm sector and overall food security. Natural resource base that sustain produc-



tion is under serious strain. Land, water, soil health and biodiversity are shrinking and deteriorating, and ground water levels are plummeting even in irrigated areas as a result of overexploitation, in several parts of the country. Continuing imbalance in use of fertilizer has affected soil fertility, and without enhancing soil health it is proving very difficult and costly to increase productivity gains. Long run sustainability of agriculture requires that land and water are used judiciously and efficiently.

#### **REGIONAL IMBALANCE**

It is widely acknowledged that there is lot of potential to raise agricultural output in the country across the states/regions/sectors. Present level of productivity of most of the crops/sectors in a large number of states is awfully low as compared to the productivity which is attainable with already available technology, and as compared to other countries of comparable levels. This potential is believed to be very large in the eastern and central regions. Regional imbalances in growth and productivity are surprisingly high, and rainfed and dry land areas continue to be in disadvantageous position.

#### **FOOD AND NUTRITIONAL SECURITY CONCERNS AND DEMAND SUPPLY**

#### **PROJECTIONS**

India ranks 67th as per Global Hunger Index (IFPRI). Half of the Children (51 per cent) are malnourished, over 55 per cent married women suffer from anaemia and 30 per cent adults suffer from protein – calorie deficiencies. Food availability to BPL and supply/distribution in disadvantaged areas and food quality / standards are other major concerns. Horticulture, milk, poultry and nutri-cereals provide an excellent opportunity on nutritional uptake. However, the awareness and reach are still limited. It is well established that malnutrition, particularly with reference to essential minerals, is a major problem, which can be addressed by inclusion of coarse cereals and millets in the diet. These crops are grown in rain-fed areas and on marginal lands without adoption of recommended package of practices including input use. Thus to utilize the potential of extinct cultivars and make available improved varieties suitable to diverse farming situation, it is pertinent to expand the umbrella of NFSM by including coarse cereals and millets in the 12th Plan.

Demand for cereal is projected to reach 235 mt and demand for pulses is projected to reach 22 mt, thus the demand for the total foodgrain is expected to reach 257 mt by the year

2016-17. Supply projections for the same indicate that India is likely to have small surplus in cereals whereas, pulses will remain in short supply. Edible oil demand is projected to reach 16.64 mt, which will require 59 mt of oilseeds. Even in the best production scenario, India remains deficit in oilseeds. The deficiency in terms of oilseeds is expected to rise to 18 to 26 mt of oilseeds. Demand for sugar is projected to grow to 26.5 mt, which can be met through sugarcane production of 279 mt. Available trend shows that India will be having surplus of sugar during the 12th Plan. Demand for vegetables and fruits are anticipated to reach 161 and 97 mt.

#### **LIVESTOCK SECTOR GROWTH/PRODUCTIVITY OF DAIRY ANIMALS/SMALL RUMINANTS**

Small holders and landless labourers own about 65-70 per cent of cattle, buffaloes, small ruminants, pigs and poultry mostly in rain fed and disadvantaged areas with low productivity. Enhancing productivity through genetic improvements, providing organized input/credit support services and marketing are required. A number of states are promoting para workers for their field programmes, however, their technical competence need to be improved through organized training. This sector is facing serious feed, fodder and health services concerns. There is need for door step delivery of health services at least of preventive type. This is far more true in case of small ruminants. Animal husbandry extension services are either missing or they are very weak. Perhaps, the forthcoming National Extension Mission should be able to strengthen the ATMA/KVK/other stakeholder linkages down the line in such a way that it addresses integrated extension delivery, and responds to the local situations as per the potentials. Rapid growth in livestock sub-sector is desirable for several reasons. The sub-sector em-

ployees include about 21 million people. It is an important source of livelihood for smallholders and landless.

**Productivity of dairy animals:** There is considerable scope to enhance productivity of dairy animal through genetic enhancement. This require production of good quality semen from high genetic sources and in desired quantity. To achieve this, the existing semen stations should be strengthened and upgraded, and / or new semen stations established to ensure at least 150 million doses of quality semen to cover 40per cent of the breedable cows and buffaloes. The larger strategy on this should be on field progeny testing for quality bull production. The AI services should be delivered at farmers' doorstep. Proposed Livestock Mission, the Dairy Entrepreneur Scheme and the World Bank funded National Dairy Plan (NDP) may be implemented in tandem and complement each other. Enhancing supplies of sexed semen will help livestock owners produce required number of males or females and contribute towards population optimization.

#### **Small ruminants and animal health care:**

The smallholders and landless labourers together control about 71 per cent of cattle, 63 per cent of buffaloes, 66 per cent of small ruminants (goat and sheep), 70 per cent of pigs, and 74 per cent of poultry. There should be adequate focus on small ruminants (Sheep/Goats) and pigs covering aspects like breeding, feeding, health care, credit and extension support. The extension arrangements for information dissemination in this sector are either weak or totally missing. Para vets and selected local community workers should be encouraged to take on extension role with proper training for this purpose. Their training and capacity building arrangements should be taken up through Krishi Vigyan Kendras, ATMs and through pri-

vate sectors. Health care infrastructure in animal husbandry sector appeared to be in adequate. Serious efforts are required to augment veterinary and health care facilities, may be through private sector investments or RKVY. It is also noticed that indigenous breeds of cattle and buffaloes need high degree of investments, and efforts for their conservation in local tracks with the support and participation of local communities, NGOs, traditional herd groups etc are needed. The issue of production of progeny tested Bulls can be linked to these efforts.

#### **Para vets and their capacity building:**

Small ruminants are playing very important role for livelihoods support systems to small, marginal and women from rainfed and tribal settings. A good number of states are promoting para vets and community volunteers, however, attention is required on their capacity building, these being crucial grassroots level functionaries directly interfacing with the farmers. There should be involvement of the State AHD Departments right from project formulation through implementation and ME, in innovative approaches for future up-scaling through selected KVKs/NGOs/Vet universities as programme partners. The outcome of the feasibility studies currently in progress under SAPPLPP in the states of Rajasthan and Madhya Pradesh may provide adequate context in this regard. Back Yard Poultry (BYP) is other area that needs serious attention as very important source of livelihoods for the poorest of the poor in rural/tribal areas, especially women folk. Linkage with GOI Schemes is essential in making good impacts. Training and capacity building of selected KVKs/Vet Universities could be taken up as a part of such interventions.

#### **DEVELOPMENT AND MANAGEMENT OF FISHERIES AND AQUACULTURE**

Globally India ranks second in total

fish production and aquaculture next to China. There is a huge potential in marine, inland and brackish water segments. This sector offers an excellent growth potential from present level of 8.44 per cent to 12.8 million tonnes during the XIIth Plan. However, the areas needing immediate attention are - by catch management, conservation of fish resources, replenishment of native stocks, fisheries infrastructure, value addition, and treating aquaculture with agriculture. Weak fisheries marketing arrangements and strengthening fisheries extension, which is either weak or non-existing, need to be addressed urgently. FFDA, Fish cooperatives, entrepreneurs, KVKs and Fisheries universities could play an important role in fish extension. Areas that would require international collaborations are - quality fish seeds/feeds and certification, management of reservoir and larger water bodies, hatchery technology for valuable species, open sea cage culture and limited capacity to harness deep sea resources.

### **INCREASED INVESTMENTS AND PROGRAMME PRIORITIES**

The projected investments in XIIth Plan in Agricultural Development Programmes of DAC are Rs.71,500 Crores, of Department of Animal Husbandry are Rs.14,179 Crores and of DARE/ICAR are Rs.25,553 Crores. The RKVY allocation has been proposed at Rs.63,246 Crores as against Rs. 25,000 Crores during XIth Plan. An analysis of the Result Framework Documents (RFDs) underlines the following priorities -

#### **THE DEPARTMENT OF AGRICULTURE AND COOPERATION (DAC):**

Increasing crop production and productivity to ensure food security, providing incentives to the states for higher public investments in agriculture and allied sectors, diversification for increased income generation, ensuring supply of agricultural inputs, soil health management, technol-

ogy dissemination and encouraging private investments in agriculture sectors on PPP mode. The Flagship Missions (NFSM/NHM/NMSA/NMAET/NMOSOP) and the RKVY constitutes major agenda of the XIIth Plan.

#### **THE DARE/ICAR**

Improved research in NRM and input use efficiency, utilizing frontier research in identified areas for better genetic exploitation, IP Management and commercialization of technologies, PHM, Farm mechanization and value addition, development of vaccines and diagnostics, monitoring of fish resources, higher education and frontline agricultural extension systems. Frontline Extension, Agricultural Education, Crop Science Research and Consortia Research Platforms forms major agenda for XIIth Plan.

The Department of Animal Husbandry Dairying and Fisheries (DAHD&F) Prevention and control of animal diseases, development of feed and fodder, increased fish production and welfare of fishers, development of poultry with focus on backyard and rural, development of small ruminants, genetic up gradation of livestock and conservation of indigenous breeds and increased milk production. The XIIth Plan agenda includes NDP, Dairy Entrepreneurs Development Scheme, the NFDB, Livestock disease and Health control programme, National Livestock Mission, etc.

#### **RKVY AS MAJOR INITIATIVE AND CONCERNS**

RKVY is a very major initiative of the GOI to incentivize the states for increased public resources in agricultural and allied sectors. It provided an outlay of Rs.25000 Crores during XIth Plan and the projected outlay for XIIth Plan is 63,246 Crores. The states are responding better as it provides flexibility to the states and provides wider coverage of allied sectors. However, the priority setting that is supposed to

have basis on C-DAPs is yet to be getting properly internalized. Also, there is need for district level mechanism to track the projects sanctioned across the sectors. Pre-screening of the projects, DPRs for the bigger projects and third party M&E would need to be considered.

### **AGRICULTURAL EXTENSION AND FARMER EMPOWERMENT**

#### **XIIth Plan Working Group recommendations**

Agricultural extension covering crops and allied sectors is the prime responsibility of the states, and it is expected that the states should drive the extension reforms process. The National Mission on Agricultural Extension and Technology may primarily support states' efforts in this direction. Further, it has been observed that the project formulation capacity of ATMA needs to be augmented to draw the location specific extension plans. The MANAGE and SAMETIs should take up leading role in driving the extension reforms at the national and state levels respectively. ATMA and KVKs should lead the extension reforms process at the district level and below, keeping in view the priorities reflected in the Comprehensive District Plans. Intensive use of ICT application, strengthening HRD / training infrastructure, empowerment of farmer groups, involvement of farm youths and farm women, field level linkages between various extension agencies and promotion of PPP arrangements in extension should also be focused. Progress on agricultural extension reforms should be put as one of the pre-conditions for release of RKVY funds to the States.

#### **REFORMS IN EXTENSION PLANNING AND MANAGEMENT**

The Project Planning and Management (PPM) capability of ATMA/KVKs and other institutions should be improved through (a) engaging a project management agency at the dis-

tract level to formulate projects, access funding, train the staff and stakeholders and support service delivery, assist project implementation and monitor project implementation; (b) improve PPM skills of ATMA, BTTs and other institutions; and (c) leveraging the capabilities of ICT to the fullest extent for formulation and implementation of the Extension Mission. ATMA shall be the platform for convergence and service delivery of all schemes and programmes of agriculture development at the district level and below, capturing priorities through C-DAPs. A convergence matrix may be prepared, which will list out schemes and component wise allocations and activities. Every proposal for funding under existing schemes or new schemes should be accompanied by a convergence matrix relating to that department. Full potential of KVKs needs to be harnessed promoting them as knowledge resource centres addressing issues like enhancing contingency grants, farm developments, linkages with development units at district / block / villages, additional SMSs in critical areas, etc. The present extension system does not pay adequate attention to livestock, fisheries and fodder. As separate extension machinery for animal husbandry and fisheries are not going to be feasible in many states, this function need to be integrated with ATMA with suitable backstopping from KVKs and private players.

### **FARMERS' EMPOWERMENT**

Empowerment of farmers and promoting farmers organizations should form the basis for sectoral growth. Aggregation of small and marginal producers, their training and capacity building, credit support and institutional back up would require to be streamlined in this process. This is absolutely essential to realize the advantages of decentralization process.

### **EXTENSION REFORMS/STRATEGIES FOR EFFECTIVE TECHNOLOGY TRANSFER**

- Extension must empower farmers, farm youth and farm women
- Extension system must respond to the extension needs of farm women (feminization of extension services—both public and private)
- Project planning and management capacities of ATMA, KVKs, and BTTs need to be improved, enabling them to develop locally relevant extension interventions
- ATMA must provide programme convergence platform at the district level and below
- C-DAPs must provide holistic extension opportunity as opposed to crop centric extension
- Promote para extension workers and alternate sources of extension delivery, across the sectors, and build their training and capacities
- Promote intensive use of ICT/FFS, supported by systematic capacity building of field functionaries and farmers for this purpose. e- extension and m-extension would provide much needed reach to the small and marginal farmers as they are generally bypassed by the village extension functionaries
- Extension must address decentralized planning process and extension outreach in disadvantaged areas like hill and mountainous, desert, chronic drought prone & tribal areas
- Proper sharing of extension/training space by various stakeholders at local level
- KVKs to lead by locally relevant science based innovations/examples
- Involvement of PRIs and increase community participation in extension programmes
- Promote PPPs and agri entrepreneurs, and provide them adequate space in extension
- Develop right equilibrium between KVKs-ATMA-Others.... for

locally effective extension strategies and their applications

- Promote best extension actor in given local situation and let others supplement
- TOT in allied areas like horticulture/animal husbandry/dairy development and fisheries need to be systematically worked out involving both public and private extension resources
- Extension must capture and provide proper feedback analysis to the local research system so the research results respond to the location specific problems
- Extension must capture and internalize successes of innovative programmes like NAIP/NICRA and globally proved best extension practices and apply them locally after due validation and assessment
- Field programmes must have in-built arrangements for extending successes
- Extension agents both in public-private must be oriented to NRM, marketing and mechanization needs of the local areas
- Flagship missions should have strong TOT/extension window with proper linkages down the lines up to field
- R & D convergence guidelines developed jointly by the DAC/ICAR must be properly understood, appreciated and implemented in true spirit by both ATMA/KVK systems to supplement and complement each other
- National Extension Mission may have an in built arrangement for extension innovations and action research as a mechanism to respond to local extension needs,
- Finally, extension must drive and facilitate locally effective, regionally relevant and globally competitive growth of agriculture & allied sectors. ♦

# *Focussed Crops*



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# Sawan Millet for Food and Nutritional Security

**T**he demand for minor millets is increasing due to technological, industrial and economical advances of the developing society in India. Traditional crops like sawan millet once again made their presence felt because of their nutritional values and awareness pertaining to healthy life style. Waking up to the prevailing trend, the UP government has made a shift to its agro policy giving importance to the cultivation of these minor millets. Minor millets are a group of grassy plants with short slender culm and small grains possessing remarkable ability to survive under severe drought. Sawan millet is a multipurpose crop which is cultivated for food and fodder. In all types of soils and adverse climatic conditions, it survives. It has an excellent rejuvenating capacity compared to other cereal crops. The fast growing nature of this crop suppresses the weed growth. It a promising crop under adverse agro-climatic conditions. Minor millets are cheap and healthy but have lost their importance mainly due to lack of knowledge about their nutritional value. Apart from making contributions to health and nutrition, sawan millets are also crucial for income generation. Sawan millets are small grained annual, warm weather cereal which is grown around the world for food and fodder. Essential similarities of the members of this group of species are the resistance and ability to thrive in harsh environments, along with nutritious seed content. It has been cultivated since time immemorial. This millet accounts for less than one percent of the food grains produced in the world today. Thus this is not important in terms of their nutritional contribution and their role in local agro-ecosystem. This crop is mostly grown in marginal areas or under agricultural conditions where major cereals would fail to give sustainable yield. The decline of sawan millet cultivation can be ascribed to a number of reasons related to agronomic aspects such as lack of suitable improved varieties, lack of

improved cultivation practices, socio-economic aspects, lack of more attractive and modern food recipes, lack of specific post-harvest and processing technologies for small users, poor capacity at both household and market levels, poorly organized or non-existent value chains, insufficient awareness of nutritional value and income opportunities, and policy aspects (lack of enabling policies to support their cultivation and use as in case of major cereals). Sawan millet is also described as nutritious millet and has received far less research and development focus than other crops with regards to crop improvement, cultivation practices and utilization. This crop is highly tolerant to alkalinity and can grow even at pH as high as 11.0. They are highly drought resistant and tolerant to water logging also. India is the largest producer of millets producing about 33-37 per cent of the total 28 million tonnes of world produce. Sawan millet is rich in proteins, vitamins and mineral content which are generally deficient in other Indian food. Most of the Indian diet is deficient in these components, so this millet is helpful in providing proteins, vitamins and minerals. This minor millet is quick maturing, drought resistant grain crop grown during emergencies, famines or when the proper season has passed sowing of the main food crop. This is also tolerant to waterlogging.

Sawan millet is closely related to weeds commonly found in dry land or sometimes in rice fields. It is grown largely in Madhya Pradesh, Uttar Pradesh and Bihar. The yield of this crops is less than 400 kg/ha. It is very resistant to drought. The dehusked grain can be cooked like rice or made into flour for porridge or chappathis. The fodder is considered to be poor in nutritional quality and is fed only under critical drought conditions. This crop is grown for food and fodder purposes. In UP, recommended varieties are Anurag and Chandan. This millet is an excellent source of dietary fibers with good amount of soluble and in-

soluble fractions. The carbohydrate content is low and slowly digestible, which makes these millets a nature's gift for the modern mankind who is engaged in sedentary activities.

Sawan millet contains vitamins - thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, folic acid, vitamin E, K and sufficient amounts of calcium, iron, magnesium, phosphorus, potassium, zinc, copper, manganese, selenium. The natural fat namely omega 3 and omega 6 fatty acids are also present in sufficient amount. The dietary fiber normalizes blood sugar and cholesterol level. Sawan millet has excellent nutritional value in view of their good protein content and better amino acid profile. Their starch composition and low glycemic index (which make them ideal for diabetic patients) are also accompanied by gluten free status of the flour, thus making very suitable for preparation of weaning products.

The flour of this millet is very nutritious and has recorded higher proportion of coarser particles and high water holding capacity (2.69g/g) than refined flour. Standardization trials indicated that incorporation of sawan millet flour at 60% in the standard recipe produces acceptable cookies with low trans fats. Highly acceptable value added cookies were developed with nutraceutical ingredient such as linseed, soya, cocoa, chocolate, dry fruits, nuts and garden cress seeds. Wide variation in physical characteristics of the cookies were noted which also exhibited shelf life of more than 120 days without apparent increase in moisture peroxide value. Control cookies could be stored for 75 days, whereas plain millet cookies were storable only for 45 days.

Sawan millet contains some anti-nutritional factors such as phytic acid and tannins. Phytic acid is an

inhibitor of iron and zinc absorption in human being. The negatively charged phosphates in the phytic acid binds strongly to metallic cations such as K, Mg, Mn, Fe, Ca and Zn to form mixed salt phytin and do not allow release of micro-nutrients in the intestine. Then any reduction in the content of phytic acid in food is likely to result in improved iron and zinc bio-availability. Tannins are polyphenolic materials which are able to precipitate proteins from solution. The presence of tannin in minor millets reduces the palatability



and digestibility of proteins. It also reduces the protein digestion by inhibiting digestive enzyme. It is also responsible for astringent taste of food also.

These anti-nutritional factors in sawan millet can be removed by some processing methods such as soaking, boiling and germination of the seeds. They are mostly present in the outer covering of the seed coat and can be eliminated after removal of the husk from the seeds automatically.

Today there is a perceptible change in the life style of people owing to rapid industrialization, improved socio-economic status,

enhanced health facilities and increased life expectancy. Economic affluence coupled with sedentary life styles and changing food patterns are contributing to several chronic degenerative diseases such as diabetes mellitus, cardiovascular diseases, and cancer. Diabetes mellitus is a silent disease and is now recognized as one of the fastest growing threats to public health in almost all countries of the world. Around 150 million people suffer from diabetes, of which above 45 million are Indians, the highest numbers in any country. The revised world health organization figures for the year 2025 is 57.2 million diabetics, the chief reason being urbanization and life style, besides heredity, race, nutritional status, stress, altered immune function, altered physiological and metabolic status, drugs and hormones.

Besides it is rich in minerals and phytochemicals. It has been proved to be suitable for people suffering from metabolic disorders such as diabetes mellitus. It is now recognized as one of the fastest growing threats to public health in almost all countries of the world and India is recognized as world capital of diabetes. Dietary modification, weight control and regular exercise are the main approaches in the management of this disease. The FAO report says there is too much focus on the quantity of food grains to attain food security while leaving behind the concern of nutrition, which will come from much more diversified diets containing minor millets and other plant based sources. So for the health conscious genre of the present world, sawan millet is perhaps one more addition to the proliferating list of healthy food owing to its nutritional superiority. With the modern people chasing ready to cook food items, the nutritive minor millet is being faded into oblivion.

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# Production and Utilization of Tropical Tuber crops in India

## Current Scenario, Issues and Future prospects

**T**here are more than 50,000 edible plant species in the world; out of which only fifteen provide 90 per cent of the world's food energy intake. Besides grains, roots and tubers like cassava, sweet potato, taro, yams, etc. are important staples for over 1 billion people in the developing world. India produced a record 252 million tonnes of food grains during 2011-12. Despite this, approximately 217 million of our people (17.50 per cent of total population) remained chronically under-nourished during 2012. India has pledged to reduce under-nourished population from 26.90 per cent in 1990-92 by half in 2015 under millennium development goal (MDG), which is unlikely to be realized in spite of satisfactory overall economic growth. According to FAO, 'nutrition-sensitive growth in a country can be ensured by supporting increased dietary diversity'. Population of India is projected to grow to 1.62 billion by 2050 and the demand for food grains which is projected to increase to 345 million tonnes in 2030, can even go up to 450 million tonnes by 2050. In this context, tropical tuber crops like cassava, sweet potato, elephant foot yam, yams, taro etc. become important for ensuring food and nutritional security of the country. India produced approximately 10.24 million metric tonnes of tropical tuber crops in the year 2010-11, with a farm harvest price of approximately Rs. 5,258 crores that constituted around 0.75 per cent of agricultural GDP.

Cassava is the most important tropical root and tuber crop. In terms of total production, cassava is the tenth most important food item globally with total production of 252.20 million tonnes in 2011 with an average yield of nearly 12.83 tonnes/ha. In tropical regions, cassava is the fourth most important source of calories in the human diet, and has higher carbohydrate content than either maize or rice. India is the ninth largest producer of cassava with a total production of 8.08 million tonnes and average

productivity of 36.48 tonnes/ha, which is thrice that of world average. Tamil Nadu, Kerala, Meghalaya, Assam, Andhra Pradesh, Karnataka, and Nagaland are the major cassava growing states in India. Sweet potato ranks sixteenth in the world in terms of total production and is grown throughout the world in approximately 10 million ha area, producing approximately 150 million tonnes. China ranks first in area and production; India with an annual production of approximately 1.05 million tonnes is seventh in rank. Odisha, West Bengal, Uttar Pradesh, Assam, Chhattisgarh, Karnataka, Madhya Pradesh, and Meghalaya are the major sweet potato growing states in India. Yams, taro and tannia are the other important root and tuber crops produced globally. Taro (arvi), elephant foot yam (jimikand), and yams are grown as vegetable crops in homestead or in semi-commercial scale throughout India. Most of them are reservoirs of resistant starch, minerals, vitamins, antioxidants, and dietary fibres.

Tuber crops have a higher biological efficiency as food producers with high dry matter production per unit area per unit time, and have gained importance not only as food crops but also for their scope in feed and agro-based industries. Tuber crops have proved to be life sustaining crops in times of natural calamities and famine. Most of the tuber crops are bestowed with resilience to global warming and climate change, potential for better return under adverse soil and weather condition, diverse industrial applications and nutritional attributes, and most of all exceptionally high CO<sub>2</sub> fixation potential. The exceptional soil carbon sequestration property of cassava makes it a potential crop for ameliorating green revolution fatigue. Besides, there is immense potential of cassava as raw material for bio-ethanol production. In fact, China has taken a policy of substituting corn with cassava for bio-ethanol production. Considering the fact that access to modern affordable energy is es-

essential for the achievement of the internationally agreed development goals, the United Nations General Assembly declared 2012 the 'International Year of Sustainable Energy for All'. Cassava may contribute in a big way towards fulfilling targets for production of green energy without disturbing food security situation.

**R&D ACHIEVEMENTS**

The Central Tuber Crops Research Institute (CTCRI) under the aegis of ICAR, solely involved in R&D activities of tropical root and tuber crops, started functioning at Thiruvananthapuram, Kerala in 1963. In order to address the issues of tuber crops and promote their development in the northern and eastern States of India, a Regional Centre of the Institute is also functioning in Bhubaneswar, Odisha. Besides, the All India Coordinated Research Project (Tuber Crops) is making concerted effort in creating awareness on the vast diversity and potentiality of tuber crops as a food and industrial crop in the traditional as well as non-traditional areas of the country, especially in the North-East India.

Over the years, the Institute has

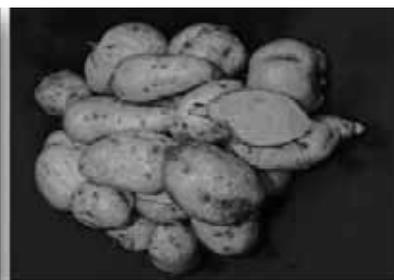
addressed many important aspects of root and tuber crop research viz., breeding, biodiversity conservation - both ex situ and in vitro, resource management, production, protection, utilization, and popularization. Sustainability of cassava production - both for edible purpose as well as for starch extraction - is largely dependent on availability of high yielding varieties. Other tuber crops like sweet potato, yams and elephant foot yam are still being used primarily as food crops, and varieties having good cooking and nutritional qualities are key desirable attributes, in addition to higher yield. Keeping those priorities in view, CTCRI has developed and released 47 improved varieties of tuber crops for cultivation in different agro-climatic regions of the country. Demand of the starch industries have been met with the development and popularization of high starch varieties of cassava like H165, H226, CMR-1 and new triploid varieties 4-2 and 5-3. Cassava mosaic disease (CMD), being a major threat to cassava cultivation, was given highest priority that resulted in the development of CMD resistant variety Sree Padmanabha and several highly resistant lines

ready for release. Similarly, sweet potato (Sree Kanaka, Gouri, ST-14) and greater yam (Da 331) varieties with higher content of carotene and anthocyanin, respectively, have been developed. Elephant foot yam (EFY) and greater yam are gaining importance as vegetables throughout India, and high yielding EFY varieties like Sree Padma and Sree Athira as well as dwarf yam variety have been developed.

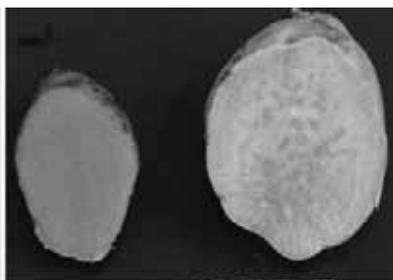
Viable multiple cropping systems were evolved for tuber crops which could provide additional income to the cultivators. Organic farming technology for aroids and yams as well as site specific nutrient management practices for cassava, integrated nutrient management technology for tuber crops, technology for large scale multiplication of planting materials were standardized and transferred to farmers. Potassium efficient lines were identified in cassava which could improve the potassium use efficiency and result in higher yield. Similarly, eco-friendly management packages have been developed for important fungal diseases like cassava tuber rot, elephant foot yam collar rot, taro blight, and



**CMD resistant cassava - Sree Padmanabha**



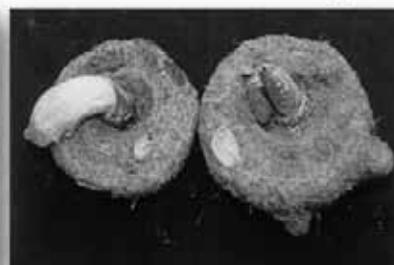
**Sree Kanaka - carotene rich sweet potato**



**ST 14 - carotene rich sweet potato**



**Leaf blight tolerant taro - Muktakeshi**



**Sree Athira - first hybrid Elephant Foot Yam**



**Sree Dhanya - first Dwarf Yam**

insect pests of sweet potato, cassava and stored products. The sweet potato variety, Sree Bhadra, was identified as trap crop for nematode management. Efficient bio-pesticides have been developed from cassava leaves that could manage several noxious pests of important crops as well as storage pests. Diagnostic techniques were standardized for the important viral diseases viz., cassava mosaic diseases, sweet potato feathery mottle, sweet potato leaf curl, elephant foot yam mosaic virus, yam mild mottle virus and yam Badna virus which forms a part of management. Strategies were developed for the production of disease free planting materials to cater to the requirement of farmers.

A major problem in the post harvest utilization of cassava is the poor shelf life of tubers, necessitating immediate processing to storable forms like chips, starch, flour etc. Besides, the very low protein content in cassava is a major drawback in its use as food. Keeping these major issues in view, CTCRI has developed a number of value added products, which include nutritionally fortified snack foods and fried chips. The technologies of snack food preparation from cassava

have been transferred to a number of small and medium entrepreneurs, while fried chip technology has been commercialized by M/S Tierra Food India Pvt. Ltd. as 'Kappo'. Besides, many starch based products like super absorbent polymers, graft co-polymerized starch, super porous hydro gels, biofilms etc. were developed that are ready for commercialization. Health foods like low glycaemic pasta/spaghetti were developed from cassava and sweet potato, which had high nutritional quality as well, substantiating the emerging role of tuber crops for food and nutrition security of India. A number of post harvest processing machinery viz., chipping machines, starch extraction machinery, granulators, adhesive plants etc were developed in the past which are having good domestic and international demand.

Technology generation and transfer being closely interlinked with the utilization by the clientele system, emphasis was also given in the past to study the impact of the technologies. Further, the Institute has established Institute Technology Management Unit (ITMU), organized Scientist- Entrepreneur Interfaces and prepared

Techno Economic Feasibility Reports (TEFRs) for the commercially viable technologies. Commercialization of value added fried snack foods are taking off in a good pace with more and more people approaching the Institute for technology adoption.

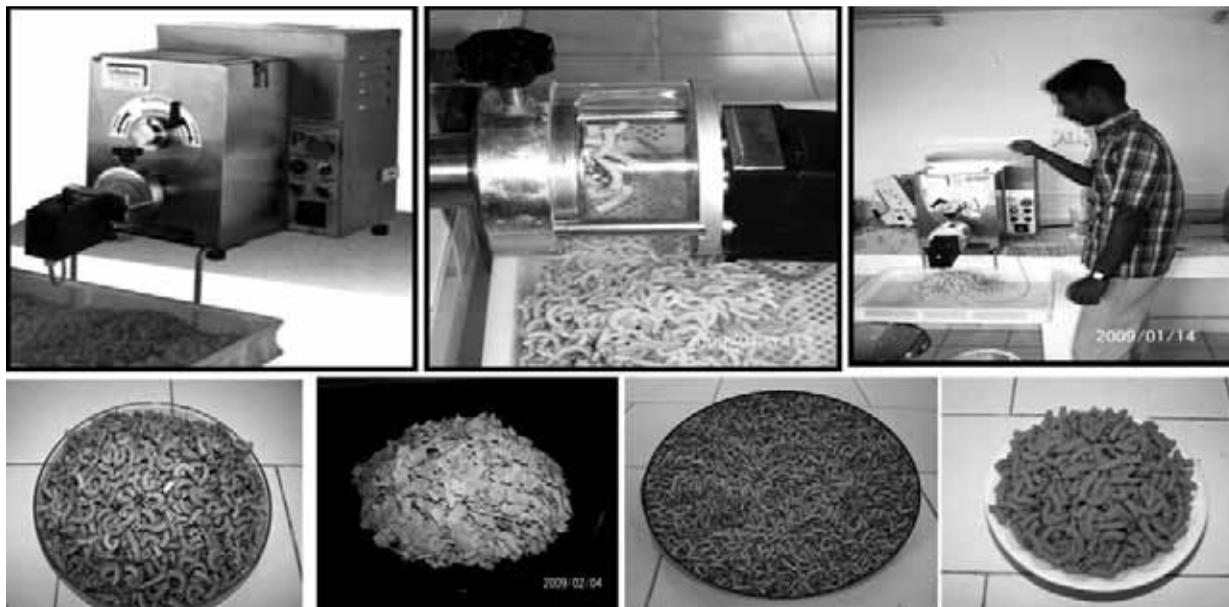
### CURRENT SCENARIO

Presently, there is a loosely knit linkage between the research, extension and clientele system in case of tuber crops. There is no well defined Government policy for root and tuber crops development, both at central or state government levels, except for two or three states. On the contrary, in countries like Thailand and Indonesia, the major root crop viz., cassava, receives adequate development support from Government, both policy and finance wise. In order to synchronize production of tuber crops with marketing, it is necessary to open new avenues for its better utilization, under the present context, where traditional uses have almost stabilized. Cassava is mainly used in industrial (60per cent), human consumption (28per cent) and animal feed sectors (12per cent). In the textile industry, starch is required for sizing of cotton yarn before weaving, and presently maize starch is the major competitor for cassava starch. The cotton yarn sizing industry is currently consuming nearly 85,000 tonnes of cassava starch.

By virtue of its good adhesive properties, cassava starch has become an important raw material in the adhesive sector. Cassava starch based adhesive finds important place of application in corrugation box industry, paper conversion industry and liquid gum industry for domestic use. Maize starch is one of the competing raw materials in adhesive sector for cassava starch. Craft paper and starch (either cassava or maize) are the important raw materials in making cor-



**Value Added Products from Tuber Crops**



**Functional foods from tuber crops**

rugation boxes. These corrugation boxes are being used in all the industries like textiles, consumer durables, processed foods etc. Currently two million tonnes of craft paper is being used in making 15,137 million sq. mt length corrugation boxes, and most of the units use cassava starch in making corrugation gums due to good adhesive properties and its low price over maize starch. As a result, this industry presently consumes 1, 15,000 tonnes of cassava starch.

#### ISSUES AND FUTURE PROSPECTS

Since agriculture in India is by and large linked to food security, it is necessary to integrate the production systems of various tuber crops with food grain production. Simultaneously, there is also the necessity to fully tap the potential of tuber crops especially cassava and sweet potato as industrial raw materials. The area, production and productivity of cassava in India has been showing an increasing trend since 1991, and growing at 0.1, 2.5 and 2.5 per cent respectively in area, production and productivity and still higher growth rates were recorded during 2001-10 (0.7per cent in area;

3.7per cent in production and 3.0per cent in yield). However, the area and production of sweet potato have been declining at an annual rate of 0.8per cent and 0.4per cent respectively, although its yield showed increasing trend at 0.2per cent per annum during 1991-2010. Greater thrust is necessary in tuber crops research, by spreading their cultivation to non-traditional areas, projecting the nutritional and food security role of tuber crops, augmenting the utilization prospects by developing value added food, feed and industrial products, developing demand assessment strategies and exploring new market options, exploring hitherto under-explored areas like developing herbal products with medicinal effects, bio-insecticides, natural food colourants, etc. Tuber crops, in general, and cassava, in particular, are well adapted to conditions of drought. They can also be cultivated under wide range of soil conditions and their ability to grow under a wide range of agro-climatic situations enhances the scope of extending the cultivation to the non-traditional regions. The phenomenal growth of cassava in harsh semi-arid environments in Tamil Nadu

and Andhra Pradesh establishes the strength of cassava crop to sustain in dry environment. Nevertheless, tuber crops, in general, are labour intensive and require large number of labour for cultivation. Reducing the cost of production through less dependence on labour and inputs is necessary to tide over this situation. Mechanization of agricultural operations like land preparation, planting, weeding and harvesting is one of the alternatives to make tuber crop cultivation remunerative.

Reduced availability of irrigation water will be a major constraint for agricultural production in India and especially so, for tuber crops production, due to climate change, and more demand for other high value crops. Further, there is need for development of precision farming technology and micro-dosing, and methods for improving fertilizer use efficiency. Being vegetatively propagated crops, quality seeds are limiting factors for rapid spread of new varieties and crops. Technology for rapid multiplication of planting material for tuber crops is yet to take off in many RTC growing states, stressing the need to create

awareness and dissemination about the technology through government machinery and NGOs.

Some of the biotic stresses include Cassava mosaic disease, sweet potato weevil, taro leaf blight, anthracnose disease and nematodes in yams, collar rot and viral diseases in elephant foot yam and the abiotic stresses include water and salinity stress, water logging, inconsistency in tuberization in sweet potato etc. Emerging pests and diseases due to climate change, and introduction of invasive pests and pathogens are also main challenges. Appropriate technologies to contain such biotic and abiotic stresses are necessary which are being addressed on a large scale at CTCRI.

Demand for cassava in the human consumption sector has been declining drastically especially in the traditional cassava consuming state of Kerala in India. The drastic reduction in consumption is because of increased availability of cereal food grains, increased per capita income and thereby increased standard of living. This creates a situation where future of tuber crops, especially cassava, lies in the industrial and livestock sectors. Lack of adequate proteins in cassava tubers is one of the major drawbacks in its use for composite feed manufacture for cattle, poultry, pig and fish. Although, cassava and sweet potato leaves have high protein content, their potential as animal feed has not been properly exploited.

With the rapidly changing food habits and increased migration to urban areas coupled with the projected rise in per capita income, there is also a projected increase in lifestyle diseases. Demand for processed and ready-to eat convenience foods may also simultaneously increase in the next 30-40 years. One of the major challenges for the country will be to provide nutritious, safe and healthy food to people. There exists potential to

develop prophylactic and therapeutic functional foods from tuber crops, as unlike fruits, the starch and flour open large avenues for processing, fortification etc. Sweet potato, despite being a health food, is seldom consumed by urban and elite, and factory level processing does not exist presently in India, unlike in China, Japan, Korea and parts of America. The immense nutritional value of tuber crops due to its anthocyanin and carotenoids content has so far not been fully exploited.

The projected per capita cotton cloth availability and the positive growth trend in the production of cotton yarn during the last two decades indicate a favourable demand for cassava starch in the textile sector. Projection of cassava starch demand in the sizing industry, based on population projections (Census Commissionerate, Govt. of India) and projections of per capita availability of cotton cloth shows that by 2016, sizing industry would require 90,383 tonnes of cassava starch; by 2021, the requirement would be 1,01,368 tonnes and by 2026, the sizing industry would require 1,15,793 tonnes of cassava starch.

Cassava starch demand in corrugation box industry is a derived demand from total industrial growth in the country. Cassava starch demand in the corrugation box industry sector shows a very favourable trend, and nearly 1.61, 2.26 and 2.96 lakh tonnes will be the starch demand by 2016, 2021 and 2025 respectively, at a projected growth rate of 7 per cent, while the demand by 2016, 2021 and 2025 would be 1.85, 2.98 and 4.36 lakh tonnes respectively, at a growth rate of 10 per cent. The starch demand by 2016, 2021 and 2025 would be 2.31, 4.65 and 8.14 lakh tonnes respectively, at an anticipated growth rate of 15 per cent. Therefore, it is very evident that large gap between demand and supply of starch is likely to be created by

2025 itself, and it may be very hypothetical to project for 2050 due to rapid changes occurring in the economy. This calls for concerted efforts to increase the production of cassava tubers, and thereby starch, both in traditional and non-traditional areas of cassava cultivation.

A major challenge faced by the cassava growers and industrialists alike (in the context of WTO agreement) is the increasing import of starch from countries like Thailand, where the cost of production is less due to cheap labour. India started facing stiff competition from Thailand in the international trade for cassava starch after liberalization and opening of our markets. Cheaper Thailand cassava starch started entering Indian starch markets, thereby affecting domestic cassava starch industries. This is likely to lead to an alarming situation, where many of the traditional starch factories will have to be closed down, which indirectly can lead to further decrease in the cultivated area under cassava, and unemployment for many who depend on the industry. Cost effective production of starch as well as its diversification to new products having domestic and international demand are thus essential for the sustainability of processing industries. There is an increasing awareness about the vast pollution caused by plastic materials as well as the inefficient and unhealthy ways of its disposal. This points to the need to develop 100 per cent biodegradable packages/allied materials like films, containers etc. Tuber crops as such provide a vast scope for diversification and value addition and there lies a great opportunity for non-traditional uses of tuber crops in the form of convenience foods, functional foods, biofuels, starch based innovative products like biofilms, thermofoams etc. ♦

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# Millets-The Nutricereals

**M**illets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. Millets are also unique due to their short growing period. They can develop from planted seeds to mature, ready to harvest plants in as little as 65 days. Small millets have a capacity for wide adaptation. They can withstand a certain degree of soil acidity and alkalinity, stress due to moisture and temperature and variation in soils from heavy to sandy infertile. They are grown from the extreme southern tip of India at sea level to the temperate north Himalayan areas up to an altitude of 3000 metres with consequent variation in photoperiod from short to long days. Unlike Paddy rice and wheat that require many inputs in terms of soil fertility and water, millets grow well in dry regions as rain-fed crops. Their long storability under ordinary conditions has made them "famine reserves". This aspect is very important as Indian agriculture suffers from vagaries of the monsoon.

## NUTRITIONAL VALUE

They can provide nutritious grain and fodder in a short span of time. Millets are highly nutritious, non-glutinous and not acid forming foods. Hence they are soothing and easy to digest. They are considered to be the least allergenic and most digestible grains available.



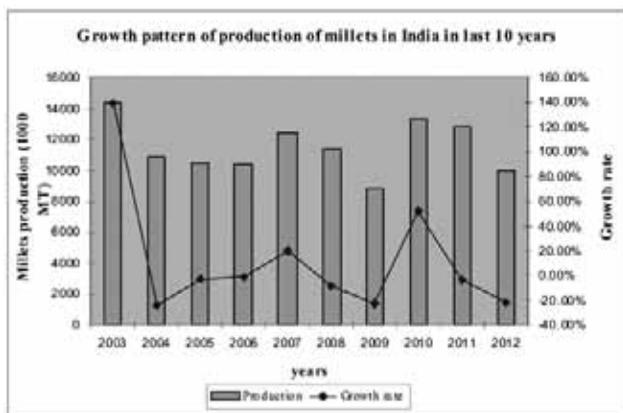
Compared to Paddy rice, especially polished Paddy rice, millets release lesser percentage of glucose and over a longer period of time. This lowers the risk of diabetes. Millets are particularly high in minerals like iron, magnesium, phosphorous and potassium. Finger millet (Ragi) is the richest in calcium content, about 10 times that of rice or wheat. Barnyard millet has 15-18 times more iron content than any other cereal.

## PRODUCTION WORLD WIDE

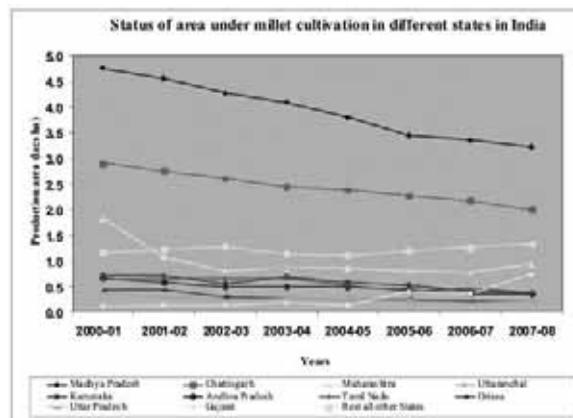
Deprived of positive policy support and emphasis on rice and wheat, there has been a decline in the number of extant varieties as well as area under millet cultivation. According to

**Composition of different nutrients in millets in comparison to rice and wheat**

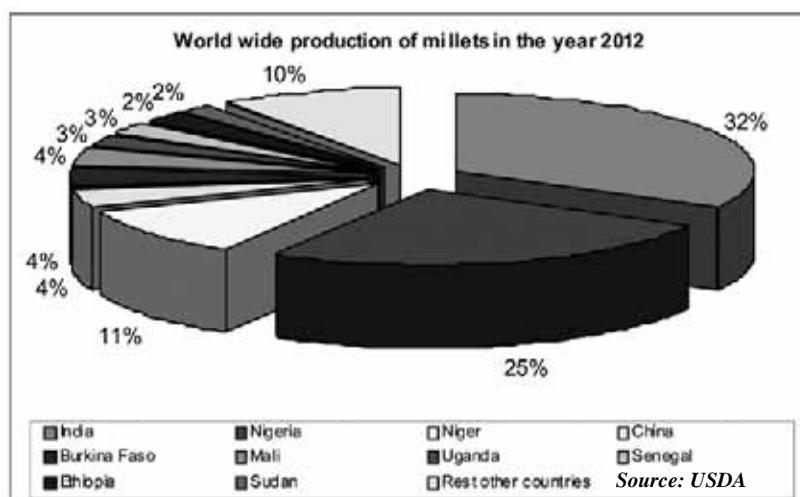
	Protein (g)	Carbohydrate (g)	Fats (g)	Mineral (g)	Fiber (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Energy	Thiamine (mg)	Niacin (mg)
Finger	7.3	72	1.3	2.7	3.6	344	283	3.9	336	0.42	1.1
Sorghum	10.4	70.7	3.1	1.2	2.0	25	222	5.4	329	0.38	4.3
Pearl	11.8	67	4.8	2.2	2.3	42	-	11	363	0.38	2.8
Foxtail	12.3	60.2	4.3	4.0	6.7	31	290	2.8	351	0.59	3.2
Little	7.7	67	4.7	1.7	7.6	17	220	9.3	329	0.3	3.2
Kodo	8.3	65.9	1.4	2.6	5.2	35	188	1.7	353	0.15	2.0
Proso	12.5	70.4	1.1	1.9	5.2	8	206	2.9	354	0.41	4.5
Barnyard	6.2	65.5	4.8	3.7	13.6	22	280	18.6	300	0.33	4.2
Rice	6.8	78.2	0.5	0.6	1.0	33	160	1.8	362	0.41	4.3
Wheat	11.8	71.2	1.5	1.5	2.0	30	306	3.5	348	0.41	5.1



Source: Directorate of Agriculture & Cooperation, India



Source: Directorate of Agriculture & Cooperation, India



Source: USDA

Deccan Development Society Survey, farmers in Andhra Pradesh believe that hybrid seeds of rice and wheat have led to fast decline in the traditional millet cultivation. Changed food habit of the young generation and dearth of organic manure like cow dung are believed to be the other contributing factors.

India is the world's largest producer of millets. This can be understood from the production trends of millets. Pearl millet, finger millet and proso millet account for a large proportion of the world production. India contributes 32 per cent of total millet production, others being China and eight countries from Africa but still there is a lot of scope to produce more.

Post Green Revolution, there

has been a systematic decline in the production of millets. Area of millet cultivation is continuously decreasing over the years. Gujarat is the only state which is showing an increase in the area of cultivation of millets

over the years. There is marginal increase in area for cultivation of millet in some states like Jharkhand, Arunachal Pradesh, Uttaranchal and Nagaland. While the major millet growing states like Madhya Pradesh and Chattisgarh are experiencing a sharp decline in the cultivated area. From 2001 to 2008, there has been a reduction of around 37 per cent in the area of millet cultivation in India.

In the year 2003, millet production was around 14350 Million ton. Millet production declined in 2004 to 10840 Million tons. In the year 2010, again there was some improvement in millet production, growth rate reaching to 51.37 percent, although very less than the growth rate in 2003 which was 139 percent.

Maximum productivity was observed in Uttarakhand followed by

**Area and Production of Small Millets in different states for the year 2007-08**

Sl.No	State	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
1	Andhra Pradesh	35.0	22.0	629
2	Chhattisgarh	199.0	52.1	262
3	Gujarat	72.0	86.0	1194
4	Karnataka	36.0	17.0	472
5	Maharashtra	92.0	48.0	522
6	Madhya Pradesh	322.0	87.5	272
7	Orissa	18.9	9.0	476
8	Tamil Nadu	38.2	37.0	969
9	Uttar Pradesh	19.1	11.8	618
10	Uttarakhand	76.0	91.0	1197
11	All India	1039.2	550.7	16958

Source: Directorate of Agriculture & Cooperation, India

Gujarat. Gujarat is the only state which shows an improvement not only in production but also in productivity and area over the years. Production of the crop can only be improved by using high yielding varieties. A lot of high yielding varieties are available in small millets. Farmer should use the variety according to the area of adaptation and should get the maximum profit from least investment. Millets have a short growing season, a low moisture demand and can play a significant role in a mixed cropping system.

### MILLETS PROVIDE MULTIPLE SECURITIES

While single crops such as rice and wheat can succeed in producing food security for India millets produce multiple securities. They include securities of food, nutrition, fodder, fiber, health, livelihood and ecology. Most of the millets have edible stalks which are the most favoured fodder for cattle. Many a time, crops such as sorghum and pearl millet are grown only for their fodder value. Besides fodder, millets are storehouses of nutrition and hence ensure nutrition security. Being hosts to diverse crops such as red gram, millet fields also produce fuel wood and fiber such as amaranth. The legume crops that are companion crops for millets are also prolific leaf shredders. This leaf fall acts as natural manure and maintains soil fertility. Thus, millet farms not just use soil fertility for their growth but also return this fertility to the soil.

### MILLET NETWORK OF INDIA

MINI is an all Indian alliance of 65 institutions, individuals consisting of farmers, scientists, nutritionists, policy makers, civil society groups and food activists representing over 15 states of India. The network has had several national consultations and has articulated that millet farming is not just about production of a

VARIETY	CHARACTERISTICS
Finger millet GPU-28, GPU-26, GPU-45 and L-5.	All the four varieties are suitable for growing in Karnataka and have been found to be resistant to fungal infections. The crop comes to harvest in about 100 - 130 days. Yield is about 2.5 tones of grains per hectare.
PRM 1	Suitable for Uttarakhand hills, Mature in 100-110 days, resistant to blast. It yields about 20-25 quintals of grain and 60-70 quintal of straw per hectare.
PRM 2, Pant Mandua 3	Suitable for Uttarakhand hills, Early maturing, mature in 90-95 days. It yields about 20-25 quintals of grains and 60-70q of straw per ha.
VL mandua 149	Suitable for all rain fed areas except Tamil Nadu and Andhra Pradesh. Grains are of copper colour, mature in 105-110 days, resistant to blast. It yields about 25-30 q/ ha
VL mandua 315,	Variety suitable for Uttarakhand hills, Grains are of copper colour, mature in 105-110 days, It yields about 20-25 q / ha
VL mandua 324	Variety suitable for Uttarakhand hills, Grains are of copper colour, mature in 105-110 days, moderately resistant to finger and neck blast. It yields about 19-22 q / ha
Chilika	Variety is suitable for Orissa, Madhya Pradesh, Gujarat, Andhra Pradesh and Tamil Nadu, Mature in 120-125 days, Yield is about 26-27 q / ha. Moderately resistant to blast, resistant to stem borer
TNAU 946	Variety is suitable for Tamil Nadu, Mature in 105-115 days, Yield is about 20-25 q/ ha
GPU 48	Variety is suitable for Karnataka, Mature in 100-105 days, Yield is about 30-35 q/ha. Early maturing, high yielding, blast resistant Suitable for summer also.
Foxtail millet PS 4	Suitable for Uttarakhand, Crop mature in 85-190 days, resistance to blast and yield about 17-18 q / ha.
PRK 1	Suitable for Uttarakhand, Early maturing variety, mature in 80-90 days, it yields about 18-20 q / ha.
Meera (SR 16)	Suitable for Rajasthan, Mature in 75-80 days, yield is 15-17 q/ ha. Stay green, tolerant to Downey Mildew
SR 51	Suitable for Rajasthan, Mature in 75-80 days, Yield is 18-20 q/ ha. Bold seeded
TNAU 196	Suitable for Tamil Nadu, Mature in 85-90 days, Yield is 18-20 q/ ha
Proso millet CO1	This variety takes about 3 months for maturity, yield is about 13 q/ ha and is suitable for rabi season. It also gives around 35-40 q/ha of straw.
MS-4872	It is a high yielding variety and takes about 65 days to mature. It yields about 17 q of grain and 10-42 q of straw per ha.
MS-4884	It is a short duration variety reaching maturity in about 50-55 days. It has a yield potential of about 10-12 q/ha of grain and suitable for Tamil Nadu.
PV 1685	It is also high yielding variety maturing in about 65-70 days yielding 17 q of grain and 36-38 q of straw per ha.
PV 196	This was developed for dry areas. Under irrigated conditions of Tamil Nadu, it gives as much as 22 q of grains per ha
PRC 1	Suitable for Uttarakhand hills, mature in 70-80 days. It has a yield potential of about 10-12 q/ha of grain and 50-55 q of straw per ha
Barnyard millet K-1	It is a suitable variety for Tamil Nadu maturing in about 100-115 days giving about 10 q of grains per ha.
T-46	It is popular in Uttar Pradesh yielding about 10-12 quintals of grain per hectare. Another variety suitable for the hilly areas of Uttar Pradesh is VL-I. It produces 12- 15 q/ha of grain.
IP-149	The grains of this variety are light brown in colour and the plant height is 145 cm. For maturity it takes 80-90 days and gives a produce of 12-13 q/ha grain
OPT-8	Plants are erect with leaves of light green colour, reaching a height of 126-130 cm. It matures in 74-80 days and the yield is around 12-13 q of grains per ha.
IPM-19	This variety matures 78-82 days. The plant height is 125-140 cm and the yield is 11-12 q/ha of grain.

IPM -97	This variety takes 83-88 days for reaching maturity. The grains are light brown in colour and about 10 q of grain per hectare yield is expected.
IPM-100	It is an early maturing variety which takes only 65-67 days to mature. It yields about 10-12 q of grain per ha.
IPM-148	This variety matures in 77-86 days and grain yield is 11-12 q/ha.
IPM-151	It takes 80-88 days for maturity and yields about 12-13 q of grain per ha.
PRJ-1	It is recommended for Uttarakhand hills, mature in 100-110 days, resistant to grain smut and leaf blight. It yields about 20-25 q of grain per ha
VL Madira 172	It is recommended for rainfed areas of Uttarakhand, Uttar Pradesh, Gujarat and Karnataka, mature in 85-90 days. Resistant to grain smut and leaf blight. It yields about 20-23 q of grain per ha
<b>Italian Millet</b> I.Sc. 201 & 119	It is recommended for Uttar Pradesh. It is a high yielding variety suitable for hilly and dry areas of the state. It takes about 95 days for maturity.
CO. 3	It is suitable for Tamil Nadu. It is a high yielding and long duration crop completing its life cycle in about 80-85 days.
CO 4	It is a short duration variety (60-65 days). It is recommended variety for Tamil Nadu with a yield potential of 10-16 q of grain per ha
I.Sc 700 and 701	It can be grown as a mixed crop with cotton and groundnut. They are very promising varieties recommended for Madhya Pradesh, Uttar Pradesh and Karnataka. Early maturing (70-75 days) with profuse tillering. The plants grow to a height of one metre. The average grain yield is 14 q/ha and fodder yield is 40 q/ha.
Arjuna	It is suitable variety for Andhra Pradesh and Karnataka. It matures in 80-85 days. It can grow up to 107 cm and has a yield potential of 12-14 q of grains per hectare. It yields about 34 q/ha of fodder.
MS 1844/2	It is a high yielding short duration variety (65- 70 days). It is suitable for Karnataka, Madhya Pradesh and Uttar Pradesh. It is adapted to a wide range of conditions.
H-1	It is recommended for Andhra Pradesh and Karnataka. It matures in 80-85 days. It does well in low rainfall areas. It is suitable for light soils of Ananthapur and Bellary region of Karnataka. H2 variety is suitable for heavy soils of Bellary.
N-1:	It matures in 90-95 days and is suitable for Guntur and Kurnool districts of Andhra Pradesh.
G-1	It comes to maturity in 80-95 days and can be grown either during June to October or from September to January. It is suitable for Guntur and Kurnool districts of Andhra Pradesh.
<b>Kodo Millet</b> Niwas -1	This variety was evolved from Madhya Pradesh. Height of the plant is about 95 cm. Grains are brown in colour. It takes 115 days to mature and grain yield is about 18 q / ha.
Dindori -73	This variety is tolerant to insect, pests and diseases. It takes about 115 days to reach maturity. The height of plant is 75 cm. Grains are bold and dark brown in colour. The grain yield is about 19-20 q/ha
Pali	This variety is tolerant to pests and diseases. Maturity period is 110-112 days with about 77 cm tall plant producing brown colour grains. Per hectare yield of grains is 20 q.
KK 2	Suitable for Uttar Pradesh, mature in 110-115 days. yield is about 20-23 q/ ha. Resistant to Drought and lodging and suitable for saline condition
<b>Little Millet</b> PM-2 and PM-96	Recommended for Tamil Nadu. These varieties take 80-85 days for maturity and yields 10 q/ ha.
Dindori-1	Most popular variety in Madhya Pradesh. They can be grown between July and October. Seed rate per hectare is 12.5 kilograms.
OLM 20	Suitable for Orissa, Madhya Pradesh and Chhattisgarh. Mature in 75-80 days, Yield is about 11-12 q/ ha. Drought tolerant

narrow array of crops but is a brilliant concept that realizes biodiversity, ecological production systems as well as food sovereignty to farming populations. Therefore they produce an extraordinary food system that can secure India's food and farming in future. That was why the MINI has refused to call millets as Coarse Cereals and renamed them as Nutri-cereals.

The question is: How much of such an impressive array of potential wealth has really been used to ensure food security and poverty alleviation. This is in spite of the money being spent on All India Coordinated Research Projects on Pearl Millets and Small Millets. Popularising millet-based food has been something that Civil Service Organizations had been engaged in, but only serious policy support from the government can make it a value-added product for India's food security. By consuming millets, we will be encouraging farmers in dry land areas to grow crops that are best suited for those regions. This is a step towards sustainable cropping practices, where by introducing diversity in our diets we respect the biodiversity in nature rather than forcefully changing cropping patterns to grow wheat and paddy rice everywhere.

Millets are nutritive, water saving, drought tolerant crops. Therefore they must be viewed as climate change compliant crops. This quality makes them India's food and farming future. This is the perspective from which the millet cultivation and its promotion must be regarded. Every millet farmer of India must be given a climate change bonus, biodiversity bonus and water. Research institutions must give a new thrust on millet areas and issues. But such research initiatives must be led by farmers since they offer exciting perspectives for the research which have to be people-centered and people directed. ♦



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# Sweet Sorghum - Food, Feed, Fodder and Energy Crop

Sweet sorghum (*Sorghum bicolor* (L.) Moench), which is also named sugar sorghum, is a variety of common grain sorghum. Like the common grain sorghum, it can also produce grain at 1,500-7,000 kg/ha. The sweetness of sweet sorghum is not from its seed, but from its stalk, which grows high and contains rich sugar. In general, it can produce 45-75 tonnes of stalk /ha. The sugar content in the juice of sweet sorghum varies in different varieties. The brix ranges generally 15 – 23 per cent. Because of its characteristics such as a wide adaptability, drought resistance, water lodging tolerance, saline- alkali resistance, fast growth, rapid sugar accumulation and with a high yield of biomass, many countries have been actively studying sweet sorghum and popularizing it with great efforts. Sweet sorghum is more suitable to China, which has a very large population and deficient arable land. Nowadays, more than 800 million people suffer from hunger and malnutrition in Africa, Asia, Latin America and even in Europe and the USA, More than 2 billion people have no access to modern energy sources. Fossil energy resources are depleting; each year 11.2 million hectares of forest disappear. Therefore, we should find a crop, which can not only produce food, but also energy, feed, fodder and fiber. The practices indicate that the high energy crop, "sweet sorghum" can meet partly the challenges. Development of sweet sorghum will play an important role in promoting the development

of agricultural production, livestock husbandry, energy sources, refining sugar, paper making etc. China and India are well positioned to become world leaders in bio-fuel production within a decade. Similarly, other countries have plans to more than double their bio-fuel production within next 15 years. Brazil currently produces 37 per cent of the world's ethanol supply, almost entirely from sugarcane. Large commitments to ethanol as a partial petroleum substitute have been set by:

- **India:** 8 billion liters for blending at 10 per cent rate with petrol (gasoline)
- **China:** 14 billion liters at 10 per cent
- **Brazil:** 16 billion liters at about 22 to 24 per cent
- **USA:** 30 billion liters at 10 per cent

Brazil, the current number one ethanol producer of the world, mainly uses sugarcane as the feedstock for ethanol production. In the USA, most of the ethanol produced is from maize. These targets are generally supported by subsidies deemed to be serving national interests in energy self-sufficiency, pollution control, and strengthening the economies of rural areas.

## ENERGY NEEDS AND FEED STOCKS

Soaring prices of fossil-fuels and environmental pollution associated with their use, has resulted in increased worldwide interest in the production and use of bio-fuels. Both developed and developing countries have made mix of policies which have triggered public and private investments in bio- fuel crop research and development and bio-fuels production.

- Many developing countries, including India, have made it mandatory to blend petrol with ethanol. A large volume of ethanol is needed to meet current and future blending requirements.
- In India, molasses (a by-product of sugarcane after the extraction of sugar), the traditional source of raw material for ethanol production, is unlikely to meet the demand in the long run.
- Molasses-based ethanol distilleries operate only for 180 days a year (during the sugarcane

## MAIN ENERGY CROPS WORLDWIDE

COUNTRY	BIO-ETHANOL	BIODIESEL
Brazil	sugar cane	---
United States	maize	soyabean
China	sweet sorghum	rapeseed, sunflower seed
Germany	sugar beet	rapeseed, sunflower seed
France	sugar beet	rapeseed, sunflower seed
India	sugarcane	jatropha
Italy	---	rapeseed, sunflower seed
Thailand	cassava	---
Spain	sugar beet	---
Denmark	---	rapeseed, sunflower seed
Australia	cereals, sugarcane	---

Sources: United States Department of Agriculture, United States Department of Energy, European Commission.

crushing season) i.e., at 50 per cent efficiency, due to lack of supply of feed stock.

#### COMPARATIVE ADVANTAGES OF SWEET

##### SORGHUM

- Growing period (about 4 months) and water requirement (8000 m<sup>3</sup> over two crops) are 4 times lesser than those of sugarcane (12 to 16 months and 36000 m<sup>3</sup> per crop respectively)
- Cost of cultivation of sweet sorghum is 3 times lower than sugarcane
- Seed propagated
- Suitable for mechanized crop production
- Ecofriendly ethanol production process compared to molasses
- Ethanol burning quality is superior - less sulphur - than from sugarcane, and high octane rating

#### PROSPECTS OF ENHANCING GENETIC POTENTIAL OF HIGH ENERGY CROP-SWEET SORGHUM

High photosynthetic efficiency - Sweet sorghum is a C<sub>4</sub> crop. It has high photosynthetic efficiency and grows fast. The quantity of carbohydrate synthesized by sweet sorghum, can be used to produce alcohol at the rate of 48 litres/ha /day, while that of maize, wheat and grain sorghum can only produce 15, 3 and 9 litres/ha/day respectively. C<sub>4</sub> plants, including sweet sorghum, have much higher photosynthetic efficiency than others because the physiological characters such as anatomical structure, physiological function and reaction to environmental conditions of CO<sub>2</sub> of C<sub>4</sub> plants differ from those of C<sub>3</sub> plants.

Wide Adaptability - Sweet sorghum has wide adaptability. It can be grown in different types of soils with pH 5 - 8.5. The drought resistance of sweet sorghum is much higher than that of maize. Sweet sorghum exhibits water logging tolerance. If sweet sorghum is immersed in flood for a week, it can re-grow quickly after the flood

#### ETHANOL YIELD FROM VARIOUS CEREAL GRAINS

Cereals	Starch content (per cent)	Protein content (per cent)	Ethanol yield (litres/tonne grain)
Sorghum	66 - 70	9 - 11	422 - 448
Broken rice	66 - 70	2 - 3	420 - 445
Maize	58 - 64	8 - 10	370 - 410
Wheat	60 - 68	10 - 12	375 - 425

Source: CFC Technical Paper No. 34, ICRISAT, Hyderabad, pp 327

#### COMPARISON OF SUGAR CONSTITUENTS (PER CENT) IN SWEET SORGHUM AND SUGARCANE

Constituents	Sweet sorghum	Sugarcane
Total solids	25 - 30	25 - 30
Sucrose	6.5 - 7	11.5 - 13.5
Reducing sugars	2.5 - 4	0.5 - 0.7
Fermentable sugars	9 - 11	12 - 14
Fiber	14 - 16	14 - 16
Water	70 - 75	70 - 75

Source: CFC Technical Paper No. 34, ICRISAT, Hyderabad, pp 329

#### COMPARISON OF PROPERTIES OF SWEET SORGHUM AND SUGARCANE

Properties	Sweet sorghum	Sugarcane
Crop duration(months)	3.5 - 4	10 - 11
Stripped green stalk yield (tonnes/hectare)	47 - 52 (per crop) (95 - 105 tonnes/year)	70 - 80
Sugar content (per cent)	9 - 11	11 - 13
Ethanol yield(litres/tonne)	55 - 65	68 - 74
Water requirement (per cent)	30 - 36 (of sugarcane requirement)	100
Fertilizer requirement (per cent)	0 - 25 (of sugarcane requirement)	100
Bagasse availability(tonnes/ha t yr-1)	12 - 13 (per crop) (28 -32)	20 - 25

Source: CFC Technical Paper No. 34, ICRISAT, Hyderabad, pp 329

retreats. Sweet sorghum can be grown in tropical, subtropical and temperate zones as long as the accumulated temperature reaches 2,600-4,500°C of above 10°C.

Sweet sorghum has high potential for genetic improvement to produce high sweet-stalk yield coupled with high sucrose per cent sweet sorghum lines. Genotypic differences for extractable juice, total sugar content, and fermentation efficiency and alcohol production have also been reported. The predominant role of non-additive gene action for plant height, stem girth, total soluble solids, millable sweet-stalk yield and extractable juice yield indicates the importance of breeding for heterosis for improving these traits.

The substantial magnitude of standard heterosis for all the traits related to ethanol production (plant height: up to 46.9 per cent, stem girth: up to 5.3 per cent, total soluble solids: up to 7.4 per cent, millable stalk yield: up to 1.5 per cent and extractable juice yield up to 122.6 per cent). Considering the utility of the sorghum crop, it can be said that it is a F<sub>4</sub> (food, fodder, feed, fuel) crop.

The present world industrial production of 33.3 billion litres of alcohol is expected to increase beyond 40 billion litres by 2015. Currently, alcohol is produced from sugar crops (60 per cent of total alcohol production), grain plus other feedstock (33 per cent of total alcohol production), and remaining 7 per cent is from synthetic products. The us-

age pattern of alcohol produced is 60 per cent in fuel, 21 per cent in industries and 11 per cent in beverages. Use of ethanol for blending in fuel has been taken up by many countries. India has initiated blending of 5 per cent ethanol in petrol; this will increase up to 10 per cent in the second phase. Sweet sorghum lines have wider adaptability and produce high biomass and sugar similar to sugarcane (*Saccharum officinarum*).

#### PUBLIC SECTOR INDUSTRY

Shree Renuka Sugars Ltd, located at Manoli village in Belgaum district, Karnataka, India commissioned an ethanol plant in 2003 and initiated a pilot project with the need for finding new substrates for producing ethanol for the National Fuel Ethanol program in collaboration with the United States Agency for International Development (USAID) and NRCS, Hyderabad. Three varieties viz., SSV 74 from the University of Agricultural Sciences, Dharwad; Madhura from Nimbakar Agricultural Research Institute, Maharashtra; and SSV 84 from Directorate of Sorghum Research, Hyderabad were supplied to farmers for evaluation. These varieties gave an average sweet stalk yield of 10–12 tonnes/acre and grain yield of 0.8–1.0 tonnes/acre under normal conditions in farmers' fields. For grain yield, Madhura and for stalk yield, SSV 84 were found better. The laboratory analysis indicated that sweet sorghum juice is very rich in total reducing sugars (TRS) and comparatively poor in sugar content, hence suitable for making alcohol. From a trial at the distillery, it was reported that 112 tonnes of sorghum stalk has 23.47 per cent juice with 8.5 per cent TRS, brix of 12 and pH 5. Alcohol yield was about 16.38 litres/tonne of stalk. The study also indicated that sweet sorghum could be cultivated in the lean period of sugarcane (as crushing period of sugarcane varies from state to state), thus extending the crushing period before and after sugar-



cane crushing. The Directorate of Sorghum Research, Hyderabad is also interacting with industries like Praj Industries at Pune, Maharashtra; GMR Sugar Industries at Sankili, Andhra Pradesh, Mohan Breweries and distilleries at Chennai, Tamil Nadu and Sagar Sugars and Allied Products, Chittoor district, Andhra Pradesh. These industries have expressed an interest in conducting large-scale trials and big mill tests on sweet sorghum as an alternative source of raw material for ethanol production to supplement sugarcane molasses.

#### PROPOSED IDEOTYPE FOR SWEET SORGHUM GENOTYPES:

- Modest grain yield (1.5 – 3.0 tonnes/hectare)
- High sugar concentration in stems (level of sugarcane)
- Thick and juicy internodes
- High biomass due to relatively late maturity (30-40 tonnes/hectare)
- Good digestibility of residues for forage (bmr gene)
- Stay-green for maintenance of stem juiciness until maturity and tolerance to terminal drought
- Different genotypic levels of photo period sensitivity to fit into local cropping and diversified cropping systems.

Issues in cultivation and utilization of sweet sorghum as raw material for ethanol production

- Sweet sorghum may be harvested in 4 months (which allows growing even two crops in year), whereas the first cutting of sugarcane is 18 months after planting.
- Sweet sorghum requires less water and other inputs than sugarcane
- Sweet sorghum production can be completely mechanized. There is no lodging problem in sweet sorghum.
- Possibilities exist for intercropping sweet sorghum with sugarcane.
- Alcohol production from sorghum can be a farm based industry. Micro distilleries can be established.
- Aroma and purity of alcohol is far better than molasses. Industry can run round the year as distillery in sugar industry runs only for 150 – 170 days per year.
- Raw material is easily available round the year. Grains of any quantity can be used - rain damaged and moldy grains can also be processed.
- The bagasse from sweet sorghum has a higher biological value than the bagasse from sugarcane when used as forage for animals.
- No license is necessary for manufacturing alcohol from non-molasses.
- The govt. of Maharashtra has been empowered to take the decision for permitting alcohol production from sorghum grain. ♦

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## New Paradigms in Spices Crops Research- Current trends and the Way Forward

India is known as the home of spices and has consistently been the major player in the production, consumption and export of spices. The world food industry overly relies on these high value low volume commodities to produce a range of products with variations that are tailor made to meet the consumer needs. Besides, spice crops provide natural colours and flavors that are superior to cheap artificial ones and are considered critical to health conscious consumers. The estimated growth rate of demand for spices in the world is around 3.19 per cent, which is a shade above the population growth rate. Though every state/union territory in the country grows at least a few spice crops, Kerala, Andhra Pradesh, Gujarat, Maharashtra, West Bengal, Karnataka, Tamil Nadu, Orissa, Madhya Pradesh and Rajasthan are the major spices producing states. There are about 109 spices listed by International Organization for Standardization, and India grows about 60 of these spices.

Indian spices flavour foods in over 130 countries and their intrinsic values make them distinctly superior in terms of taste, colour and fragrance. The USA, Canada, Germany, Japan, Saudi Arabia, Kuwait, Bahrain and Israel are the main markets for Indian spices. North America (USA and Canada) and Western Europe are the most important regions in terms of import de-

mand for many of the spices. Mexico continues to be the major importer of cinnamon and cassia, while Saudi Arabia, Bahrain, Kuwait and Israel are the major markets for green cardamom, black pepper, ginger and turmeric. We have near monopoly in spice oils and oleoresins. Indian spices have obtained geographical indicators such as Malabar pepper, Alleppey Green Cardamom, Coorg Green Cardamom and Naga chilli.

Though India rules the roost in spices cultivation and export, there is now stiff international competition from other spice producing countries such as Vietnam (for black pepper), Guatemala (for cardamom) and China (for ginger) etc. Therefore, the diverse challenges and constraints like growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing spice crops research.

### AREA, PRODUCTION AND EXPORT

In 2011-12, the estimates suggest a production of 63.25 lakh tonnes from 35.42 lakh ha. Though the production was an all time high, the increase was a meager 6.6 per cent compared to 2010-11. Advance estimates for 2012-13, however, suggest a decrease in both area and production of spices. In fact, the production is expected to decrease by 8.3 per cent and area by 10.4 per cent.

According to Spices Board of India, spices exports have registered appreciable growth during the last five years, registering an annual average growth rate of 21 per cent in value and 8 per cent in volume. During the year 2010-11, spices export from India registered an all time high both in terms of quantity and value. In 2010-11, the export of spices from India was 525750 tonnes valued at Rs.6840.70 crores (US \$ 1502.85 million), thereby registering an increase of 28 per cent in dollar terms of value and 5 per cent in volume compared



**DECADAL CROP-WISE AREA AND PRODUCTION OF SPICES IN INDIA**

Crops	2002-03		2010-11		2011-2012 (E)		2012-13 (E)	
	Area	Prodn.	Area	Prodn.	Area	Prodn.	Area	Prodn.
Black pepper	223.94	70.92	183.78	48.00	201.381	43.00	201.381	55.00
Ginger	103.22	422.820	167.432	937.043	161.850	773.060	157.839	745.269
Chilli	827.95	906.994	716.428	1299.191	840.610	1426.520	793.584	1299.919
Turmeric	149.71	526.289	232.022	1268.28	237.72	1246.22	192.916	973.098
Cardamom (S)	73.125	11.920	71.012	10.380	71.285	15.00	69.870	124.20
Garlic	114.92	459.08	202.888	1085.740	262.780	1302.070	247.251	1256.400
Coriander	302.45	188.95	474.250	372.366	540.700	511.760	547.421	527.390
Cumin	521.25	134.753	625.087	403.744	842.560	461.160	593.980	394.328
Fennel	22.898	27.602	81.890	125.710	100.610	142.960	997.23	142.995
Fenugreek	50.596	64.221	94.760	127.850	93.170	117.320	93.090	112.845
Ajwan	10.375	1.629	27.257	19.327	45.700	28.050	35.376	26.778
Clove	2.076	1.369	2.195	0.963	2.100	1.110	2.373	1.091
Nutmeg	8.668	2.208	17.760	12.088	18.440	12.21	17.485	12.618
Tamarind	61.958	178.974	56.530	203.936	60.680	205.180	58.110	201.560
Cinnamon	0.398	0.077	0.187	0.036	0.458	0.035	0.508	0.042
Others (1)	5.345	0.09853	7.102	1.073	7.10	1.07		
Grand total (including other seed spices, tejpat, celery, dill, poppy seeds etc)	2498.74	3023.20	3043.583	5933.126	3541.804	6324.920	3172.468	5801.114

Source: Spices Board, Kochi and Directorate of Arecanut and Spices Development, Calicut

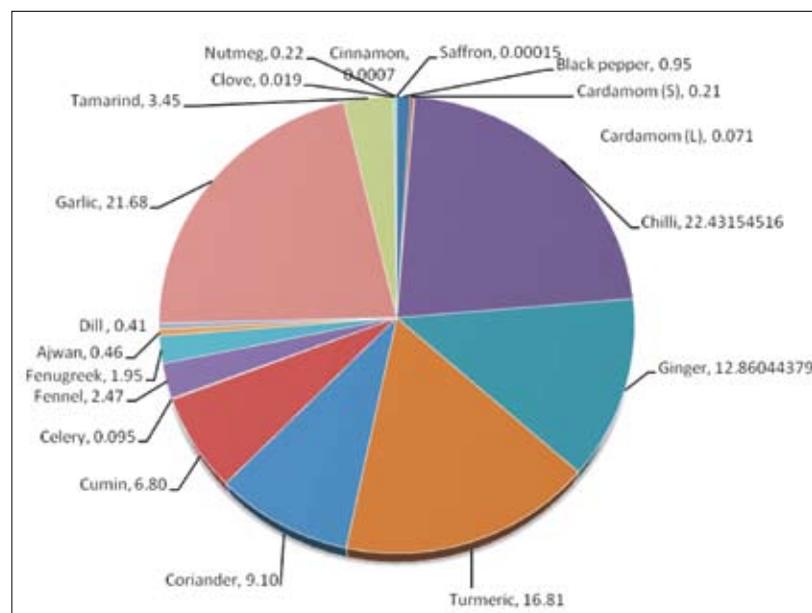
E- Estimate; (1) Others: Vanilla and Saffron

to the preceding year. Total volume of spices exported from the country during 2011-12 was estimated at 575270 tonnes valued at Rs 9783.48 crores (US \$ 2037.76 million), a rise of

36 per cent in dollar terms. The total export of Spices during 2011-12 was also expected to exceed the target in terms of both quantity and value. As a matter of fact, the target fixed by the

Spices Board was 500000 tons worth Rs.6500.00 crores (US\$1450 million) for the financial year 2011-12. Apparently, the total spices export during 2011-12 indicated an increase of 115 per cent in terms of quantity and 151 per cent in rupee and 141 per cent in dollar terms. In 2012-13, it is estimated that India would be exporting an all time high of 699, 170 tonnes valued at Rs.1,117,116.48 lakhs (US\$ 2,040.18 million). This achievement in export earning is remarkable, thanks to the rigorous focus and initiatives taken by the Spices Board for value addition and higher end processing of spices.

Export of all the major spices like black pepper, ginger, turmeric, cumin, fennel, fenugreek, mustard, aniseed, ajowain seed, nutmeg and mace, asafoetida, tamarind etc have increased both in terms of volume and value. In terms of volume, it is estimated that chilli (42 per cent), seed spices and



Estimated production share (per cent) under major spices in India in 2012-13 (Source: Spices Board, [http://www.indianspices.com/pdf/Major\\_spicewise\\_area\\_production.pdf](http://www.indianspices.com/pdf/Major_spicewise_area_production.pdf); accessed on 16/08/2013)

turmeric will be the top contenders. In terms of value, mint and mint products and chilli will continue to remain as the top earners among the spices.

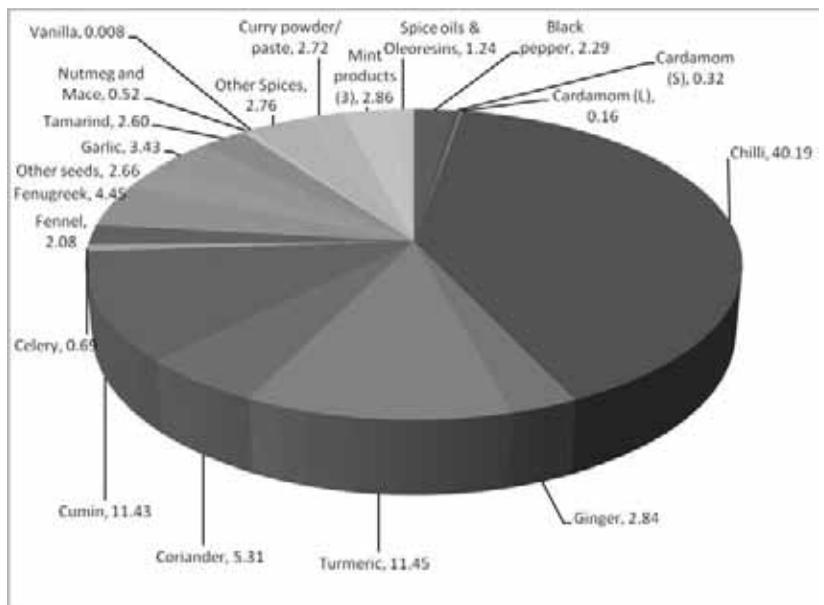
### SPICES CONSUMPTION ESTIMATES

The consumption of spices is growing in the country with increase in purchasing power. It is envisaged that everyone in India would be consuming one spice or the other with a high per capita consumption. It is estimated that we may have a population of about 1.69 billion people during 2050 and approximately the per capita consumption of black pepper, cardamom, turmeric, and ginger is expected to be about 148 g, 54 g, 1.6 kg and 1.2 kg, respectively.

The mission should be to produce spices without increasing the area under the crop. The objective is also to have a 20 per cent increase in spice export. If this is the case, the productivity in black pepper must increase from the present level of 260 kg to 943 kg ha<sup>-1</sup>. Similarly cardamom, turmeric, and ginger should yield 0.98, 10.0, 9.3 t ha<sup>-1</sup> respectively.

### SPICE CULTIVATION-PRESENT STATUS

India possesses many innate advantages over other spice producing countries such as its large genetic base, varied soil and climatic conditions, and skilled human power. However, in many of the spice crops, productivity is low in India. Yields of black pepper and small cardamom are low compared to other producing states. Poor soil fertility, use of low level of inputs like manures, fertilizers and crop protection measures, high labour cost and crop loss due to diseases, lack of resistant varieties and post harvest losses are the major reasons for low productivity. The biggest handicaps



Estimated share (per cent) of spices and spice products in terms of volume exported in 2012-13 (Source: Spices Board: <http://www.indianspices.com/pdf/Export-2013.pdf> accessed on 16/08/13)

that Indian spices face in the international market are the high cost of the product and high level of microbial contaminants including mycotoxin in the finished product. We need to

make concerted efforts for producing clean spices at competitive prices. India can withstand the competition only by increasing productivity and reducing cost of cultivation leading to low cost per unit of production. Considerable efforts will have to be made to improve the present post harvest processing and storage systems and in educating the farmers and traders in handling/processing the produce hygienically and promotion of spices in consumer packs, as ethnic foods or ethnic medicine would boost up production.

Higher productivity, clean spices through improved post harvest techniques and reasonable threshold price affordable to food industry are the keys to future spice trade. Future trading is going to be tough in view of stringent regulations imposed by ASTA, FDA, USDA and EPA. Though the pace in spice production has slowed down, a revolution in spices production technologies is imminent. While there is a great deal of path-breaking efforts to

### COMPETING COUNTRIES WITH INDIA IN PRODUCTION AND EXPORT OF MAJOR SPICES

Spice	Competing country
Black pepper	Indonesia, Brazil, Malaysia, Thailand, Sri Lanka, Vietnam, China (P.R), Madagascar, Mexico
Cardamom	Guatemala, El Salvador, Indonesia, Malaysia, Papua, New Guinea, Sri Lanka
Ginger	China (P.R), Thailand, Japan, Bangladesh, South Korea, Malaysia, Fiji, Philippines, Jamaica, Nigeria, Sierra Leone
Turmeric	China (P.R), Pakistan, Bangladesh, Thailand, Peru, Jamaica, Spain
Clove	Brazil, Indonesia, Madagascar, Malaysia, Papua New Guinea, Sri Lanka
Nutmeg and Mace	Grenada, Guatemala, Mexico, Nicaragua, Sri Lanka
Cassia	China, Indonesia, Madagascar, Malaysia, Vietnam, Sri Lanka
Cinnamon	Madagascar, Papua New Guinea, Seychelles

be made, technologies that may not hold as much promise of profit-making, need to be slashed. This would transform the existing fatigue in spices production making it into a vibrant and competitive profit making sector. Apparently, there is a need for bold initiatives that would often cross state boundaries and bring together unprecedented success.

The forecasted population increase is up to 1619 million in 2050 with increased GDP and per capita food spending. As spices are of high value with nutraceuticals compounds, its per capita demand may increase many fold. The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148 g, 53 g, 1.22 kg and 1.63 kg respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7-5.7 folds from the present levels.

As the international trade barriers are steadily coming down, India will have to develop very competitive edge in all respects, if it has to retain



and increase its present position in the international trade of spices. To realize the above objectives, thrust should be on conservation of genetic resources, research in frontier areas of science, secondary agriculture, bio risk management, mechanization, eco-spices etc.

### CHALLENGES

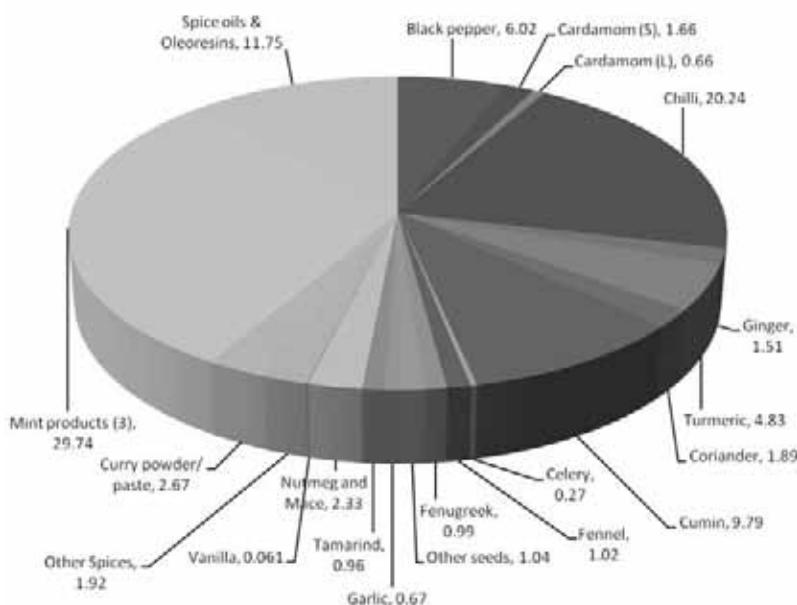
The productivity level in India is believed to be low compared to other countries. However, the collection of data is far from being scientific. Many competing countries are in the spices trade with the opening of in-

ternational market. A major effort is needed to bridge this gap in productivity. In India, even the gap between national average and the realizable yield is very wide. In pepper, it is around 2445 kg/ha and in cardamom his amounts to 1625 kg/ha (national average is 290 kg/ha and 120 kg/ha respectively). Bridging this gap is sufficient to increase country's production many fold. Hence the strategic planning need to focus natural, biological, environmental, sustainability, research, value addition and development factors.

The envisaged increase in share of value added products in the export basket of spices needs strengthening of processing facilities.

### THE MAJOR RISK FACTORS INVOLVED IN SPICES PRODUCTION ARE:

- Shrinking cultivable land and water resources
- Emergence and epidemics of pests and diseases
- Vagaries of monsoon resulting in drought
- Emergence of other major spice producing countries which compete with India in the international market.
- Shifting of interests of growers to more profitable/less risky crops.
- Adulteration of spices
- Cyclic market fluctuations at international and national level



Estimated share (per cent) of spices and spice products in terms of value exported in 2012-13 (Source: Spices Board: <http://www.indianspices.com/pdf/Export-2013.pdf> accessed on 16/08/13)

- Lack of awareness about pesticide residues and mycotoxin contaminants in the products and lack of MRL and ADI standards in some of the pesticides used in spices

### STRATEGIES FOR RESEARCH: THE WAY FORWARD

Locating resistance sources and evolving high yielding and disease resistant lines through selection, mutation, polyploidy breeding and biotechnological methods are among the important programmes for spices improvement.

Multi location testing of varieties for adaptation and quality, evaluation of lines suited to organic production, scaling up the production of nucleus planting material of elite lines through soil less medium/ aero/ hydroponics will enable the production of disease free planting units that are the basic for development of spices productivity.

Studies may be oriented towards identification of varieties which can adapt to climate change and also management strategies to mitigate the ill effects of climate change. Spices like ginger, turmeric and most of the tree spices like nutmeg, cinnamon, cassia and garcinia can be exploited for intensive agriculture under mixed farming systems along with other horticultural crops.

Another important facet that needs serious consideration is protected cultivation of spice crops. It is an upcoming and alternative production system involving high-tech and intensive practices mainly for urban and export demands of spices for food, nutrition and economic security.

Besides, introducing spices into non-traditional areas would also help in boosting spice production. A strategy of Spice Board is to encourage farmers in non-traditional areas to cultivate spices for export require-

ments, while exporters will assure purchases at a premium price under prior contracts.

Another strategy that would help us tide over shrinking land resources is multi-tier farming/ vertical farming. This is a futuristic concept that would involve the construction of urban food production centers - vertical farms – in which all crops including spices would be continuously grown inside tall buildings within the built environment. This approach would ensure that no crops would ever fail due to extreme events (pests, diseases, floods, droughts, hurricanes, etc.).

### THE MAIN RESEARCHABLE AREAS SHOULD BE

- Conservation of genetic resources, bar-coding and crop improvement: To have a complete information on gene pool which is native to India for sustainable utilization and conservation and raise the production to targeted levels by developing improved varieties with high yield, quality traits and disease/ pest resistance.
- Breeding strategies involving conventional/ biotechnological/ nanotechnological tools.
- Quality planting material production and supply: To raise production levels by using quality planting materials of improved varieties.
- Productivity enhancement technologies and systems through better input management: Resource budgeting and management of cropping system for efficient use, stable yield, quality and income.
- Exploiting the medicinal value of spices to serve as functional foods and nutraceuticals to vastly improve human health, reduce health care costs and support economic development.
- Bio risk management: To raise the

production levels through IDM/ IPM.

- New market oriented technologies for secondary agriculture and value addition: To increase the acceptability, demand and value of spices and developing new markets
- Effective transfer of technologies to the target groups: Effective technology dissemination, adoption and further refinement

It is imperative that major thrusts in research programmes are oriented towards increasing productivity through mission mode programmes especially to overcome the major production constraints. Increasing the productivity per unit area through spice based farming systems, development of varieties with high degree of resistance to biotic and abiotic stresses, development of agro technology towards low input management, precision farming, developing ecofriendly IPM strategies, post harvest technologies with value addition for diversified uses, exploiting its medicinal properties, and popularization of proven technologies through extension network are the major areas of priority. Besides, the new areas like nanotechnology, bioinformatics, carbon and water footprints and knowledge management would further strengthen the research programmes on climate resilient agriculture. Also, value addition/ secondary agriculture should be a major agenda. While ICAR is focusing on high value compounds from plants, especially spices as a major research platform in the XII plan, the Spices Board hopes that 75-80 per cent of the total export revenue target of \$3 billion over the next five years will come from value addition in mint, chillies, pepper, ginger, turmeric, cumin, garlic, spice oils and oleoresins, nutmeg and cardamom. ♦

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# CROP PROTECTION FOR ASSURED FOOD and NUTRITIONAL SECURITY

## FOOD AND NUTRITIONAL SECURITY-STATUS AND CONCERNS

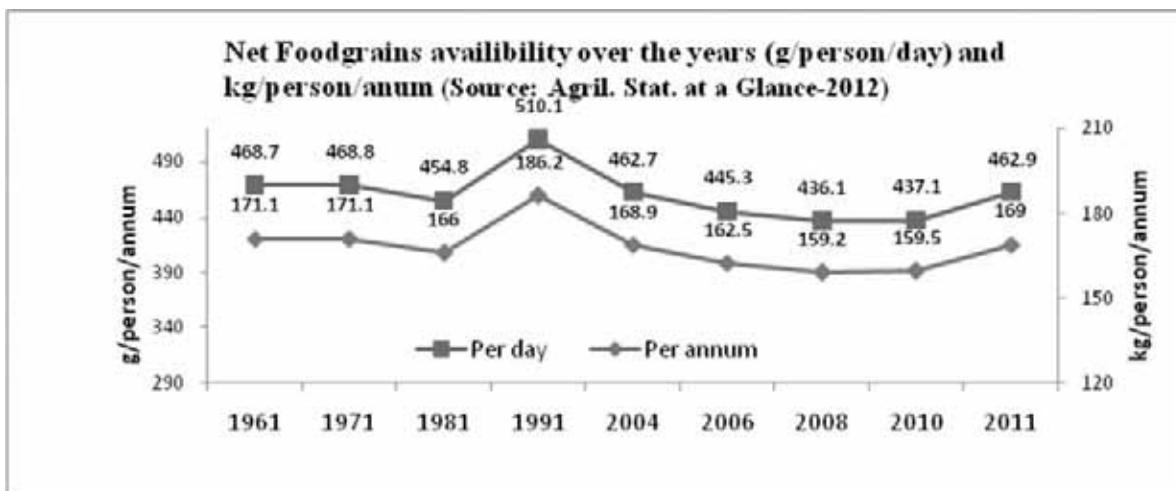
India has achieved five-fold increase in foodgrains production (from mere 50.8 million tonnes in 1950-51 to an all-time record production of 257.4 million tonnes in 2011-12), which itself connotes that, by yield-augmenting technological change (blend of improved technology, favourable political climate, accelerated transfer of technology, and availability of other necessary inputs), such an appreciable growth was achievable. However, the increase in foodgrains could not match the increase in population. Considering the rising incomes due to rapid economic growth, it is estimated that by 2020 and 2050, the foodgrains requirement is likely to be 297 and 450 million tonnes respectively. In real terms, the foodgrains availability per person per day has actually declined from 510g in 1991 to 462.9g in 2011. Therefore, the nutritional status of Indian population is a critical issue.

The rising population and increasing demand along with changing food preferences on one side, and technology fatigue, diminishing arable land, rising cost of inputs, limited technology reach, climatic changes and likely change in pest scenario, degraded natural resources etc. on the other, are posing several serious challenges for augmenting foodgrains

production. The situation is further complicated as some urbanites, not well conversant with ground reality, under the garb of saving environment, are calling for non-use of chemical fertilizers and pesticides for raising crops and advocating organic agriculture instead. The emotional pronouncements and demands for a legislation to ban the use of pesticides have left the public confused regarding the role of pesticides in agriculture and public health and their effect on environment.

## BREAKING THE YIELD-GAPS AT THE NATIONAL AND STATE LEVELS

Despite a huge land mass under agriculture (~48 per cent), the overall crop productivity in India is far less than several other countries. The per hectare yield of rice, and maize in USA was 2.3 times and 4.8 times more than India respec-





tively, while in case of wheat, the per hectare yield in China was 1.7 times more than India. In case of sugarcane, in Mauritius per hectare yield was 1.1 times more than India (FAO Regional Office for Asia & the Pacific, Bangkok, 2010). As the scope for area expansion for cropping is very little, one important option for enhancing the total foodgrains production is by narrowing the yield differences amongst and within the States. Nine States (Gujarat, Uttarakhand, Jharkhand, Assam, Karnataka, Madhya Pradesh, Odisha, Rajasthan and Maharashtra) had their productivity of foodgrains less than even the all India average. As against the highest productivity of 4339 Kg/ha in Punjab, it was only 1297 Kg/ha in Odisha -3.3 times less.

### PESTICIDE USE –PRESENT STATUS AND SCOPE

From the earliest days, agriculturists have been beset by pest problems. There is evidence that humans have utilized pesticides to protect their crops before 2000 BC. The first known pesticide was elemental sulfur dusting used in ancient Sumer about 4,500 years ago

in ancient Mesopotamia. The benefits of crop protection chemicals for enhancing and protecting crop productivity is difficult to separate from the effect of high yielding varieties responsive to chemical fertilizers and irrigation. Several research studies in the Indian context have shown the significant positive contribution of chemical pesticide use for increase in productivity and production of foodgrains. Pesticides are used both in agriculture and as vector control agents in public-health programmes. Significant amounts are also used in forestry and livestock protection.

### LOSSES BY PESTS

A study by the Division of Agrochemicals, IARI (2008) reported avoidable losses ranging from 8 to 90 per cent in different crops. The highest loss was in cotton (49 to 90 per cent), followed by in pulses (40 to 88 per cent). In reply to an unstarred question no. 62 in the Rajya Sabha on 2 March 2007, the Union Minister of Agriculture said that, 'The crop loss due to pests, weeds and diseases is approximately assessed to be ranging between 10 to 30 per

cent of crop production'. Obviously, the extent of loss may vary depending upon these as on and extent of insect pests, diseases and weeds, etc. As per thirty seventh report of the Standing Committee on Petroleum & Chemicals (2002), the annual loss due to pests was reported as Rs. 90,000 crore. However, as per the estimate based on Minimum Support Price (MSP) in 2008, the loss was Rs. 2.5 lakh crore. Due to increase in MSP over the years, this loss at present could be around Rs. 3 lakh crore per annum.

### RETURN TO INVESTMENT ON PESTICIDE USE

As per Division of Agrochemicals, IARI (2008), highest cost: benefit ratio of 1:28 for chemical control was in groundnut, followed by in sugarcane (1:13), mustard (1:12), sunflower (1:8) and 1:7 in cotton, rice, and vegetables. In general, it is estimated that every rupee spent on plant protection saves on an average the produce worth five rupees!

### EXTENT OF CHEMICAL PESTICIDE USE

Pesticides use in India is very minimal (0.5 kg/ha) as compared to

several other countries like USA, Europe, Japan, China, etc., where pesticide use is 20 times more than India, and therefore, their crop yields are much higher to ours. Thus, there is enormous potential for increasing consumption of crop protection products. Pesticide consumption got impetus with the introduction of green revolution and the consumption rose to 50,432 tonnes in 1973-74, as against 2,353 tonnes in 1955-56. After green revolution, pesticides consumption (technical grade) in India was highest in 1988-89 (75,418 tonnes). During 1997-98 to 2004-05, it was around 40,000 tonnes / year, and increased to 55,540 tonnes in 2010-11. However, in 2011-12, it was 50,583 tonnes. The decline was primarily due to the introduction of eco-friendly new molecules where the recommended dose was farless. However, due to intensive farmer's education on judicious use of pesticides, there had been expansion in area under crop protection.

#### **SCOPE FOR ENHANCED AREA AND CROPS UNDER ASSURED PLANT PROTECTION**

As per the data available, during 2009-10, five States-UP (22.8 per cent), Punjab (13.9 per cent), Maharashtra (11.1 per cent), Haryana (9.7 per cent) and Rajasthan (8.4 per cent) consumed together over 66 per cent of the pesticides used in the country. The consumption was highly skewed in favour of a few crops – rice, cotton and wheat (together 52 per cent) and very negligible for pulses, soybean, sugarcane, potato, tea and fruits (together 35 per cent). It is therefore, desirable to have increased, though judicious, use of pesticides to enhance productivity of pulses and horticulture crops, as these are the major sources of protein, and necessary vitamins respectively.



#### **MISCONCEPTIONS ABOUT PESTICIDES RESIDUE, NOT AS PER SCIENCE BASED FACTS**

Sometimes there is news in the press and media about pesticides residue in fruits, vegetables, etc. The scientific facts do not support this misconception as mere presence of pesticides in trace amount does not mean that the product is unhealthy. The Ministry of Agriculture, Govt. of India had replied to this issue in the Lok Sabha and Rajya Sabha to starred and unstarred questions on 10 May 2007 and 27 April 2012 respectively. The Government of India has set-up a Division which continuously monitors pesticides residue in fruits and vegetables available in the markets across the country. Report of the AICRP on Pesticide Residue, IARI have shown that out of 15,321 samples of food commodities analyzed between April 2010 to March 2011, only in 1.23 per cent samples pesticide residue was above prescribed MRL. Thus there was no cause for panic.

#### **DHANUKA'S INITIATIVES IN MAKING AVAILABLE QUALITY PESTICIDE PRODUCTS**

Dhanuka Group is one of the leading and reputed commercial groups/companies in the field of plant protection chemicals. The group has international collaboration with lead-

ing manufacturers in USA, Japan and Norway. During the last more than three decades of its existence, it has been striving for providing state-of-the-art eco-friendly pesticides to farmers, and is fully committed to educate and train the farmers about new agriculture technologies of Integrated Crop, through its pan India presence. The Group was the first to have public-private partnership (PPP) with the government of Madhya Pradesh for agricultural extension management in Hoshangabad district. It also has PPPs with MANAGE, Hyderabad; AAU, Anand & NAU, Navsari for DAESI programme; mobile soil and water testing van with government of Rajasthan, and training of farmers with KVK, Chomu, etc.

In order to ensure food and nutritional security, bringing more area and crops under assured crop protection is one of the important viable options. This however, is possible only by taking a holistic approach towards Integrated Crop Management and initiating more intensive pro-active steps like accelerating process of registration of new molecules, higher allocation of resources for R&D to the ICAR Institutes and SAUs, incentives to the pesticides industry for more R&D, etc. More & more programmes under public-private partnership are urgently called for education and training of Agri-Input dealers and farmers, intensive on farm demonstrations on judicious use of pesticides, enhanced exposure to the State Department personnel about new eco-friendly molecules, assuring availability of quality products, etc. An effective control of weeds, and seed and soil-borne diseases alone offer enormous opportunity for significant yield gains in foodgrains and pulses. ♦

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## AN INTROSPECTION OF FOREIGN DIRECT INVESTMENT (FDI) IN AGRICULTURE

The unprecedented growth of global FDI in nineties around the world makes FDI an important and vital component of development strategy in both developed and developing nations, and policies are designed in order to stimulate inward flows. India's economic reforms way back in 1991 had generated strong interest in foreign investors turning India into one of the favourite destinations for global FDI flows.

The International Monetary Fund, defines foreign direct investment, commonly known as FDI, "... as an investment made to acquire lasting or long-term interest in enterprises operating outside of the economy of the investor." India ranks second in the World in terms of attractiveness for FDI. A.T. Kearney's Global Services Locations Index ranks India as the most preferred destination in terms of financial attractiveness, people and skills availability and business environment. The country's domestic demand-driven growth model is playing a catalyst role in attracting foreign investment in the country.

"India has emerged as the second most attractive destination for FDI after China and ahead of the US, Russia and Brazil" (UNCTAD, 2012). FDI inflows rose by 36per cent during January-October, 2011. Cumulative amount of FDI equity inflows (April 2000-October 2011) is US\$ 226.05 billion (Ministry of Commerce, 2011). The important characteristics which is attracting

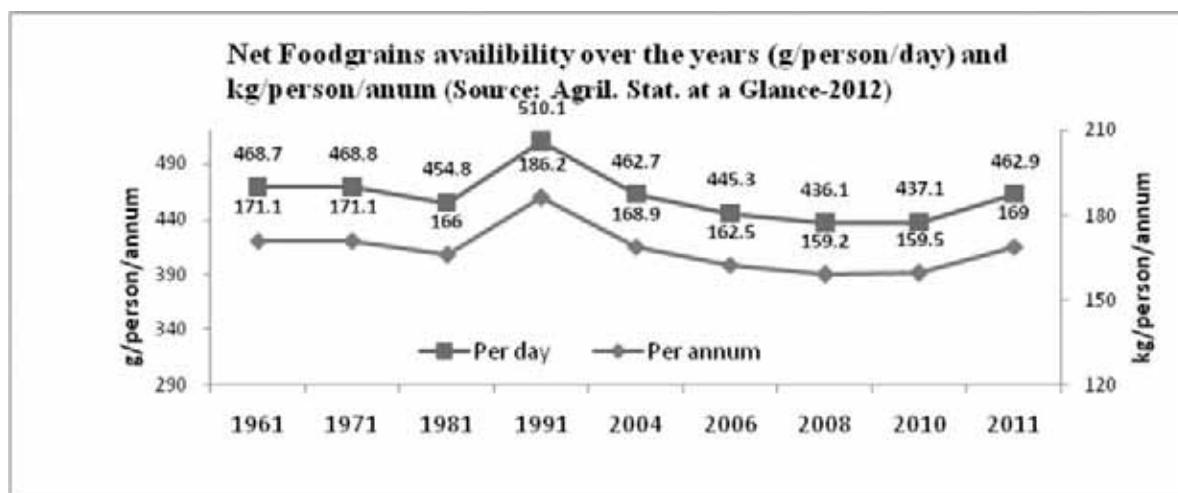
FDI towards the Indian market are

- The high potential of the domestic market.
- Cost competitiveness.
- Access to a highly qualified worked force.

### PRESENT STATUS OF AGRICULTURE

Majority of the workforce of Indian population is dependent on agriculture. Till today, in India, majority of the workforce resides in rural area capitalizing on agriculture as the main occupation. In India, agriculture is an important sector of the Indian economy and accounts for around 14per cent of Indian gross domestic products. Agriculture is the main stay of the Indian economy and the backbone of rural India which accomodates more than 68 per cent of the total Indian population.

Despite a fair production in the country during the last few years, we are still facing many problems in the context of farmers. There are many factors which have added to the agrarian distress like small and fragmented land holdings, dependence on the monsoon, lack of international competitiveness of its produce, poor access of the farmers to good roads, market information, infrastructure, refrigerated transportation of goods. Though India is the second largest producer of fruits and vegetables, it has a very limited integrated cold-chain infrastructure. Lack of adequate storage facilities causes heavy losses to farmers, in terms of wastage in quality and



quantity of produce, in general, and of fruits and vegetables, in particular. Demand for processed/convenience food is constantly on the rise. Presently, a very small percentage of these are processed into value added products. Storage infrastructure is necessary for carrying over the agricultural produce from production periods to the rest of the year and to prevent distress sales. Inadequate storage facility causes heavy loss to farmers in terms of wastage as well as selling price. Poor quality seeds, fertilizers and pesticides are obtained at higher prices, the dealers and middlemen provide credit for purchase of agricultural inputs and palm off substandard items. Majority of the farmers are lacking scientific farming practices. Farmers are unable to apply fertilizers and pesticides at the right time, owing to lack of liquidity. Farmers are forced to sell their output to the money lenders at low prices as a part of the loan conditions. Owing to lack of storage facilities, farmers have to sell off their output at harvest time. The difference in price between the flush and lean season could be 100 per cent or more.

**GOVERNMENT POLICY OF FDI IN AGRICULTURE**

The sectors which attracted higher inflows were services, telecommunication, construction, computer software and hardware. Comparatively, agriculture sector is getting the low FDI equity inflows in India.

To improve the present condition of Agriculture sector, Government has decided to allow FDI upto 100 per cent through the automatic route in the horticulture, floriculture, development of seeds, animal husbandry, pisciculture, aqua culture, cultivation of vegetables, mushroom and services related to agro and allied sectors. Cent percent FDI is allowed through Government approval in Tea sector including tea plantations subject to the conditions



of divestment of 26 per cent equity of the company in favour of an Indian partner/ Indian public within a period of five years; and prior approval of the state government concerned in case of any future land use change. Beside these, FDI is not allowed in any other agricultural sector/ activity. The government has announced 100 per cent FDI in the agriculture sector including seeds, plantation, horticulture and cultivation of vegetables. According to the circular by DIPP (Department of Industrial Policy and Promotion) animal husbandry, pisciculture, aquaculture under controlled conditions and services related to agro and allied sectors have also been provided with 100 per cent FDI along with the tea sector. DIPP has imposed certain conditions for companies dealing with growth of transgenic seeds and vegetables. While dealing with genetically modified seeds or planting material, the company is expected to comply with safety requirements in accordance with laws enacted under the Environment (Protection) Act on the genetically modified organisms; any import of genetically modified materials, if required, shall be subject to the conditions laid down in notifications issued under Foreign Trade (Development and Regulation) Act, 1992. Further un-

dertaking of business activities involving the use of genetically engineered cells and material shall be subject to the approvals from Genetic Engineering Approval Committee (GEAC) and Review Committee on Genetic Manipulation (RCGM). The circular also states the term “under controlled conditions”. As per the defined term, the “under controlled conditions” for the categories of floriculture, horticulture, cultivation of vegetables and mushrooms is the practice of cultivation wherein rainfall, temperature, solar radiation, air humidity and culture medium are controlled artificially.

Control in these parameters may be affected through protected cultivation under green houses, net houses, poly houses or any other improved infrastructure facilities where micro-climatic conditions are regulated anthropogenically. In addition, in case of animal husbandry, the term under controlled conditions includes: rearing of animals under intensive farming systems with stall-feeding. Intensive farming system will require climate systems (ventilation, temperature/humidity management), health care and nutrition, herd registering/pedigree recording, use of machinery, waste management systems. Poultry breeding farms and hatcheries, where

microclimate is controlled through requires advanced technologies like incubators, ventilation systems etc. In the case of pisciculture and aquaculture, it includes: aquariums hatcheries where eggs are artificially fertilized and fry are hatched and incubated in an enclosed environment with artificial climate control (DIPP, Ministry of commerce and Industry Govt. of India, April 10, 2012).

#### **POSSIBLE CHANGES IN AGRICULTURE THROUGH FDI ALLOWANCE**

FDI plays a significant role in increasing productivity by offsetting the investment and technological gap. Through FDI allowance, "farm-to fork" system helps to cut down intermediaries, benefiting the farmers by giving better and remunerative prices helping in the stability and economics of scale which will benefit, in the ultimate analysis for both the farmers and consumers.

Direct purchase from farms will hugely benefit small farmers who are not getting good returns by selling in the local mandi. Improvement of supply chain/ distribution efficiencies, coupled with capacity building and introduction of modern technology will help arrest wastages (in the present situation improper storage facilities and lack of investment in logistics have been creating inefficiencies in food supply chain, leading to significant wastages). Almost half of the total food wastage can be prevented if fruit and vegetable retailers have access to specialized cold storage facilities and refrigerated trucks. The organized retail will bring in efficient practices that will help farmers in the procurement process, reduce wastage with efficient storage and will finally cut the losses. The giant retailers will help India to have strong storage system with highly developed transportation. If the market is opened, then the pricing could also change and the monopoly of certain domestic Indian companies

will be challenged. According to some of the reports, an average Indian farmer realises only one-third of the price, which the final consumer pays. It creates transparency in the system; the intermediaries operating as per mandi norms do not have transparency in their pricing. High value crops which are grown by progressive farmers do not find any proper market for their produce, but now through FDI allowance, farmers have better opportunity of market to get good price for their produce and consumers will also get a quality agro produce at reasonable price to maintain their health.

#### **DEMERITS ABOUT FDI**

The hardworking bread earners, comprising the majority of the people will surely not be benefitted. Vendors are used to sell much fresher than any of the organised retail or corporate shops. Long distance chain and refrigeration means stale fruits and vegetables. In order to give a fresh look and high quality, corporate extensively use pesticides and chemicals. Monopolization of the market may take place. Where supermarkets cannot source from medium- or large-scale farmers, and small farmers lack the needed assets, supermarket chains (or their agents such as the specialized and dedicated wholesalers) sometimes help farmers with training, credit, equipment, and other needs. Such assistance is not likely to become generalized, however, and so overtime resource poor farmers will face increasing challenges surviving in the market as it modernizes. Distortion of culture may take place among the youths. FDI has a significant impact over economic growth of the country with increasing labour standards, skills, transfer of technology, innovative ideas, marketing strategy, up-gradation of technology, access to global managerial skills and practices, optimal utilization of human capabilities and natural resources, making

agriculture sector internationally competitive, opening up export markets, access to international quality goods and services. It promises to benefit a broader segment of population by generating higher incomes for farmers, reducing spoilage, augmenting employment opportunities, supply chains and delivering affordable products as per the demand of the clients. It will bring about improvements in farmer income and agricultural growth and assist in lowering consumer price inflation. India will significantly flourish in terms of quality standards and consumer expectations, since the inflow of FDI in agricultural and retail sector is bound to pull up the quality standards and cost competitiveness of Indian farmers.

But the government of India must be cautious as it a dicey task, where large population depends on agriculture for their livelihood. Due care must be taken before implementing any policies as there are many baffling issues around FDI, where still the clear-cut picture is not available, apprehensions raised by the critics should also be considered and adequate safeguards must be taken so that the positive effects may outweigh the negative ones. It should be first experimented in a limited area, then after studying its impact; it can be applied to the whole country. Government should look after the issue in such a way whether farmers are benefitted and getting their remunerative price for their produce or whether they are being exploited; taking all these points in view policies should be made and a nodal agency should be appointed separately to look after these issues. Appropriate mix of policies by centre and state governments will bring the desired change in farmers. It should ensure adequate flow of capital into rural economy in a manner likely to promote the welfare of all sections of society, particularly farmers and consumers. ♦

# INTERNATIONAL AGRICULTURE CONSULTING GROUP

## Indian initiative towards food and agriculture solutions

### Vision

Our vision is to be a leading provider of Indian regional expertise in food and agriculture and to outstand as key advisory partners on food security concerns, policy planning and strategy framework for sustainable development through agriculture.

### Mission

Our mission is to initiate and support micro and macro level changes in agriculture by providing Indian expertise and solutions for research, extension, education, training, institutional frame, policy planning, agribusiness and project consulting so as to address their major agricultural concerns relating to farm production, food security, environment sustainability, rural employment, economic growth and human resource development.



### Objectives

1. Provide Indian expertise to deliver solutions to agricultural issues and concerns through formulation of agro and rural development projects, farming solutions, micro and macro level national agriculture planning, policy support, organized research, extension infrastructure and institutional set-ups, value addition and market linkage services.
2. Manage short terms management programs, training and entrepreneurship course for farmers, research & extension personnel, officials and professionals of various countries while recognizing and understanding ecological, technological, social and economic concerns related to their food and agriculture sector.
3. Facilitating students from different countries in enrolling in food and agricultural degree programs; management and entrepreneurship courses offered by various institutes and recognized universities of India, so as to help various countries in developing human resource for creative and productive change at ground level.
4. Organizing delegation level visits from India to various countries and of different countries to India for participation in agri and business summits, learning and exposure at technology institutions, agri universities, model farms etc., and discussing possibilities for joint ventures, collaborations and promoting better understanding in agriculture and agribusiness.
5. Facilitating Governments, Corporates or Institutions to venture globally and act as total solutions providers in implementation of foreign agriculture projects by providing research structure, technical assistance and investment planning in food, farming, agribusiness or agriculture development programs.



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# *Livestock*

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# REPROPAGATION OF INDIAN MILCH CATTLE FOR SUSTAINABLE MILK PRODUCTION

India underwent a second agricultural revolution called the “White Revolution” in late sixties in which the government promoted the use of India’s native Zebu cattle crossed with European dairy cattle to increase the production of milk. The estimated milk production in the country today is 133 million tonne (DAHDF Annual Report: 2012-13), out of which indigenous breeds contribute 47 per cent of total cow milk produced. Theoretically, country’s breeding schemes were based on grading up of local cattle with improved indigenous breeds, selection within the indigenous breeds, and crossbreeding of native cattle with temperate dairy breeds with the objective of increasing productivity per animal. However, since last 50 years, the focus of Indian dairy farmers/stakeholders has been fixated on crossbreeding, as it exhibited short term gains viz., better milk production than indigenous breeds and were more adaptable to the tropics than exotic breeds.

## CURRENT SCENARIO AND FATE OF CROSSBREEDING

In India, European missionaries, as early as 1875 started crossbreeding involving Shorthorn and local native breed of Patna, Bihar to develop synthetic breed named

“Taylor”. At institutional level, crossbreeding programme was started at Imperial Dairy Research Institute, Bangalore involving Ayshire X Haryana (Year 1910), Ayshire X Sahiwal (Year 1913), Ayshire X Red Sindhi (Year 1917) and Holstein Friesian X Red Sindhi (1938) crosses. Allahabad Agricultural Institute, Naini, at its institutional farm, started crossbreeding as early as 1924 involving Jersey X Red Sindhi and Brown Swiss X Red Sindhi crosses to develop Jersind and Brownsindh synthetic strains, respectively. Indian Council of Agricultural Research (ICAR) institutes like National Dairy Research Institute (NDRI), Bangalore developed Jerthar in 1958 and thereafter in 1980, NDRI Karnal, developed modified synthetic strains like Karan Swiss and Karan Fries. The milk production of Karan Swiss and Karan Fries crossbreds enhanced from 2200 kg to 4000 kg in field condition and from 2562 kg to 5553 kg in organized herd, however, the population of these breeds are only in hundreds. Other ICAR institutes like Project Directorate on Cattle, Meerut in collaboration with Military Dairy farms utilized Friesian-Sahiwal cross-breeds as a base for the evolution of a new milch strain - “Frieswal”. Since the past 21 years, average of 300 days lactation yield of Frieswal has oscillated between 3101kg to 3274 kg.

Dairy cattle breeding principle, behind this



Propagation of the first battery of Bulls Progeny Test in Brazil (1993), Evaluation Period: 07 Years (Source: www.girleiteiro.org.br).



Decade of 90 in Brazil was marked by the emergence of high producing animals from matings of proven bulls. (Source: [www.girleiteiro.org.br](http://www.girleiteiro.org.br)).

effort, was to combine high milk yield and early maturity of European dairy breeds with hardiness, disease resistance, and adaptability of local dairy cattle. These attempts were actually species hybridization, as it was the crossing between two species *Bos taurus* and *Bos indicus*, in which next generations exhibited more complications in performance traits. Initially, various fatal disease outbreaks occurred which hindered the efforts of planned crossbreeding, however, wide spread use of prophylactics minimized these setbacks. The crossbreeding had, of course, enhanced short term production, but at the same time, it has left many negative long-term scars, with regards to animal productivity, reproductivity, sound health and adaptability potential. In addition to the above setbacks, the tropical conditions made conception relatively difficult and increased embryonic deaths. The maintainance of crossbreds is expensive for a marginal farmer as it requires intensive care, good feeding, and management, veterinary health care and various vaccinations. The

problem of infertility is again very serious in crossbreds, as 55-60 per cent bulls did not produce quality frozen semen and hence culled from selection and breeding. Therefore, time has arrived to sit and introspect for the overall highs and lows of past breeding policy decisions, proof read it and find the next best option.

#### **FLOURISHING PERFORMANCE OF ZEBU BREEDS IN OTHER COUNTRIES – A LESSON TO BE TAKEN**

According to the scientific community in India, the major limitations for improvement of indigenous cattle for milk production were low levels of milk production; absence of performance recording with the farmers' animals and poor spread of AI. Assuming an annual genetic gain of one per cent per year, it would take approximately 100 years to double the milk production of a herd with an average lactation yield of 1172 kg. Therefore, the scientific community ignored the genetic potential of indigenous dairy cattle.

However, the superior value

of India's native cow breeds has attracted attention of people from all continents who had carried these breeds to their native lands and successfully re-bred them there. Brazilians have raised thousands of Gir, Guzerat/Kankrej, Red Sindhi and Ongole cows of Indian origin, New Zealanders have redeveloped the Indian "Vechur" breed and Kenyans have developed Sahiwal breed. The import of cattle breeds like Guzerat/Kankrej and Gir started early in 1870 and 1911 respectively. Implementation of the national program for improvement of dairy Gir started in Brazil in 1985; and from 2000 onwards this breed improved considerably. In 2011, a pure Gir cow named Quimbanda Cal broke its own 2010 record of yielding 10,230 kilolitres of milk a year, with a daily yield of 56.17 kilolitres. Recently, Sire directory published by ABS –Pecplan, 2013 for Zebu Gir reported sires with predicted transmitting ability (PTA) in the range from 134 to 485, when mated with dams with lactation yield range from 4500 to 15000 kg in a year. Similarly, average milk production of Kenyan

Sahiwal ranged between 53 to 57 kiloliters per day. This outstanding achievement is the result of perception of future and of the persistence in the work in selection of breeders and environment. Summarily, these achievements indicate that indigenous breeds can perform extremely well if they are selected for milk production and given right environment.

### **NEXT BEST OPTION -REPROGATION OF INDIGENOUS MILCH CATTLES**

The milk yield of Indian dairy breeds ranged from 1000-5000 kg with unique qualities of survival under low input, harsh climate and resistance to diseases. Indigenous breeds like Sahiwal yields an average of 2000 kg in field conditions, whereas organized farms like NDRI has reported around 2562 kg milk yield in one lactation. The best Gir cows maintained at Swaminarayan temple, Gondal and Sarangpur and Bhuvneshwri Peth, Gondal have demonstrated high milk yield of up to 4000-6000 kg per lactation. The heritability estimates for milk yield

in indigenous breeds averaged around 0.25 to 0.30, thus suggesting that a large complement of genetic variability for milk production existed in these breeds.

The repropagation of indigenous dairy breeds is necessary because they are very well adaptable to local environment, need low maintenance and low input sustainable production. Recent studies on indigenous cow, buffalo and exotic cows have revealed that A1 allele is more frequent in exotic cattle, while Indian native dairy cows and buffaloes have only A2 allele, and hence are a source for safe milk. A1 variant has histidine at position 67 of the amino acid sequence, while A2 possess proline at this position and is considered to be healthier milk. This single amino acid change in A1 variant causes the release of bioactive peptides upon gastro intestinal digestion. Morphine like opioid beta casomorphine-7 (BCM-7) thus released from A1 milk is reported to cause various illness like diabetes mellitus, heart diseases, atherosclerosis,

schizophrenia and sudden infant death syndrome (SIDS). The major consumer market for A2 milk is in Australia where it is available in some 800 supermarkets and 200 convenience stores. However, overall market share is probably less than 1 per cent because of limited publicity. In an increasingly health conscious world, this creates a huge potential for global demand for the A2 milk of our indigenous breeds.

The omega-3 fatty acid docosahexaenoic acid (DHA) is crucial for the healthy structure and function of the brain. An optimal intake of DHA is especially essential for pregnant and nursing mothers to ensure adequate brain development in their children and is also essential for the adult brain, where it impacts the brain's structure and signalling systems. Indigenous cow milk contains DHA, which is essential for brain development of children.

It has been observed that cow urine has increased the phagocytic activity of macrophages and thus helpful in prevention and control of bacterial infections. It also increases



**Repropagation of Indian Milch Cattle is need for Future Sustainable Milk Production**



**Selection and Breeding Indian Milch Cattle for Environmental Sustainability in India**

the secretion of interleukin-1 and interleukin-2. Thus, cow urine has been considered to modulate the immunity in a manner that can be used as an immunomodulatory drug in animals. It is reported that cow urine also acts as a disinfectant and thus purifies atmosphere and improves the fertility of the land. Recently, cow urine has been granted U.S. patents (No. 6,896,907 and 6,410,059) for its medicinal properties.

The cow dung is a "gold mine" due to its wide applications in the field of agriculture, energy resource, environmental protection and therapeutic applications. Cow dung is a cheap and easily available rich source of microflora. Though cow dung has been used in several studies, the breed of cow has not been mentioned. As per Indian Vedic scriptures, cow dung obtained from Indian Zebu breeds is better than that of other newer breeds. Ideally, the source of cow dung as per ayurveda should be from a healthy Zebu cow, fed with healthy diet of pastures including various natural herbs and which has been reared hygienically. Thus, indigenous breeds are unique

at various levels which has to be capitalized to improve breed and production value.

India does possess the world's biggest cattle herd, but typically, the individual yield of these malnourished cows is very low. Crossbreeding, that was primarily aimed to use non-descript cows, has unfortunately led to systemic erosion of the indigenous Indian cows and new exotic crossbreeds have not still been adapted to Indian conditions. In conclusion, efforts to enhance the productivity of existing sizable population of crossbred cows may continue, however, maximum attention needs to be given for the development of indigenous milch breeds of cattle, as India still can produce top dairy breeds.

The lesson from the past breeding achievements and commitment to the genetic enhancement of Indian cattle based on scientific information aligned with field experience can bring dramatic turnaround in per animal productivity and total milk production. Broadening the genetic base of population of indigenous cattle with imported elite semen from other countries having superior

germplasm of indigenous breeds like Sahiwal, Gir, Red Sindhi, Tharparkar and Kankrej is priority step. The strategic breeding approach should focus on meticulous selection of high genetic merit bulls, implying high selection pressure on females. A timely policy shift and public investment in local breeds is the need of time which can revive our precious breeds in 25-35 years — which amounts to four to five cattle generations. Investment in research and development for identification and development of unique DNA Markers/Signatures in indigenous breeds for economic traits can aid to implement Marker Assisted Selection (MAS) to enhance genetic potential of local milch cattle. Development of SNP Chips exclusively for indigenous breeds can be a milestone for genomic selection which can increase the precision of breeding value prediction. The modern advanced reproductive and genomic biotechnologies should complement the traditional selection and breeding methods to achieve faster genetic progress in productivity of Indian dairy breeds. ♦

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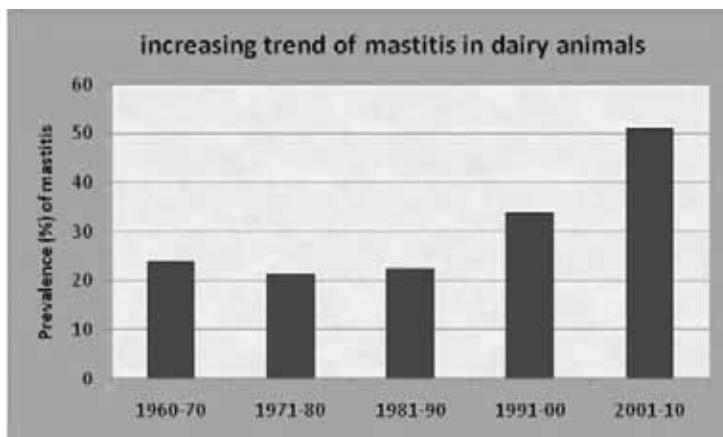
## Bovine mastitis: A major impediment in increasing milk production

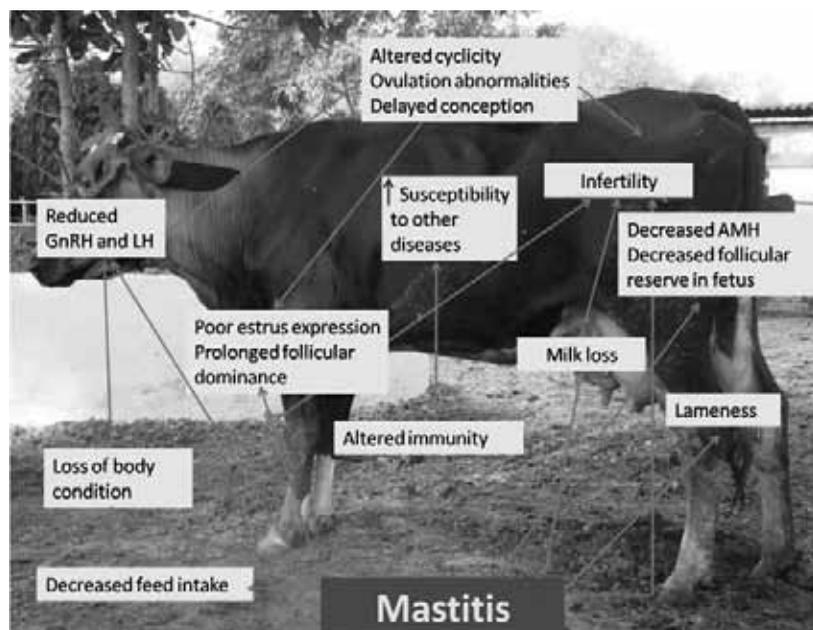
In India, milk production has registered impressive growth during the post independence era when it jumped from 17 million tonnes in 1950-51 to 127.8 million tonnes in 2011-12. The increased production of milk has improved the per capita milk availability to 291 grams per day. The rate of growth in milk production has also been more than three times higher than the world average of 1.5 per cent per annum. The demand of milk and milk products in India is projected to increase to 142.9 million tonnes in 2015 and further to 191.3 million tonnes in 2020. At the existing rate of growth in milk production, in next ten years, supply is likely to fall short of the demand. Among the several barriers in achieving the milk production targets, mastitis continues to remain as the most challenging impediment, since the affected quarters show 30 per cent less productivity and cow loses about 15 per cent production.

Mastitis, an inflammatory reaction of the mammary gland, is induced when pathogenic microorganisms enter the udder through the teat canal, overcome the cow's defense mechanisms, begin to multiply in the udder, and produce toxins that are harmful to the mammary glands. During the last decade, mastitis stood just next to FMD as the most challenging disease in high yielding dairy animals. But recent evidences suggest that mastitis may stand at first position, because

prevalence of mastitis has been reported to be very high in high yielding cross bred dairy cows. After analyzing the published reports, one can safely say that the average prevalence of mastitis in 1960s to early 1990s was not more than 30 per cent, however afterwards, the prevalence increased to even more than 60 per cent. Two decades ago, the average incidence of clinical mastitis in India was 1-10 per cent with subclinical mastitis ranging from 10-50 per cent in cows and 5-20 per cent in buffaloes, while recent studies reported high incidence of subclinical mastitis ranging from 20 to 83 per cent in cows and 45 per cent in buffaloes. Analyzing data reported by more than 100 recent studies spread over 21 states of India indicate that the overall prevalence of mastitis ranges from 25 to 97 per cent with an average prevalence of about 50 per cent. This clearly indicates drastic increase in the prevalence of mastitis, especially the subclinical form of the disease, which is an alarming situation for the dairy sector in the country.

Bovine mastitis has huge effects on farm economics due to reduction in milk production and the treatment costs. Since mastitis affects the milk quality, its consequences are not restricted only to the farm, but expand beyond the dairy farm. Worries about the antimicrobial residues, antimicrobial resistance, milk quality and animal welfare all become a concern to the consumers and the society. According to a study, the estimated loss following clinical mastitis was almost 700 kg for cows in first lactation and 1,200 kg for cows in second or higher lactation. Each case of clinical mastitis has been estimated to cost between \$100 and \$200 per cow within the lactation. Several studies at the United States show that costs related to mastitis on dairy farms are approximately US\$ 200 per cow/year, and this gives an annual loss of 2 billion dollars for dairy industry. In India, annual economic losses incurred by dairy industry on account of udder infections have been estimated at about Rs.6053.21





crore. Out of this, loss of Rs. 4365.32 crore (70 - 80 per cent) has been attributed to sub-clinical version of udder infections. In another report from India, the annual economic losses due to mastitis, has been calculated to be approximately Rs.7165.51 crores; losses being almost same for cows (3649.56 crores) and buffaloes (Rs.3515.95 crores). Subclinical mastitis has been estimated to account for 57.93 per cent (Rs.4151.16 crores) of the total economic loss due to mastitis.

Earlier, it was thought that the effect of mastitis was restricted to udder only, but now it has been proved, beyond doubt, that mastitis affects the reproduction efficiency of the animals also, especially during early lactation period. Extensive research has reported that both clinical and sub-clinical mastitis alter the reproductive process at several levels. Mastitis delays the postpartum ovarian function and alters some of the key reproductive functions like ovulation, fertilization, implantation, and pregnancy maintenance. Acute mastitis delays

the calving to first service interval, calving to conception interval, and increase the number of services per conception. When clinical mastitis occurs before the first AI, calving to first service interval was significantly increased, compared to when it occurs after the first AI. The following figure depicts the possible effects of mastitis on dairy animal reproduction.

Pathogenic microorganisms that most frequently cause mastitis can be divided into two groups based on their source: environmental pathogens and contagious pathogens. Coliform organisms (*Escherichia coli*, *Klebsiella* spp. etc.) and streptococcal organisms (*Streptococcus uberis*, *Streptococcus bovis* and *Streptococcus dysgalactiae*) are the important environmental pathogens. The major contagious pathogens are *Streptococcus agalactiae*, *Staphylococcus aureus*, *Corynebacterium bovis* and *Mycoplasma* spp. Among different pathogens, their distribution varies among countries and even within the country, production systems, farms and individual animals. For

example, *Staphylococcus aureus* is most frequently involved in clinical mastitis, followed by *Streptococcus dysgalactiae* in Norway. In the mid-western United States, coliforms are the most frequently isolated bacteria, whereas in the United States, *Klebsiella* and *E. coli* mastitis are of equal importance. In Europe, clinical *Klebsiella* mastitis occurs less frequently than clinical *E. coli* mastitis. In contrast, coliforms are less important and *Streptococcus uberis* is the main concern in both clinical and subclinical mastitis in New Zealand.

In India, many workers have reported that *Staphylococcus* spp. is the chief etiological agent of mastitis in cattle and buffaloes. However, there are no studies on nationwide distribution of mastitis-causing bacteria in India. Apart from regional differences, cows in tie-stalls have higher incidence of *Staphylococcus aureus*, *Streptococcus uberis*, coagulase-negative staphylococci and other streptococcal infections compared with those in free-stalls, where *Klebsiella* spp. and *E. coli* are main concern. Collectively it suggests that distribution of organisms may vary between regions and husbandry systems, and it is important to know the epidemiological pattern of mastitis pathogen before the implementation of control strategies.

#### MASTITIS CONTROL: THE WAY AHEAD

Mastitis control is based upon adoption of preventive and control strategies including proper maintenance of animals, good milking hygiene, use of properly functioning milking equipment, provision of clean and dry housing areas, sound nutritional programs and proper identification and treatment of cows that are infected with subclinical and clinical

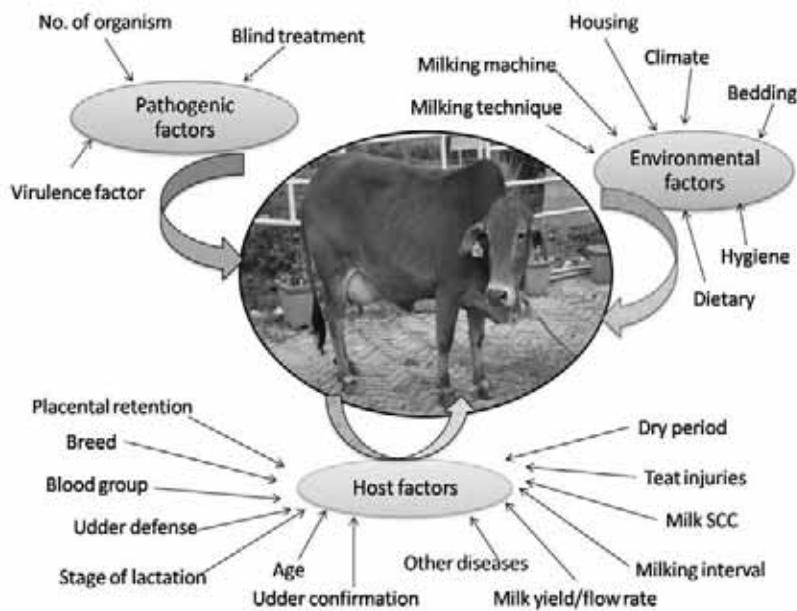


Figure indicates various risk factors for mastitis in dairy animals

mastitis.

Traditional mastitis control programs have been focused on udder health management through treatment strategy and hygienic and preventive measures. The genetic selection has been ignored as part of control strategy due to low heritability of mastitis. This view has changed in recent times, and selection tools are being adapted in many countries (e.g. Norway, Sweden, Finland and Denmark). However, still some controversies exist, and need further validation before expanding its application.

Research on mastitis vaccines has been conducted for at least 30 years and few mastitis vaccines are commercially available. An ideal mastitis vaccine should be able to reduce the severity and frequency of mastitis, prevent new infections and eliminate existing infections. While these expectations seem reasonable, it is unlikely that any one vaccine will be able to achieve all these outcomes. As the available vaccines are not 100 per cent effective in preventing infection, it is difficult to eradicate the disease

by vaccination alone. It is generally accepted that commercially available *Staphylococcus aureus* vaccines have limited ability to prevent new infections. The efficacy of these vaccines is not consistent, and varies with the herd. There has been a sustained and focused research effort for vaccines against *Streptococcus uberis*, however, at this time there are no commercial vaccines available that can protect against *Streptococcus mastitis*. An improvement of the herd immunity along with good sanitation could check spread of infections.

In developed countries, it has become easy to ensure the milk quality through automated systems. In countries like India, the smallholder production system comprising few heads of cattle is the most common. Due to the diverse characteristics of this system, it has been difficult to establish stringent quality parameters to meet the market demand. Occupying the premier position in milk production, the country needs to ensure production of milk that meets the required quality parameters to compete in the global

market. Thus, it is desirable to set up control and compliance systems for milk production in smallholder dairy production system. To evolve such quality production practices, we need to have primary database on the quality of milk produced under the smallholder system, which is the first and foremost step to be taken up.

In UK and EU, the prevalence of mastitis has been brought down significantly either by adopting five-point or ten-point plans. The five point plan or five-pronged approach comprised of rapid identification and treatment of clinical cases, routine whole herd antibiotic dry cow therapy, post milking teat disinfection, culling of chronically affected cows and the routine maintenance of milking machine. At the end of the last century, the National Mastitis Council extended the five-point plan to a ten-point plan with 73 sub points. The ten points are: establishment of goals for udder health; maintenance of a clean, dry and comfortable environment; proper milking procedures; proper maintenance and use of milking equipment; good record keeping; appropriate management of clinical mastitis during lactation; effective dry cow management; maintenance of biosecurity for contagious pathogens and culling of chronically infected cows; regular monitoring of udder health status; and periodic review of the mastitis control program. In India, we do not have such programs in place, and it is high time to develop a new program or modify the above cited program to adapt to the production system and other local needs. Establishment of a separate body (e.g. National Mastitis Council in USA and Canada) to look after the issues of mastitis has been shown to be very effective in

reducing the prevalence of mastitis in several countries. We also need to have such separate body comprising of planners, researchers and farmers to evolve different mastitis control programs, prioritizing research areas to address mastitis associated problems, specific nationwide plans and to monitor its implementation.

Thorough evaluation of epidemiological status in different regions of the country and identifying the high, moderate and low prevalence areas based on average prevalence is the foremost important step before formulating any control or eradication strategies. Sufficient diagnostic facilities along with veterinary services, animal movement control particularly from high prevalent area to other areas and vaccination are the basic requirement for control programme. At the initial level, effective control strategy is important to reduce the disease, particularly at high prevalent areas. The major objectives of the epidemiological investigations include the identification of risk factors at farm level, major organisms involved and the susceptibility of the host. In this diversified country, with different farming systems and agro-climatic nature, the prevalence of mastitis and the organism involved would be different. Hence obtaining the ground situation of the disease and characterization of epidemiological units to be intervened are of paramount importance. Effective organization of veterinary services with periodical training is important for good performance. It should contain all the stake holders with clear definition of their duties for effective execution of mastitis control programme. Awareness camps to understand the responsibilities and potential benefits for sustained involvement of the participants are also important.

Taken together, it is needless to say that a well-planned and operational mastitis control programme is urgently needed to ward off huge economic losses to dairy industry. For success of the programme, close monitoring during its implementation along with good husbandry practices are essentially required. There is a strong need for health education to all the personnel engaged in control programme as well as the farmers.

Mastitis, although not a new problem, is associated with huge economic losses to the farmers and the country. In some developed



countries, the prevalence of mastitis in dairy animals has been brought down significantly by adopting specific mastitis control programs. Due to implementation of either a five or ten-point mastitis control program, the last forty years have seen a dramatic decrease in clinical mastitis incidence but this has been accompanied by a change in the relative and absolute importance of different pathogens. *Escherichia coli* and *Staphylococcus aureus* are now the two most common causes of bovine mastitis. In India, while milk productivity is increasing in one hand, the incidence of mastitis is also increasing on the other hand. The factors

like herd size, agro-climatic conditions of the region, variations in socio-cultural practices, milk marketing, literacy level of the animal owner, system of feeding, and management were implicated in the incidence of subclinical mastitis. Despite several attempts, we do not have safe and effective mastitis vaccines that would protect against several mastitis causing organisms. Considerable progress has been made in characterizing transcriptomic responses of the mammary gland to infections. Recent knowledge has advanced our understanding of host-pathogen interactions involved in bovine mastitis and provides mechanistic insight into disease progression. In most herds, the most effective control strategy is the prevention of new infections by the use of good management practices. The use of *Staphylococcus aureus* vaccines is not universally recommended but may be useful in some herds as an adjunct to prevention oriented control programs. Till date, mastitis control has been based mainly on widespread and unsustainable antibiotic usage to treat the clinically affected animals. However, the pressure to reduce antibiotic usage and changing etiology and epidemiology of mastitis in different production systems is an additional burden, which will provide new challenges to both the researcher and veterinarians to develop effective mastitis control programs. Any such strategies or programs should be developed keeping in mind the regional differences and should be tailored to the type of production systems so that it will result in reduced severity of mastitis, increased production and profitability, and supply of safe and nutritious milk and milk products to the consumers. ♦



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# Nutritional Feeding Strategies in Livestock

India has different climatic zones, natural resources, socio economic strata which make feeding of ruminant different in various parts of the country. This is in contrast to the western part of the world.

In fact in our country livestock plays a key role in the natural resources based livelihood, which is mostly confined to rural areas. In fact livestock rearing in our country is quite different for subsistence farmers, where risk management is more important than the developed market driven systems. Apart from unfriendly climate, we have problems of large human and animal population, pressure on land, scarcity of pasture land, shortage of feed and fodder, resulting in comparatively lower productivity and consequently low economic returns.

In spite of the above, we should all be proud that livestock sector is showing better promise (growth of 4-5per cent) than the agriculture sector (growth of -1 to 1per cent). The key point to be observed here is that majority of our ruminants are reared under suboptimal conditions, as the small livestock holders and landless together hold around 70 per cent of our country livestock. However, planning and involving the stakeholders for holistic interactions with plants and soil, involving TRM

(Total Resources Management), which means optimum utilization of the available resources including the available biomass, through its recycling would help in improving the overall animal health solution.

## SCENARIO OF FEED RESOURCES

The inadequate feed resource is the major constraint in the productivity of livestock. Since feed is the only raw material required for the production of foods of animal origin, improved supply of nutrients can bring out the full potential of the animal to the fore. Feed is also the main input factor for milk and meat production from livestock, constituting 60-70per cent of the cost of livestock products. Inadequate feed supply is coupled with the availability of low quality fibrous feeds forming the major roughage source. The cost of feed ingredients is spiralling higher and higher with each passing day. In India, another reason for the high cost of good quality feeds is the sudden spurt in the export of these ingredients during the last few years. It is really beyond the means of resource poor animal keepers to buy good quality feeds, as they even don't get the remunerative price for their produce, making a vicious circle which eventually results in sub-optimal performance from their animals. There is still not a good market for good quality feed.

NIANP Bangalore has shown that the present deficit with regard to dry fodder, green fodder and concentrate has been shown to be to the tune of 11, 28 and 35per cent respectively.

## VALUE ADDED COMPOUND FEED

Though there is improvement in usage of cattle feed amongst farmers, the quality of this feed is a big question mark. Off late certain value added feeds, which are nutritionally balanced, and also possess the herbs for improving digestion, stress, production etc., are also available. These feed may cost little higher but are known to de-





liver results. Ayurvet Uttam is one such brand in India. The current issue that most of the raw materials viz., DORB and Oil cakes worth crores are being exported leading to high cost of feeding and inflation. It is high time government looked at the farmer's plight and supported the dairy industry.

### ENHANCING GREEN HERBAGE

In India, the area under fodder cultivation has remained static for the last three decades at 4.5 per cent of the total cultivable land, due to pressure of human population. The only way to increase fodder production is through intensive fodder cultivation, especially using high yielding varieties of fodder crops. But it is important that the farmers are supplied seeds of high yielding fodder varieties, as its non availability is yet another bottleneck in enhancing fodder production. Intercropping of cereal and a forage legume can serve the dual purpose of increased grain yield (wheat) and provide good grazing. Integration of forage legumes improves soil fertility

and soil structure, and controls soil erosion and thus, helps in the sustainable development of agriculture.

### TOP FEEDS/ TREE LEAVES AS FODDER BANKS

Species of *Leucaena*, *Glyceridia* and *Sesbania* are excellent multipurpose, rather wonder trees and bushes, which can regularly provide high quality browse as well as serve as fodder bank. Their cultivation also improves soil fertility and the larger branches provide firewood. These trees can also be planted alongside roads and around ponds and edges of paddy fields, as well as in spaces not suitable for cultivation. *Leucaena* leaf meal is protein rich, which serves as a bypass protein source for ruminants. However, due to the presence of the toxic metabolite mimosine, its incorporation in the ruminant diet has to be restricted.

### ENCOURAGING SILVI-PASTURE SYSTEM AND GRASSLAND DEVELOPMENT

Although the land base for livestock

has been shrinking in India, which can be attributed to various kinds of pressures, the possibility still exists to obtain more herbage from about 60m ha of the country's land area, through silvi-pasture system and better grassland management. An integrated system of agro-forestry system in which legumes, pulses (pigeon pea) and grasses can be sown in association with fodder tree like *Leucaena leucocephala* can provide fodder without any reduction in pulses yield. Similarly, Guinea grass could successfully be grown under coconut plantation, or pasture grass like stylo, or citrus or cowpea can be cultivated in the first few years of plantation of citrus or zizphus.

### HYDROPONICS: A NOVEL INITIATIVE FOR GREEN FEED

The word hydroponics has been derived from the Greek word where 'Hydro' means water and 'Ponic' means working, i.e. Water working. Plants require 3 things to flourish- water, nutrients and sunlight; Hydroponics



is a straightforward way of providing all these nutrients without the need of soil under controlled environment conditions to optimize the growth of plants. It is referred as feed because when compared to conventional fodder, protein content is about three times higher, and energy values are about double in Hydroponics feed. The conventionally harvested green fodder consists only of cut grass but the Hydroponics feed consists of grass, along with grain and root. This method of producing green feed has many advantages for the farmer, the ecology and the environment.

**ADVANTAGES OF HYDROPONICS**

**Saving of water:** It takes 2 to 3 liters of water to produce 1 Kg of green feed as compared with 80-90 liters/ day required in conventional system. Therefore, it uses minimal water for

maximum fodder production. Water that is not used by the fodder is not wasted, as it can be recycled & reused again.

**Marginal land usage:** Fodder production in our hydroponics machine provides huge ecological and economical advantages, as the production of lush green feed requires minimal land usage as compared to field grown grasses and fodder (only 135 sq. feet for 240 Kg fodder production against 2178 sq. feet in conventional system). This reduction in the amount of land required for maximum fodder production is an asset for both regions, where agriculture is difficult, and in densely populated regions that lack sufficient growing space.

**Constant feed supply:** Hydroponics

technology will remove the need for long- term storage of feeds. With hydroponics machine, a consistent supply of green fodder is guaranteed 358 days (365-7) of the year irrespective of rain, storm, sunshine or snow. Therefore, the farmer knows exactly what feed that are available every day of the year, regardless of the seasonal conditions, as it takes an initial investment of just 7 days to produce up to 240 kg of fresh green feed per day, and a minimum of 75-84 tonnes of fodder per year.

**Reduction in growth time:** The growing time of hydroponics plants takes as little as 7 days from seed germination to a fully-grown plant at a height of 25- 30 cm, ready for harvest. Also, the biomass conversion ratio is as high as 6-8 times. Thus, for every 1 Kg of seed, 6- 10 kg of green feed is produced. However, to grow the same amount of fodder in a conventional situation, if there was sufficient water for irrigation, would take up to 12 weeks from seed germination until ready to feed out to livestock.

**Comparison of Hydroponics fodder with conventional fodder (Barley)**

Nutrient	Grain Barley	Conventional Fodder	Hydroponics Fodder
Protein per cent	10.1	11.5	31.99
Fibre per cent	6.80	31.8	24.75
Energy (Kcal/kg)	3900	2600	4727
Ash per cent	2.79	11.4	5.70

**Reduced labor requirement:** This process of growing cattle feed requires minimal man-hour ratio per day. It is as little as 2 to 3 hours per day, needed to maintain and produce hydroponics fodder, as compared to the many hours of intense labour required for growing the same amount of feed as a pasture crop.

**Enhancement of Nutritional value:** Hydroponics fodder is a highly effective, particularly nutritious feed, which produces three times more protein as compared to conventional fodder. It has high energy content and very high moisture content. Feeding livestock with hydroponically produced feed may increase considerably the fertility rates of cattle. Hydroponics fodder can also help improve the quality and quantity of milk production.



**Completely natural:** An important factor about growing green feed in Ayurvet's hydroponics machine is that it is a completely natural product. Therefore, there are no pesticides or fungicides used that could alternatively contaminate the milk or meat that are being produced.

### **CROP RESIDUES AVAILABILITY AND THEIR IMPROVED UTILIZATION**

With the constant increase in cereal production, as a result of green revolution in the country, there has been a spill over effect, rather a matching or even greater increase in the availability of cereal straws (straw: grain ratio varying from 1:1 to 1:3 in different crops). Surprisingly, the availability of maize straw has

increased by 75 per cent during the last two decades, which is mainly due to the increase in the area under maize cultivation. Since large proportion of maize is now being diverted for bio-fuels, this is also having an adverse effect on poultry feeds, through the byproduct from ethanol production from maize i.e. DDGS (distiller's dried grain solubles) can also serve as a valuable feed ingredient in cattle feed. Increase in sugar production (83 per cent during the last two decades) has also resulted

in large availability of sugarcane pith and bagasse, which being fibrous in nature, has only a limited use as feed for ruminants. During the flush season of sugarcane, the tops serve as green fodder and even the whole sugarcane plant may be diverted for animal feeding. Ayurvet has developed with help of DBT, Biotech Feed which can replace 50 per cent of the maize in the conventional feed. This is actually wheat straw treated with special type of fungus.

### **IMPROVING GENETIC VARIABILITY IN NUTRITIONAL QUALITY OF STRAWS**

Genetic variability in straw quality could be as high as 10-15 units, which has been studied in most of the cereal crop residues viz., rice,

wheat, barley, sorghum and millets. In the crop-livestock sustainable production system, better quality of straw can result in 10 per cent increase in productivity of ruminants. Cereal breeders have often overlooked this point. It is high time that the cereal breeders planned their breeding programmes in collaboration with animal nutritionists, and thus improved the economic situation of resource poor farmers.

### **ADOPTING THE TECHNOLOGY OF UREA TREATMENT OF STRAW**

Out of the several chemicals tried for cleaving the lignocelluloses bonds in fibrous crop residues and improving their digestibility, urea/ammonia treatment has emerged as the most effective one, and is particularly more feasible under tropical situation. In spite of all these good points, farmers in India, by and large, have not adopted this useful technology.

However, millions of dairy farmers in Asia, including China, are successfully using this technology to increase the nutritive value of straws. Efforts need to be continued for the adoption of this technology by the dairy farmers in India.

### **BIOTECH FEED**

The new upcoming research claims that the straw when treated with a special fungus breaks the lignin bonds and releases energy. This may even help in replacing the grain portion from the feed.

### **IMPROVING THE MANAGEMENT OF CROP RESIDUES**

In some parts of India, where large farmers use combine harvester, the

surplus paddy straw is burnt in the field itself, which is not only a waste of feed resource, but a source of environmental pollution, as well as soil degradation. Around 20 million tonnes of straw is burnt in the field itself in these areas, which is worth hundreds of crores of rupees. Proper management of this feed resource is urgently required, like providing reapers and bailers to the farmers, so that it can be later converted into feed blocks, and thus, save the feed from wastage, and make it a marketable surplus for the farmer which adds to his income.

**DENSIFIED COMPLETE FEED BLOCK**

This is an innovative feed technology, rather a novel nutrient for 24 hours, as a balanced ration. The dry roughage and the concentrate are the two major components and the micronutrient supplements from the third, minor component. The technology allows all the ingredients (major or minor) to get sufficiently blended so that the concentrate particulate matter sticks to fibre particles with the help of binder or molasses. This helps in preventing the separation of ingredients, making it as much as a homogenous feed and leaving little



scope for the selectivity by the animal. The combined feed is enriched (value added) with necessary mineral and vitamin supplements and feed additives, making it a wholesome complete balanced ration for a specific category or dairy stock.

**FEEDING OF BYPASS NUTRIENTS**

When the technology of bypass nutrients was introduced and successfully applied in western countries, about three decades back, it was thought that the technologies are suitable for only high yielding animals. Feeding of bypass protein not only saves dietary proteins from excessive degradation to ammonia, most of which is lost as urea through urine, but supplies more amino acids to the animal. The extra amino acids are converted to glucose in liver, to compensate for the inadequate energy supply to dairy animals in

tropical countries, and thereby boost up their production. Bypass protein thus, has emerged as the cheapest feeding technology for feeding ruminants, especially the dairy animals, which is now a successful commercial feed technology in India, pushing up the milk yield by 10-15per cent.

As far the bypass fat technology is concerned, the indigenous production is still absent and the country is depending on imports. Maybe technology can be made cost effective, if cheaper oil sources are used. Again, earlier it was thought that this technology is suitable only for high yielding animals, but that notion has been proved wrong through the number of trials conducted on medium producing cows and buffaloes fed with bypass fat supplements. The bypass fat, supplies concentrated form of energy and thus, compensates for the inadequate supply of energy from the original diet. The sufficient energy supply boosts up milk production in energy limiting animals. The increase in milk yield is from 10-25per cent. Hilak is one of such leading products in market. Apart from significant increase in milk production, feeding



bypass fat has several added advantages to the farmer. The animal exhibits regularity in reproductive cycle, reducing the inter-calving period to the desired minimum. During the summer months, feeding of bypass fat, also helps the animal to fight heat stress, because when bypass fat is fed to the animal, the amount of straw consumption goes down, which otherwise produces excessive heat of fermentation in rumen and animal starts panting.

### USE OF MINERAL SUPPLEMENTS

Majority of the feeds generally available in India and other tropical countries are deficient in mineral content, especially trace minerals. Also, the intensive crop production for the last four decades has caused an imbalance of minerals in the soils, which not only affects the growth of plants, but causes mineral deficiency in animals as well. The lower intake of mineral by the animals can lead to their suboptimal growth, production and reproduction. Surveys conducted recently in different regions of India have clearly brought out two things to the fore. Firstly, that the mineral deficiencies vary from region to region and secondly, that the dairy farmers in India, by large, are not aware of the importance of feeding mineral mixture to their animals. The dairy animals in the rural areas invariably have the problem of repeat breeding, which can be mostly attributed to mineral deficiencies, especially that of trace minerals. The deficiency of trace minerals varies from region to region in the country. Therefore, we need to develop region specific mineral supplements based on the survey conducted in each region. There is an urgent need for the extension agencies in the country

to educate the farmers about the benefits of feeding mineral mixture/ chelated minerals to their livestock, so that their livestock can perform at optimum level with respect to production as well as reproduction.

### REDUCING METHANE EMISSION THROUGH DIETARY INTERVENTIONS

The conditions, under which the high density ruminant stock is reared in India and other tropical countries, are conducive for release of high levels of methane from enteric/ rumen fermentation into the atmosphere. It calls for making efforts to reduce these levels of emission through technical interventions such as supplementations, fibre fortifications and fiber polarization. Lately, some herbal extracts, including the supplements containing spices like fenugreek seeds and garlic extracts have been shown to have some positive effect on rumen metabolism, including the definition and luminal methane reduction.

Another breakthrough has been achieved at Ayurved in collaboration with IVRI, a formulation of herbs which not only improves immunity, but also reduces the production of methane.

### HERBACEUTICALS

The focus as of now is on alternative measures like efficient biosecurity measures, optimized nutrition, the use of biologically active peptides, organic acids, probiotic, prebiotic etc. Herbal medicines have also started making its place in this category. Herbal medicine is today a valid and proven science, with great potential for integration with allopathic medicine to the benefit of animal health. The herbs mentioned in the Ayurveda have

been critically evaluated, their genus and species and active parts have been identified, and their chemical investigation for identification of active principles, confirmation of biological activities and safety data have been scientifically studied and established. The information on several herbs which have withstood the scientific evaluations in latest screening models testify the wisdom of our ancestors for having identified such plants from nature and collective wisdom from the traditional usage is continuing till date. Ayurved is the leader in this segment.

In our country feed shortage, especially the shortage of quality feeds is a serious problem. For increasing the supply of green herbage, the strategies needed are: conservation of degraded pasturelands and development of wastelands, even introducing shrubs and trees, to provide top feeds for livestock. Feeding strategies for ruminants in tropics should also include environmental protection, through reduced methane emission, apart from increasing the productivity of ruminant stock. Some feeding technologies are commercially available today, viz., feeding of bypass nutrients and densified TMR, which can boost up the productivity of ruminant stock, and also reduce methane emission. Improving the utilization of the straw is a big opportunity, and scientists are confident about the breakthrough. Similarly green feed from hydroponics system is the new way of animal feeding for improving animal reproductive health. This would help in saving save land and water. Needless to mention, herbal medicines have started replacing antibiotics for improving animal health and productivity. ♦

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## Oxytocin – *facts and fiction*

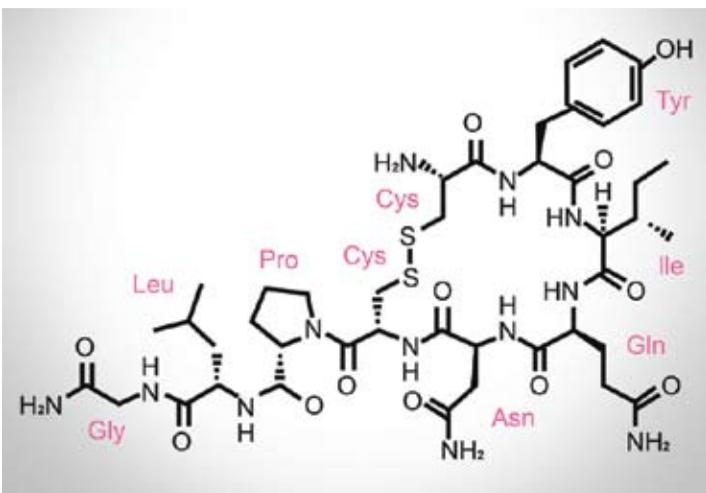
Oxytocin is a peptide hormone made up of nine amino acids that is responsible for milk let down. The structure is identical in primate and bovine species. Under natural conditions, it is released from the posterior pituitary and causes contraction of the muscle cells surrounding the milk alveoli in the cow udder (and breasts in women) for milk let down. In the mammary gland about 80 per cent of milk is stored in the alveoli and is transferred into the milk cistern by the milk ejection reflex. Milk ejection is a neuroendocrine reflex; oxytocin, released from the pituitary in response to tactile teat stimulation, causes myoepithelial cells surrounding the alveoli to contract, forcing milk stored in the alveoli into the mammary ducts and gland cistern. The remaining residual milk can be removed after i.v. administration of oxytocin at supraphysiological dosage. So every time the cow/buffalo is milked there is a natural release of minute quantities of this hormone into blood only for a few minutes at the time of milking. Oxytocin is also known to be released at the time of parturition i.e., during delivery of the new born calf or child. It is therefore, used as a therapeutic agent in inducing labour in women.

We now know that oxytocin is made in several peripheral tissues, including testis, ovary, uterus and placenta. Indeed, at parturition,

the concentration of oxytocin mRNA in the rat uterus may be 70 times higher than that in the hypothalamus. At parturition, the uterus may be influenced by local paracrine release of oxytocin even in the absence of increased circulating concentrations of the hormone from the pituitary. In addition to this potential paracrine role within the uterus, oxytocin receptors are present in a great number of tissues, including the brain, kidney, thymus, as well as male and female reproductive tracts, suggesting that the traditional description of oxytocin as an endocrine hormone for labour and nursing will need to be revised to include several new physiological roles.

### OVARIAN OXYTOCIN

There are now several independent pieces of evidence suggesting that oxytocin plays a role in controlling ovarian cyclicity in ruminants. 1) It causes premature regression of the corpora lutea on administration to heifers, sheep and goats. 2) It causes the release of prostaglandin F<sub>2α</sub> (PGF<sub>2α</sub>) from the uterus. 3) It is released into the circulation simultaneously with episodes of release of PGF<sub>2α</sub> at the time of luteolysis. 4) Uterine concentrations of the oxytocin receptor rise towards the end of the luteal phase of the estrous cycle, to peak at estrus. 5) Immunization against the peptide delays luteolysis, whether carried out actively or passively. This last piece of evidence is probably the most conclusive, since it implies a role for endogenously secreted, rather than administered, oxytocin. Luteal oxytocin plays an important role in pregnancy establishment in ruminants. Oxytocin is synthesized in and secreted by the corpus luteum, exclusively by the large luteal cells and its concentration in the circulation parallels that of progesterone during the estrous cycle. Since the corpus luteum is a major contributor to circulating oxytocin, and in the light of the ability of PGF<sub>2α</sub> and its analogues to stimulate luteal oxytocin secretion, it appears that oxytocin of luteal (rather than pituitary) origin may principally



be involved in the control of luteal function.

### **PARENTAL BEHAVIOUR**

One of the first attempts to investigate the effects of oxytocin within the Central Nervous System (CNS) tested the hypothesis that oxytocin in the brain would induce maternal behaviour that coordinated with the effects of the hormone on labour and lactation. Several studies have reported that oxytocin given centrally (but not peripherally) to virgin female rats induces full maternal behaviour within minutes. It is important to realise that virgin female rats display little interest in infants and when presented with foster young will either avoid or cannibalise them. Just before parturition (or after specific steroid regimens that mimic the physiological changes of parturition), there is a rapid, dramatic shift in motivation from a lack of interest to a driven, relentless pursuit of nestbuilding, retrieval, licking, grouping and protection of pups. No other peptide or drug has been shown to induce maternal behaviour so quickly in virgin females. However, oxytocin does not act alone. In all the studies demonstrating an induction of maternal behaviour after central oxytocin administration, the response appears dependent on priming with gonadal steroids – no effects of oxytocin are observed in ovariectomized females unless they are treated with oestradiol. The sites at which oxytocin functions to induce maternal behaviour remain incompletely defined, although results from site-specific injections implicate the medial preoptic area, the ventral tegmental area, and the olfactory bulb, paradoxically regions with very low receptor expression.

### **OXYTOCIN INCREASES TRUST IN HUMANS**

Trust is indispensable in friendship, love, families and organizations, and plays a key role in economic exchange and politics. In the absence of trust among trading partners, market transactions break down. In the absence of trust in a country's institutions and leaders, political legitimacy breaks down. Much recent evidence indicates that trust contributes to economic, political and social success. Little is known, however, about the biological basis of trust among humans. Oxytocin shapes the neural circuitry of trust and trust adaptation in humans. Intranasal administration of oxytocin, a neuropeptide that plays a key role in social attachment and affiliation in non-human mammals, causes a substantial increase in trust among humans, thereby greatly increasing the benefits from social interactions. They also showed that the effect of oxytocin on trust was not due to a general increase in the readiness to bear risks. On the contrary, oxytocin specifically affects an individual's willingness to accept social risks arising through interpersonal interactions. These results concur with animal research suggesting an essential role for oxytocin as a biological basis of prosocial approach behaviour.

### **OXYTOCIN AND BONDING**

The hormone oxytocin plays a significant role in many animals' instinct to love and form social bonds. In fact, it has been called jokingly, "the cuddle hormone." Monogamy is usually reasoned to be the result of an attachment that is strong enough to make someone be true to their loved one. Studies have been conducted in prairie voles which provides some evidence that oxytocin may have a

role to play in sexual bonding. Prairie voles are monogamous creatures, so much that eighty percent of the time males refuse to mate with any vole other than their first mate, and both parents tend to their offspring. Oxytocin, in females, and vasopressin, in males are the two chemicals which help prairie voles to be monogamous. These same chemicals are present in montane voles, but do not have the same effect. Oxytocin and vasopressin are released after the prairie voles mate, so that they form an "attachment." Unfortunately, there has been no real data regarding oxytocin levels in humans in relation to the formation of relationships. And there are, of course, some very significant differences between voles and humans. Obviously the vole brain and the human brain are not identical, nor are their mating habits or reasons for forming social attachments. However, studying the biology behind love and social bonding in other animals could help us in understanding our own species.

### **VETERINARY APPLICATIONS**

In veterinary medicine, oxytocin has been used for induction or enhancement of uterine contractions at parturition, treatment of postpartum retained placenta and metritis, mastitis therapy, uterine involution after manual correction of prolapsed uterus in dogs, and in treating agalactia. In dairy practice, exogenous oxytocin is frequently administered to cows before milking to cure disturbed milk ejection caused by reduced oxytocin release.

### **CONCERNS**

In recent years, people have voiced their concern over the rampant use of oxytocin administration in



dairy livestock in some countries for milk letdown. Media reports in India on health concerns to human beings drinking milk from oxytocin administered bovines appear frequently. "Adolescent girls appear to be adult prematurely", "number of cattle is reducing at fast pace and reproduction capacity gets reduced", "such milk lacks sufficient nutritive elements, it lacks natural antibodies due to which resistance of body is reduced", "such milk has blood of animals which is harmful for body" etc. are some of the concerns voiced in the media which are not supported by research findings.

To address people's concerns from the consumer viewpoint of oxytocin administration to lactating bovines, a study was carried out with the objectives of a) to establish an enzyme immunoassay (EIA) method for oxytocin determination in milk and b) quantify oxytocin in milk of cows administered with high doses of oxytocin. A sensitive and specific EIA using the second antibody earlier developed in blood plasma was suitably adapted for oxytocin determination in skim milk of cows and validated according to the criteria of EU-Decision 2002/657/EC. The immunoassay

allowed determination of oxytocin in bovine skim milk in an analytical range of 10 – 250 pg/ml with a decision limit (CC $\alpha$ ) of 30 pg/ml and detection capability (CC $\beta$ ) of 41.5 pg/ml. A total of 19 cows were administered high doses of 25 IU (n=10) or 50 IU (n=9) oxytocin just prior to morning milking. Milk samples collected after oxytocin administration were investigated for the presence of oxytocin in skim milk. There was no significant difference among both groups with the mean concentrations of oxytocin being 23.2 and 20.2 pg/ml for cows subjected to 25 and 50 IU oxytocin respectively which were well below the decision limit of 30 pg/ml (CC $\alpha$ ). The results indicated clearly that the transfer or leakage of oxytocin into milk of cows administered even upto 83  $\mu$ g (equivalent of 50 IU) of oxytocin is minimal. Under normal circumstances, administration of only 0.1 IU of oxytocin are required for milk let-down. Despite administering 250-500 fold higher oxytocin than the recommended dose, the authors recorded lower oxytocin concentrations in milk than the peak oxytocin concentrations observed in blood plasma during normal milk let-down. Calculated

on the basis of oxytocin in total milk the overall quantity is about 240 ng (1 ng =  $1 \times 10^{-9}$  g) in 15 L of milk (average milk yield of the cows recorded after the oxytocin treatment), which amounts to about 0.3- 0.6% of the total injected dose. Oxytocin is rapidly metabolized by oxytocinases in blood, tissues and organs within its short half-life of 3-6 min.

Since the concentrations observed in milk were minimal from oxytocin administered cows, and mostly lower than the physiological peak plasma oxytocin concentrations actually recorded in earlier studies in untreated cows during milk let-down, the milk consumption by humans from oxytocin treated cows (upto 50 IU administration) was quite safe since it was highly unlikely that these minimal amounts of oxytocin will remain intact during enzymatic digestion in the gastrointestinal tract after consumption. However, even if one were to assume that some oxytocin available in milk were somehow absorbed undegraded from the gastro-intestinal tract, the concentrations of oxytocin in the body would still be within physiological limits, and the hormone would be degraded rapidly due to its short systemic half-life.

The importance of the hormone oxytocin has been undermined and downplayed. Apart from its noted roles in milk let down and parturition, its other important roles especially on social interactions are currently under intense investigation. The recent studies on the milk oxytocin concentrations being minimal after oxytocin administrations also showed that milk from cows administered with oxytocin even to the tune of 50IU can be considered safe for human consumption. ♦



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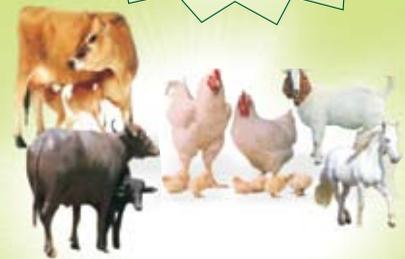
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## A Viable Option for Crop Diversification in Punjab

Livestock has been an integral component of India's agricultural and rural economy since time immemorial, supplying energy for crop production in the form of draught power and organic manure, and in turn deriving their own energy requirements from crop byproducts and residues – straw and stover. The advances in bio-chemical and mechanical technologies have weakened the synergy between livestock and crops. Livestock is now more valued as a source of food and contributed Rs.260300 crores (24.5 per cent) to the India's agricultural gross domestic product of Rs.1062004 crores (2010-11). Livestock sector, in addition to regular income, provides household nutritional security, employment generation and poverty alleviation. The state where the share of livestock in agricultural value of output is higher, rural poverty is low e.g. Punjab-share of livestock is 31 per cent and rural poverty only 5.9 per cent (Basic Animal Husbandry Statistics, Government of India, 2010-11).

Livestock farming, especially dairying, has shown higher profits and acceptability over years, and emerged as a viable alternative to crop agriculture in Punjab, Haryana, Maharashtra and many other states. Average daily milk yield in Punjab vs India was 8.59 kg vs 4.58 kg in buffalo and 10.95 kg vs 6.63 kg in cross bred cows (2010-11). The potential of animals in Punjab is still higher and the yield gap can therefore be exploited through improved feeding and reproductive and breeding technologies. Conservation and improvement of important indigenous breeds viz., Nili Ravi and Sahiwal is another challenge and should be an integral part of breeding policy.

Punjab is the fourth largest producer of milk in the country. With only 2 per cent of India's livestock population, the state produces 9.6 million tonnes of milk annually with a highest



per capita availability of 937 gm/day (2010-11). Up to 1997, the growth in milk production was mainly due to increase in numbers. Since 1997, the bovine population has been declining, mostly the males, un-productive animals and indigenous cattle. Decline in cattle and buffalo population during 2003-07 was 13 per cent and 17 per cent, respectively. Proportion of female: male in 2007 in Punjab was around 76:24 in cattle and 90:10 in buffalo. Apparently, unwanted and low producers are moving out of the production system resulting in higher productivity per unit animal. In spite of the decline in numbers, milk production is going up; it rose from 7.8 million tonnes in 2000-01 to 9.4 million tonnes in 2010-11.

Demand for animal food products is responsive to income changes, and is expected to further increase. For meeting the ever increasing demand for livestock products in the state, a sustained growth rate of excess of 5 per cent annum for milk as against 3.7 per cent at present would be essential. Future growth in livestock sector is going to be technology driven. Livestock sector would require addressing challenges of effective breed improvement, managing high reproductive and productive disorders, improving value and quality of feed and fodder. The high quality semen of Holstein Friesian should be imported as per policy and

needs. Research focus should be on developing new high-yielding and more nutritious fodder varieties. The state has been mapped for mineral status. Corrective steps now need to be taken to address specific mineral deficiencies which significantly affect both reproduction and productivity of livestock. Production of elite buffalo and crossbred cattle males and their evaluation for milk production should receive priority.

There is considerable scope of value addition of milk in the state. The current level of milk handling under organized sector which is 18 per cent can safely be increased to 30 per cent. This would ensure full capacity utilization of 79 existing plants which are utilizing around 60 per cent of their capacity. Dairy by-product utilization is another area which requires due attention not only because of economic loss but it also poses problems of environmental pollution. Among the dairy by-products, whey is one of the important by product. Whey can be used for making flavoured drinks.

Another feature of current production system is that most of milk (more than 30 per cent) procurement

### Trends in Livestock Population in Punjab

Species /Year	1997	2003	2007	Growth over 1997 (per cent)	Growth over 2003 (per cent)
Total Cattle( in lakhs)	26.39	20.39	17.61	-22.74	-13.93
Crossbred (in lakhs)	18.29	15.31	12.58	-16.29	-17.83
Indigenous (in lakhs)	8.10	5.09	5.03	-37.28	-1.18
Ratio of female to male (per cent)	73:27	70:30	76:24	-	-
Buffaloes(in lakhs)	61.71	59.95	50.02	-2.85	-16.56
Ratio of female to male (per cent)	88:12	90:10	90:10	-	-

in the state is in the unorganised sector (local vendors, halwais etc). The predominance of the un-organized sector in milk marketing is a major hindrance to further expansion of the dairy industry. Informal market intermediaries often exploit both the producers and consumers through larger price manipulations. The priority, therefore, should be to bring more and more milk procurement into the organised sector, so that food quality standards are met and appropriate price given to the producers. With globalization of raw material supply, food adulteration is an increasing

threat. Detection of adulterants and pathogens in milk and milk products is critical for ensuring quality - both for consumption and exports. This calls for development of effective sensing technologies.

Although medium and large herds of cattle and buffalo have come up for commercial milk production in the state, about 70 per cent of milk is still produced by small farmers. A project entitled "Economics of milk production and its regular monitoring in Punjab" undertaken by GADVASU revealed that small dairy farms with herd size of less than 5 animals have poor viability and that profitability increased with the increase in herd size.

Especially on small farms, comparatively low milk yields, high reproductive disorders, poor marketing network and poor availability of inputs and resources are responsible for higher cost of production, per litre of milk. Small dairy farmers are utilizing family labour on their farms. The dairy farm profits are directly linked to input costs and sale price of milk. Unfortunately, dairy farm profitability of all categories of farm sizes has declined mainly due to the higher cost of feed and fodder, and

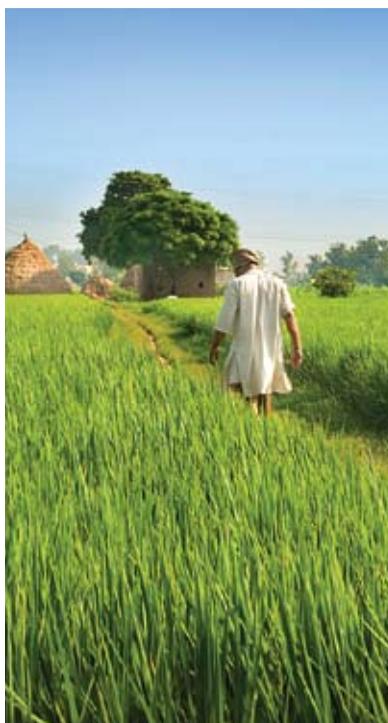


### Economics of Milk Production in Punjab State in 2011-2012

Particulars	Small (5)	Medium (10)	Large (20)
<b>CATTLE</b>			
Average milk yield/ animal in milk(kgs)	9.6	11.9	13.4
Average annual milk production/ animal (kgs)	3523.7	4358.5	4907.6
Sale price (Rs/litre)	19.8	21.1	21.7
Cost of milk production/ litre	18.0	14.3	13.8
Profit (Rs/year/animal)	6378	29638	38770
<b>BUFFALO</b>			
Average milk yield/ animal in milk(kgs)	7.5	8.3	9.2
Annual milk production/ animal (kgs)	2743.0	3031.6	3360.5
Sale price (Rs/litre)	27.9	28.4	29.0
Cost of milk production /litre	22.8	20.9	20.4
Profit (Rs/year/animal)	13989	22737	28900

labour. Cost of milk production has increased by about 25 per cent. Cost of green fodder per milch animal has increased by about 34 per cent, concentrates by 53 per cent and labour by 38-50 per cent during 2010-2012. In the current scenario of higher cost of feed and labour inputs, small sized dairy farms are the worst affected. Such categories of farmers must be protected. As input costs vary across seasons and between years, the price of milk should be linked to the cost of inputs in the market and the quality of milk. Suitable incentives should be given for quality milk so as to encourage the farmers to produce clean milk. Government should come up with new policies and subsidies for small dairy farm enterprises so as to make such units viable and sustainable. We need quality feed at affordable prices to raise the milk yield.

Most veterinary services except AI, are at fixed places. It has been observed that dairy farmers are reluctant to bring their animals to veterinary clinics for treatment. Present situation demands that veterinary services should be provided at the



farmers door step. A large component of mobile veterinary clinics should be introduced for doorstep delivery of veterinary services with a provision of at least one mobile clinical van in each of the 145 blocks in the state. Such a mechanism shall help in improving animal health and reproductive status, thus enhancing

the productivity of animals.

Existing production system of dairy farming, which is being dominated by small sized dairy farmers, requires a robust extension system. Extension education plays a pivotal role in the dissemination of knowledge and technologies to the farmers. Animal Husbandry extension network, in general, is poor and is lagging behind agricultural extension. There is a need to evolve appropriate models for the delivery and demonstration of technologies for enhancing livestock productivity and profitability. Animal husbandry research, especially in dairy production and processing, needs greater attention. Although dairying contributes significantly to state's GDP (31 per cent), unfortunately less than one per cent of state GDP is being spent on Animal Husbandry and Dairy research. Strengthening infrastructure for research, extension and developmental should receive larger funds.

Livestock development should get priority in all the planned budget schemes of the government. Unfortunately, the allocation to Animal Husbandry and Dairying sector as percentage of total agriculture outlay in Punjab declined from 40 per cent in 2007-08 to 16 per cent in 2011-2012. It has further been reduced to 10.35 per cent in 2013-14. In spite of the huge potential of livestock sector for providing gainful employment to the farmers of the state, such an allocation is very low against the requirement. The above analysis calls for revisiting and restructuring existing system of investments and subsidies. The government cannot any more afford to neglect livestock sector, especially dairy farming, for sustainable and inclusive growth of the state. ♦

*Major Initiative*



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## IARI Led Basmati Revolution

**B**asmati rice from the Indian subcontinent attracts premium price in the international market for its unique quality. It is primarily grown in Indo-Gangetic region of north-western India, involving seven states namely Punjab, Haryana, Himachal Pradesh, Uttarakhand, Jammu and Kathua districts from Jammu and Kashmir and 27 districts of western Uttar Pradesh. The traditional Basmati cultivars are tall, prone to lodging, photo-thermo and temperature sensitive and very low yielding. Therefore, production and productivity were limited. Basmati rice did not acquire a status of a commercial enterprise till IARI took the lead to improve the plant type through research spanning five decades since the 1960s. The genetic improvement of Basmati rice carried out at the institute has reduced the duration from 160 days to 115-140 days, and enhanced its average productivity from 2- 2.5 tons/ha to more than 5 tons/ha in the improved dwarf varieties as compared to Traditional Basmati varieties. This has resulted in a significant savings of irrigation water as well as improvement in country's forex earnings from Rs.276 crores (1990-91) to Rs.19,391 crores (2012-13). The contribution of IARI varieties, particularly Pusa Basmati 1121 and Pusa Basmati 1 in this endeavor, is approximately 75per cent (~Rs.14,500 crores).

The traditional Basmati rice varieties though had excellent grain and cooking quality traits, they suffered from several undesirable traits such as, tall plant height, temperature and photoperiod sensitiveness, longer duration, lodging and low yielding ability. In the early 1920s, the Basmati rice from Dehradun valley became popular in the trade circles as Dehradun Basmati. The first systematic programme for Basmati rice research and improvement started at Rice Research Station, Kala Shah Kaku (part of erstwhile united India and now in Punjab province of Pakistan). A large collection of Basmati rice cultivars from tarai region were evaluated extensively, and one of them was released as Basmati 370 for cultivation in 1933. In trade circles, it was known as Dehradun / Amritsari Basmati.

In order to combine the quality attributes of traditional Basmati rice varieties in the high yielding background, a systematic breeding programme on genetic improvement of Basmati rice was initiated at the Indian Agricultural Research Institute (IARI), New Delhi in 1966 under the leadership of Dr. M. S. Swaminathan. Pioneering research work was carried out at Indian Agricultural Research Institute, New Delhi during seventies on standardization of protocols for estimating various Basmati quality parameters such as



*A traditional tall Basmati rice cultivar prone to lodging due to its weak stem*



*Pusa Basmati 1, the world's first semi-dwarf, photo-period insensitive high yielding Basmati rice variety developed and released for commercial cultivation by IARI in 1989*

aroma, grain length and cooked kernel length and their nature of inheritance.

#### **DEVELOPMENT OF HIGH YIELDING NON-LODGING SEMI-DWARF BASMATI RICE VARIETIES**

A harmonious combination of traits that provides commercial uniqueness to Basmati rice viz., desirable kernel dimension, appealing aroma, high linear kernel elongation with minimum breadth wise swelling on cooking, fluffiness, palatability, easy digestibility and longer shelf-life were strictly instilled into the breeding objectives in the Basmati rice improvement programme.

The first breakthrough in Basmati rice breeding came in 1989 with the release of Pusa Basmati 1, the world's first semi-dwarf, photoperiod insensitive and high yielding Basmati rice variety developed from the cross between Pusa 150 and Karnal Local. Extra-long slender aromatic grains, less cooking time and higher linear cooked kernel elongation of freshly harvested rice coupled with potential grain yield of 6-7 tonnes/

ha and medium early duration (135-140 days seed to seed maturity) made Pusa Basmati 1, the most sought after variety by the farmers, exporters and consumers. The release of Pusa Basmati 1 has revolutionized the Basmati rice production in the country.

During the period of 1995-2007, this variety contributed nearly 60 per cent of the total Basmati rice export value (Rs. 24,031/-), which approximately comes to nearly Rs.14,000 crores of foreign exchange earnings, and brought

prosperity to Basmati rice farmers of Punjab, Haryana, western UP and Uttarakhand. Pusa Basmati 1 has been extensively used as a donor for Basmati quality traits and high yield in the breeding programme, nationally and internationally.

#### **PUSA BASMATI 1121 - THE BASMATI RICE VARIETY WITH GRAIN QUALITY PAR EXCELLENCE**

Pusa Basmati 1121 developed by intercrossing the sister lines of Pusa Basmati 1, was released in Delhi as Pusa 1121 (Pusa Sugandh 4) in 2003 and subsequently re-notified as Pusa Basmati 1121 under the Seed Act 1966 in the year 2008. This variety combines unique Basmati quality characters possessing extra-long slender (7.71 mm), highly aromatic grains with 52.9 per cent head rice recovery and very occasionally chalky grains. It has longest kernel length after cooking (up to 22 mm) with an exceptionally high cooked kernel elongation ratio of 2.5, volume expansion more than four times, intermediate amylose content, appealing taste, good mouth feel and easy digestibility.

Higher profitability from Pusa



*Pusa Basmati 1121 – A variety with grain and cooking quality par excellence*



*Empowered to fight blight: Shri Pritam Singh, a farmer from village Urlana, Panipat, Haryana amidst the bumper crop of "Improved Pusa Basmati 1"*

Basmati 1121 resulted in major shift in cultivation of Basmati rice towards this variety. According to the estimates provided by the President, All India Rice Exporters' Association (AIREA), nearly 50-60 per cent of 1.5 million ha under Basmati rice has been planted with Pusa Basmati 1121. Since, its release in 2003, the area under Pusa Basmati 1121 has been increasing rapidly. Encouraged with the response in the international market, the traders and millers in India were able to pay good price for Pusa Basmati 1121 to farmers. During Kharif 2008, the average yield of Pusa Basmati 1121 on farmers' field was recorded as 4.5 tonnes /ha, and the average paddy price of this variety in the various Mandis was between Rs.2500-3500/q during peak season, bringing the average gross return of Rs.1,35,000/ha to farmers as against Rs. 75,000/ha from cultivation of

Taraori Basmati and Rs.1,20,000/ ha from Pusa Basmati 1 or Improved Pusa Basmati 1.

Farmer with 10 hectares of land could, with one season of crop, make as much as Rs.12.5 to Rs.17.5 lakhs. This variety requires low inputs with cost of cultivation being less than Rs.10,000 per hectare. It is best suited for organic farming.

#### **IMPROVED PUSA BASMATI 1 (PUSA 1460) - A PRODUCT OF MOLECULAR BREEDING**

The productivity of Pusa Basmati 1, the most widely cultivated Basmati rice variety for over a decade, has suffered badly in the past due to its susceptibility to bacterial blight (BB). This variety was improved for resistance to BB through marker assisted foreground selection for BB resistance -xa13 and Xa21, and background selection using microsatellite markers for hastening

the recovery of recurrent parent genome, while compressing the breeding cycle. The improved version of Pusa Basmati 1 with resistance to BB was released as Improved Pusa Basmati 1 (Pusa 1460) by the CVRC during April 2007. This variety had sturdy stem, non-shattering habit and thus ideal for mechanical harvesting. The average yield of Improved Pusa Basmati 1 on farmers' field has been 55 q/ha with market paddy price of Rs.2200/q, giving gross returns of Rs.1,21,000/ha. This variety has strong aroma and less than 5 per cent chalky grains.

#### **PUSA BASMATI 6 (PUSA 1401) - AN IMPROVEMENT OVER PUSA BASMATI 1121**

Pusa Basmati 6 (Pusa 1401) is an improved Basmati rice variety with better yielding ability, agronomy and cooking quality. The variety was released recently in August 2008

**Grain and cooking quality characteristics of evolved Basmati/aromatic rice varieties compared to national checks Pusa Basmati 1 and Taraori Basmati**

Variety	Milling per cent	HRR per cent	KLBC (mm)	KBBC (mm)	KLAC (mm)	ER
Taraori Basmati	67.80	54.20	6.94	1.80	13.97	1.97
Pusa Basmati 1	68.90	58.50	7.38	1.80	14.30	1.93
Pusa Basmati 1121	64.40	53.80	7.66	1.94	17.37	2.26
Improved Pusa Basmati 1	66.71	46.46	7.40	1.79	13.73	1.84
Pusa Basmati 6	66.70	57.30	7.31	1.73	16.07	2.19
Pusa Punjab Basmati 1509	68.10	49.50	8.19	1.86	18.20	2.22

HRR-Head rice recovery, KLBC-Kernel length before cooking, KBBC - Kernel breadth before cooking, KLAC-Kernel length after cooking, ER-Elongation ratio

and notified in November 2008. It has semi-dwarf plant stature and is tolerant to lodging. This variety has been developed from the cross of Pusa Basmati 1 with Pusa 1121. In terms of grain and cooking quality traits, its grain on cooking have uniform shape compared to tapering end in Pusa 1121. It has strong aroma and chalky grains less than 4 per cent. Currently, incorporation of genes for resistance to BB, blast and BPH in Pusa 1121 and Pusa 1401 is in progress, which will help in stabilizing their yields, and thus the profitability to farmers in years to come.

**PUSA PUNJAB BASMATI 1509 - ACLIMATE SMART BASMATI RICE VARIETY**

Pusa Punjab Basmati 1509 developed at Indian Agricultural Research

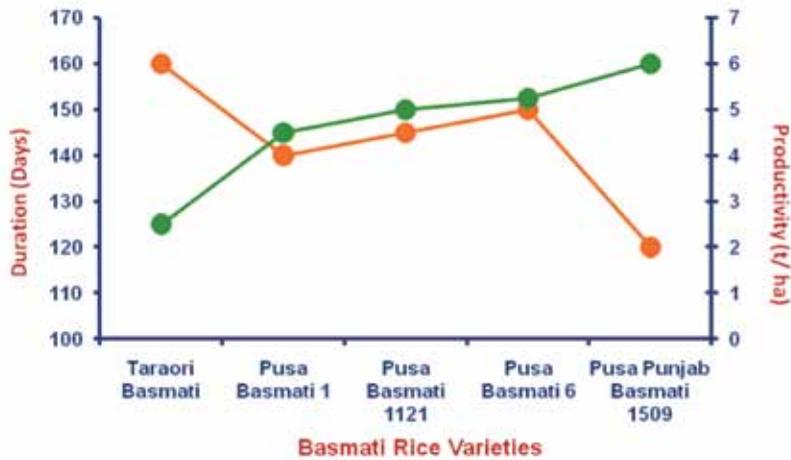
Institute, New Delhi, is a semi-dwarf early maturing Basmati rice variety, which has been released for the state of Punjab on the recommendation of Punjab Agricultural University, Ludhiana. In Punjab state, there is a growing concern of reducing water table due to pumping of underground water for puddling operations before transplanting and frequent irrigation of rice crop. A sizeable area of Punjab is under Basmati rice and is a steady income earner for farmers of the area. If Basmati rice cultivation is not taken up, there is no obvious alternative crop with similar economic returns. Therefore, it is necessary to produce Basmati rice variety that would facilitate less use of water, make best use of rain water during the crop

growth. In addition, there is another concern of burning of paddy straw after harvest by farmers to dispose the residue which is considered as a major pollution causing element leading to wide-spread smog and fog during winters. Most Basmati varieties also have a tendency to lodge and therefore, cannot withstand high fertilizer nitrogen dosage which results in reduced productivity. The farmers in Punjab have been known for their penchant towards using high inputs without hesitation, which however has not been effective in Basmati due to their lodging as evidenced in the case of variety, Pusa Basmati 1121. The Basmati rice breeding group of IARI has been able to successfully accomplish this feat that has led to the development of the variety Pusa Punjab Basmati 1509.

IARI has been instrumental in genetic improvement of Basmati rice leading to release of Pusa Basmati 1, the first semi-dwarf, photo insensitive, high yielding Basmati rice variety in 1989. Since then, IARI has released several popular Basmati rice varieties such as Pusa Basmati 1121, Improved Pusa Basmati 1, Pusa Basmati 6 and Pusa Punjab Basmati 1509 which has been in great demand among the farmers in the Basmati growing states of India. At



Field view of the Basmati rice variety Pusa Punjab Basmati 1509



*Combining high yield with short duration in Basmati Rice through Genetic Improvement at IARI*

present, based on the breeders seed indent of the Basmati rice varieties across the Basmati growing regions of India, the improved high yielding Basmati varieties developed at IARI covers around 75per cent of the total breeder seed indent for Basmati rice and accordingly the proportionate area under Basmati rice cultivation. The breeder seed indent for Basmati rice, varieties released by IARI during the last five years (2006 - 2011) is

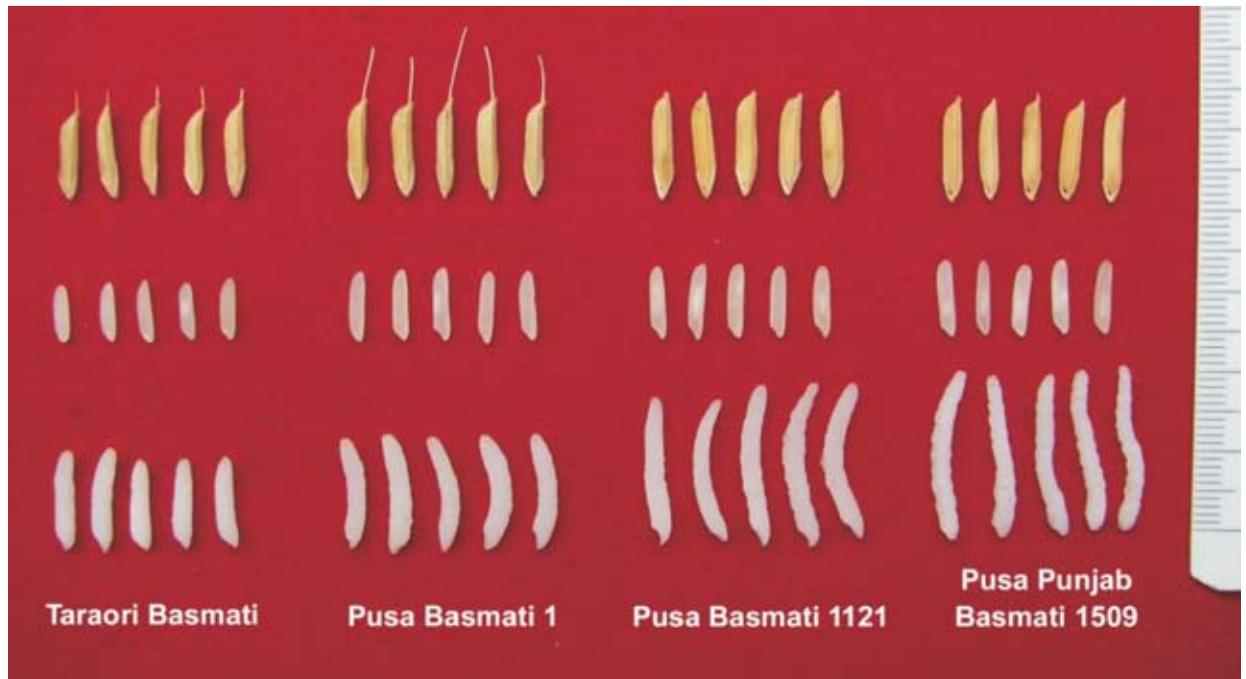
1071 quintals as against 106 quintals for other Basmati rice varieties.

### HIGH YIELDING BASMATI VARIETIES AND FOREX EARNING

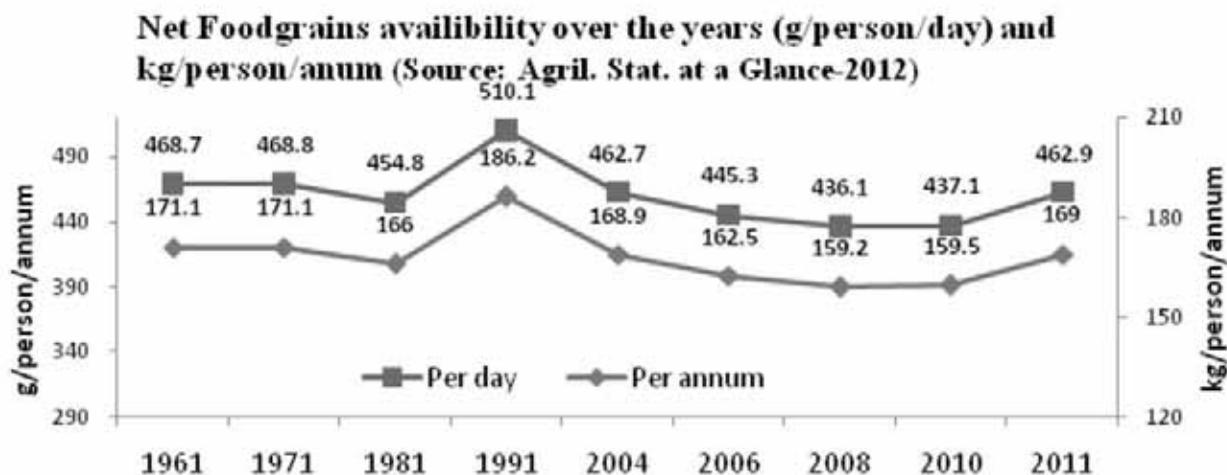
Genetic improvement of Basmati rice at Indian Agricultural Research Institute, New Delhi has not only improved the yield but also led to quantum jump in forex earnings through export of Basmati rice. Pusa Basmati 1 released by IARI,

New Delhi in 1989 became very popular among the farmers in the Basmati growing states of India, and it covered around 75per cent of the total Basmati rice area within five years of its release due its wide spread adoption by the farmers. When the higher productivity of Basmati rice was complemented by the rice mills with superior processing technology, the foreign exchange earnings from export of Basmati rice saw a phenomenal rise from Rs. 294 crores in 1990-91 to Rs. 850 crores in 1995-96.

The release of Pusa Basmati 1121, the improved Basmati rice variety possessing the longest cooked kernel length, created a revolution in Basmati rice improvement due to the hitherto unparalleled improvement in grain quality. This variety became very popular among the farmers in the Basmati growing states of India and is very popular both with the Basmati rice farming community as well as exporters. Because of its



*Improvement in milled rice length and kernel length after cooking in Basmati rice varieties released by IARI*



*Foreign exchange earnings through the export of Basmati rice from India for the past two decades*

superior grain and cooking quality attributes, the wide spread adoption of this variety by the farmers and high demand among the consumers has resulted in quantum jump in the earnings from export of Basmati rice from Rs.2,792 crores in 2006-07 to Rs.19,391 crores in 2012-13.

### PERSPECTIVES AND FUTURE PROSPECTS

Overall, the Basmati rice research work carried out at IARI has resulted in reduction in crop duration from 160 days in Traditional Basmati to 115-135 days, coupled with tripling the production from 2.5 tonnes/ha to 6-8 tonnes/ha resulting in nearly 80 per cent higher per day productivity and saving of inputs like fertilizer, irrigation and pesticides, thus bringing down the cost of cultivation.

Basmati rice varieties in general are susceptible to several biotic stresses such as bacterial blight (BB) caused by *Xanthomonas oryzae* pv. *oryzae*, blast caused by *Magnaporthea oryzae* and Brown Plant Hopper (BPH) infection by *Nilaparvata lugens*, reducing yield and quality of rice. The most effective and environ-

mentally friendly management strategy of combating these stresses is exploitation of host plant resistance. A huge number of genes governing resistance to bacterial blight, blast, BPH and QTLs for sheath blight have been identified, mapped to specific chromosomal location, and tightly linked molecular markers have been developed. However, all these genes are available in non-Basmati sources, and their transfer to Basmati background impairs the grain and cooking quality traits of Basmati rice varieties. Under such situations, marker assisted backcross breeding (MABB) offers a great opportunity for transferring desirable genes from unadapted donors to otherwise, agronomically superior cultivars having specific weakness. The complete sequencing of rice genome, genetic and molecular characterization of complex nature of Basmati quality, identification of molecular markers linked to traits like aroma, grain shape, elongation ratio and amylose content etc., and genes for resistance to biotic stresses, namely, bacterial blight, blast, brown plant hopper and sheath blight has opened al-

together new dimension in Basmati rice breeding. With the availability of molecular markers and saturated molecular genetic map of rice, MAS has now become feasible both for traits controlled by major genes as well as QTLs. With a view to develop Basmati rice cultivars with resistance to BB, Blast, BPH, Sheath blight and salt tolerance, number of resistance genes/ QTLs are being incorporated into the Basmati varieties using novel molecular breeding approaches. It is expected that in years to come, it should be possible to have designer Basmati rice variety, superior to traditional Basmati with still higher yield and inbuilt resistance to insect-pest and diseases.

The breakthrough in the genetic improvement of Basmati rice achieved at IARI has brought prosperity to the Indian farmers, accessibility of premium quality Basmati to consumers at an affordable price and has enabled the country to earn forex to the tune of ~US\$ 3.5 billion (Rs.19,391/- crores) during 2012-13, which can be appropriately described as Basmati Revolution. ♦

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# AGMARKNET

## In the Service of Farmers

**A**gricultural Marketing Information Network (AGMARKNET) was launched in March 2000 by the Union Ministry of Agriculture. The Directorate of Marketing and Inspection (DMI), under the Ministry, linked around 7,000 agricultural wholesale markets in India with the State Agricultural Marketing Boards and Directorates for effective information exchange. This e-governance portal AGMARKNET, implemented by National Informatics Centre (NIC), facilitates generation and transmission of prices, commodity arrival information from agricultural produce markets, and web-based dissemination to producers, consumers, traders, and policy makers, transparently and quickly.

Directorate of Marketing and Inspection (DMI) maintains liaison with the State Agricultural Marketing Boards and Directorates for Agricultural Marketing Development in the country. Agricultural Produce Market Committee (APMC) displays the prices prevailing in the market on the notice boards, and broadcasts this information through All India Radio and other media. This information is also supplied to state and central government from important markets. The statistics of arrival, sales, prices etc., are generally maintained by APMCs.

It facilitates web-based information flow, of the daily arrivals and prices of commodities in the agricultural produce markets spread across the country. The data transmitted from all the markets is available on the AGMARKNET portal in eight regional languages and English. It displays commodity-wise, variety-wise

daily prices and arrivals information from all wholesale markets. Various types of reports can be viewed including trend reports for prices and arrivals for important commodities. The AGMARKNET portal now has a database of about 300 commodities and 2,000 varieties.

### **NICNET BASED AGRICULTURAL MARKETING INFORMATION NETWORK (AGMARKNET)**

While the revamping of the agricultural marketing system in the country is ongoing, the need for establishing a sound agricultural marketing information system in the country has been strongly felt. Such a system will ensure proper utilization of the emerging trade opportunities by the farming community. Market information is needed by farmers in planning production and marketing. Other market participants also need it for taking appropriate trade decisions. Almost all the states and union territories have their own system of providing market information to the users. However, mostly the prevailing systems of dissemination of market information are based on conventional methods, due to which the communication of information to the target groups usually gets delayed, thereby losing its relevance. Keeping in view the time sensitiveness of market information, it is important that gap between generation and dissemination of information is minimized. Information and Communication Technology (ICT) can play a vital role in bridging this gap. Appropriate use of ICT will strengthen the interface between government and the farming community, by providing a channel for reaping the benefits accruing from the reforms



process.

In order to improve the present market information system, Directorate of Marketing and Inspection (DMI), Ministry of Agriculture has formulated a central sector scheme (Agricultural Research and Marketing Information Network) for linking all regulated markets (approximately 7000) spread all over the country, State Agriculture Marketing Boards/ Directorates and DMI headquarters by providing computing facilities and internet services through NIC-NET in a phased manner. The project AGMARKNET has been entrusted to National Informatics Centre, Department of Information Technology and Government of India, for implementation on turnkey basis.

#### OBJECTIVES OF AGMARKNET

The objectives of the system are to:

- Establish a nationwide market information network for speedy collection and dissemination of market information and data for its efficient and timely utilization.
- Facilitate collection and dissemination of information related to better price realization by the farmers.
- Sensitize and orient farmers to respond to new challenges in agricultural marketing by using IT as a vehicle of extension.
- Improve efficiency in agricultural marketing through regular training and extension for reaching the region specific farmers in their own language.
- Provide assistance for marketing research to generate marketing information for its dissemination to farmers and other marketing functionaries at grassroots level to create an ambience of good marketing prices in the country. AGMARKNET, the Internet based

information system, aims at providing 'single window' service, catering to diversified demands of information. It will facilitate information sharing and development of data infrastructure for enterprises, industry, farmers, policy makers, academic organizations, government agencies, etc. With development of information and data, infrastructure market places will perform role of information service providers. It will encourage information exchange and dissemination for the benefit of farmers and other market participants as well. Online marketing information service will connect distant markets and promote efficient marketing in near future.

#### AGMARKNET PROJECT COMPONENTS

The broad project components identified for achieving the objectives were:

- Computing Facilities and Networking
- Development of Human Resource
- Information Transmission
- Database Development
- Portal on Market Information

#### Establishment of computer and communication:

It was decided to provide minimum essential computing facilities to each market in order to cover maximum number of markets within the limited budget. Each market needs to be connected to NICNET (the e-governance network of Government of India) through dial-up to facilitate data transmission and browsing.

#### Application and database development:

Conventionally, the markets maintain information in the form of registers. It was, therefore, required to develop application software to facilitate creation of database at local (market) level and

generation of various reports in local language.

**Portal on market information:** It was decided to develop a portal to facilitate dissemination of commodity-wise daily prices and arrivals information, received from various markets on daily basis. Eventually, all agricultural marketing related information has to be made available through the portal and it has to serve as a single window to facilitate market led extension.

#### Development of human resource:

Under the project, necessary computer training was required to be organized for all the identified markets. One person from each market was to be trained on using application software, internet and e-mail, besides basic computer operations.

#### Constraints and remedial measures:

The constraints/difficulties faced and the remedial measures, taken from time to time, while implementing this project were:

**System integration** - Keeping into view the complexities involved in system integration while dealing with different vendors, it seemed logical to go for a single vendor solution. Therefore, the number of vendors involved was minimized to the extent possible.

**Bandwidth and ISPs** - Many of the markets are located at below district level where, in general, the communication system in the country is not reliable enough to enable implementation of web based data entry applications over dial-up lines. In fact, after discussions with major Internet Service Providers in India, it emerged that there is no single ISP who could provide internet service to all the markets covered under the project. A flexible approach was adopted i.e., wherever it was not feasible to provide connectivity through

NICNET, markets were suggested to obtain connectivity through any local ISP. In case of non-availability of ISP, arrangements were made for markets to prepare data and use internet facilities at the nearest NIC-District Centre for data transmission and information access.

**Unfamiliarity with computers** - Computers were being introduced for the first time in most of the markets, and as such the officers were supposed to be unfamiliar with computer. There was an initial apprehension as to whether the markets would be able to use the computers effectively and justify the investment made in the networking programme.

**Local languages support** - Farmers and other functionaries in the markets are usually familiar with local language only. It was therefore required that the application software has the necessary local language interfaces for data entry and report generation. Therefore, market level software (AGMARK) was integrated with multilingual fonts.

**Onsite support** - Due to lack of prior experience with computers, the market personnel would initially require onsite support. It is therefore important to have arrangements for onsite support on need basis, to ensure sustainability of the computerization program.

**Reliability of Reported Data** - The data reported by a market would be in public domain and accessible all over the world through World Wide Web. The reported data has, therefore, to be monitored regularly for accuracy to avoid wrong decisions by the users of information. Therefore, before publishing on WWW, the daily data received from various markets are hosted on intranet of DMI. The prices and deviations in (Max, Min) range are examined. Doubtful



information, if any, is segregated and published only after cross verification with such markets.

#### **ADMINISTRATIVE**

**Autonomous nature of markets** - The agriculture produce markets are autonomous bodies under respective State Marketing Boards/Directorates. The central project sponsoring authority i.e., DMI, has no control over the markets. Due to autonomous nature of markets, DMI cannot make it mandatory for markets to report data on daily basis. The success of the project however, depends on the number of markets who regularly report reliable market data for sharing with others.

**Manpower** - The project has to be managed with the existing staff. No additional posts can be created for this project in line with the government directive banning fresh recruitment. The work assignments of the staff members have been/are being redefined to generate manpower resources for the new project.

**Financial** - The number of wholesale markets being large (~ 7000), only basic minimum computing infrastructure has to be created at each market. The project has to be executed in a phased manner keeping into view the budgetary constraints. It has also to

be ensured that adequate numbers of important markets of all the states are recovered in the project.

#### **ROLE OF AGMARKNET IN AGRICULTURE**

AGMARKNET is also expected to play a crucial role in enabling e-commerce in agricultural marketing. The portal has helped to reach farmers who do not have sufficient resources to get adequate market information.

#### **MARKETING INFORMATION**

Agricultural marketing information comprises of collection, analysis, compilation and dissemination of agricultural marketing related information to the farmers for modern market oriented farming by improving the quality and productivity of the produce. To improve this entire system, Government of India, started 'Market Research and Information Network' (MRIN) Scheme through the Directorate of Marketing and Inspection (DMI) and its website i.e., [www.agmarknet.nic.in](http://www.agmarknet.nic.in).

#### **MARKETING EXTENSION**

Marketing extension is a tool to educate and grow awareness among the farmers and other beneficiaries, regarding the modern postharvest measures of agro-commodities for their efficient marketability. Importantly, it has helped reduce

distress sale.

### IMPACT OF AGMARKNET

The portal is being extensively used by various stakeholders. The market committees, by contributing daily information, are gradually getting transformed as change agents for the Market Reforms Process initiated by the Ministry of Agriculture.

AGMARKNET has also generated interest among various organizations in the public and private sector for helping the farming community. Agriwatch newspaper is using daily prices and arrivals information from the portal and publishing it in Hindi and English. Indian Farmers Fertilizers Cooperative Ltd. (IFFCO), a multistate co-operative society is in the process of installing 500 multimedia kiosks at their service centers in rural areas (12 have already been installed) with AGMARKNET interface. Procedures are also being worked out to have interface with mobile phones for widening the reach. Major mobile phone operators have already approached NIC.

### PROJECT COORDINATION AND MONITORING FRAMEWORK

For proper coordination of the implementation of the system and receipt of feedback for corrections, improvements etc. a committee has been constituted at state level comprising of officers from State Marketing Departments/Boards, State National Informatics Centre and Directorate of Marketing and Inspection. The committee meets every month to review the progress and remove the operating difficulties. Implementation committee consisting of Agricultural Marketing Adviser and Joint Secretary (Agricultural Marketing) to the Government of India, Dy. Director General NIC, National Project Direc-

tor NIC, and Nodal Officer, Marketing Research and Information Network in the Head Office of the DMI is responsible for operation, management and coordination of the project.

### FUTURE PERSPECTIVE: USING ICT FOR MARKET LED EXTENSION THROUGH AGMARKNET

AGMARKNET is considered as a flagship project of the Government of India and efforts are afoot to make it of real use/service to the farmers. Further strengthening of AGMARKNET requires:

- Developing a network based farmers advisory system on agricultural marketing
- Developing a decision support system for planners and decision makers
- Conducting regular market studies to assess information needs of different target groups.

### FARMERS ADVISORY SYSTEM ON AGRICULTURAL MARKETING

In the liberalised trade environments, there are several aspects with which the farmer needs to be familiarized with regularly, to enable him to plan his production for best returns. This is possible only through constant market research and making their findings available to farmers in the form of an advisory service. The farmers advisory system will help the farmers in adopting good marketing practices. It will help him in taking decisions such as - which commodities to produce; how much to produce; how much to sell and at what price, etc.

### ADVANTAGES TO THE FARMERS:

- The AGMARKNET website (<http://www.agmarknet.nic.in>) is a G2C e-governance portal that caters to

the needs of various stakeholders such as farmers, industry, policy makers and academic institutions by providing agricultural marketing related information from a single window.

- The portal has helped to reach farmers who do not have sufficient resources to get adequate market information. By giving farmers their right to information, it has acted as a base for production planning, and provided a base for market-led extension.
- Client-server architecture was implemented using technologies like messaging queues and the Biz Talk Server, to overcome the problem of poor connectivity in rural areas. In addition, AGMARKNET has now been integrated with 100 IT kiosks installed by IFFCO in rural areas.
- AGMARKNET data is also published in agricultural newspapers, and disseminated through Doordarshan's television channels. To keep track of the performance of the large number of markets in the network, a performance monitoring system has been implemented.

### DISADVANTAGES

- The small and medium farmers are always lacking resources.
- The central and state government departments will have reservoir of databases. And it will also bring farmers, researchers, scientists and administrators together, by establishing 'Agriculture Online' through exchange of ideas and information.

### HIGHLIGHTS OF FEEDBACK/KEY LEARNING

- The agricultural marketing relat-

ed information being disseminated through the portal service was found to be useful by participants belonging to different organizations, individual farmers etc., apart from the officials of markets and State Marketing Boards/Directorates. However, it was generally felt that the data reported on the portal has to be reliable.

- The portal service needs to be made available in local languages for better absorption.
- Punjab Mandi Board has implemented the concept of extending regular project related support to the markets through a core team of trained officials. The best performing market personnel in terms of data reporting are formally rewarded in an annual function.
- Agricultural co-operatives are willing to become part of the project, as has specifically emerged in the workshops held in Assam.
- One of the reasons of irregular reporting by certain markets that emerged was non-availability of staff to collect and report prices and arrivals, as in the case of Manipur. There is lack of organized markets in Manipur due to which a considerable amount of horticulture produce is spoiled every year.
- Certain markets in remote areas are not able to send data due to lack of internet connectivity. They were advised to prepare data in offline mode and transmit it as e-mail attachment through nearest cyber-café/ NIC district unit.
- It was generally observed that there is lack of awareness about the project among other related

organizations. As such other extension/service delivery schemes/programmes at state level may not be drawing benefits from this project.

#### **SYNTHESIZED RECOMMENDATIONS**

- There is need to build institutional linkages among related organizations at state level such as the Department of Information Technology, Department of Agriculture/Horticulture, Krishi Vigyan Kendra, Agricultural Co-operatives, Agricultural extension units, etc. Besides ensuring wider dissemination of market information, this will facilitate launching of online help desk to address farmers' queries.
- The participants felt the need for conducting such workshops regularly at state as well as district and panchayat levels. In particular, the Punjab Mandi Board has proposed for, and shall be supporting by providing mobile vans for spreading awareness at Panchayats level.
- The core team concept as introduced by Punjab Mandi Board may be considered for replication by other State Marketing Boards/Directorates.
- The online performance monitoring facilities provided on the portal need be extensively used by the State Marketing Boards/Directorates and DMI field officials.
- The state level monthly review meetings among Marketing Boards/Directorates, DMI and NIC need to be revived for ensuring smooth operationalization of the project which include resolving hardware, software and connectivity related issues, reporting of reliable data, up-dating of

market profiles (particularly with respect to e-mail, phone no. facilities available, approach, etc.), incentives to market personnel, replacement of obsolete systems, etc.

- Market information need to be disseminated through different channels such as SMS and 24x7 regional TV channels.
- Markets which report quality data throughout the year may be considered for national level award by the DMI.
- Prices of machinery/tools, inputs like seeds, pesticides, and fertilizers need also to be provided through this portal service.
- The fruits and vegetables surplus states, like Jharkhand, have felt the need for extending these products also under MSP scheme.
- The portal should separately provide prices of organic products. It is also required to publish information about surplus produce in different parts of the country.
- Interactive platform for buyers and sellers need to be introduced as further enhancement of the service. The portal should facilitate 'e-Trade' at national as well as international level by integrating with appropriate storage and transportation linkages.
- States may submit proposals to the DMI for connecting all the marketing yards/sub yards which have not yet been covered under AGMARKNET.
- The 'Uzhavar Santhai' (Farmer's Market) experiment at Sivaganga (Tamil Nadu) by the Corporation Bank may be considered for replication across the country for connecting rural haats/ Bazaars with AGMARKNET. ♦



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## Enhancing Smallholder Farmer Participation in Markets: The IMOD Way

### AGRICULTURAL DEVELOPMENT: THE LONG VIEW

The CGIAR was established in the early 1970s at a time when mass famines were thought to be inevitable in the developing world. Food production was short of the needs of rapidly increasing populations. So, increasing the production of staple food crops, particularly cereals, was the CGIAR's urgent first priority.

That effort helped to fulfill the promise of the Green Revolution in rice and wheat, which had begun a few years earlier. Production gains were so rapid that famine was averted. This was an enormous achievement!

Yet, while the yields of those crops more than doubled, hundreds of millions of people still remained hungry and malnourished, particularly those living in marginal farming areas such as the drylands. The Green Revolution varieties were not well suited to the dry areas, because irrigation and fertilizers were not easily available.

Then, the 1990s brought major economic upheaval to the developing world through 'structural adjustment' and economic liberalization. Agriculture slipped to a lower priority on national agendas. Industrial and urban development became higher priorities. Many agricultural support programs and institutions were downsized or dismantled.

Marketing was deregulated, so more opportunities were opened to the private sector

which was less interested in poor smallholders and preferred sourcing its raw materials from big commercial growers to minimize costs and maximize profits.

All these changes hit the poor hard. Smallholder farming families lost many of their supporting institutions and services. Costs of inputs soared with the removal of subsidies. Meanwhile, the prices of crops fluctuated wildly due to market deregulation and their lack of power in the marketplace.

As poor smallholders were increasingly "on their own", economists realized that they were hungry not only because they were not growing enough food, but because they couldn't afford to buy the food that they were unable to produce. To become food-secure, they needed options that both increased their production and increased their incomes.

At the same time, we in the CGIAR, were struggling to adapt to these enormous changes. We did not have a solid framework for addressing the new world economic structure. In reviewing the science agenda in 2001, the CGIAR's highest science body, the Technical Advisory Committee (TAC), said:

"In order to address the stubborn persistence of poverty, particularly in the rural areas amidst rising global food supplies, the CGIAR has explicitly redirected its mission toward sustainable poverty reduction... However... not



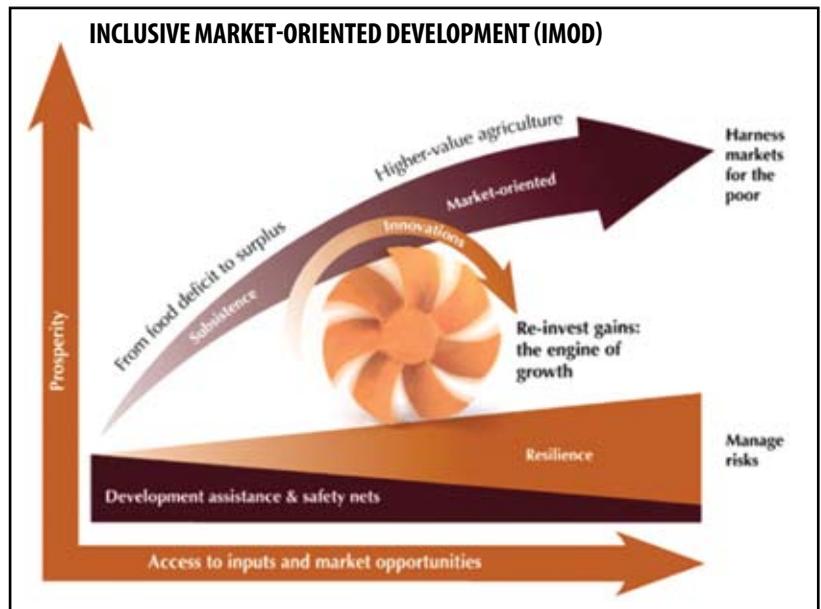
enough [is] known about the processes and conditions under which agricultural technology can be an effective instrument for poverty reduction... TAC considers that it is important to rigorously establish causal linkages..."

During the first decade of this century, the CGIAR and many other institutions carried out studies to better understand how agriculture could reduce poverty. But the next big step forward came from outside the CGIAR. The World Bank's 2008 World Development Report on 'Agriculture for Development, a comprehensive 386 page analysis of new trends in agriculture, said:

"The world of agriculture has dramatically changed since the 1982 World Development Report on agriculture. An emerging vision of agriculture for development redefines the roles of producers, the private sector and the state. Production is mainly by smallholders, who often remain the most efficient producers, in particular when supported by their organizations. The private sector drives the organization of value chains that bring the market to smallholders... The state... corrects market failures, regulates competition... and supports the greater inclusion of smallholders and rural workers. In this emerging vision, agriculture assumes a prominent role in the development agenda."

Implementing this vision, the World Bank's Policy Objective number one in agriculture-for-development became, "Improve access to markets and establish efficient value chains."

The World Bank study helped to refocus global attention on market-oriented development. It articulated the "causal linkages" between agriculture and poverty reduction that



the CGIAR's TAC had called for eight years earlier.

In this context of change, we at ICRISAT sought a new strategy for the decade 2011-2020. We consulted both staff and a wide range of partners and stakeholders. An insistent theme arose – that to escape hunger and poverty in the drylands, smallholder farmers needed to have better connections to markets. We decided to make it the centerpiece of our new strategy. We called it IMOD, for Inclusive Market-Oriented Development.

**WHAT IS IMOD?**

The first element in the IMOD diagram is the big bold curve which represents harnessing markets specifically to benefit the poor, carrying them from impoverished subsistence farming to prosperous market orientation. Conventional value chains don't have this focus on the poor. Without this focus, larger-scale farmers and wealthy middlemen tend to capture most of the market opportunities.

Underneath the big curve in the diagram is the rotating wheel. This is the "engine of growth" that increases

the incomes of the poor. The "fuel" of this engine is innovations designed for the poor. These are quite different kinds of innovations from those found in conventional value chains, which favor the large farmer and the wealthy. Including the poor also requires new kinds of partnerships.

The third major element of IMOD at the bottom of the diagram is managing the risks that poor people face. Risks are especially high for smallholders, because they have few resources to fall back on if something goes wrong. Diversification is essential for risk management. For the poorest, risk management requires outside help through development assistance such as subsidies, emergency food reserves, NGO aid and other safety nets. As their incomes increase through IMOD, smallholders become more and more able to stand on their own; that is, they become more resilient.

**IMOD VERSUS VALUE CHAIN**

IMOD's explicit goal is to include the poor in value chains. This requires major innovation and needs to be highlighted. Conventional value

chain innovations tend to deliver more benefits to the non-poor.

### **IMOD IS A DYNAMIC DEVELOPMENT PATHWAY**

IMOD is a process of movement along a development pathway from impoverished subsistence farming, to prosperous market-oriented farming. The dynamic nature of IMOD changed our thinking in fundamental ways. It compelled us to put priority on innovations that would move farmers from poverty to prosperity, instead of innovations that would leave them only a little less poor.

### **Escaping subsistence farming: Micro dosing and small seed packs**

Before IMOD, the CGIAR's focus was on achieving maximum yields of staple grain crops. If farmers used high rates of fertilizer, irrigation and improved varieties, their yields could increase three to five times. We bred for higher and higher yield potential, even though, Norman Borlaug pointed out many years ago that "farmers can't eat potential."

The problem that Dr. Borlaug alluded to was that poor farmers couldn't afford high rates of fertilizer and irrigation, especially in Africa.

Without these inputs, the improved varieties could not express their high yield potential on-farm. IMOD gives us a way to get past this poverty roadblock.

According to our research, small-holder fields are usually nutrient-deficient, so that even a small amount of fertilizer would generate a large and profitable response from the crop. Applying just one-sixth of the recommended rate of fertilizer resulted in 50-100 per cent yield increases. We studied the physiology and economics of this microdosing system using crop models and they indicated that, contrary to conventional wisdom, low rates of fertilizer are not overly risky. With low rates, crops don't become too leafy and run out of water before maturity. On the contrary, these low rates of fertilizer cause plant roots to grow faster and more extensively, and make the plants more drought-hardy.

If farmers started off with low fertilizer rates, and if they were supported by effective technologies and institutions, the profits could propel them ahead the following year. Year after year, they could use increasing profits to improve their family's living conditions, increase their fertilizer

rates, buy improved seed, and improve other management practices.

This cycle of increasing investment and increasing rewards, is what is meant by dynamic development that progresses along the IMOD curve from a state of poverty, to a state of prosperity.

The uptake of microdosing has been strong. About 400,000 farmers, on both sides of the African continent, are currently testing or adopting it.

As fertilizer use increases, so does the yield response by improved varieties. This is a strong IMOD dynamic. So, with strengthened donor support in recent years we've been encouraging both microdosing and improved seed across Africa. Just as micro quantities of fertilizer are more accessible to the poor, so are small-sized packets of improved seed; these are much in demand by the poor wherever we've tested them, especially by women for their home gardens and field crops, which in turn impact the nutrition of their families.

### **STATE POWERS UP ITS AGRICULTURAL ENGINE**

Government can ignite the IMOD engine, too. An initiative called Bhoochetana (Land Rejuvenation) is helping four million dryland farm families in Karnataka, to boost yields by 30 per cent on 3.7 million ha. A major method is by overcoming micronutrient deficiencies through targeted fertilizer dissemination and other soil and water management interventions. The economic benefits during the 2011 rainy season alone were US\$ 130 million, returning 14 dollars for every dollar invested by the state.

### **A WATERSHED ACHIEVEMENT**

Insufficient water is the defining con-



straint of the drylands. Yet much water is either wasted or allowed to flow by without being used. Improved water control is IMOD-strategic, because it reduces drought risk for the poor and it enables the cultivation of more diverse, higher-value, nutritious crops such as vegetables and fruits.

Effective partnerships with national and local agencies have improved watershed productivity and diversity through smallholder community action, benefiting 2.4 million farmers (12 million people in farming households) in India, China, Thailand, Vietnam and in several West African countries. In Asia, net crop income doubled on average, and cow milk yield has risen from 1.5 to 4.0 liters/day. Returns to investment in Andhra Pradesh state, India, alone have been US\$608 million over the past decade.

### REVITALIZING THE VALUE CHAIN FOR RAINY SEASON SORGHUM IN INDIA

Rainy-season sorghum is a US\$690 million smallholder crop in India. It is used for cattle and poultry feed, processed foods and alcohol. In sorghum IMOD chain, major weaknesses were found in grain grading, linkages to input and credit agencies, and marketing outlets. These constraints were overcome by:

- Facilitating their grouping into farmer associations so they could link more effectively to input and credit suppliers and become more empowered in market negotiations;
- Breeding and disseminating better-quality cultivars;
- Training farmers in integrated crop management; and
- Helping farmers improve their on-farm storage of grain.

As a result of these combined interventions, sorghum grain and fodder yields rose by 25-50 per cent for

the participating farmers. Income per hectare from the improved sorghum crop has nearly doubled, from \$162/ha to \$365/ha.

### THE CHICKPEA IMOD ENGINE

IMOD dynamics have sparked chickpea revolutions in India, Myanmar and Ethiopia.

Originally a crop of the cooler, more moist latitudes of northern India, chickpea has, by virtue of the last twelve years research-for-development, adapted to hot, dry tropical conditions. Early-maturing, heat-tolerant Kabuli grain varieties,



mechanization of field operations through hourly contracting of tractor services, strengthening of formal and informal seed production, awareness and training programs, growing markets (domestic and export), and cold storage (achieving better prices and seeds for next season) have all played a major role. These innovations have sparked 50 per cent increases in yield (from 600 to 900 kg/ha), a threefold increase in chickpea area (from 0.47 to 1.5 million ha) and a 4.8-fold increase in production (0.28 to 1.35 million t).

The Kabuli chickpea IMOD revolution in Myanmar has been no less dramatic. Following two decades of almost no export earnings from the crop, Myanmar re-initiated exports of chickpea in 2001. From 2001-10, Myanmar exported an average of

50,000 tons annually, worth \$22 million. Chickpea production increased four-fold (117,000 to 467,000 tons) due to a doubling of sown area (164,000 ha to 332,000 ha) and a doubling of grain yields (712 kg to 1.40 tons per ha).

Africa is also benefiting from the chickpea boom. Germplasm-sharing and capacity-building assistance from ICRISAT to Ethiopia-EIAR contributed to major chickpea production gains in the East Shewa Zone of Oromia and Amhara regions, benefiting nearly one million farm households. Yields increased by 75 per cent to 1.4 tons/ha from 2003-05 to 2010, and national production increased by 136 per cent to 402,000 tons from 2003-05 to 2012. About a quarter of the crop is exported; export earnings increased 21-fold, to \$21 million per annum from 2005 to 2010. Models predict that these gains will lift at least 0.7 million people out of poverty during 2001-2030.

### GROUNDNUT GAINS THROUGH IMOD

#### India

The world's largest groundnut producing district is Anantapur, a drought-prone district of Andhra Pradesh. More than 70 per cent of the cultivated area in the district (about one million hectares) is sown with this crop because of its ability to survive long dry spells, and for its cash value both for oil and food uses. It is also valued as a source of fodder for livestock when other crops fail.

The variety ICGV 91114 created a new beginning in 2006. Bred and developed at ICRISAT, it features higher yields, earlier maturity, drought tolerance, high shelling turnover, high oil and protein content, good palatability and digestibility of haulms by livestock. It increases pod yield by 23 per cent on average. Net income to



adopting smallholders has increased by 35 per cent worth \$110 extra US dollars per household. Cows fed with the haulms (vegetative biomass) of this variety produce 11 per cent more milk. Its drought tolerance has reduced yield variability by 30 per cent compared to an earlier variety.

Farmer associations were formed to produce seed of ICGV 91114, enabling it to spread to about 3 per cent of the Anantapur groundnut area by 2010, annually contributing an additional 42,000 tons of groundnut worth US\$3.7 million to 30,000 farm households (150,000 people). Assuming 35 per cent adoption by 2020, these benefits will rise to \$500 million annually.

### Malawi

The 100,000 member-strong National Smallholder Farmers' Association of Malawi (NASFAM) called on ICRISAT's help in rekindling its groundnut export industry. The high-yielding ICRISAT-bred variety CG-7 now accounts for half of the national groundnut production. ICRISAT assistance in training and technology transfer for aflatoxin management, testing and certification has reduced contamination and allowed groundnut exports to the UK. Stimulated by these suc-

cesses, groundnut production grew at an annual rate of 7.5 per cent per annum from 2002-2011.

### PIGEONPEA'S QUICKENING PULSE IN AFRICA

Pigeonpea is in high demand in India and worldwide. Pigeonpea has long been grown in Africa, but mostly on a household garden level or as a subsistence intercrop with maize. A concerted IMOD effort in Tanzania has invigorated pigeonpea production for cash export. Fusarium wilt-resistant, seasonally-adapted, export grain quality varieties have been adopted on 45 per cent of the crop's area (double from five years ago) in northern Tanzania, producing an additional 1.3 tons per hectare or 33,000 total extra tons – delivering approximately US\$33 million in extra value to impoverished farmers, while improving soil fertility and farming system resilience.

### HYBRID FUEL FOR THE IMOD HIGHWAY

Access to improved seed is a major speed bump along the IMOD pathway. Developing hybrid varieties of crops is important in overcoming this obstacle, because it provides an incentive for seed companies to invest in crop improvement and seed

dissemination. To foster hybrids, ICRISAT catalyzed the formation of the Hybrid Parents Research Consortium (HPRC) in India. HPRC currently consists of 36 private seed companies that provide nearly a million US dollars in research and knowledge-sharing funding annually. HPRC enhances the availability of hybrid seed to smallholder dryland farmers across the country. Nearly 60 per cent of the hybrid sorghum and 80 per cent of the hybrid pearl millet sold by seed companies in India today derives from ICRISAT germplasm.

### INCUBATING IMOD

The Agribusiness and Innovation Platform (AIP) of ICRISAT is a public-private partnership model that fosters innovative agri-enterprise to bring R4D innovations of ICRISAT and partners to the marketplace for IMOD impact. It has attracted US\$5.5 million over the past four years including support for 108 joint ventures. Through its NutriPlus initiative, AIP incubates partners that develop, test and market innovative processed food products from staple grains that can increase incomes for smallholders.

A strategic framework is like a lantern in the night, providing vision in the darkness. It guides our work along the path that leads to our most cherished goals. It prevents us from going astray, and helps us to better help the poor to fulfill their deepest aspiration – not just to be less poor, but to escape poverty altogether. That is the purpose of IMOD.

IMOD prompts us to go far beyond just increasing yield potential. It requires that we measure the actual value that our innovations bring to the lives of the poor. At the end of the day, that value is what matters most to us. ♦

**DR. G.C. SHROTRIYA**  
Head [Value-Added  
Services]. IKSL  
New Delhi

# Empowering Rural India by Technology

**A**ccess to timely and relevant information to our villages, many of them remote and inaccessible, is expected to empower rural population. Increasing awareness and knowledge levels through information on government schemes and welfare measures can go a long way in improving the quality of living in rural India, as most of them do not have access to the sincere efforts made for their welfare. Latest and contextual advisories on all aspects of relevance to our villages – like agriculture, animal husbandry, education, health, livelihoods, etc., can bridge the knowledge-gap between rural and urban India and can radically transform rural landscape.

A holistic approach to reach out to the rural citizens, while challenging, has potential for improving constant engagement, encouraging participation and, above all, appreciation and understanding of various technologies now available and several measures undertaken by the Government for the upliftment of rural areas.

It is well recognized that there is a dire need for taking knowledge to intended beneficiaries, majority of whom live in villages with low levels of literacy and poor access to

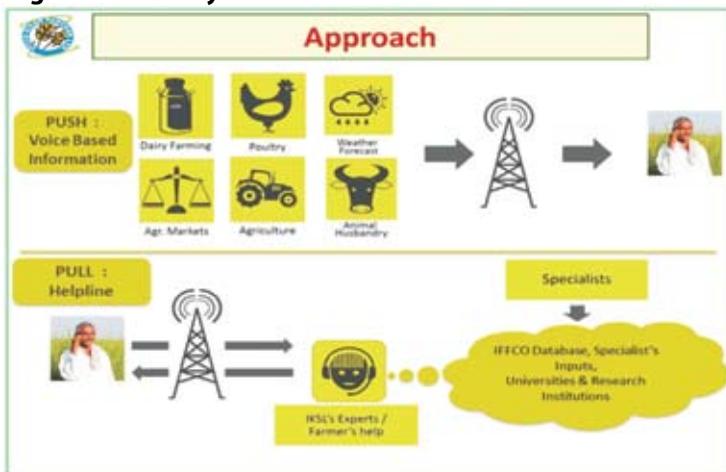
information. An innovative initiative of IFFCO Kisan Sanchar Limited [IKSL] is presented here, which leverages the ubiquitous mobile phone as a device for empowerment of people living in villages.

Indian Farmers Fertiliser Cooperative Limited [IFFCO] promoted a joint venture, IKSL, in association with Star Global Resources and Bharti Airtel in the year 2007 to more effectively leverage mobile technology for the benefit of farmers. IKSL's mission was to empower Indian farmers by converting their mobile phone into a power-house of knowledge, helping to them not only fight poverty, but also hunger of their fellow countrymen.

On mobile phones, IKSL provides timely and pertinent agro-advisory services to farmers to improve the yield, reduce cost of production, reduce wastage, enhance quality, expand their markets, increase farm income, and educate them on health, environment and other aspects of importance. The agricultural advisories are provided as voice messages in local languages to ensure that even illiterate farmers benefit from the services.

The same SIM Card which is used for normal tele-communication is leveraged to provide free-of-cost information as value-added service to IKSL subscribers. This initiative was launched in 2007 – at a time when the penetration of mobile phone in rural India was insignificant, which outlines the visionary and innovative nature of the service.

**Figure-1: Two-Way Communication Model of IKSL**



## APPROACH

The IKSL model is simple and is based on two-way communication with the farmers. The 'PUSH' approach ensures that the farmers receive latest updates and advisories of immediate relevance to them. The information is provided as one-minute capsule in voice form in local languages/dialects. The 'PULL' approach provides an opportunity for the farmers to call

a Helpline for additional information on the messages provided to them or seek solutions for their specific problems.

**KEY FEATURES OF IKSL VALUE-ADDED SERVICES**

**Voice Messages:** Every day, upto four free voice messages, are delivered to the farmers. Each such voice message is of one minute duration and covers diverse areas related to agriculture like soil management, crop management, animal husbandry, horticulture, plant protection, market rates, weather forecasts, preventive human health, employment opportunities, government schemes, etc. In addition, one SMS is also sent on weather information.

**Helpline:** The subscribers of Green Card of IKSL have the privilege of access to a dedicated helpline which is managed by experts. Farmers can get a solution to their problems or get additional information on the voice messages already shared with them. Experienced professionals are accessible on this helpline

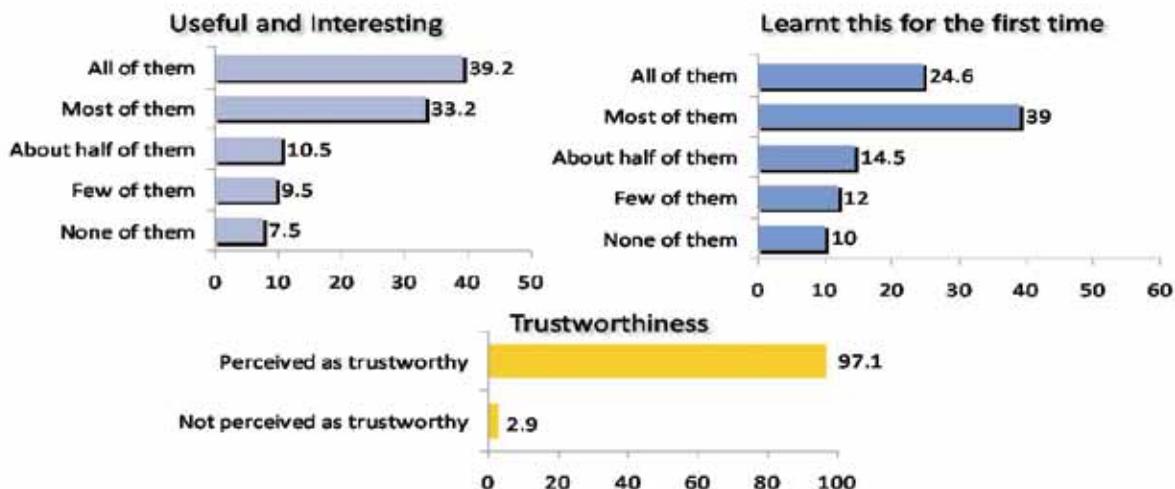
**Crop Calendar v/s Information need for transplanted rice crop**

(Zero sowing date should be adjusted for different cultivation situation and maturity cycle of the variety/hybrid under cultivation)

Crop stage/Crop life (days)/ Information need		
<b>Pre-sowing (-30days)</b>	<b>Nursery raising (-5 to 0 days)</b>	<b>Nursery (0-25 days)</b>
Soil testing Field preparation Soil amelioration(S/FYM/ Green manuring) Hybrid/variety selection Inputs availability	Soil treatment/sanitation Seedbed preparation Seed treatment (Bacterial/Fungal) Application of fertilizers Seed rate, seeding method)	Weed control Water management Biotic-abiotic stresses (termites, hoppers, birds, b light)
<b>Transplanting ( 25-35 days)</b>	<b>Preflowering (35-60 days)</b>	<b>Post flowering ( 60-80 days)</b>
Puddling Basal nutrients application Seedlings treatment (pesticide/nutrient) Transplanting (spacing/seedling number)	Top dressing of urea Water management (alternate wetting/drainage, critical stages) Alerts & Management of Insects (hoppers, shoot borer, termites) and diseases (blight, blast)	Alerts & management of insects (hoppers, bugs, borers) and diseases (neck blast, smuts) Water management Rouging
<b>Maturity/harvest (80-150 days)</b>	<b>Post harvest</b>	
Water management Rouging Harvesting	Threshing Winnowing/Field drying Storage/fumigation Mandi rates/arrivals	

**Results of Survey by TNS Engaged by GSMA Foundation**

**Perceived usefulness of Voice Messages**



who provide solutions to farmers. Whenever required, subject-matter specialists are taken on conference call to provide advanced information.

**Call Back Facility:** For those subscribers, who have missed a voice message or would like to listen to the messages again, a facility is available to call a short code which provides opportunity for listening to a day's messages again.

**Phone-in Expert Program:** Apart from the above value-added services, IKSL organizes live phone-in program where experts related to a pre-announced subject are available on a scheduled date and time for all the IKSL Green Card subscribers for redressal of any issues, clarifications, etc.

**Mobile Quiz Program:** Mobile based quiz programs based on the content provided earlier are organized to sharpen the knowledge levels of subscribers and for assessing the understanding and retention of information by farmers on the voice messages delivered to them. Quiz Winners are given token gift to keep their interest live and retain their continuous engagement on the network.

**Focused Communities:** To further improve the relevance and

effectiveness of the information offered, IKSL promotes special communities/groups with common interest to extend focused services. These focused communities include goat-rearing women, coastal fishermen, poultry farmers, Basmati rice growers etc. at different places. This approach provides an opportunity to extend most relevant advisory services which is of common interest to the community members.

The voice and text message services are provided free-of-cost to the IKSL Green SIM Card holders without disruption as long as the subscribers are actively availing the service. For calling helpline and services like re-listening, phone-in and quiz, normal call rates are applicable in that telecom circle of the network provider i.e., Airtel. Subscribers use the IKSL Green SIM Card like any other pre-paid SIM for making and receiving calls for which they need to buy talk time as per their personal requirement.

**INFRASTRUCTURE**

IKSL has developed a state-of-the-art infrastructure to manage the services in 18 major States except Jammu and Kashmir and North East. IKSL's content team consists of experienced and well-qualified professionals related to agricultural and allied areas. In addition, the content managers are supported by a panel of eminent

and experienced experts on diverse subjects from various agriculture universities/research institutions of the country.

Voice messages are jointly prepared by the subject-matter specialists/ experts and content manager on the relevant area of interest in a State. Crop-related information is based on the cropping pattern of the area and crop stage/ calendar.

Content managers ensure that these messages are delivered within a one minute capsule as a voice message and in local languages/dialects. A peer panel of national/international repute, reviews and monitors quality assurance aspect. CABI, a reputed international organization on knowledge management in agriculture, supports IKSL in evolving best practices for content creation, collation and delivery along with conducting periodic audits of the services. IKSL has developed a strong IT Backbone and necessary expertise on all aspects of its value-added service activities.

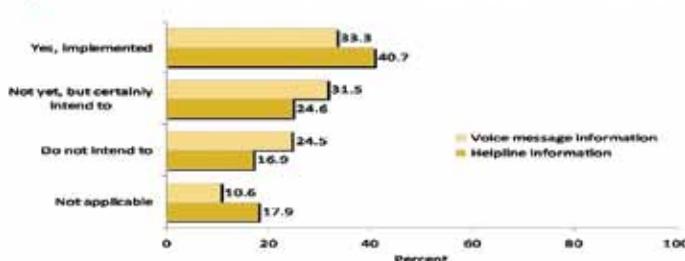
A comprehensive system 'Integrated Information Management System [IIMS]' for managing all the content-related aspects has been developed in-house and implemented. IIMS is a source of information for Content team as well as a repository of all documentation and voice files for quality monitoring.

**QUALITY PROCESSES**

IKSL maintains stringent standards and protocols to ensure that the information delivered is of highest quality. India is divided into 108 zones to provide contextual information on the basis of agro-climatic conditions. Further, focused communities with a common interest to the group are formed who are provided with more

Results of Survey by TNS Engaged by GSMA Foundation

**Implementation of Information Received**





**US President Obama at IKSL stall, Agri-Expo in Mumbai, November 7, 2010**

refined and specific information. Each information capsule going out from IKSL system is audited for its accuracy, adequacy, authenticity and clarity. Periodic studies are conducted to study the impact, assess the effectiveness and undertake improvement measures.

### **IMPACT ASSESSMENT**

Positive impacts on the lives of the farmers have been documented by IKSL as well as by independent external agencies. There is evidence to show that farmers have improved their income and produce quality, reduced costs and enhanced their ability to make informed decision making. Majority of subscribers have found that services are useful as their access to other information sources is either limited or missing.

A sizable percentage of subscribers implement or intend to implement the advisories received through voice message or helpline.

### **ACCOLADES FOR IKSL: US PRESIDENT OBAMA ON IKSL**

Since its inception, IKSL has been receiving several awards and rec-

ognitions. The vision of IFFCO in promoting IKSL as an institution for promoting rural empowerment received international recognition with the President of the U.S.A., Mr. Barack Obama visiting the Agriculture Expo at St. Xavier's College, Mumbai on November 7, 2010, appreciated IKSL's initiative and stated: "It is a Great Idea. Do it across the world. Great Work. Keep it up."

President Obama not only took keen interest in knowing the details but had referred to this in his speech next day at the joint session of Indian Parliament where he said, "Today, India is a leader in using technology to empower farmers, like those I met yesterday who get free updates on market and weather conditions on their cell phones"

### **KISAN CALL CENTER [KCC] SERVICES**

Department of Agriculture & Cooperation [DAC], Ministry of Agriculture [MoA], Government of India, engaged IKSL for managing the Kisan Call Centre [KCC] Services. IKSL is operating the KCC Services of the Government of India since 1st May 2012 for the entire country from 14

locations. IKSL set up the necessary infrastructure, including ICT facilities and manpower. About 400 Agricultural Graduates are working in three shifts between 6.00 am to 10.00 pm all 365 days of the year. The number of calls received per month presently range from 7-10 lakhs. After each call from a farmer, the details are documented and gist of solution provided is also sent through SMS after every successful call.

The mobile phone centric approach developed by IKSL provides the convenience and comfort of receiving information without having to wait for trickling down of information or depend on doubtful sources for advice. Flexibility of listening to the content at any time and place is a major strength of the approach. Mobile phone not only transcends literacy barrier but provides personal touch to the services. The approach provides privacy and 'any time' and 'any place' access facility to the advisories of the day.

The Model developed by IKSL is scalable, replicable and sustainable. ♦

**DR. S. DAM ROY**  
Director  
Central Agricultural  
Research Institute, Port  
Blair  
Andaman & Nicobar  
Islands

# Climate Resilient Agriculture in Tropical Islands

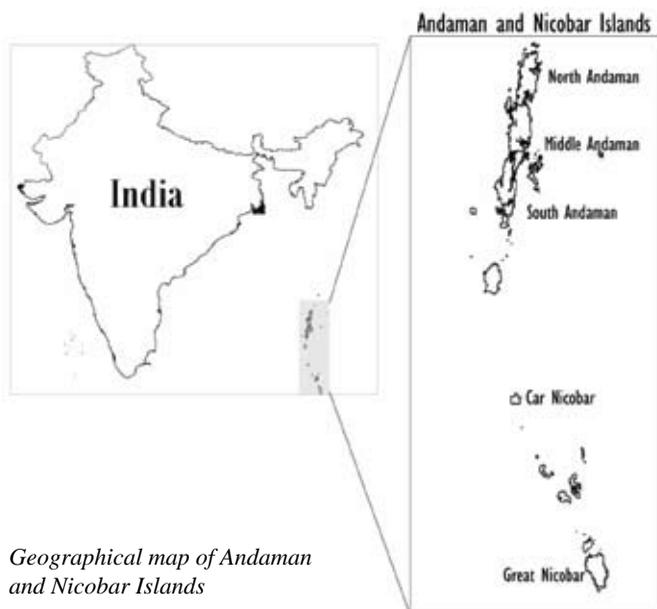
## ISLAND AGRI-GEOGRAPHY

The archipelago of Andaman and Nicobar Islands constitutes of 572 islands in Bay of Bengal in Indian Ocean with a geographical area of 8249 sq km. It stretches between 6° N to 14° N on 92° E to 94°E. Geographically, these islands can be divided into five groups, namely North Andaman, Middle Andaman, South Andaman, Car Nicobar, Nancowry and Campbell Bay. The Andaman and Nicobar Islands are located 1100 km from Chennai and 1300 km from Kolkata, the nearest cities of mainland India. Land use pattern indicates major share under forest (87per cent) followed by revenue lands (7 per cent), and only 6per cent for agriculture.

Therefore, there is great challenge to meet up the food demands of 3.79 lakhs of local people from only 50000 ha area of cultivated land, which is scattered across the 38 inhabited islands. The islands also have indigenous tribes such as Onge, Sentinelese, Jarawa and Andamanes of the Negroid origin, and Shompen and Nicobarese of Mongoloid

descent which constitutes 8 per cent of total population of islands. Their food resources and preferences are quite different from settler population. These people are entirely depended on forest and coastal resources for their food and other basic requirements. Thus, variations in food cultures of heterogeneous tribes and settler communities make it necessary to use the island resources in sustainable manner.

On the other hand, the settler population depends on agriculture. Though, some islands have emerged as commercial production centres for different agri-horticultural crops and acting as supply source for non-farming population, many of the settlements are depended on traditional farming practices. This spatial disparity has to be considered seriously for making islands self-sufficient in food and nutritional needs in the era of climate change. The integration of climate change resilient components of agriculture and their optimization through systematic investigations and planning is the top priority of the research and policy makers.



*Geographical map of Andaman and Nicobar Islands*

## NUTRITIONAL SECURITY THROUGH LOCAL RESOURCES

Tropical region covering 20per cent of land surface and sustaining 40per cent of world population has potential for tropical agriculture and allied sectors. The projections, particularly for childhood malnutrition says that the levels will increase dramatically under climate change by between 9 and 11 million children, in addition to the 65 million children projected to remain malnourished in 2050 even under current climate conditions. On one side, the islands are rich centres of floral and faunal biodiversity, but on other side they have large pool of undernourished children and women. The Andaman and Nicobar Islands are typical tropical island



*Floral biodiversity of Andaman Islands*

ecosystems, where limited land resources are catering to the needs of local and tourist population. The investigations, particularly amongst tribals of Negroid origin say that indigenous tribes are deficient in iron, calcium, beta-carotene and vitamin C. The efforts through highlighting the nutritional potential of native underutilized fruits, vegetables, fishes and poultry are changing the perceptions of people about these neglected resources. The mineral and vitamin rich leafy vegetables, protein rich self-recruiting fish species, disease resistant poultry strains have been identified for the benefit of local people. The value added and fortified products are prepared from locally available high density sources of iron, calcium and vitamins. The promotion of these traditional food resources in the habitats and home gardens of indigenous tribes through training and sensitization approaches are producing desirable results.

### **CLIMATE CHANGE AND ISLAND AGRICULTURE**

Climate change has been perceived

as a major threat and will have impact on crops, due to erratic rainfall, more demand of water during dry months, enhanced biotic and abiotic stresses. The resilience of agriculture related ecosystems depends largely on slowly changing variables, such as climate, land use, nutrient availability, and the size of the farming system. In addition, agriculture is a source of livelihood for billions of people, particularly the poor, and their income directly

contributes to society's resilience. As a result, enacting measures to build agricultural resilience requires an understanding of strategies to reduce vulnerability, while at the same time generating income and reducing poverty.

However, the changes will not only be harmful as enhanced photosynthesis and increased temperature may hasten the process of maturity. Increased temperature will exert more effort on



*Faunal biodiversity of Andaman Islands*



*Fether's star in Nicobar sea*

reproductive biology, and reduced water may affect the productivity, but adaptive mechanism like time adjustment and productive use of water shall reduce the negative impact. The systematic vulnerability mapping of Nicobar Islands using remote sensing technique clearly showed great threat to pristine island ecosystem in this archipelago. The CARI has played significant role in post-tsunami (2004) rehabilitation programme through providing appropriate technological back up to the line departments, which have restored the livelihood and confidence of farming community of the islands. In continuation of the efforts for such foreseen climate change impact in future, the CARI has identified some of the microbes which can sustain upto 70°C, salt tolerant genotypes of brinjal and vegetables which can sustain well in marshy land for use as source of genes for developing climate resilient crops in coming years. The investigations showed promise of shrimp farming in brackish water, adaptation of

ducks in brackish water in coastal area of islands, suitability of *Morinda citrifolia* and coconut husk based raised bed techniques in sea water challenged lands.

#### **ISLAND BIODIVERSITY AND UTILIZATION**

The Andaman and Nicobar Islands (ANI) are rich in biodiversity with 2500 angiosperms, 200 endemic and 1300 species non-available at mainland. This flora includes 300 species of medicinal plants, 130 species of orchids, 120 species of ferns, more than 150 species of fruits and vegetables, around 10 species of oil yielding plants, and more than 50 species of timber and fuel yielding trees. Around 52 species are being used as source of food and medicine by the primitive tribes. The islands and its coastal areas have rich diversity in mangroves and microflora including fungi, bacteria, algae etc. Among faunal diversity, the islands are immense treasure of fishes, butterflies, birds, reptiles, and insects. The islands have around

1200, 300 and 120 species of fishes, corals and sponges respectively. The unique Teresa goats, Nicobari pigs, Hawa Bill birds, Nicobari poultry etc are indigenous to islands.

These are being preserved by the primitive tribes over centuries but recent settlements and natural calamities have made some of the indigenous species extinct or vulnerable. Central Agricultural Research Institute, Port Blair (ANI), is the only research institute working on island agricultural biodiversity with a mandate for "the conservation and utilization of island biodiversity in a sustainable manner". Using the local biodiversity, the CARI has developed high yielding varieties/strains of coconut (4), sweet potato (2), rice (5), brinjal (1), leafy vegetables (2), Morinda (4), tuber crops (30 and poultry (2). Around six unique germ-plasms have been registered to NB-PGR, New Delhi.

#### **INTEGRATED AGRICULTURE**

Intergradations of various crop, animal and fisheries components

to resilience level strengthen the mitigation strategy in agriculture sector. The CARI has developed three different integrated farming system models for upland, medium land and low lands with suitable components. These models also proved profitable and have been adopted by many of local farmers as livelihood option in post tsunami period. This also showed efficient use of farm resources in sustainable manner. The vegetables are mostly cultivated in uplands during rainy season, while low lands were under rice or fallow. The high price of vegetables and flowers during this season attracted researchers and farmers to develop broad bed and furrow system and raised bed technologies for diversification of land use pattern. The CARI has also developed multi-storey cropping system for tropical island conditions for increasing carbon sequestration, efficient utilization of sun light and water resources, and risk mitigation in farming sector.

#### DEVELOPMENT OF CLIMATE RESILIENT SEEDS

The tropical islands are rich in floral diversity but identification of donor sources for climate resilient traits is a big challenge for breeders. The genes involved in determining yield and adaptation potential and their importance and expression patterns vary widely depending on the crop and growing environment. Even so, genes that directly affect yield and adaptation are being identified in different agricultural crops in islands. The marker-assisted breeding has clear advantages over conventional breeding practices regarding rates of gain of crop yield and associated traits. This programme is a tool for aggressive breeding programs

which reduce time and cost of trait identification and breeding of new varieties, indicating the potential for relatively rapid adjustment to more adverse climate conditions.

#### TOURISM SECTOR AND ISLAND AGRICULTURE

Tourism is the largest service industry in India with a contribution of 6.23 per cent to the national gross domestic product (GDP) and 8.7 per cent of total employment in India. The tourism industry in India generated

fragile ecosystem. CARI has taken the initiative with local farmers to develop eco-tourism and orchard tourism in different regions of Islands. Further, the food primarily high value vegetables, baby corn, fruits and flower needs of the tourism sector, are still largely being met through transport from mainland.

Since its inception, CARI has broadened its role from Andaman and Nicobar Islands to tropical islands in tropical regions. The successful models in tropical island situa-



about US \$ 100 billion in 2008 and that is expected to increase to US \$ 275.5 billion by 2018 at a 9.4 per cent annual growth rate. Similarly, tourism is an important source of income in islands and during 2011-12 around 2.5 lakhs tourist arrived in islands. The CARI with line department has been promoting protected cultivation of high value vegetables and flowers for island conditions which showed positive impact in some localities. This local production will cater to the needs of tourism sector and reduce the money flow from island economy and give the opportunity to spend in islands. Further, commercial tourism is also posing threat to the

tions like integrated farming system, sustainable biodiversity utilization for benefit of farmers, working in post-tsunami rehabilitation program through technological interventions, improving agricultural scenario by strengthening local production of perishable food items, developing human resource in islands and now developing entrepreneurship in rural and tribal youth with agriculture and allied sectors are highlighting CARI as an institute of excellence in tropical regions. The climate change is now accepted as reality, and efforts of institutes like CARI in most vulnerable tropical islands is very vital for the benefit of mankind. ♦



# Institute of Agribusiness Management



## Institute of Agribusiness Management

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Your fastest route to a global career

# *Emerging Areas*

**BALRAJ SINGH**  
 National Research  
 Centre on Seed Spices  
 Tabiji-Ajmer

## Progress, Challenges and Strategies to Scale up Protected Cultivation in India



*Low tunnel technology for offseason vegetable cultivation for northern plain of India*

**A**griculture is highly dependent on environment, and it is very difficult to get favourable climate and other conditions for optimum crop growth and development as per crop need. Open field conditions have a high direct effect of the prevailing weather conditions on crop growth, and also on population dynamics of viruses, fungus, bacteria, insects etc. With time, crops adopt themselves to specific seasons, but the fast changing climatic conditions across the globe has changed the climatic characteristics of a season. This has resulted in untimely rains, high temperature fluctuations and changes in other abiotic and biotic factors in geographically varied locations. Therefore, there is need to develop suitable technologies to sustain these challenges. Protected cultivation technology can solve most of these problems, but it's a tricky and skill oriented technology highly dependent upon intelligent implementation of protected structures for crop cultivation by having a knowhow on "What, When, Where and Why" to implement. Every protected structure has its own limitations and advantages, but the basic benefit is that it provides extra protective shelter restricting or minimizing the exposure

of the crops to various biotic or abiotic factors which is not possible in open conditions.

### **NATIONAL SCENARIO OF PROTECTED CULTIVATION: INITIATIVES AND CONSTRAINTS**

Protected cultivation in India was adopted from the western countries, and the initial structures made were mostly copies of the Western models. The adopted design resulted in negligible profits, most of the enterprises across the nation failed due to lack of the understanding required for designs required as per Indian conditions. The only success attained was in specific locations like Pune and Bengaluru having mild climates which favoured the crop grown. Therefore protected cultivation was more concentrated in these areas restricted to cultivation of only cut flowers (Gerbera, Carnation and Dutch roses) and capsicum. These products were new in the Indian market and farmers were getting premium price. So no need was felt to test the performance of other crops. Till the tail end of the 20th century, states of Maharashtra and Karnataka were the leaders in protected cultivation.

Initial research and development activities started in mid 1980's at IARI, New Delhi. Modi-

fied designs suitable in Northern Plains for peak winter season were developed. A collaborative Indo-Israel Project on R & D in Hi-Tech Horticulture at IARI, New Delhi helped to create model infrastructure facilities of various kinds of protected structures in an area of 1.5 ha, this also made us to understand the research needs as per Indian conditions on commercial horticulture. After the end of the project, it was renamed as 'Centre for Protected Cultivation Technology (CPCT)'. CPCT has now developed standardized permanent and temporary structures suiting different agro-climatic conditions to take up high scale commercial vegetable and flower cultivation in India and also identified potential areas for protected cultivation. Simultaneously, research on protected cultivation has also been started in few State Agricultural Universities and other Government agencies.

Popularity of protected cultivation in the country came only after the launch of subsidy based Government Schemes in VIII and XI Plan during late 1990's and early years of 21st century. Plasticulture Scheme launched in VIII Plan with earmarked amount of Rs.2.20 million helped in promotion of protected/greenhouse cultivation. National Horticul-

ture Board also provided soft loans for Export Oriented Units of floriculture projects mostly around Bangalore and Pune. Under DAC scheme, nearly 400 ha area was developed under green houses in Leh & Laddakh, Maharashtra, Madhya Pradesh, Karnataka, Kerala and the North Eastern States. In XI plan, naturally ventilated green houses were also given preference. In 1999, a FAO assisted Project entitled "Greenhouse Floriculture Technology for Small-Scale farmers" to demonstrate the simple cost-effective greenhouse technology to small-scale traditional flower growers, specifically women, was launched for three locations i.e., Bangalore (Karnataka), Pune (Maharashtra) and Srinagar (Jammu & Kashmir). Under Xth Plan, 10,247 greenhouses of both 500 and 100 sq mts size and 13 Model Floriculture Centres were created in North Eastern and Himalayan States. To an extent, good efforts were also made under World Bank funded Projects like NATP and NAIP in strengthening research and development on protected cultivation.

In the XIth Plan period, protected cultivation got a boost in the North Indian Plains, with the concerted efforts under Government schemes and R & D support of CPCT, IARI

New Delhi and other public sector agencies/institutions. Designs were modified as per the requirements and crops and varieties were identified to be raised under protected conditions. But even after concerted efforts, the national coverage of area under protected cultivation has only increased hardly to 30,000 hectares, which includes plastic mulching, plastic low tunnels, walk-in-tunnels, insect proof net houses, shade net houses, small sized poly houses, naturally ventilated green houses, semi-climate controlled green houses having pad and fan system and climate controlled greenhouses (at research institutions). In recent years, protected cultivation has garnered some support.

- Protected cultivation has now gained success in Maharashtra, Karnataka, NE and Himalayan regions, Chhattisgarh, Odisha, Tribal areas of Jharkhand, Punjab, and Haryana and is increasing day by day in other regions. Mainly due to government promotional schemes and up to some extent by proper consultation of type of protected structures needed and crops to be grown
- The intervention of raised bed, drip fertigation along with plastic mulching is the key factor for success of protected vegetable cultivation in parts of Chhattisgarh, Jharkhand and adjoining belt.
- Low cost temporary structures, like plastic low tunnels have proven rewarding in raising off-season vegetables in Haryana and Punjab
- Naturally ventilated green houses are most successful for growing cut flowers and vegetables in and around Bengaluru, Himachal Pradesh, Uttarakhand, Jharkhand, Odisha, NE region



Raising of planting material under net houses



*Gerbera under Naturally Ventilated Green House*

- and other parts
- Plug tray nursery raising technology is now a huge business in form of small scale industries in and around Bengaluru for supply of planting material of vegetables in the country
- Insect proof net houses proved best to raise virus free commercial vegetable crops in northern plains and other parts of the country
- Shade nets equipped with foggers received huge success in NE regions to grow anthurium and other flower crops
- Adoption of small poly houses in temperate hilly tracks of Himachal Pradesh, Uttarkhand and Jammu & Kashmir for growing vegetables and flowers proved beneficial
- Initial adoption of protected cultivation under small areas are now getting expanded in the form of high scale commercial farms in many parts of the country

#### **MAJOR CHALLENGES FOR PROTECTED CULTIVATION IN INDIA**

- Lack of trained professionals and skilled manpower

- Lack of proper guidance about region specific design of protected structures
- Lack of understanding of the quality of basic steel and cladding material used for fabrication of structures
- Improper guidance and unavailability of crop varieties and planting materials specific to protected cultivation and its management practices.
- Higher cost of the available planting material/seeds.
- Lack of demand driven cultivation without proper marketing strategy creates problem for proper disposal of the quality produce and farmers get low premium price. Therefore, cluster approach for taking up protected cultivation as a whole is required.

#### **STRATEGIES FOR SCALING UP PROTECTED CULTIVATION IN INDIA**

- Large scale motivation and training of educated unemployed youths in the field of protected cultivation
- Extension of government support for self fabrication mode of tem-

porary low cost structures like insect proof net houses, shade net houses, walk-in-tunnels and plastic low tunnels for the production of vegetables and flowers.

- Large scale production and distribution of healthy vegetable and flower seedlings to the large section of growers on nominal price.
- Government should support and promote protected cultivation in cluster approach, especially in peri-urban areas of the country
- Government should promote to develop input hubs for protected cultivation in multi-locations in PPP mode.
- Protected cultivation has hitherto been promoted from the view point of more and more construction of greenhouses by providing subsidy. However, there is need to link such subsidies with production system *i.e.*, when the protected cultivation produce is sold/auctioned by the grower some of the subsidy may be realized to him at this level incentive as on.
- All the protected cultivation clusters must be mandatorily clubbed

with rain water harvesting infrastructure and facilities.

- Suggest most suitable crop sequences for different protected structures and seasons based on research data.
- Large scale promotion of low pressure drip irrigation system for low cost small scale protected cultivation in hilly states and plains
- Large scale use of different colour plastic mulches for different seasons clubbed with raised beds and drip fertigation system for vegetable and flower production under open field conditions and also discourage expensive surface irrigation in horticultural crops.
- Promotion of large scale mechanization in vegetable and flower cultivation by using raised bed makers, plastic laying machines, plastic low tunnel making machines, pipe bending machines for making walk-in-tunnels, drip lateral laying and binding machines
- Establish convergence and synergy among various ongoing and planned government programmes in the field of protected cultivation development.
- Ensure adequate, appropriate, time bound and concurrent at-

tention to all links in production under protected conditions, post production on farm value addition, processing and consumption chain.

- Use of solar energy for running drip system and up to some extent for running heating and cooling devices of the protected structures.

Considering the increasing population, climate change, decreasing land holding, increasing pressure on natural resources (land and water) and high demand for quality horticultural fresh produce, we are forced to shift towards protected cultivation as seen in China. China started protected cultivation in mid 1990's along with India, but today they are the world leaders in vegetable production, converting more than 2.5 million hectares of area under protected cultivation of which 90 per cent area is under vegetables cultivation. This shows the real potential of the hi-tech technology, but a proper approach is needed to convert maximum area of the present 9.0 million ha under vegetables for increasing the national productivity. Similarly, this can be replicated for flowers, fruits and other suitable crops. Promotion of protected cultivation will

help in creation self-employment opportunities for unemployed educated youths and will also raise the national economy by sale of high quality produce in domestic and international markets. Under the new era of FDI (Foreign Direct Investment) in retail, these kinds of models possess high potential for enhancing the income of farmers opting for quality and offseason vegetable and cut flower cultivation through protected cultivation. Production of vegetable and cut flower crops under protected conditions provides higher water and nutrient use efficiency under varied agro climatic conditions of the country. This technology has a very good potential, especially in peri-urban areas adjoining the major cities, which is a fast growing market of the country, since it can be profitably used for growing high value vegetable crops like, tomato, cherry tomato, coloured peppers, parthenocarpic cucumber, cut flowers like roses, gerbera, carnation, chrysanthemum etc., and virus free seedlings in agri-entrepreneurial models. But protected cultivation technology requires careful planning, attention and details about timing of production and moreover, harvest time to coincide with high market prices, choice of varieties adopted to the off season environments, and able to produce economical yields of high quality produce. The application of chemicals for controlling biotic stresses is low under protected structures which gives high quality safe vegetables for human consumption. By using protected structures, it is also possible to raise offseason and long duration vegetables crop of high quality. Vegetable and cut flower farming in agri-entrepreneurial models targeting various niche markets of the big cities can therefore diversify from traditional ways of crop cultivation to the modern methods. ♦



*Seed less cucumber under Naturally Ventilated Green House*

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# Scientific Storage Options Crucial for Potatoes

**P**otato is an important food crop world over. At global level, total potato production in the year 2012 was 374.4 million tonnes. India ranked second in the world with a total production of 42.34 million tonnes which is about 11.3 per cent of the total potato production at global level. Potato crop in India is grown on area of 1.86 million hectares with productivity of 22.7 tonnes per hectare. Productivity of potato in India is higher than the world average of 17.7 tonnes per hectare.

About 89.5 per cent of the total potato production in India comes from the Northern plains (also referred as Indo-Gangetic plains. In this region, potato crop is grown during winter, planted in October-November and harvested in February-March. The problems of storage of potatoes in India are different from that in European countries. In India, harvest of potatoes is followed by hot summer months, whereas in Europe, harvest is followed by cool winter months. Huge arrival of potatoes in the market immediately after harvest results in glut (especially during the years of record production), and this leads to distress sale by the farmers. Fresh potatoes are available only for 2-3 months

(February to April) and therefore, storage of potatoes is necessary to meet the requirements of the remaining period of 9-10 months in a year. Storage of potatoes helps in regulating the time of their arrival in the market, and this also reduces the transport related problems. Post-harvest losses in potatoes can be upto 40 per cent, if not handled properly and if stored only under non-refrigerated conditions. Proper and timely storage of potatoes contributes in effective postharvest management of potatoes reducing the extent of postharvest losses.

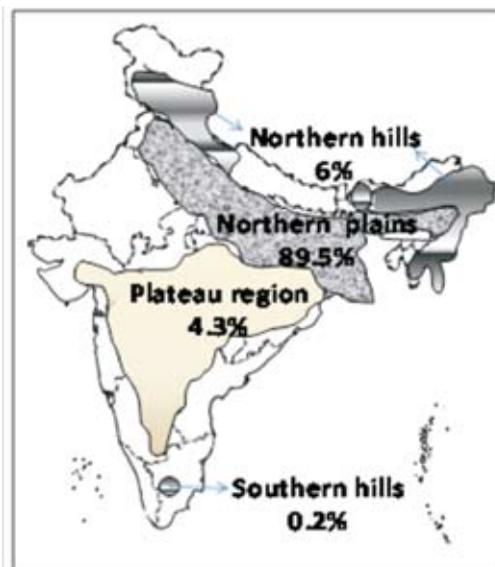
## POSTHARVEST PROBLEMS

From the time of harvest of potato tuber to the time of sprout initiation on the tuber (duration is called dormancy period and the event of sprouting is referred to as dormancy break), moisture loss from potatoes is a major concern. Moisture loss from the tuber contributes to weight loss in potato. Harvested potatoes suffer from quantitative as well as qualitative losses. Once the dormancy period (which is about 45 to 60 days, it starts from the day of haulm cutting and depends on the variety and the conditions to which tuber is exposed to) is over, sprouting starts. Sprout growth results in enhanced weight loss due to highly permeable nature of the epidermis of the sprout to the water vapours. In this way, sprouting results in higher storage loss. In addition to this, sprouting is also highly detrimental to nutritional status and quality of potatoes. Control of sprout growth is therefore a key issue during the period of potato storage.

## POTATO STORAGE: HOW AND WHY?

As per the present status of potato production in India (42.34 million tonnes), the available cold storage (2-4 °C and 90-95 per cent RH) facility in our country is sufficient only for 42 to 44 per cent of the total potato production. There are certain other problems as well, that are associated with cold storage of potatoes like –

- Cold storage is expensive (Rs 150 per bag



*Different potato growing regions with percent contribution to the total potato production in India*



Heap method of potato storage A: Potato heap in open, B-C: Potato heap under the thatched roof

- of 100 kg per season),
- Cold stores are unevenly distributed in our country.
- Non-accessibility of cold store facility for poor and remotely placed farmers
- Low temperature storage brings about some biochemical changes in potato tuber that makes the potatoes sweet in taste (because of accumulation of sugars in the stored tubers). This sweet taste makes the tubers less acceptable for table purpose as the consumers do not like to eat potatoes which taste sweet. In addition to this, sweet tubers are also not suitable for processing. This is because of the fact that accumulated sugars (reducing sugars) results in the development of unacceptable dark brown colour on the processed

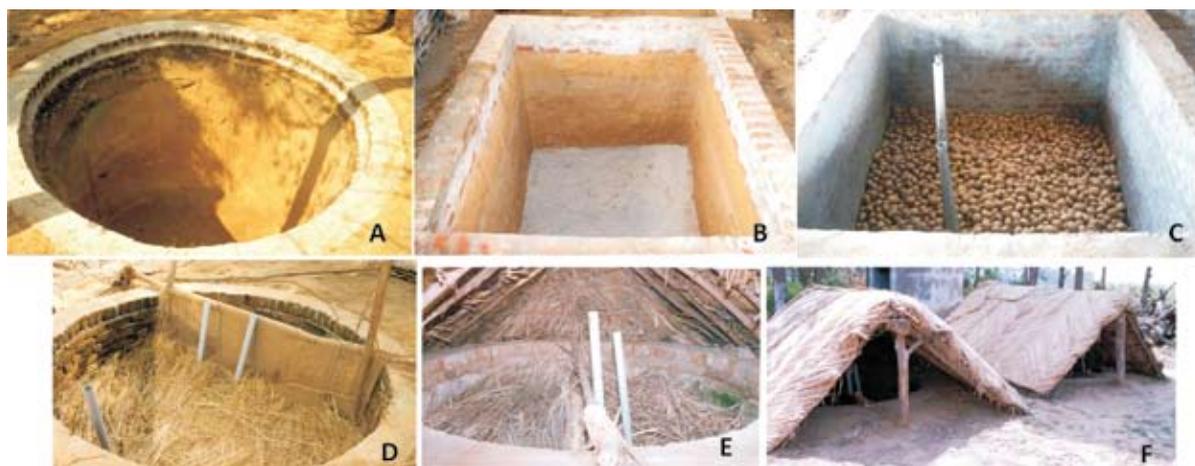
products (such as chips, French fries and flakes).

Glut has now become a common feature in case of potatoes with frequent bumper crop production. In this situation, it is very important to divert adequate quantity of potatoes for processing and value-addition, and this need to be done at appropriate time. A decade ago even the suitable raw material for chips and French fries was not available in our country. But since then, potato processing industry in India has witnessed a sea change with the gradual increase in the availability of quality raw material round the year. The Central Potato Research Institute (CPRI), Shimla has released several varieties including Kufri Chipsona-1, Kufri Chipsona-2, Kufri-Chipsona-3 and Kufri Himsona for catering to the needs of

processing industries. These varieties have higher dry matter and low levels of reducing sugars. Proper selection of variety, its maturity at the time of harvest and proper storage help in keeping the tubers suitable for consumption, either as table or in the form of processed products. There are various options that are now available in India for better storage of harvested potatoes.

**SHORT-TERM STORAGE (2 TO 3 MONTHS) METHODS FOR POTATOES**

Improved traditional storage methods for potatoes meant for table purpose: Traditional methods of potato storage (heap, katccha pit and pucca pit) were evaluated (for 60 to 90 days) and improvised by CPRI for Indo-Gangetic plains of India. These methods are cost-effective and practically feasible (can be prepared



Two different types of pit storage methods. A: Katccha pit (circular), B: Katccha pit (rectangular), C: Pucca pit (rectangular), D: Pucca pit (circular), E and F: Pits under the protection of thatched roof (protection from heat and rains).



*Storage of potatoes in leno bags is preferred for storing at 10-12°C and 85-90 per cent RH with the fogging treatment of CIPC*

with locally available materials) in minimizing the post harvest losses. Total losses in potato variety, Kufri Bahar after 90 days of storage were found to be 15.8, 15.5 and 15.6 per cent in heap, katkachapit and pucca pit, respectively. Such losses in another potato variety i.e., Kufri Jyoti were only 12.8, 10.9 and 9.7 per cent. Acceptable levels of losses in improved versions of traditional storage methods demonstrate them as option for short-term storage (60 and 90 days) of potatoes.

Improved and low-cost traditional storage methods for potatoes meant for processing: At CPRI and its regional stations (located in different states), studies were conducted on effect of maturity of potato tubers on the final processing quality in different varieties when tubers were stored for 60 and 90 days. Maximum improvement in processing attributes and acceptable chip colour was achieved after 60 and 90 days of storage in katcatcha pit method of storage. In addition to this, use of CIPC [isopropyl N-(3-chlorophenyl) carbamate] also known as chlorpropham] in the form of dustable powder was also evaluat-

ed, standardized and recommended for traditional methods of potato storage. CIPC is the most commonly and commercially used sprout suppressant on potatoes world over. Results indicated 30 per cent reduction in the levels of reducing sugars in potatoes stored for 90 days. This subsequently resulted in improvement in chip colour. In this way, stored potatoes were found to be suitable not only for table, but also for processing purposes. Storability and suitability of variety Kufri Chipsona-1 (a processing variety) was also demonstrated up to 110 days under traditional storage methods (with the use of CIPC). In this variety, levels of sugars decreased from initial value of 155 to 34 mg per 100 g tuber weight during the period of storage. CIPC residue was also found below the permissible level of 10 mg per kg of tuber weight at the end of storage period.

#### **LONG-TERM STORAGE (3 TO 9 MONTHS) METHODS FOR POTATOES**

Large-scale potato storage at 10-12°C with CIPC treatment (in commercial cold stores): Standardization of this storage technique was carried out at CPRI by using different

storage temperatures and doses of CIPC. Evaluation and suitability for Indian potato varieties for short-term and long-term storage were tested. It was then recommended that potatoes meant for processing can be stored for a maximum period of 6 months at 10-12°C (85-90 per cent RH) with two fogging applications of CIPC. In order to come up with the most effective and minimum possible use of CIPC, trials were conducted at small and large scales. It was found that potato treatment with CIPC formulation [usually available in the form of 50 per cent ai of CIPC (w/v)] need to be applied 35 ml per tonne on stored potatoes, either once or twice depending up on the duration for which the storage is required. This dose of CIPC was also tested and evaluated on the potatoes stored in different commercial cold stores located in Northern and Central India. In contrast to the storage at 2-4°C, the accumulation of sugars in potatoes is minimum at storage temperature of 10-12°C. Processing quality of potatoes stored through this technique yielded acceptable results. By this technology, harvested potatoes can be stored and supplied to the processing industry for 3-6 months. In view of its beneficial effects, this approach is now becoming popular among the farmers, suppliers, stockists and multinational companies.

Improved version of large-scale potato storage at 10-12°C with CIPC treatment and regulated level of CO<sub>2</sub> (in commercial cold stores): In a recent development as an outcome of a joint study by CPRI, Shimla and Central Scientific Instruments Organization (CSIO), Chandigarh, it has now been demonstrated that potatoes can be stored even up to 9 months without much effect on their processing quality. The technique made use of continuous

measurements and automatic setting of temperature, humidity and CO<sub>2</sub>(carbon dioxide) levels to desired values of 10-12°C, 85-90 per cent and less than 0.5 per cent (equivalent to 5,000 ppm), respectively throughout the storage period along with the use of CIPC treatment twice. This combination not only checked the problem of sweetening and sprouting of potato tubers, but also reduced rotting of potatoes during the period of storage. In comparison to previous methods (as described above), improvement in the duration of storability of potatoes from 3-6 months to about 9 months by this method was primarily due to the maintenance of low level of CO<sub>2</sub> during the period of storage.

### **SPREAD AND IMPACT OF DIFFERENT POTATO STORAGE METHODS ACROSS THE COUNTRY**

Non-refrigerated traditional storage methods for potato storage are preferred by farmers as they are highly cost-effective and help in extending the time period for marketing. In view of the higher storage temperatures (21 to 32 °C with RH ranges from 51 to 95 per cent), potatoes stored in heap and pit have low levels of sugars, and this makes them suitable for processing. Today, thousands of tonnes of potatoes are being stored by these on-farm methods in states like Punjab, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra and Karnataka.

Storage of potatoes at 10-12°C is being profitably used by farmers, cold store owners and traders not only for processing potatoes, but also for table potatoes (as these potatoes get higher price in the market due to their better taste). In the year 2006, 168 cold stores adopted and practiced the technology of storing potatoes at 10-12°C with CIPC

treatment, and around 0.2395 million tonnes of potatoes were stored. Due to the beneficial aspects of this technology, a quantum jump was noticed in the adoption of this technology. This is evident from the fact that in the year 2011, 390 cold stores practiced this technology for storing 1.065 million tonnes of potatoes at 10-12°C with CIPC treatment. By regulating the level of CO<sub>2</sub> during the period of storage, further improvement in the above technology was achieved. After getting convinced with demonstration, cold storage operators and owners have agreed to use the latest storage technology (large-scale potato storage in cold stores at 10-12 °C with CIPC treatment and regulated level of CO<sub>2</sub>) in six cold storages across the country in states like Gujarat, Uttar Pradesh, West Bengal, Madhya Pradesh and Punjab. Long-term beneficial impact of this technology requires further popularization of this technology.

Potato chips, French fries, potato flakes and Alu Bhujia are the major processed potato products in the country. At present, approximately 2.6 million tonnes of potatoes are now processed in India, and this figure is expected to grow further as this constitutes only around six per cent of the total potato production in India. So India has a vast scope of diverting its potato produce for processing and value-addition. To achieve this, we must have suitable as well as diversified ways of storing the harvested potatoes.

### **SOME RESEARCHABLE ISSUES**

Some research areas that need to be undertaken for further bringing down the problem of postharvest losses in potatoes and thereby improving its utilization are

- To prolong the natural dormancy period of potato from its current

duration of 45 - 60 days to 60 - 90 days or more.

- To breed for varieties having improved processing quality attributes along with the ability of minimum losses during storage. For this, incorporation of traits like lower rate of transpiration and respiration of potato tubers even under ambient storage conditions will be of great practical relevance.
- Development or search for other viable and effective natural sprout suppressants. Efforts in these directions will help and contribute significantly in further improving the postharvest management of potatoes in our country.

### **FUTURE PERSPECTIVES**

In the last one decade, India has made a visible progress not only in the production and productivity of potato, but also in channelizing the surplus potato production into processing and value-addition sector. Availability of different storage options for the harvested potatoes along with their gradual popularization among the farmers have contributed significantly in the above said progress. Proper and timely storage of potatoes has helped our country in sustaining the higher production with economic gains, and also partly in alleviating the adverse effects of gluts and postharvest losses in potato. In future, potato is going to play a major role in contributing towards food security, nutrition, poverty alleviation, environmental conservation and sustainable development. In this context as well, further spread and improvement in different methods of potato storage along with timely availability of suitable storage option to the farmers will bring about a paradigm shift in potato storage and thereby its utilization in our country. ♦

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# Hydroponics Fodder - The Solution for Fodder Scarcity in India

In India, livestock plays an important role in nutritional security, particularly of the small and marginal farmers. India's livestock population is 529.70 million which includes 199.08 million (37.59 per cent) cattle, 105.34 million (19.89 per cent) buffaloes, 71.56 million (13.51 per cent) sheep and 140.54 million (26.54 per cent) goats. The growth rate during the last 56 years (1951-2007) shows increasing trend in cattle (28.19 per cent), buffaloes (142.72 per cent), sheep (83.02 per cent) and goat (197.76 per cent), and the overall growth rate in livestock is 80.91 per cent. The increase in the livestock population along with intensive rearing system has resulted in an increase in demands for feeds and fodder in the country. Feed scarcity has been the main limiting factor in improving the livestock productivity. Land allocation for cultivation of green fodder is limited to only 5 per cent of the gross cropped area; but by 2020, India would require a total 526, 855 and 56 million tons of dry matter, green fodder and concentrates respectively.

The productive and reproductive efficiency of livestock is adversely affected due to the unavailability of good quality green fodder. Besides the unavailability of land for fodder cultivation, scarcity of water or saline water, more labour requirements for cultivation (sowing, earthing up, weeding, harvesting etc.), more

growth time, non-availability of same quality green fodder round the year, requirement of manure and fertilizer and natural calamities are the major constraints for production of green fodder by the livestock farmers. Due to the above constraints of the conventional method of fodder cultivation, hydroponics technology is coming up as an alternative to grow fodder for farm animals. Further, hydroponics technology for fodder production will be very effective for rearing small ruminants (sheep and goats), as these animals have lesser dry matter requirement and are being shifted from extensive to intensive rearing system.

## HYDROPONICS TECHNOLOGY FOR FODDER PRODUCTION

The word hydroponics has been derived from the Greek word 'water working'. Hydro means 'water' and ponics means 'working', and it is a technology of sprouting grains or growing plants without soil, but only with water or nutrient rich solution. However, hydroponics fodder can be well produced with the use of fresh water only, and the use of nutrient rich solution is not obligatory. The added expenses of the nutrient solution also do not justify its use rather than the fresh water, unless there is significant improvement in the feeding value of the hydroponics fodder due to the use of the nutrient solution. The metabolism of the nutrient re-



*Hi-tech greenhouse for production of hydroponics fodder*



*Low cost shade net wooden greenhouse for production of hydroponics fodder*

serves of the seeds is enough to fuel the growth of the fodder plants for a short duration. The water used for sprouting of grains should be clean and free from chemical agents, as the major source of microbial contamination is water. Fodder crops produced by hydroponics technology are also known as hydroponics fodder, sprouted fodder or sprouted grain. Sprouting of the grains is done inside a greenhouse within a short period of approximately seven days. A greenhouse is a framed or inflated structure covered with a transparent or translucent material in which the crops could be grown under the conditions at least partially controlled environment and which is large enough to permit a person to work within it to carry out cultural operations.

Earlier, it was perceived that hydroponics fodder can only be grown in hi-tech greenhouses, which is very much costly. The hi-tech hydroponics fodder production unit of ICAR Research Complex for Goa, Old Goa is being visited by many farmers and officials from all over the country. Although, the production of fodder by the hydroponics

technology is impressive; but the only constraint was the high cost of the structure, and hence there was a need for a low cost device to produce hydroponics fodder. Finally, ICAR Research Complex for Goa, Old Goa and Govind Milk and Milk Products Pvt. Ltd., Phaltan, Satara, Maharashtra, played major roles in facilitating the farmers of the Satara district of Maharashtra in developing low cost devices (greenhouses) for production of hydroponics fodder.

(i) Hi-tech greenhouse: This type of greenhouse is highly advanced, fully automatic and costly. The requirement for water, light, temperature and humidity is maintained by water fogging or sprinkling and tube lights, controlled automatically through the sensors of the control unit. To save water, provision for recycling of water is made inside the greenhouse with water tank and pump facility. Hi-tech greenhouse may be with or without air conditioner. Even if manufactured in India, the cost of a hi-tech greenhouse without air conditioner and with daily production potential of about 600 kg hydroponics maize fodder is approximately Rs. 15 lakhs.

Although all types of fodder crops can be grown in hi-tech greenhouses, the routine operational cost is more, particularly for growing rabi type of crops (barley, oat, wheat etc.) due to requirement of air conditioner in the hydroponics system to maintain cold and dry environment.

(ii) Low cost device: Hydroponics fodder can be produced in low cost device 'shade net structure (greenhouse)'. The cost of this type of structure depends upon the type of construction material; but is significantly lower than the hi-tech greenhouse. The shade net structure can be constructed with bamboo or wood or MS or GI pipes or brick masonry. The existing wall of a house can also be used to construct lean-to-shade net greenhouse, which reduces the cost of fabrication. The irrigation of the hydroponics fodder can be by micro-sprinklers (manual or automatic) or a knapsack sprayer at frequent intervals. In shade net structure, the internal environment of the greenhouse is more influenced by the outside climatic condition and therefore, the types of fodder to be grown hydroponically depends upon the season and climatic condition of the locality. About 17 farmers of the Satara district of Maharashtra are producing hydroponics fodder by different types of low cost shade net greenhouse and feeding to their dairy animals. Besides, about 10 farmers have taken initiation for producing hydroponics fodder by low cost shade net greenhouse. The cost of the wooden shade net greenhouse with daily production potential of about 30-350 kg fresh hydroponics fodder was approximately Rs. 6000-50000/-; while the cost of the MS shade net greenhouse with daily production potential of about 150-750 kg fresh hydroponics fodder was approximately Rs. 25000-



150000/-.

Different types of fodders viz., maize, wheat, cowpea, etc. can be grown by hydroponics technology. However, the choice of grain for hydroponics technology depends up on the geographical and agro-climatic conditions and easy availability of seeds. In India, maize should be the choice grain for production of hydroponics fodder due to its easy availability, lower cost, good biomass production and quick growing habit. The grains should be clean, sound, undamaged or not insect infested, untreated, viable and of good quality. For the production of hydroponics fodder, seeds are soaked in normal water for 4-24 hours, depending upon the type of seeds followed by draining and placing it in individual greenhouse trays for growing inside the greenhouse. For maize, 4 hours soaking in normal water is sufficient. The seed rate (quantity of seeds loaded per unit

surface area) also affects the yield of the hydroponics fodder, which varies with the type of seeds. Hydroponics maize fodder can be well produced with seed rate of 6.4-7.6 kg/m<sup>2</sup>. If seed density is high, there is more chance for microbial contamination in the root mat, which affects the growth of the fodder. The starting of germination and visibility of roots varies with the type of seeds. In case of maize and cowpea seeds, germination start about second and first day, and the roots were clearly visible from third and second day onwards, respectively. Maintenance of cleanliness and hygiene is very much important in the production of hydroponics fodder, as greenhouse is highly susceptible to microbial contamination, particularly of mould growth due to high humidity. Inside the greenhouse, generally the grains are allowed to sprout for seven days, and on day eight, these are fed to the dairy animals.

#### **ADVANTAGES OF HYDROPONICS TECHNOLOGY**

The major limitations in the conventional method of fodder cultivations are overcome by the hydroponics technology. Less land is required as the vertical growing process allows the production of large volume of hydroponics fodder on a fraction of the area required by conventional cultivation, and thus there is high yield in small area with increase in stocking capacity. Under hydroponics technology, about 600 kg maize fodder can be produced daily in seven days only in 50 sq. m. area. It is estimated that to produce the same amount of fodder, about one hectare land is required. Water requirement in hydroponics technology is very less, as water can be applied and re-applied continuously. To produce one kg of fresh hydroponics maize fodder (7-d), about one litre (if water is reused) to three (if water is not reused) liters of water is required against about 30 liters of

water per kg of fresh green fodder grown in laterite soil under conventional practices. However, if water is not reused, the regular drained water of the hydroponics system can be used in a garden near to the unit. Only one person is sufficient to work in the hydroponics system to produce 600 kg of hydroponics maize fodder daily. Besides, there is no need for costly soil preparation for fodder production, constant weed removal, fencing etc. There is no post-harvest loss of fodder as seen in the conventional practices as the hydroponics fodder can be produced as per the daily requirement. There are added advantages of round the year similar high quality fodder supply to the farm, which are free from antibiotics, hormones, pesticides, or herbicides. Besides, in this technology, there is no need of fuel for harvesting and post harvesting processes and no damage from insects or roaming animals, etc., leading to low maintenance requirement. The electricity requirement for the production of hydroponics fodder is lower than the conventional fodder. In hi-tech greenhouse, about 8-16 units of electricity is required to produce 600 kg of hydroponics maize fodder daily, which can be reduced significantly in low cost shade net structure.

#### **YIELD AND FEEDING VALUE OF THE HYDROPONICS FODDER**

There is increase in fresh weight and decrease in the dry matter content during sprouting of seeds. Yields of 5-6 folds on fresh basis (1 kg seed produces 5-6 kg fodder) and dry matter content of 11-14 per cent are common for hydroponics maize fodder; however, sometimes dry matter content up to 18 per cent has also been observed. Farmers of the Satara district of Maharashtra revealed fresh yield up to 8-10 folds for hydroponics maize fodder in shade-net green-

house system. The yield and dry matter content are influenced by many factors, mostly the type and quality of the seed; degree of drainage of free water prior to weighing, and clean and hygienic condition of the greenhouse. The hydroponics maize fodder looks like a mat of 20-30cm height consisting of germinated seeds embedded in their white roots and green shoots. In Goa condition with hi-tech greenhouse, the cost of production of fresh hydroponics maize fodder is about Rs. 4-4.50 per kg, in which the seed cost, constitutes about 98 per cent. However, farmers of the Satara district of Maharashtra revealed that in low cost shade net system with home-grown or locally purchased seeds, the cost of production of the hydroponics fodder is very minimal and reasonable (about Rs.2-3.50).

The hydroponics fodder is more nutritious than the conventional fodder. The nutrient changes during the growth (sprouting) of hydroponics fodder are increase in the crude protein (CP), ether extract (EE), nitrogen free extract (NFE) and decrease in crude fibre (CF), total ash (TA) and insoluble ash (AIA).

Besides, hydroponics fodder has more potential health benefits. Sprouts are the most enzyme rich food on the planet and the period of greatest enzyme activity is generally between germination and 7 days of age. They are rich source of antioxidants in the form of  $\beta$ -carotene, vitamin-C, E and related trace minerals such as selenium and zinc. As sprouted grains are rich in enzymes, and enzyme-rich feeds are generally alkaline in nature, feeding of the sprouted grains improve the animals' productivity by developing a stronger immune system due to neutralization of the acidic condition. Besides, helping in the elimination of the anti-nutritional factors such as phytic acid of the grains; sprouted grains are good

sources of chlorophyll and contain a grass juice factor that improves the performance of the livestock. However, the energy content is decreased during sprouting as the stored energy inside the grain is used and dissipated during the process.

Hydroponics fodders have good palatability. The germinated seeds embedded in the root system are also consumed along with the shoots of the plants, so there is no nutrient wasting. The intake of fresh hydroponics maize fodder by dairy cows may be up to 25 kg/ animal/ day along with limited concentrate mixture and jowar straw. Supplementation of the hydroponics fodder in the ration of the dairy cows improves digestibility of nutrients in dairy cows.

There are reports of increase in milk yield of 7.8 per cent and 9.3 per cent (FCM yield); 12.5per cent and 13.73per cent due to feeding of hydroponics fodder to lactating cows. The feedback from the farmers of the Satara district of Maharashtra revealed increase in the milk yield by 0.5-2.5 litres per animal per day and net profit by Rs. 25-50/- per animal per day due to feeding of hydroponics fodder to their dairy animals. Besides, other advantages observed by the farmers were increase in fat and SNF content of the milk, improvement in health and conception rate of the dairy animals, reduction in cattle feed requirement by 25 per cent, increase in taste (sweetness) of the milk, whiter milk, reduction in labour cost, requirement of less space and water, freshness and high palatability of the hydroponics fodder etc.

Hydroponics fodder is nutritious, palatable and digestible and can be grown in low cost devices with locally home grown grains. Hydroponics fodder is the solution for fodder scarcity and is a very promising technology for sustainable livestock production in different regions of India. ♦



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# Traceability in Fisheries Trade

**G**lobal fish trade has crossed 125 billion in 2011, a rise of 6 per cent over the previous year and 197 countries reported export of fish and fishery products (FAO 2012). Though India does not figure among the top ten seafood exporting countries in the world, the export earnings have substantially increased over the past decade to Rs.18856 crores in 2012-13. While in rupee term, the increase was over 13 per cent, it was more due to the devaluation of rupee against dollar than actual increase in foreign exchange earnings. Despite 7.68 per cent increase in quantity of fish export, increase in export earnings in dollars was only 0.1 per cent over the previous year (2010-11). The stagnation in the value realization out of the exports is due, along with many factors, to the inability of many of our exporters to comply with specifications and guidelines required to trade in the EU, Japan and the US markets. Traceability requirements are going to be very important deciding factors of our export performance in future years. Small countries like Vietnam, Thailand and Norway with much less water resources have out-performed India in export performance in recent years (FAO 2012). European council's regulation number 1224/2009 established a community control system for ensuring compliance with common fisheries policy and has come in to force since 2010. It has become mandatory for the European fish importers to ensure that each lot is traceable

at all stages of production processing and distribution from catching or harvesting till consumption. In order to collect history of the product, the European buyer's specifications require details on harvesting, preprocessing and processing. In case of aquaculture products, the documentation requirement goes till the pond level and, in the case of the captured fish, it goes till the boat level.

## WHAT IS TRACEABILITY IN INTERNATIONAL TRADE?

Traceability is the ability to follow the movement of food throughout the supply chain from farm to fork. With the growing awareness among the consumers about their rights, it has become imperative for the suppliers to provide information. It is therefore necessary for the supply chain managers to know the history of the product by tracing and to know the current location of the product by tracking. Though ensuring the traceability can involve complex biochemical, electronic and genetic methods, International organization for standardization (ISO) had relied only on recorded information. ISO defines traceability as our ability to trace the history, application and location of an entity by means of recorded identification. (ISO 1994). However, recent modification to the same definition under the ambit of food safety management system puts traceability as ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution (ISO-22005:2007, 2007). Traceability requirement is gradually becoming binding on supply chain management of all food that are traded, more so in those traded beyond sovereign boundary. Fish and fish products being most traded commodity in the world, traceability is a very important consideration. Further, the risks associated with fish and fishery products are far greater than those associated with other animal and plant based products.



## NEED FOR A FISH TRACEABILITY SYSTEM

The safety concerns are the most important



driving forces for the traceability requirements. Fish is an extremely perishable food product and needs quick and efficient handling to maintain its quality. The pathogenic and spoilage organisms can grow very rapidly in fish because of the near neutral pH, high protein and non-protein nitrogenous compounds and high water content. These organisms, contaminating the food at any stage of the supply chain i.e., production, processing, storage, transportation and retailing, can proliferate very fast affecting the quality and safety. A proper tracing and tracking system can indicate points of the microbial hazard incorporation, hazard amplification and help devising means to eliminate these hazards. Physical and chemical hazards also can find entry into foods at some point of supply chain. Water being ultimate disposing ground for all toxic wastes from industry, agricultural fields and from other human activities such as marine transportation, oil exploration etc, challenges to contain the risk associated with aquatic food are enormous. Ultimately, when the

food reaches the consumer, after passing through any contamination point, may carry significant levels of hazards and may pose risk.

The incorrect declaration with respect to the source, content or the date of processing, amounts to commercial fraud and thus requires tracing the history of food. Fish caught in one country are reprocessed in another country and traded either under a disguised declaration or a wrong declaration. Traceability is also aimed to reduce this kind of improper practice. The traceability is also an outcome of the efforts to build better consumer confidence in the products. In addition to the concerns related to fraud and risks, the food can be used for bioterrorism. The foods, both aquatic and terrestrial, can be used as vehicles for transmitting serious pathogens.



Food Traceability Systems (FTSs) is the result of attempts to address the above listed concerns.

### TRACEABILITY METHODS

There are many traceability methods used in the food industry ranging from an alphanumeric code to radio frequency identification (RFID) code, a few of which are discussed here. Alphanumeric codes are a series of different numbers and letters that are attached to the packaging of the product. These codes carry location indicator, processing pattern and sources. European article number (EAN) system is a 13 digit barcode on consumer packages. The organization can develop a 13 digit barcode designating 3 digits for a country, 5 digits for a company, 4 digit for a product and a single digit as running digit to give its sequence. India is designated by a country code of "890" by this system. Bar codes carry the information about the product and is encoded in the form of vertical bars. Encoded information is read by the machine. This helps in information collection and storage. The bar code system is less popular in the food industry compared to their use in retail sector for being less precise and carrying less information in encrypted form. Radio-frequency identification (RFID) uses wireless microchips to trace a product through the supply chain and automatically record its movement. The RFID tags are machine created and are not ordinarily affected by human interference. The tag's information is stored electronically in a non-volatile memory and work on the principle of transmission and reception of radio frequency. Seafood containers and packets are usually coded by one of these methods and are tracked during their transporta-



tion and retailing.

**BENEFITS OF TRACEABILITY**

Traceability practices have helped tracing and tracking the product and has become an integral part of the logistics management. The traceability helps in increase in customer satisfaction because of transparency involved, by default, by providing adequate information to consumers. Simultaneously, it helps to track unsafe products and help recall process. While complying with the traceability requirements, each link in the supply chain becomes more accountable, transparent and also legally answerable. The process also helps in mitigating crises and allow acceptance of reasonable risk. Ability to avoid crises can also help in protecting brand names. On the whole, the traceability improves the supply chain management by improving transparent communication among the links in the supply chain. Further, a good record keeping ensures competence development in quicker processing and disposal leading to supply of better quality product to

the consumers. It is also foreseen that effective traceability systems in fishery trade may minimize losses in the supply chain and may contribute to fishery sustainability.

**STATUS OF TRACEABILITY RELATED STANDARDS AND THEIR IMPLEMENTATION IN SEAFOOD SECTOR**

At present, many processors are complying with the documentation required for traceability. It is easier to trace the aquacultured products than the captured products to their origin. This is because the multispecies nature of our seas offer fragmented catch of many species in a single haul compared to the captures in temperate waters. This makes documenting, segregating and ensuring transparency very difficult. Marine Products Export Development Authority (MPEDA) has brought in many changes in the catch certification methods to ensure traceability. International organization for standardization has already developed standards for

traceability of finfish product. The new standard ISO 12875:2011: Traceability of finfish products – Specification on the information to be recorded in captured finfish distribution chains, specifies the information to be recorded in marine-captured finfish supply chains in order to establish traceability, was adopted in 2011. Currently, ISO technical committee 234 is also developing standards for shellfish products. To implement the traceability requirements at present, it has become binding on the fishing vessels to record the fish catch details in terms of its location and volume. They have been mandatorily recording catch details in the fishing log. The data on the vessel, location of catch, place of preprocessing and processing are encoded and are part of the data on packages and documents that are used for transportation and trading. This is not a small target to achieve. A high degree of traceability in fishery products may need upgradation of our landing centres, vessels and data collection systems. ♦

*Future outlook*

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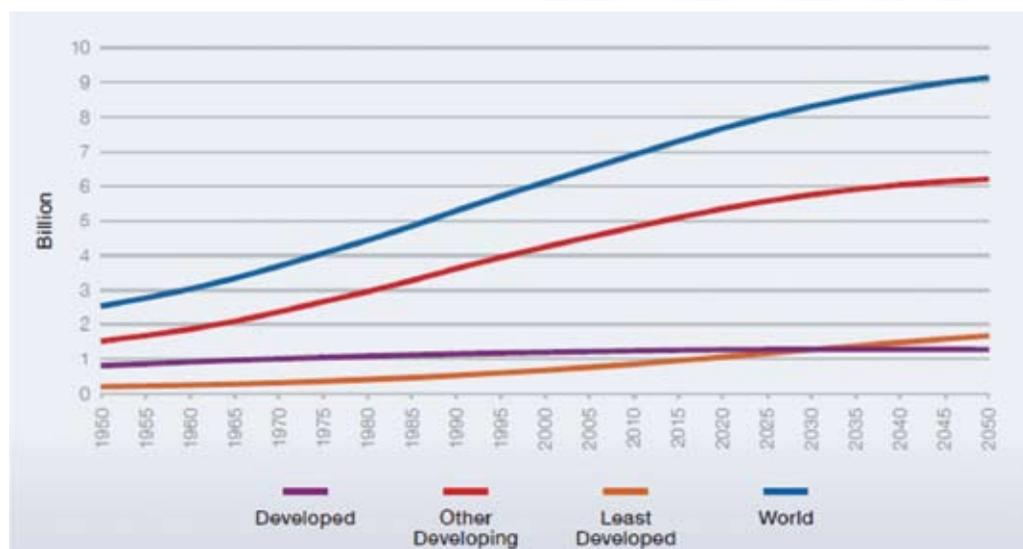
## India's food production towards 2050 - Challenges, opportunities and strategies

**W**orldwide, agriculture suffers from a daunting task of producing sufficient food to meet its growing demand. Agricultural productivity across countries is not increasing consistently or rapidly to meet the food demand by 2050 posed by multiple challenges like population growth, diet preferences, climatic vulnerability, farmland degradation and diverse products. Globally, a fall in food production will push millions of people into hunger. Foodgrains production across countries is already facing stress from credit crunch, and hence the production must be doubled by 2050 to prevent mass hunger. Literature quotes that a substantial quantity of food items is required in absolute terms to feed the burgeoning population, despite several production challenges. For instance, in view of degrading farm land, FAO projects that farmers have to produce 70 per cent additional food by 2050 to meet an estimated world population of nine billion. This accounts for about one billion tonnes additional rice, wheat and other cereals. To meet this projected demand, world cereal production has to reach 3 billion tonnes.

The world population, by 2050, is expected to reach 9.6 billion from an estimated 8.1 billion

in 2025, and 7.2 billion currently. Significant increase in population poses the challenge of meeting global food demand. A significant share of world food production comes from the developing countries like China and India. However, developing world have the toughest challenge of matching the demand for and supply of food. Preponderantly, demand arises from the rate of population growth and supply from the crop production. Since the population growth rate is expected to be more in the developing world in comparison to developed world coupled with land scarcity for crop cultivation, increasing productivity is the only viable option to meet the estimated food demand.

Agriculture has been a way of life in India, and is one of the key sectors of Indian economy, in spite of significant fall in GDP share. It caters to the food and nutritional demand of 1.24 billion



Source: UN Population Division, adapted from van der Mensbrugge *et al.* (2009)

people, and continues to be the foremost livelihood of rural masses. Given the production challenges, changes in consumption pattern and an estimated food demand of 405 million tonnes by 2050, a major technological breakthrough to increase the existing productivity of food crops is of extreme importance since yield level of major food crops is reaching their plateau. Indian agriculture at a glance explicitly shows that technological interventions, for instance, wide spread of semi-dwarf varieties replacing tall wheat varieties, System of Rice Intensification (SRI) and recently, National Food Security Mission (NFSM) led to increased growth rate in agriculture and expanding food supplies. Food and nutrition security being the national interest, an attempt has been made to answer strategically the ways and means of increasing the productivity level of major food crops in India.

#### Profile of area, production and productivity of food grains across countries

Irrespective of commodities, India's growth during the past five decades has been commendable. Barring area under coarse grains and pulses, none of the commodities showed a negative growth or high instability, in terms of area, production and productivity. India finds a secured place in the positive growth coupled with less instability quadrant in growth-instability matrix analysis. Among food crops, performance of wheat excelled others. The rate of growth in area, production and productivity was estimated at 1.54 per cent, 4.34 per cent and 2.77 per cent respectively. The main reason was introduction and spread of high yielding genotypes that emerged as a green revolution in the country. The most interesting feature of wheat is that all the parameter values

#### Growth and instability in selected food grains (triennium ending 1963 to 2011)

Commodity	Country/ Country Group	Area		Production		Productivity	
		Growth (per cent)	Instability (per cent)	Growth (per cent)	Instability (per cent)	Growth (per cent)	Instability (per cent)
Rice	Bangladesh	0.32	2.80	2.48	12.21	2.15	10.19
	China	-0.23	6.95	1.82	10.11	2.06	6.42
	India	0.47	2.23	2.42	5.37	1.95	4.32
	Pakistan	1.48	4.53	2.93	10.53	1.43	8.05
	World	0.49	2.21	2.23	2.50	1.73	2.52
	Africa	2.49	6.38	3.20	12.32	0.69	4.18
	Americas	0.13	12.09	2.36	4.18	2.23	9.61
	Asia	0.43	1.92	2.21	2.81	1.77	2.85
	Eastern Asia	-0.32	6.20	1.47	9.28	1.81	5.66
	Southern Asia	0.50	1.80	2.44	4.53	1.93	3.96
	South-Eastern Asia	1.02	2.98	3.12	7.32	2.08	2.89
	Western Asia	0.94	17.76	1.46	24.70	0.53	19.32
	Europe	-0.28	25.80	0.76	20.69	1.05	6.45
Wheat	Bangladesh	5.37	37.56	8.11	43.60	2.61	18.67
	China	-0.06	9.54	3.83	15.09	3.90	5.88
	India	1.54	6.35	4.34	5.88	2.77	5.33
	Pakistan	1.18	3.77	3.71	3.88	2.50	2.98
	World	-0.01	3.30	2.00	5.16	2.00	3.19
	Africa	0.26	6.26	2.78	11.43	2.50	7.20
	Americas	-0.01	11.51	1.24	11.69	1.25	3.88
	Asia	1.13	4.87	3.83	6.26	2.67	5.88
	Eastern Asia	-0.10	9.38	3.72	14.95	3.82	5.84
	Southern Asia	1.29	4.89	3.93	3.47	2.61	3.04
	South-Eastern Asia	0.87	23.15	3.18	35.06	2.35	25.00
	Western Asia	0.44	5.72	2.30	8.43	1.85	6.31
	Europe	-1.41	6.51	0.88	8.24	2.32	4.20
Maize	Bangladesh	6.68	165.13	11.06	195.53	4.03	66.62
	China	1.39	6.70	4.43	9.40	3.00	6.61
	India	0.86	7.14	2.80	18.10	1.93	9.48
	Pakistan	1.51	3.93	3.80	31.66	2.25	26.32
	World	0.77	2.69	2.73	6.93	1.94	3.13
	Africa	1.39	5.77	2.51	8.81	1.10	6.50
	Americas	0.54	3.48	2.53	7.98	1.98	5.00
	Asia	1.17	4.48	4.06	10.65	2.85	3.65
	Eastern Asia	1.34	6.39	4.30	8.74	2.92	6.86
	Southern Asia	0.92	5.98	2.83	21.32	1.90	12.28
	South-Eastern Asia	0.92	7.10	3.95	16.61	3.01	13.07
	Western Asia	0.83	9.10	3.97	18.44	3.11	13.22
	Europe	-0.32	5.90	1.51	8.84	1.83	5.80

<b>Coarse Grains</b>	Bangladesh	0.50	29.60	3.84	120.83	3.30	75.52
	China	-0.41	7.74	2.95	7.21	3.37	5.06
	India	-1.23	4.18	0.80	5.93	2.06	8.29
	Pakistan	-0.26	3.18	2.15	22.70	2.43	22.41
	World	-0.17	2.77	1.66	4.50	1.83	3.25
	Africa	1.35	6.73	2.19	8.05	0.83	5.20
	Americas	-0.12	3.89	1.91	6.74	2.03	5.01
	Asia	-0.44	2.51	2.41	6.70	2.87	5.69
	Eastern Asia	-0.50	7.65	2.72	6.77	3.24	5.07
	Southern Asia	-1.04	4.01	1.10	6.74	2.16	9.78
	South-Eastern Asia	0.99	6.68	3.95	16.24	2.93	12.33
	Western Asia	0.23	8.85	1.71	8.62	1.47	6.09
	Europe	-1.20	11.19	0.49	12.05	1.70	4.74
<b>Pulses</b>	Bangladesh	-0.60	33.90	-0.23	29.34	0.37	6.41
	China	-2.53	16.09	-1.32	14.45	1.24	5.65
	India	-0.06	4.15	0.70	5.75	0.76	5.57
	Pakistan	-0.24	6.16	0.23	9.43	0.46	7.81
	World	0.23	4.14	0.98	5.65	0.75	2.84
	Africa	1.95	11.47	2.39	12.81	0.43	7.21
	Americas	0.84	3.98	2.23	11.59	1.38	12.36
	Asia	-0.07	3.41	0.58	5.70	0.65	3.28
	Eastern Asia	-2.38	15.03	-1.25	13.33	1.15	5.49
	Southern Asia	0.02	3.90	0.74	5.15	0.73	4.79
	South-Eastern Asia	3.08	15.87	4.08	29.94	0.97	10.65
	Western Asia	1.88	28.07	2.18	22.05	0.30	8.79
	Europe	-3.14	17.84	-0.79	23.85	2.43	11.24

<b>Growth and instability matrix in rice (triennium ending 1963 to 2011)</b>		
<b>Growth</b>	<b>Instability</b>	
	Low (<6)	High (>6)
AREA		
Negative	--	China, Eastern Asia and Europe
Positive	Bangladesh, India, Pakistan, World, Asia, Southern Asia and South-Eastern Asia	Africa, Americas and Western Asia
PRODUCTION	Low (<14)	High (>14)
Negative	--	--
Positive	Bangladesh, China, India, Pakistan, World, Africa, Americas, Asia, Eastern Asia, Southern Asia and Southern-Eastern Asia	Western Asia and Europe
PRODUCTIVITY	Low (<10)	High (>10)
Negative	--	--
Positive	China, India, Pakistan, World, Africa, Americas, Asia, Eastern Asia, Southern Asia, South-Eastern Asia and Europe	Bangladesh and Western Asia

Note: Instability slab was fixed based on the average value in the respective parameter

were found within the safer limits in growth-instability matrix. Further, among the selected developing countries, India consistently appears in the safe quadrant of growth-instability matrix. It is one of the indicators that the future demand for food can be met with appropriate production technologies with respect to food crops by utilising the country's maximum potential in crop production. However, it needs a synergy between scientific research, technology development and extension programmes.

### **VISION 2050 VIS-À-VIS PRODUCTION TARGETS**

Food production target has been set by the crop institutes under the aegis of Indian Council of Agricultural Research (ICAR), New Delhi. According to which, rice has the highest production target (132-162 mt) owing to its primary consumption followed by wheat (120 mt), the cheapest source of calorie intake. To reach this attainable target, productivity level has to be increased irrespective of crops.

### **SWOT ANALYSIS**

India by its geographical location is much suitable for producing all types of crops. Yet, in order to achieve the production target of food grains set for 2050, it is mandatory to perform a SWOT analysis of the agricultural research system in India.

### **STRENGTHS (WITHIN SYSTEM THAT HELP TO ACHIEVE THE SET TARGET)**

- Strong support to devise novel research and development programmes from the parental organisation - Indian Council of Agricultural Research (ICAR), New Delhi.
- Availability of huge collection of germplasm and possibility for

Growth and instability matrix in wheat (triennium ending 1963 to 2011)		
Growth	Instability	
	Low (<10)	High (>10)
AREA		
Negative	China, World, Eastern Asia and Europe	Americas
Positive	India, Pakistan, Africa, Asia, Southern Asia, Western Asia	Bangladesh and South-Eastern Asia
PRODUCTION	Low (<13)	High (>13)
Negative	--	--
Positive	India, Pakistan, World, Africa, Americas, Asia, Southern Asia, Western Asia and Europe	Bangladesh, China, Eastern Asia and South-Eastern Asia
PRODUCTIVITY	Low (<7)	High (>7)
Negative	--	--
Positive	China, India, Pakistan, World, Americas, Asia, Eastern Asia, Southern Asia, Western Asia and Europe	Bangladesh, Africa and South-Eastern Asia

Note: Instability slab was fixed based on the average value in the respective parameter

Growth and instability matrix in maize (triennium ending 1963 to 2011)		
Growth	Instability	
	Low (<17)	High (>17)
AREA		
Negative	Europe	--
Positive	China, India, Pakistan, World, Africa, Americas, Asia, Eastern Asia, Southern Asia, South-Eastern Asia and Western Asia	Bangladesh
PRODUCTION	Low (<27)	High (>27)
Negative	--	--
Positive	China, India, World, Africa, Americas, Asia, Eastern Asia, South-Eastern Asia, Southern Asia, Western Asia and Europe	Bangladesh and Pakistan
PRODUCTIVITY	Low (<13)	High (>13)
Negative	--	--
Positive	China, India, World, Africa, Americas, Asia, Eastern Asia, Southern Asia, Europe	Bangladesh, Pakistan, South-Eastern Asia and Western Asia

Note: Instability slab was fixed based on the average value in the respective parameter

North-Eastern India that have tremendous potential for raising the productivity level.

- Prevalence of huge domestic and international demand for value added and diverse food products owing to change in food consumption pattern and dietary preferences.
- Easy access to recent biotechnological and bio-informatics tools to augment the crop productivity coupled with opportunities for outsourcing high throughput marker analysis.
- Export advantage (shipping) as per the geographical location of the country.

**Threats (outside the system that hinders in achieving the set target)**

- Burgeoning population growth rate adds more pressure to the existing food production.
- Climatic vulnerability which poses a huge threat to crop production.
- Declining soil health owing to intensive use of fertilizers and plant protection chemicals.
- Emergence of a range of new pests and diseases.
- Exploitation of irrigation water leading to decline in water table.
- Strong intellectual property rights which opts for patent regulated genetic flow.
- Volatility in agricultural commodity prices across countries hinders the healthy trade flow across nations. In consequence, government has to take contingent policies pertaining to export and import of commodities.
- Fragmentation of farm land owing to nuclear family system, and decline in cultivable area due to urbanization.

**FUTURISTIC RESEARCH OUTLOOK**

- utilising its genetic diversity.
- Eminent breeders across all crop institutes to develop a suitable variety, better apt for diverse agro-climatic zones.
- International linkages for knowledge and resource sharing.
- Multitude of extension personnel within the system to carry successful technologies from lab to field.
- central to state governments.
- Lack of commercialization due to poor linkage between public and private sector.
- Opportunities (outside the system that help to achieve the set target)**
- Despite technological breakthroughs, yield gaps still prevalent across regions, giving a huge scope for increasing the country's food production.
- To target low productivity states like Bihar and regions like western Uttar Pradesh and

**Weaknesses (within system that affect in achieving the set target)**

- Passive technology transfer from

<b>Growth and instability matrix in Coarse Grains (triennium ending 1963 to 2011)</b>		
<b>Growth</b>	<b>Instability</b>	
	Low (<7)	High (>7)
AREA		
Negative	India, Pakistan, World, Americas, Asia, Southern Asia and South-Eastern Asia	China, Eastern Asia and Europe
Positive	Africa	Bangladesh and Western Asia
PRODUCTION	Low (<17)	High (>17)
Negative	--	--
Positive	China, India, World, Africa, Americas, Asia, Eastern Asia, South-Eastern Asia, Southern Asia, Western Asia and Europe	Bangladesh and Pakistan
PRODUCTIVITY	Low (<12)	High (>12)
Negative	--	--
Positive	China, India, World, Africa, Americas, Asia, Eastern Asia, Southern Asia, Western Asia and Europe	Bangladesh, Pakistan and South-Eastern Asia

Note: Instability slab was fixed based on the average value in the respective parameter

The issue in the recent past is that acreage and productivity of major food crops has already struck a plateau. Increasing crop acreage is directly beyond the control of research managers in ICAR, whereas, productivity can be increased by regular technological interventions. By increased productivity, profitability will rise and thereby the crop invites more acreage. With the current area under each food crops, the yield levels have to be increased substantially to meet the set production target. To get the desired target of 133-162 mt of rice, with the current acreage under the crop, yield has to be increased from 2462 kg/ha to 3136-3820 kg/ha. Similarly, for wheat, the estimated incremental yield stood at 928 kg/ha. For maize, it is 4910 kg/ha; for pulses, it is 1344 kg/ha; and for foodgrains, it is 1246 kg/ha.

A massive yield increase as observed during 1960s owing to the spread of high yielding semi-dwarf genotypes in the form of green revolution seems impossible now. However, a pragmatic approach can be followed to reach the estimated additional productivity of crops gradually and

consistently. The following section presents the thrust areas for research and strategic planning to reach the set target for each commodity (adapted from the respective Vision 2050 document). Further, irrespective of crops, bridging yield gaps by reducing the gap between scientific knowledge and technology, and bridging the gap between technology and adoption will pave way for targeted output.

#### RICE

- Redesigning the crop with more photosynthetic efficiency,

biomass and harvest index to enhance genetic yield potential.

- Stabilizing the productivity by improving the resistance against biotic and abiotic stresses and using high quality seed.
- Increasing the crop yield by enhancing the productivity of irrigation water.
- Increasing yield by improving input use efficiency through precision nutrient management.
- Selective mechanization to reduce drudgery and improve profitability.
- Development of C4 rice for better yield with less usage of water.
- Designing the crop with biological nitrogen fixation ability for additional yield.
- Pre-breeding for broadening the genetic base to enhance yield, duality and stress tolerance.

#### WHEAT

- Promoting novel wheat breeding programmes like adopting doubled haploids to save time, and integrating conventional breeding and biotechnological tools.
- Trait focus on wheat productivity, rust resistance, second tier diseases, quality, input use

<b>Growth and instability matrix in Pulses (triennium ending 1963 to 2011)</b>		
<b>Growth</b>	<b>Instability</b>	
	Low (<12)	High (>12)
AREA		
Negative	India, Pakistan and Asia	Bangladesh, China, Eastern Asia and Europe
Positive	World, Africa, Americas and South-Eastern Asia	South-Eastern Asia and Western Asia
PRODUCTION	Low (<14)	High (>14)
Negative	Eastern Asia	Bangladesh and China
Positive	India, Pakistan, World, Africa, Americas, Asia and Southern Asia	South-Eastern Asia, Western Asia and Europe
PRODUCTIVITY	Low (<7)	High (>7)
Negative	--	--
Positive	Bangladesh, China, India, World, Asia, Eastern Asia and Southern Asia	Pakistan, Africa, Americas, South-Eastern Asia, Western Asia and Europe

Note: Instability slab was fixed based on the average value in the respective parameter

**Food production target by 2050**

Commodity (target source)	Production (mt) in 2012-13*	Production target (mt) in 2049-50**
Rice (DRR, Hyderabad)	104.40	133-162
Wheat (DWR, Karnal)	92.46	120
Maize (DMR, New Delhi)	22.23	65
Coarse cereals	40.06	N.A.
Pulses (IIPR, Kanpur)	18.45	50
Foodgrains (NCAP, New Delhi)	255.36	405

Note: \* indicates the 4th Advance Estimates of Directorate of Economics and Statistics, Government of India and \*\* indicates the target set by the respective crop institutes under ICAR.

**Estimated productivity target of foodgrains by 2050**

Commodity	Area (mha) in 2012-13*	Production target (kg/ha) in 2012-13*	Productivity (kg/ha) in 2049-50**
Rice	42.41	2462	3136-3820
Wheat	29.65	3119	4047
Maize	8.71	2553	7463
Coarse cereals	24.64	1626	Not estimated
Pulses	23.47	786	2130
Foodgrains	120.16	2125	3371

Note: \* indicates the 4th Advance Estimates of Directorate of Economics and Statistics, Government of India.

efficiency and abiotic stress tolerance for incremental yield.

- Designing agro-technological packages like site specific nutrient management, Furrow Irrigated Raised Bed System (FIRBS), need based nitrogen application for better yield.
- Special initiatives on integrated pest management, monitoring *Puccinia striiformis* virulence across national borders and Pest Risk Analysis (PRA) for developing quality products to consumers.
- Developing hybrid wheat for incremental yield, and C4 wheat for resource saving.
- Special focus on abiotic stresses in central zone to reduce the yield loss
- Technology promotion through extension and market intelligence
- Developing varieties for specific Resource Conservation Technologies (RCTs).

**MAIZE**

- Exploring basic mechanisms of

development and adaptation to biotic-abiotic stresses.

- Screening germplasm and discovering trait specific novel genes from maize genomes.
- Thoroughly integrating marker assisted selection in breeding schemes.
- Delivering superior single cross hybrids for various segments.
- Inventing a new generation of eco-friendly and biosafe technologies for value chain.
- Developing and popularizing high yielding, profitable and ecologically sustainable maize based farming systems.
- Fostering precision input management for higher productivity and profitability.
- Utilising extension personnel for promoting RCTs for better yield.

**PULSES**

- Development of saturated linkage maps for gene-mining, cloning and mapping.
- Exploitation of wild relatives for gene transfer and utilization of

gene-pool.

- Development of efficient high yielding short duration varieties having multiple and multiracial resistance to pests and diseases.
- Targeting for efficient pulse crops with respect to input usage.
- Exploitation of hybrid vigour potential in pigeon pea.
- Promotion of improved management practices through demonstrations for higher yield.

Undoubtedly, world agriculture faces a looming crisis in view of the future food demand which cannot be met by the existing yield level of food crops. However, the country has enough potential to meet its own food target by 2050 through the synergy between research, developmental and extension programmes. Participatory breeding programmes, blending conventional breeding with biotechnological tools in varietal development, genotypes withstanding biotic and abiotic stresses and devising strategies for efficient use of scarce resources should be the mode for research. Genetic yield potential of food crops should be near reached through scientific management coupled with application of standard package of practices. National developmental programmes like National Food Security Mission (NFSM), Bringing Ever Green Revolution in Eastern India (BEGRI) should emerge more in number to accelerate the growth momentum in agricultural production. Nevertheless, the vast multitude of extension personnel should be used to their potential in taking the successful technologies from lab to land. The above integrated mission mode approach will be the foundation stone to build the nation against food and nutritional insecurity. ♦

**DR. GURBACHAN  
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Chairman, Agricultural  
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## CLIMATE CHANGE AND INDIAN AGRICULTURE ISSUES AND STRATEGIES

**T**he natural resources of soil, water, climate and biodiversity have been over-exploited and over stretched in the past to keep pace of food production with population pressure.

Global warming caused by the anthropogenic emission of green housegases (GHG) has emerged as a serious issue for the future food, nutrition, environment and livelihood security in India. The recent projections are that South Asia may have an increase in temperature from 0.4°C to 2.0°C by 2070. The mean global annual temperatures are reported to have increased between 0.4 to 0.7°C during the last century. The last decade was recorded as the warmest globally, and year 2010 has been reported the warmest since the records are available. It is further predicted that if global warming continued at its present level of GHG emissions, the temperatures may rise up to 1.4 to 5.8°C by the end of this century. Developed economies like US, Russia, UK, South Africa and China etc., are reported to contribute maximum to GHG emissions. Compared to India's reported GHG emissions of 1.18 tonnes/capita/year as in 2008, the emissions in

countries like USA, Russia, UK, South Africa and China are reported at 19.1, 11.2, 8.6, 7.3 and 4.6 tonnes/capita/year respectively. The world average of GHG emissions is reported as 4.38 tonnes/capita/year. These figures indicate that underdeveloped and developing countries like India which contribute minimum to global warming (climate change) suffer maximum in terms of adverse impacts of climate change on agriculture.

Achieving food and nutritional security in a scenario of degrading natural resources and predicted climate change trends in near future in India seems a big challenge. Further, diversion of agricultural land for non-agricultural use, declining land holding size and increased cost of cultivation are bound to add to food crisis in the future. Global warming triggered melting of glaciers, sea level rise, submergence of islands/ coastal areas and change in rainfall and temperature pattern over the next century are predicted. Such changes are bound to affect water availability and biodiversity pattern which will demand a new set of land use pattern including enterprises, commodities, and crops varieties. Global



warming related ozone depletion has also been reported which may lead to increased ultra violet radiation with far reaching adverse impact on earth's environment and human as well as livestock populations including microbial communities.

Such effects of climate change have already started impacting agricultural productivity in several agroclimatic regions and sub-regions of India. The country experienced one of the severest droughts of this century, during 2002 and 2009, that lowered food grain production by more than 29 and 17 million tonnes, respectively. The cold wave of 2002-2003, 2005-2006 and 2007-2008, caused significant damage to winter crops in the states of Punjab, Haryana, Rajasthan, and western Uttar Pradesh. Agricultural crops like winter maize, mustard, gram; fruit crops like litchi, papaya, mango; vegetables like potato, tomato, brinjal, peas and flower crops like marigold, chrysanthemum and dahlia were extensively damaged. Five to ten years old multipurpose trees like *Prosopis juliflora*, *Cassia siamea*, *Azadirachta indica*, *Emblia officinalis*, *Tamarindus indica* were also damaged and defoliated. During 2010-11 winter season, most of the pulse crops, including gram and pigeonpea, were badly damaged in Central India due to frost. The heat waves of March 2004 and 2010 in northern states coincided with the ripening phase (grain filling) of wheat and affected translocation of photosynthetic assimilates from vegetative parts to grain, and impaired the production by more than 4 and 2 million tonnes, respectively. Prolonged cool temperature during 2010-11 winter, favoured higher wheat productivity, but also proved highly conducive for the onset of yellow rust disease on



wheat. Monsoon behaviour in 2007 over Kerala (Coastal region) was totally different to that of previous years, and very heavy rains were observed between June and September leading to severe flooding in low lying areas. Traditionally assured and high rainfall areas of east India like West Bengal, Bihar, Jharkhand and Assam experienced drought like situation during 2009 and 2010. The monsoon rainfall even during 2013 is reported less than the average rainfall for that period.

Predicted spatial redistribution of precipitation, droughts, floods, heat waves, cold waves, hailstorms and water balance will change the land use pattern, cropping systems, pests and diseases. One of the potential effects of climate change on agriculture will be the shifts in the sowing time and length of growing seasons, which would alter sowing and harvesting dates. High temperature induced higher evapotranspiration would call for much greater efficiency of water and nutrients. There may be a shift in climatic zones due to increased temperatures. Significant shift in latitude for apple cultivation has already been reported in Himalayas.

Further, climate change effects will be more serious in the coastal regions. Such impacts will include rise in sea level, increase in sea surface temperature, decrease in sea-ice cover, changes in salinity/alkalinity/acidity. It is reported that oceans will be more acidic by 2050 due to carbon dissolving, thus putting a threat on marine food chain. These changes will necessitate the need to devise research strategies to deal with predicted changes to sustain agricultural productivity and to achieve food and nutritional security in 21st century.

Adaptations of agriculture to climate change will call upon proactive or anticipatory research on enterprises, commodities, crops, varieties and farming systems resistant to cold, heat, disease, pests and moisture stresses. Agronomic manipulations such as improved fertilizer use to reduce emissions of methane and nitrous oxide, irrigation management for minimum methane production and conservation agriculture practices will be highly demanding for achieving desired goals. *Ex-situ* and *in-situ* harvesting and conservation of rainwater, raising horticulture and

agro-forestry plantations on all kinds of wastelands to sequester carbon, substitution of fossil fuels with bio-fuels (*Jatropha* and *Pongamia* plantations), weather based forewarning for agricultural practices and operations will play a significant role in moderating climate change. Animal husbandry reported to account for about 18 per cent of GHG emissions that cause global warming. Several manure management practices may play a significant role in decreasing GHG emissions from manure storage and after application in the soil. Improving forage quality and overall efficiency of nutrient use in the diet can also play a pivotal role in decreasing GHG emissions per unit of animal products. Several agro-forestry models / best management practices have been developed by ICAR research institutes and State Agricultural Universities for different agro-climatic regions of the country. Such practices / models need to be up-scaled by incorporating location specific adjustments. There are a number of multipurpose, multi stress-tolerant trees, bushes and shrubs which naturally grow in landscapes in general, and wastelands in particular, like genus *Prosopis* and *Opuntia* (edible cactus). Such species have ample scope to be used as an alternate source of food and fodder/ feed in dry areas and also a viable option to sequester carbon in the vegetation and soil.

To address the issues of climate change at global level, Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the world Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP).

This panel is meeting frequently and has brought out several assessment reports. These reports are providing ample opportunities to the member countries to devise adoption and mitigation strategies to deal with perceived climate change scenario. In India, ICAR has initiated a mega project entitled National Initiative on Climate Resilient Agriculture (NICRA) to develop adoption and mitigation strategy for climate change. All sectors of agriculture viz., crops, horticulture, livestock, fisheries and microbes are included in this initiative. Similarly, Department of Agriculture and Co-operation, Ministry of Agriculture has developed a programme on sustainable agriculture with major emphasis on adoption and mitigation of climate change. Creating awareness about dangers of predicted climate change and mobilizing community effort will go a long way in tackling climate change at local, regional, national and global scale.

It may be included that climate change and its adverse impact on agriculture has become almost a reality. Shift in rainfall, temperature, relative humidity, pests and diseases and altitudinal limits of crops has been observed in different agro-eco regions of India. The same region is experiencing exposure of crops during growth to different stresses like drought, submergence, salinity, heat wave, cold wave and frost etc. Developing crops, commodities, enterprises and cropping systems keeping in view single stress management approach is unlikely to yield desired results. The future research to make agriculture resilient to climate change need to focus on:

- Establishment of benchmarking studies at all the research centres to understand weekly, monthly and yearly pattern of moisture, temperature, pests/diseases/weeds and correlating it with phenophases of the crops grown in the region/area
- Identification and development of multi-stress tolerant crops and varieties using genetic engineering / gene pyramiding approach
- Benchmarking of glaciers and yearly monitoring of snowfall melt to understand the flow of water in perennial rivers which are the backbone of irrigated agriculture
- Benchmarking of sea water rise in coastal areas and ingression of sea water in agricultural lands, periodic monitoring for preventive and management strategies
- Conversion of C3 plants to C4 mechanism of photosynthesis to take advantage of increasing CO<sup>2</sup> levels likely to be available in the atmosphere as a result of increased green house gas emissions
- Development of multi-enterprise agriculture systems to cover risk of crop failure, to increase carbon sequestration/carbon trading and to ensure multiple use of resources
- Exploring opportunities for taking advantage of climate change triggered rise in temperate in temperate and polar regions
- Development of bio-shield models for coastal regions as a preventive option to tackle tsunamis and cyclones. ♦

# **IDBI Advt**



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## Towards Achieving Self-sufficiency in Pulses Production

**P**ulse crops are one of the most important constituents of cereal-based vegetarian diets of the Indian subcontinent. With their high protein content and an ability to fix atmospheric nitrogen, which reduces fertilizer use in agriculture, grain legumes have a great scope for agricultural, environmental and biotechnological research. Their seeds contain 16-40 per cent protein and provide one third of all dietary protein. Besides, these are also an important source of the 15 essential minerals. They also fix atmospheric nitrogen in the soil increasing its fertility. Food legumes are also important source of fodder in many agricultural systems, and are grown increasingly on a large-scale in many parts of the world. In India, over a dozen pulse crops including chickpea, pigeonpea, cowpea, mungbean (green gram), urdbean (black gram), lentil, French bean, horse gram, field pea, moth bean, lathyrus, etc., are grown in one or the other part of the country. However, the most important pulse crops grown are chickpea (41 per cent), pigeonpea (15 per cent), urdbean (10 per cent), mungbean (9 per cent), cowpea (7 per cent) lentil (5 per cent) and fieldpea (5 per cent).

The production of pulses in the country has witnessed an upward trend during the last 3 years. The latest production figure of 18.45

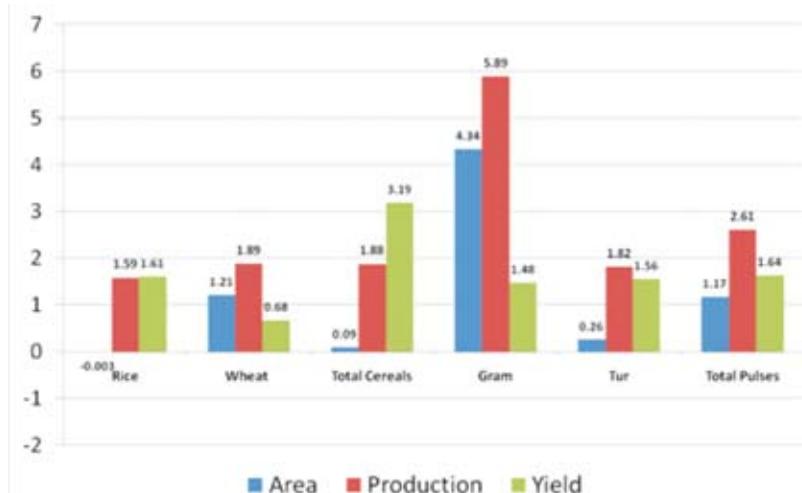
million tonnes for the year 2012-13 is an all time high record. It appears to be a ground-breaking movement for the agricultural fraternity towards achieving self sufficiency in pulses production which has been a long pending demand. Not looking far beyond, the scenario was entirely different before 2010, when the total production of pulses was continuously stagnating at around 14-15 million tonnes, and was about 2-3 mt short of the national demand. The deficit was compensated by import of pulses from other countries bearing a heavy burden on the public exchequer. Therefore, there was always a pressure to boost up the production and minimize the import. However, with the shrinking agricultural land and scarce natural resources, pulses could not find suitable areas for expansion and continued to be pushed into marginal areas, without much input and assured irrigation. Therefore, increasing the production of pulses within limited land and resources always remained a challenge. Today, effective area under pulses cultivation in the country is estimated to be about 25-26 million hectares, while the realized productivity is less than 1 tonne per hectare. Shortfall in pulses has been attributed to a number of factors, the major being ever-increasing population, geographical shift, abrupt climatic changes, complex disease-pest syndrome, socio-economic conditions of the farmers and market opportunities. Owing to the demand-supply gap, the country has also emerged as the largest importer of pulses in the world importing 2.5 to 3.0 million tonnes every year. However, visualizing the feat achieved in last few years, and opportunities available for vertical and horizontal expansion of pulses, the picture do not seem to be gloomy and we are steadily marching ahead towards achieving self sufficiency in pulses.



### STATISTICS AND GROWTH PATTERN

India is the largest producer and consumer

**GROWTH RATE OF MAJOR CROPS 2001-2010**



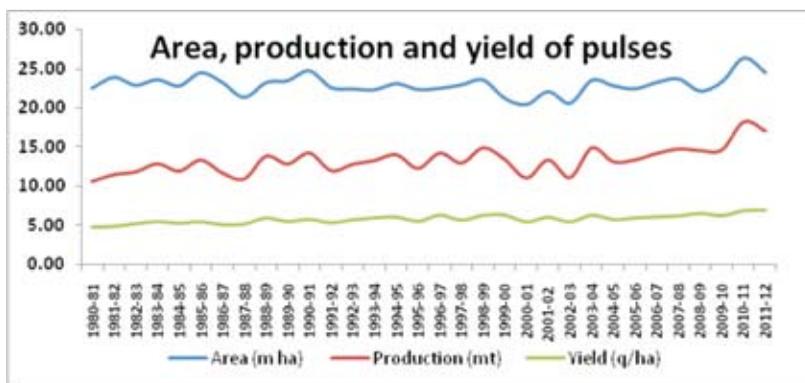
**IMPORT-EXPORT STATUS**

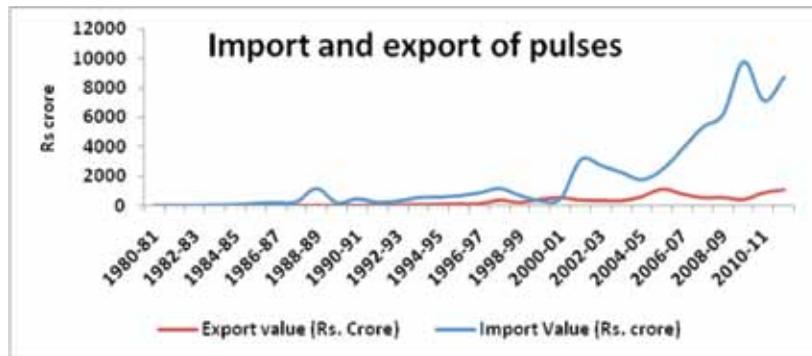
Despite an impressive growth of pulses in the country, import has also shown a positive trend over the years. While the exponential growth rate of pulses was only 9.09 per cent for the period between 1980-81 and 2011-12, the growth in terms of value of imports was 16.26per cent. Nevertheless, the growth in quantity of pulses imported slowed down to 12.16per cent after 2000-01. On the contrary, the growth in export of pulses was negative (-2.41 per cent) for the period 2000-01 to 2011-12. The major factor behind this negative trend is that the export of pulses has been banned from India since June 27, 2006, except for the export of commercially important kabuli chana and 10,000 tonnes of organic pulses and lentils. Before the ban, India exported around 447.44 thousand tonnes during 2005-06, which then fell to 250.7 thousand tonnes during 2006-07 with a decline of 44per cent. Ban on export of pulses was further extended by a year till March 2014 to enhance the domestic supply. Further, to meet the domestic demand, customs duty on import of pulses has also been reduced to zero with effect from June 8, 2006, which has been extended up to 31-3-2014. Due to the above reasons, the per capita availability of pulses also showed a significantly positive trend

of pulses in the world. During 2012-13, the total pulse production in India was estimated at 18.45 million tonnes with an increase of about 8per cent over the production of 17.09milliontonnesduring 2011-12. This production has sustained since the last three years. Exponential growth rate has been worked out for area, production, yield and other important aspects of pulses. While the growth in area cultivated under pulses in the country was not significant for the overall period of three decades between 1970 and 2000, a positive and significant growth (1.17per cent) was observed after 2000-01. Similarly, the growth in case of production as well as for productivity during 2000-2012 was also positive and higher than that of the preceding three decades. In fact, the growth rate in pulse production (2.61 per cent) during this decade was even higher than the growth rate of rice (1.59 per cent), wheat (1.89 per cent) and all the cereals (1.88 per cent). Among different pulses, the highest growth rate was observed in chickpea production (5.89 per cent) followed by pigeonpea (2.61 per cent).

the impressive performance of pulses in India. Systematic and continuous efforts have been undertaken during the last few decades. With more than 550 improved varieties in different pulse crops, development of several pulse production and protection technologies, and active government and policy support, a significant gain in pulses production and productivity could be achieved. Consequently, pulse production has increased from 12.70 million tonnes in 1960-1961 to 18.45 million tonnes in 2012-13 and productivity from 539 kg/ha to 699 kg/ha. The biggest contribution in this growth of pulses has come from an increase in chickpea production which witnessed a record production of 88.80 mt during 2012-13 as per the estimates.

There are several factors behind





during 2000 to 2012 with a growth of 2.10per cent.

### GEOGRAPHICAL SHIFT IN PULSES IN INDIA

The Indo-Gangetic plains (IGP) of northern India used to be the major pulse basket of the country till the 1970s, after which a declining trend started, the area replaced by wheat, rice and maize due to increasing irrigation facilities. However, this reduction in area under pulses in IGP was compensated by an increase in central and southern parts of India, Andhra Pradesh becoming the leader in total pulse production with an average increase in the yield of two of major pulses, chickpea and pigeonpea, to the tune of about 81-100 per cent during the last two decades (1991-2010). Consequently, looking at total pulses, the area in central and south India increased from 11.34 million hectares to 15.01 million hectares during the last three decades. The short duration chickpea varieties developed by ICAR-NARS-ICRISAT collaboration played a key role in expanding the area and productivity of chickpea in southern India. Similarly, the area of lentil increased significantly in Madhya Pradesh, and pigeonpea in Andhra Pradesh and Karnataka. Development and adoption of appropriate varieties led to increase in area, production and yield of lentil in Jharkhand

and Rajasthan. On the contrary, an increasing trend was observed in the area under mungbean and urdbean in north India, which increased to almost double along with a significant increase in productivity.

During the XIth Plan period alone, significant improvement in production and productivity of total pulses has been observed in Jharkhand, Gujarat and Andhra Pradesh. In chickpea, there was a positive growth in area, production and productivity in Andhra Pradesh, Gujarat, and Maharashtra. Production of pigeonpea was enhanced by about 2.53 lakh tonnes in Karnataka, 1.26 lakh tonnes in Gujarat and 1.13 lakh tonnes in Andhra Pradesh. Similarly, significant area expansion of pigeonpea by 1.13 lakh ha was noticed in Karnataka and 0.74 lakh

ha in Andhra Pradesh. With the development of short-duration varieties, there was expansion of mungbean in summer season under rice-wheat system in north India. Similarly, in peas also, there was a significant increase in area and production in Uttar Pradesh (1.17 lakh ha and 1.8 lakh tonnes).

### TRANSFORMATION IN PULSE PRODUCTION

Besides soil and climatic factors, non-availability of quality seeds in adequate quantity was one of the major constraints in pulses production in India till now. Seed replacement rate was also very low (5 to 10 per cent) and recurrent unfavorable weather conditions and gaps in technological know-how further added to the constraints in pulses production. Realizing this, with technological back up and interventions of National Agricultural Research System and well planned financial support of Planning Commission and Ministry of Agriculture, Govt. of India, several programmes viz., National food security Mission-Pulses, Accelerated Pulses Production Programme (A3P), Rashtriya Krishi Vikas Yojna (RKVY), 60,000 Pulses Villages, etc. were launched



during the XIth Plan period to boost pulses production in the country with an objective to add 2 million tonnes of pulse grains to the current production. Situation-specific, cost effective and system-based technological know-how and packages of pulses were disseminated among the farmers through farmers' participatory research and extension (FPRE), on-farm demonstrations, front line demonstrations, and skill based training to bridge the gap between potential and realized yield in pulses. Inclusion and adoption of improved varieties of different pulse crops under different farming systems also helped in increasing productivity per unit area. The policy initiatives such as increasing the minimum support price by the government encouraged the farmers to take up pulse cultivation as a profitable venture.

Under the National Food Security Mission-Pulses component, production of breeder seed of pulses was strengthened, besides the strengthening of training infrastructure and organizing national agricultural training programmes. With these initiatives and implementation of a mega seed project, the breeder seed production was doubled which ensured availability of quality seed of pulses in sufficient quantities. The seed supply model has been practically successful, and it led to one important step forward towards this transformation. Technology demonstration programme for harnessing pulses production was launched in the year 2010 through active collaboration of IIPR and Division of Agricultural Extension, ICAR, New Delhi. With networking of 137 Krishi Vigyan Kendras of 11 states of country, 6000 demonstrations on pulses were laid out on pulse package technologies. All these efforts together have



undoubtedly resulted in yielding encouraging results and enhancing pulses production in the country. Besides the above listed factors, moderate to good monsoon and effective farm-oriented government policy support, have also had their share in this success.

#### THE WAY AHEAD

The population of the country is predicted to become 1.68 billion by 2030 from the present figure of 1.22 billion. Accordingly, the pulse requirement for the year 2030 has been projected at 32 million tonnes, thereby requiring an annual growth rate of 4.2 per cent. With the current growth rate of 3.5 per cent, this target does not seem to be unachievable. Nevertheless, to meet this requirement, the productivity needs to be enhanced to 810 kg per ha and an additional area of about 3.0 million ha requires to be brought under pulses, besides reducing post-harvest losses. This task has to be accomplished under more severe production constraints, especially abiotic stresses, abrupt climatic changes, and emerging secondary and micro-nutrient deficiency in soil. This requires a paradigm shift

in research, technology generation, dissemination, and commercialization along with capacity building in frontier areas of research as well as a horizontal expansion in area of pulses. The following three-pronged strategy has been devised to meet target which can have substantial bearing on the pulses production without further constraining natural resources:

- Vertical expansion
- Horizontal expansion
- Bridging the yield gaps

#### VERTICAL EXPANSION

This mainly encompasses breaking yield barrier and manipulation of production environments to attain highest possible yield from the varieties currently available. To achieve the target of self sufficiency, yield enhancement from the current level of 699 kg/ha to 810 kg/ha has to be achieved till 2030, which can be done through development of high input responsive varieties, varieties with multiple resistance to diseases and insect-pests, development of short duration varieties which can fit well into different crop rotations and cropping systems, increasing the harvest index, development

of drought tolerant varieties and development of hybrids in pigeonpea and transgenics in chickpea and pigeonpea for resistance to pod borer and tolerance to drought. The major drivers behind increasing the pulses production will be the existing and newly emerging technologies, and institutional support, policy support such as minimum support price, assured procurement and development of new technologies.

Minimizing post-harvest losses is one of the key areas which may address our target of achieving self-sufficiency in pulses by 2025. Farm mechanization and custom hiring of farm machineries and implements may help in reducing upto 0.4 million tonnes of post-harvest losses in pulses. Similarly infrastructure development for storage and post harvest processing, and timely availability of farm machinery may help in further reducing the post harvest losses by another 1.5 million tonnes of pulse grains.

### **HORIZONTAL EXPANSION**

The next step to achieve self sufficiency in pulses is targeting at bringing an additional area to the tune of 3.0 million hectares under pulses cultivation in the next 10-12 years. This can be achieved through promoting intensive cropping systems, introduction of pulses in non-traditional areas, incorporation of pulses as intercrops and adopting pulses as substitute for low value crop. Out of the 3.0 million hectare targeted area, manipulation of cropping systems, crop diversification and multiple cropping systems are expected to bring about 1.0 million hectares of additional area under pulses. Another 1.5 million hectares may be increased by introducing pulse cultivation in newer niches such

as rice fallows in peninsular India, kharif fallows of Bundelkhand, wheat fallows of Punjab and Uttar Pradesh, foot hills of tarai, etc., while another 0.5 million hectare area may be increased by promoting pulses in high productivity zones as intercrops. This increase of 3.0 million hectares additional area under pulses is envisaged to produce 2.5 million tonnes extra pulse grains by the middle of next decade.

### **BRIDGING YIELD GAPS**

One of the major constraints in realizing high productivity of pulses in India is the huge gap between the potential and harvestable crop yield. Technology transfer and aggressive promotion of recommended agro-techniques may help in bridging this yield gap. The major strategies to bridge yield gap may be making the farmers aware of optimum time of planting and maintenance of plant population, raised bed planting system, especially during kharif season, use of bio fertilizers and integrated nutrient management, foliar spray of nutrients, use of crop mulch and residue management for green manuring and organic matter and integrated weed management using pre- and post-emergence herbicides.

Improving seed replacement rate by an advance seed planning for each state, rolling seed plan with appropriate emphasis to the newly released varieties, maintenance of seed buffer of improved varieties and farmer's participatory seed production for farmer to farmer seed spread may further help in increasing pulse productivity per unit area. The availability of critical inputs like biofertilizers, sulphur, zinc, biopesticides, etc., and feasibility of life saving irrigation through sprinklers and rainwater harvesting

in farm ponds and community reservoirs will further pave the way towards self sufficiency in pulses.

With the current growth rate in pulses and the tremendous opportunities available for their vertical as well as horizontal expansion, it can be safely predicted that India is now slowly moving ahead towards achieving self sufficiency in pulses. While the last few years' production figures give us a moment to rejoice this progress, it is also not a time to be contented, since we still have a mammoth task of producing about 30-32 million tonnes of pulse grains by 2030 with an annual growth rate of about 4.2 per cent. With the recent technological advancements, opportunities for horizontal expansion in cultivable areas of pulses, scope of increasing their productivity, larger prospects of reducing post harvest losses, and above all government's willingness and policy support to increase pulses, the target of achieving more than 4 per cent growth rate is quite feasible. However, this will require envisioning newer strategies to increase production to achieve self-sufficiency for all times. Bringing newer niches such as rice and wheat fallows under pulse cultivation, more effective seed and varietal replacement, development of pulse-based cropping systems, intercropping and relay cropping, resource conservation technologies, use of genomic tools and transgenics, effective post harvest management, farm mechanization, technological and infrastructural support, policy initiatives and proper storage and disposal of pulse produce are some of the key areas which will require concerted efforts to address most of the production related issues in pulses. ♦



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*A Thought*

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# Agriculture and Nutrition Linkages in India

**T**he link between agriculture and nutrition has been discussed extensively in recent years. The basic rationale for exploring this linkage in developing countries is that a large percentage of population depends upon agriculture for their livelihoods. There is also a persistent problem of malnutrition in many of the developing countries, especially among rural population. It is perceived that by encouraging agricultural growth and diversification, we may improve the livelihoods of the poor in rural areas, improve food consumption of the vulnerable sections of the population and also impact on the nutrition status. Thus, conceptually a strong agriculture and nutrition linkage within rural areas hinges on the nature of agricultural growth that reduces poverty, diversifies production and consumption, given the existence of good health infrastructure, sanitation and safe drinking water supply.

Agriculture can influence nutrition through five major pathways. They are a) subsistence-oriented agricultural production for the household's own consumption (b) income-oriented agricultural production for sale in markets that reduces poverty, increases the purchasing power and leads to better nutrition; (c) reduction in real food

prices associated with increased agricultural production; (d) empowerment of women as agents instrumental to household food security and health outcomes and (e) indirect relationship between increasing agricultural productivity and nutrition outcomes through the agriculture sector's contribution to national income and macroeconomic growth.

## **MORE AGRICULTURAL GROWTH MEANS BETTER POVERTY REDUCTION**

In the literature on agricultural growth and poverty reduction, the argument has been that, "growth in agriculture is beneficial to the poor than growth in other sectors". Most of the studies pertain to Asian agriculture. "Agricultural productivity growth in the past forty years has been proclaimed as the single most significant factor reducing poverty" (DFID 2004). Gallup et al. (1997) showed that every one per cent growth in per capita agricultural Gross Domestic Product (GDP) led to 1.61 per cent growth in the incomes of the poorest 20 per cent of the population – much greater than the impact of similar increases in the manufacturing or service sectors.

In the Indian context, however, the evidence is mixed. With respect to the pro-poor benefits of growth in agriculture, Datt and Ravallion (1996) demonstrated that rural sector growth in India reduced poverty in both rural and urban areas, while economic growth in urban areas did little to reduce rural poverty. Study using data between 1983 and 2000 has shown that per worker agricultural output has a significant negative impact on rural poverty (Gaurav Nayyar 2005). Analysis of the National Sample Survey data on farm households in 1993-94 shows that consumption out of home-grown produce is associated with less poverty (Kumar and Joshi 2000). However, Ghalaband Reddy (2011) showed





that households who sell their produce in their market have lower underweight rates among children. Another study using India Human Development Survey (IHDS) data for India indicate that agricultural income did not show any positive impact on poverty reduction or reduction in underweight and stunting. Crop diversity in irrigated agriculture was found to improve dietary diversity on small and marginal farms. Ownership of livestock seemed to improve the milk consumption. Using household level data, the study found that non-agricultural income is associated in rural areas with better nutritional outcomes (Bhagowalia et al. 2012).

The existing literature clearly indicates that agricultural achievement does not automatically translate into better nutritional outcomes for those engaged in agriculture, and for the population in general. Agricultural growth during green revolution up to the turn of the century seems to have reduced rural poverty, as it was more inclusive. The recent growth in agriculture

after 2000 is driven by the crop diversification into pulses, fruits and vegetables and commercial crops, production of milk, eggs and poultry. Food prices are also driven by high prices of protein foods that make them out of reach to the rural poor. Between 1990-91 and 2009-10, the share of cereals declined from 23 per cent to 18 per cent. The share of horticulture, increased from 16 to 20 per cent, and that of livestock increased from 20 to 25 per cent and fisheries from 3 to 5 per cent (State of Agriculture 2011-12). Hence the crucial question to ask now is, "Is agricultural growth (driven by high value products) reducing rural poverty in India? Is it inclusive growth?"

#### **LINKING MALNUTRITION TO AGRICULTURE THROUGH NON-AGRICULTURAL FACTORS**

Conceptually, malnutrition is recognized through the medium term and long term outcomes on growth trajectories of children adolescents and adults. The indicators are stunting and underweight in children and body mass index and heights

of adults and adolescents. Micro nutrient deficiency with respect to iron, vitamin A, and zinc are also of major concern in the Indian situation. Thus, the ultimate concern is not just the intake of balanced food by all but the final outcome visible in children, women and men's anthropometry. Since healthy children turn out to be healthy adults, the focus is on children. It is also increasingly recognised the world over and stressed by the World Health Organization that the thousand days starting from conception to three years of age is the critical period for giving proper nutrition to the unborn in the womb, the born infant and the early childhood. Hence, the stress on maternal health and child nutrition.

Height-for-age (stunting) in children below the age of three is a measure of linear growth retardation - primarily reflecting chronic long-term undernourishment. Weight-for-age (underweight) is a measure of both chronic and acute malnutrition. (National Family Health Survey Bulletin, No. 15, February 2000). If one has to judge the under nutrition

status of a country by the growth trajectory of the children below the age three, one is really looking at the entire development scenario.

Attention paid to child-care in general and child's feeding including nutrition knowledge, immunization and awareness about sanitation and health, especially among the childcare givers contribute to a lowering of the percentage of underweight and stunted children. Economic resources at the disposal of women and the freedom of the women, level of education of women show association with underweight and stunting in children. Several studies show that child health is affected only indirectly through the improved usage of health care, which is determined by women's education and control over the household resources or bargaining power.

As per the article of Dean Spears (2012), sanitation is the most important issue. The association of lack of sanitation (open defecation) to larger percentage of stunted children has been the focus of this

article. On the other hand, there are questions about using international standards for Indian children. A number of other questions could be raised on the percentage of mental impairment explained by stunting and underweight as against lack of proper educational facilities for functional literacy. Questions may arise on food habits of people such as the animal protein versus vegetable protein in reducing underweight and improving heights. The point is not split hair to see if it is 49 per cent or 30 per cent are undernourished, but to accept the fact that some amount undernutrition exists, and we need to make sure that an all round improvement takes place. There are many studies that use Indian standards, and not the WHO standards. The need of the hour is to reduce the existing levels of malnourishment through better nutrition and sanitation in rural areas dependent on agriculture.

#### **THE POLICY INITIATIVE AND CHALLENGES**

The government of India has

already chalked out a programme to address the issue. The Ministry of Women and Child Development has recognized 200 high burden districts (the tentative list is received and final list will be announced soon). These districts have been identified based on key criteria like anaemia in women, children and adolescent girls, and underweight in children. At the first glance, most of these districts not only have a burden of malnourishment, but some are located in ecologically fragile agricultural backgrounds and backward regions with high levels of poverty. Hundred of these districts have been chosen for the implementation of a programme to reduce malnourishment among children with a special allocation of Rs.1000 Crores, each. Further, in these districts, the promotion of 'nutrifarms' for self-consumption by small and marginal farms have been accepted following Prof. M.S.Swaminathan's advice. As we know, we need to face the following three challenges to foster the agriculture nutrition linkages. First, the diversified high value agricultural production should lead to poverty reduction. Second, agricultural labour, marginal and small farms especially in fragile and backward areas should be able to consume local production which is also nutrition-rich. Third, sanitation with running water facility, safe drinking water (treated piped water supply) and health facilities with doctors and medicines are a pre requisite. Fourth, all the public food related schemes need to be efficiently run. An integrated effort on all the fronts together is a big challenge at the district level. ♦



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# Constitutional Amendment - Call to Strengthen Indian Cooperatives

The 97th Amendment to the Indian Constitution is regarded as a landmark in the development of the Indian Cooperative Movement which strengthened the fundamental rights of the citizens and gave a further direction to the state, as a matter of policy, to promote and strengthen the cooperative institutions and the rights of the people, at large. In the Directive Principles of State Policy, states are expected to promote voluntary formation, autonomous functioning, democratic control and professional management of cooperative societies. State governments are expected to realign their existing cooperative acts with the Constitutional Amendment within a period of one year i.e., by February 14, 2013. Only a few States have taken steps in this direction.

The amendment has come as a result of the demands from a host of cooperative leaders, studies, recommendations of conferences and specialized institutions. In order to realise the spirit of the Amendment, governments and the Indian Cooperative Movement are expected to launch a large scale member awareness and employees' professionalisation programmes to strengthen the Cooperative Movement.

Some of the key issues relating to the management of cooperatives are: protection of interests of members, security of funds invested by the members, safeguarding the Principles of Cooperation, taking objective decisions, and strengthening cooperatives to face competition in the market.

## BACKGROUND OF AMENDMENT

Pursuant of the development programmes of the Government to ensure the democratic, autonomous and professional functioning of cooperatives it was decided to initiate a proposal to amend the Constitution in order to overcome some of the problems which had arisen due to political and other considerations since

Cooperation is a state subject. Some of the major recommendations made by the following prompted the Amendment:

- The Conference of State Cooperative Ministers held on December 07, 2004 resolved to amend the Constitution;
- High-powered Committee on Cooperation under Shri GS Patil also recommended the amendment of the Constitution;
- The Sub-Group of the Planning Commission on 'Outreach of Institutional Finance and Cooperative Reforms' in its report submitted in 2008 had also taken note of the need for reforms in the cooperative legislation and had recommended that suitable efforts may be made to amend the Constitution of India. The Report discusses almost all the points of the amended Constitution.
- The Constitutional Amendment in both houses of the Parliament was commented by a number of members. There was no opposition to the amendment.
- The Act came into effect from February 15, 2012.

## Important Features of the Amendment Act

The following are the features of the Amendment:

- Right to form cooperative societies as a Fundamental Right [Article 19];
- Insertion of Article 43B in Part-IV of the Constitution as Directive Principles of State Policy for voluntary formation, autonomous functioning, democratic control and professional management of cooperative societies;
- Provision for incorporation, regulation and winding up of cooperatives;
- Specifying the maximum number of directors of a cooperative society to be not exceeding 21;
- Regular and timely conduct of general body meetings;

- Uniform tenure of managing committee;
- Provision for maximum two [2] functional directors;
- Timely conduct of elections and constitution of an authority or a body for the same;
- Maximum time limit of 6 months [one year for cooperative banks] for supersession or suspension of Board in following cases: Persistent default; Negligence in performance of duties; Board has committed act prejudicial to the interest of society or members; Stalemate in constitution of Board; Failure to conduct elections .
- Independent and professional audit;
- Reservation of one seat for SCs or STs and two seats for women on the board of every cooperative society, which have individuals as members from such categories;
- Right of a member for access to information;
- Compulsory system of filing returns;
- Provisions for offences and penalties;
- States to amend Cooperative Societies Acts to make them consistent with Constitutional Amendment within one year i.e., by February 14, 2013.

### **ROLE OF CONCERNED AGENCIES**

Since the amendment is a path-breaking step after the enactment of the Multi-state Cooperative Societies Act-2002 which granted a considerable amount of freedom of action to cooperatives in the country, serious steps need to be taken not only by the government agencies but also by cooperative institutions in the country to ensure that cooperative institutions promote autonomous functioning, democratic control and

professional management of cooperative societies.

With a view to accelerate the process of implementation of the amendment in a proper manner, there is a need to identify the areas of responsibilities which need to be identified for various agencies.

#### [i] Role of governments

- Realignment of existing cooperative laws [Central and State] with the Constitutional Amendment within a period of one year;
- Providing guidelines to state governments on the methods and programmes to strengthen cooperative structures by providing training and information;
- Instituting a mechanism of monitoring of follow-up of the Amendment;
- Governments to ensure that the spirit behind the enactment of Amendment is truly reflected in all programmes of cooperative development.

[ii] The National Cooperative Union of India [NCUI] and all other national and state cooperative unions/federations to organize extensive cooperative member education and training programmes to bring home the spirit of Constitutional Amendment in the development activities.

Among the various provisions of the 97th Constitutional Amendment -2012, relating to cooperatives, it is expected that all state legislatures would amend/re-enact their cooperative laws by the 14th of February 2013. In order to make the state laws effective and specific, the following features are of special significance:

[iii] The State Legislature may define the offences and penalties related to cooperative societies. An offence is committed if:

- [a] A cooperative files a false return;

[b] Willfully disobeys any summon or requisition issued under the state act;

[c] Any employer who, without sufficient cause does not pay to the cooperative society the amount deducted from an employee within a period of 14 days;

[d] Any officer who willfully does not hand over custody of books, accounts or cash of a cooperative society to an authorized person; and

[e] Any person who adopts corrupt practices before, during or after the election of board members or office-bearers.

The above changes have given rise to hope that it would usher in an era of 'Professionalisation' and 'Democratisation' and together with the structural reforms mentioned above will strengthen the Cooperative Movement.

### **SPECTRUM OF INDIAN COOPERATIVE MOVEMENT**

Though the cooperative activity, as a social and economic institution, has been in existence in India since time immemorial, its formal introduction as an economic enterprise came into being in 1904, when it was introduced as a safety-net for the peasants. It has, more after the Independence in 1947, come into full bloom as an economic pillar of the national economic development. It is now world's largest movement covering almost 30 per cent of India's national population.

The Indian Cooperative Movement encompasses almost all those economic and social activities which influence human needs. These institutions are people's own organisations which are owned and managed by the members themselves. These are autonomous and democratic organi-

## Indian Cooperative Movement at a Glance 2009-2010

Villages covered by cooperatives	98per cent
National Level Cooperative Federations	20
State Level Cooperative Federations	390
District Level Cooperative Federations	3,571

### Number of Cooperatives [All Level]

Primary Agricultural & Credit Cooperatives [All Types]	147,991
Primary Non-Credit Cooperatives [All Types]	458,068

### Membership of Cooperatives [Grassroots Cooperatives]

Membership of Primary Agricultural Credit Cooperatives	181.150 mn
Membership of Primary Non-Credit Cooperatives	68.150 mn

### Share of Indian Cooperatives in National Economy [Selected indicators]

Total Agricultural Credit Disbursed by Cooperatives	16.9per cent
Short-Term Agricultural Credit Disbursed by Cooperatives	20per cent
Fertiliser Distributed by Cooperatives	36per cent
Fertiliser Produced by Cooperatives	28.3per cent
Installed Capacity of Fertiliser Manufacturing Units	30.3per cent
Installed Number of Sugar Factories [324 Coop Sugar Mills]	48.2per cent
Sugar Production by Cooperative Sugar Mills	39.7per cent
Wheat Procurement by Cooperatives for National Food Stock	24.8per cent
Paddy Procurement by Cooperatives for National Food Stock	14.8per cent
Milk Procurement to Total Production by Cooperatives	7.85per cent
Ice Cream Manufacture by Cooperatives	45per cent
Edible Oil Marketed [branded] by Cooperatives	49per cent
Fishermen in Cooperatives [Active]	23per cent
Direct Employment Generated by Cooperatives	1.22 million
Self-Employment Generated by Cooperatives [Persons]	16.58 million

### Recent Trends in Cooperative Movement of India

- More emphasis on making cooperatives more autonomous and independent;
- More emphasis on professional management of cooperatives;
- Strengthening/Revitalising cooperatives through structural reforms;
- Laying emphasis on diversification, expansion and modernisation of cooperatives;
- Strengthening financial base of cooperatives;
- Need to strengthen cooperative education and employees training;
- Minimising regional/state level imbalances in cooperative movement;
- Involving women and youth and other weaker sections in cooperatives;
- Improving good image of cooperatives by attracting leaders with vision;
- Adoption of modern technology and information systems;
- Improving competitive power, quality of services and customers satisfaction.

Source: National Cooperative Union of India, New Delhi. A Profile. 2012

sations and operate within the legal framework provided by the State. Some of the areas in which cooperatives operate are: Agriculture, Credit, Consumer, Banking, Dairy, Fertiliser, fisheries, Forestry, Housing, Handloom, Hospital, Industry, Irrigation, Labour, Poultry, Sugar, Tribal, Weavers, Women and Youth, Construction, Training and Education etc.

### COOPERATIVES VS. COLLECTIVES

In most countries, there exists what may be called 'dichotomy' of laws, because more than one set of laws with sharply varying degrees of 'compliance with ICA Principles' seem to operate creating legal environment uncongenial to proper growth of cooperatives as a 'strategic' or balancing sector. In this case, the landmark orders of the Supreme Court of India in two cases are important because the order in the Andhra Pradesh Dairy Development Cooperative Federation case brought out how the operation of two cooperative laws – a new law substantially ICA Principles-compliant, and, the old law providing over-riding powers to the State could stifle the growth of cooperatives.

The order in the other case establishes the scope of the 'right to form association' as a fundamental right which is the foundation of cooperatives and the interpretation of 'voluntary' character of cooperatives extending to the right of the cooperatives to restrict membership to 'like-minded persons'. This differentiates 'cooperatives' from state-sponsored 'collectives' which are often passed on as 'cooperatives' in some country laws of 'socialist' governments. It follows that unless the right to form cooperatives is guaranteed in the constitution, the cooperatives cannot have any strong foundation.

**ILO RECOMMENDATION NO. 193 OF 2002**

While the cooperative movement and the government develop and implement their strategies to bring about reforms, international organisations, like the International Labour Organisation, provide guidelines to its member-states to bring about reforms. The ILO Recommendation No. 193 of 2002 recommends to its member-states to observe and follow its guidelines. The ILO recommended the following:

**Implementation of Public Policies for the Promotion of Cooperatives**

Member-States should adopt specific legislation and regulations on cooperatives which are guided by the Cooperative Values and Principles.

Governments should facilitate access of cooperatives to support services in order to strengthen them, their business viability and their capacity to create employment and income. These services should include, wherever possible:

[a] Human resource development programmes; [b] Research and management consultancy services; [c] Access to finance and investment; [d]

Accountancy and audit services; [e] Management information services; [f] Information and public relations services; [g] Consultancy services on technology and innovation; [h] Legal and taxation services; [i] Support services for marketing; and [j] other support services where appropriate.

13. For the promotion of the Cooperative Movement, governments should encourage conditions favouring the development of technical, commercial and financial linkages among all forms of cooperatives so as to facilitate an exchange of experience and the sharing of risks and benefits.

Since the enactment of the Multi-State Cooperative Societies Act-2002 and pronouncement of the National Cooperative Development Policy, the status and mention of 'Cooperation' in the Plan Documents, Union Budgets and government development plans and programmes have been constantly diminishing so much so that in the Union Budget 2013-14 not a single word on cooperatives has been mentioned. The Constitutional Amendment has tried to encourage the government through the

Directive Principles of State Policy to strengthen the Cooperative Movement. The Indian Cooperative Movement needs to rise to the occasion and persuade not only the government structure but also to impress upon the political parties to recognize the importance of 'cooperation' in generation of income, employment and reduction of poverty in the country. All political parties should be impressed upon to recast/revisit their election manifestoes to give due importance to cooperatives. After all, all national economic development programmes cannot be undertaken by business houses alone, a major work can also be done by cooperatives.

As economic and social enterprises, cooperatives have also been playing significant role in rural development. Cooperatives provide enormous income and employment generation opportunities in rural areas so much so that almost 67 per cent of rural household needs are covered by cooperatives. These institutions play significant role in food, horticulture and animal husbandry sectors. These facts are very well known to the political parties. It is, therefore, worthwhile for the cooperative institutions at national and state levels to develop an effective interface with political parties.

The rural development programmes and Panchayati Raj development activities e.g., Mahatma Gandhi National Rural Employment Guarantee Scheme, Pradhan Mantri Gram Sadak Yojana, etc. should make use of cooperative institutions. Cooperatives are the logical development partners in national economic development efforts.

In India with over a century-old tradition of Cooperative Movement, neither the 11th Five Year Plan document nor the Approach Paper to the



12th Plan, made any detailed reference to the role of cooperatives in different sectors, nor, any view taken on why the share of the cooperatives in rural credit in India has been consistently falling and if the acute distress among farmers in part of the country has been also due to the failure of cooperatives at the primary 'grassroots level' to deliver credit inputs.

### **POLITICAL PATRONAGE IN COOPERATIVES**

Experience has shown that the cooperatives progressed well where there has been a strong linkage with political structure. Cooperatives in Gujarat, Maharashtra and Karnataka have progressed because they enjoyed the support and patronage of political parties. Whenever such a patronage got decreased, cooperatives slowed down their progress. Milk cooperatives and sugar cooperatives had the benefit of strong and tall political leadership to mobilize masses and they were guided in such a way that a lot of government programmes were linked with them. People at large were attracted by the charismatic leaders who had considerable and genuine links with government programmes.

It may be recalled that during the immediate post-Independence period, due to the strong support provided by Prime Minister Jawahar Lal Nehru and his Congress Party, the Cooperative Movement had made huge successes together with the Community Development Plans. The Cooperative Sugar Movement in Maharashtra was also the offshoot of the sentiments of political leaders who had worked for the independence movement.

### **WORLD ECONOMIC SCENARIO AND COOPERATIVES**

The recent changes in the world eco-

nomical conditions such as unstable financial systems, economic disparity and unstable food supply has forced the world to look at alternate economic models of development and cooperatives are at the forefront of these models. Economists and governments worldwide are looking into the reasons for the success of the cooperative model and ways for further developing and leveraging the success of this model.

The United Nations General Assembly had declared 2012 as the International Year of Cooperatives, highlighting the contribution of cooperatives to socio-economic development in particular recognizing their impact on poverty reduction, employment generation and social integration. Goals of the International Year of Cooperatives-2012 were stated as follows:[a]Increase public awareness about cooperatives and their contributions to socio-economic development and the achievement of the Millennium Development Goals;[b]Promote the formation and growth of cooperatives;[c]Encourage governments to establish policies, laws and regulations conducive to the formation, growth and stability of cooperatives.

### **WHAT ARE THE IMPLICATIONS?**

The State is sovereign and it has the right to frame laws, rules and regulations for the citizens. It creates a statute [constitution] which lays down rules and regulations to be followed by the citizens, executive, legislature and judiciary. All regulations emanate from the constitution. Nobody can go against the regulations laid down in the constitution and all the provisions are enforceable, unless altered by the people through a well-defined procedure. Amendments to the constitution are made by the na-

tional parliament.

The Indian constitution enshrines a set of fundamental rights which cannot be infringed by the executive and these are protected and enforced by the judiciary. The constitution also lays down a set of Directive Principles of State Policy which serve as guidelines for the executive to protect the interests of the citizens as well as enact laws which are beneficial for the welfare of the citizens.

The 97th Amendment of the Constitution on cooperatives is one good example which grants the right to the citizens to form cooperative societies. This means that the citizens have been given a fundamental right to form cooperative societies along with associations and unions. Under the Directive Principles of State Policy it has been said, 'State shall endeavour to promote voluntary formation, autonomous functioning, democratic control and professional management of cooperative societies in the same manner as for the Panchayati Raj and Local-Self Government agencies.'

This Amendment applies to all types of cooperative societies e.g., normal cooperative societies, autonomous cooperative societies, cooperative federations and multi-state cooperative institutions.

### **ACTION NEEDED BY STATE GOVERNMENTS**

Amending the State Cooperative Societies Act, in tune with provision of the above Amendment in the Constitution - This will not only ensure autonomous and democratic functioning of cooperatives but also ensure accountability of the management of these cooperative societies to their members and other stakeholders, as well as serving to enhance public faith in these institutions.

In the operation of a Cooperative Movement of such a magnitude there are various elements which hinder a smooth operation which are due to ill-informed, ambitious and ill-educated members and local leaders. In such a highly people oriented institution there are other factors e.g., political and self-interest elements which tarnish the image of a cooperative institution.

With the Constitutional Amendment now in hands, the path of progress of the Indian Cooperative Movement seems to be easy. For the development of any organisation, business or promotional, there is a need for a law, a set of rules and regulations, and ethical approaches to ensure safety and security of members' interests and their financial stakes. The Constitutional Amendment has given a broad frame, but the rules and regulations are to be framed by the State legislatures/administrations. A cooperative institution is a business enterprise with a high degree of social content. This means a lot of people and their financial interests are involved. They need to be secured.

There are a large number of cooperative institutions in the country where a large number of members have invested huge sums of money. The efficiently-run cooperative institutions, by their professionally-managed operations, not only ensure the security and safety of these large sums of money but also give dividends to the members. The business operations are transparent and the decisions are taken on the basis of well-researched proposals before presentation to the Boards of Management.

The operational decisions are taken after analyzing carefully the proposals and funds are employed

in a transparent manner. Some of these examples are the Indian Farmers Fertiliser Cooperative Limited [IFFCO] and the milk cooperative societies and their federations. These institutions have been successful due to: professional management, technical competency, business decisions taken on carefully analysed proposals before going to the Board of Management, and employment of money in a transparent manner, and generating member awareness among the members.

However, there are other institutions; some of them are in the marketing sector, where business decisions are taken on the sly outside the Board, and by the process of manipulations, get the business decisions ratified by the Board in a hurry. Business deals which have nothing to do with the marketing activities or the related commodities are taken to serve self-interests. Such a situation results in huge losses to the institutions and leaving the investors in lurch, leave alone not giving out any dividends to the investor-members.

The Constitutional Amendment speaks of the 'professionalisation of cooperative business' but there are doubts if at the implementation stage no guarantee is given to ensure the security and safety of funds of investor-members. It is, therefore, essential that the members' interests are ensured through some suitable mechanism thereby enabling the members to repose their loyalty and confidence in their cooperative enterprises.

On the issue of elections in cooperatives, there have been several proposals. These are:

- [i] Constitution of an independent Cooperative Election Board at national and state level;
- [ii] The existing National/State Elec-

tion Commission;

- [iii] Election officers just like a Cooperative Auditor within the Cooperative Department;
- [iv] The sectoral national federation acts as an election officer;
- [v] The Panchayati Raj election system to be applied to cooperative elections; or
- [vi] An election committee within the cooperative institution like that of the education or audit committee. The three-member Committee may consist of the following members: One ordinary member, Chairman of the local Panchayat, and a local school teacher.

The autonomy of cooperatives must rest on the political will and zeal of officials of State administrations. Even now, there are more than 36,000 cooperative institutions in Tamil Nadu which continue to be governed/managed by State-appointed Special Officers. No elections have been held for the last three decades or even more. Since Cooperation is a State subject, the autonomous character of cooperative institutions rests on the whims and fancies of state political leaders, unless someone gathers the courage to get the Constitutional Amendment enforced through the Court of Law.

The Constitutional Amendment urgently calls for taking urgent action on the following three aspects:

- [i] Compliance of the Amendment by State Legislatures. This step should have been taken by 14th of February 2013, but not many State legislatures have re-enacted their cooperative laws;
- [ii] Member awareness through the education of members of coop-

erative institutions so that the members know the implications of the Constitutional Amendment. This aspect needs to be taken care of by the National and State Cooperative Unions and the sectoral federations. Since a large number of cooperative institutions, barring a few exceptions, have not been running in profit, they have not been able to make any financial contribution to the mandatory Cooperative Education Fund [CEF] which is maintained by the National Cooperative Union of India and the State Cooperative Unions. There is, therefore, a severe shortage of funds to conduct cooperative member education programme; and

[iii] Professionalisation of business and management of cooperative institutions. A large number of cooperatives [almost 50 per cent of the 600,000 cooperatives] are unable to have any paid employee. Most of the business is done by honorary workers [mostly members of the Board]. Other cooperatives have either part-time secretaries or secretaries from the government constituted [managed] cadres.

Some of the cooperatives in the fertilizer, sugar, milk, thrift and credit and similar sectors do sponsor their managers for short-term training at the NCUI/NCCT's institutes of cooperative management. Such training institutes are run by the NCUI/NCCT, NCDC's TOPIC, and ACSTIs. Other institutions which offer cooperative training accept candidates from cooperatives and outside on paid courses basis. These are expensive. NCUI/NCCT's programmes are reasonably priced and some time are

free. The problem faced by NCUI/NCCT's training institutions is the low intake from cooperatives because cooperatives consider such training programmes are expensive and they are unable to spare their employees for longer terms.

The NCUI is responsible for member education and employees training programmes. Due to financial constraints, the programmes are getting less attention and the attention to awareness-generation is getting diluted. The funding support to the NCCT programme is from the Government of India and that too is on a tapering scale. There is, therefore, shortage of competent and adequate faculty, low level of teaching and residential facilities and high operational expenses. The purpose and spirit of Constitutional Amendment, in view of the above, gets defeated as there is no member awareness, low level of professionalisation and slow re-enactment of state cooperative laws.

#### WHAT NEXT?

Taking the above into consideration, the following measures need to be taken urgently by the Government and the Indian Cooperative Movement:

[a] A mechanism to be established to ensure that all State Legislatures/ Administrations comply with the terms of the Amendment as soon as possible;

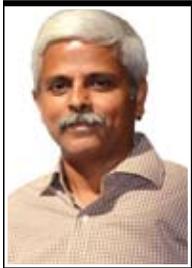
[b] A well-structured and comprehensive member education programme is developed and appropriate funding provided to the NCUI and State Cooperative Unions just in the same manner as that of 'Right to Education'. Cooperative member education is an adult

education programme and it is the responsibility of the government to ensure that proper education is given to cooperative members through the network of over 600,000 cooperative societies.

Institutions like the IFFCO and other high profit-generating democratically-controlled autonomous cooperatives should be allowed to make use of 50 per cent of the Cooperative Education Fund allocation for its own member education programmes.

It is somewhat impractical if the re-enactment of cooperative laws is left to the States without providing them with any guidelines. It is, therefore, essential that model cooperative societies laws are prepared by the NCUI and the Government of India and made available to the State administrations. A small committee consisting of experts in cooperative legislation, HRD, cooperative business enterprises should be quickly constituted for this purpose. Experiences of institutions like the IFFCO, IFFCO Foundation, Gujarat Milk Federation, NDDDB, Institute of Rural Management [IRMA], Bankers' Institute of Rural Development [BIRD] etc. are valuable for this purpose.

The 97th Constitutional Amendment is a bold initiative taken by the Government of India to streamline the organisation and management of the Indian Cooperative Movement to move faster towards professionalisation and to be strong enough to provide a higher quality of service to the members. A level playing field has been made available to the Movement to compete and succeed and be a strong economic power with a high level of social objectives. Much now depends on the leaders and managers to provide a high level of economic and social security to a vast number of members. ♦



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# Sustainable Agriculture – The Way Forward

**T**he word “sustain” comes from the Latin “sustinere” (sus from below and tenere to hold) which implies permanence. Sustainable agriculture thus remains for perpetuity. Sustainable agriculture has been the foundation for human settlements, and it is still the way of life in many rural societies in India. Sustainable agriculture, like sustainable development [“development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”], is often misunderstood, and is contentious. This essay will first explore the facets of sustainable agriculture with the help a few definitions, distill its essence into an operational definition, explain why sustainable agriculture was relegated to the background and emphasize its relevance as the food security bill is going to be a reality which necessitates India to improve its productivity without putting our already stretched ecosystems in to distress.

## **SUSTAINABLE AGRICULTURE: SOME DEFINITIONS**

Terentius Varro, a Roman landowner in the 1st

century BC explains, “Agriculture is a science, which teaches us what crops are to be planted in each kind of soil and what operations are to be carried on, in order that the land may produce the highest yields in perpetuity”.

“Sustainable agriculture over the long term enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; economically viable and enhances the quality of life as a whole”, according to American Society of Agronomy (1989).

Steve Diver (1996) opines that sustainable agriculture is a philosophy and has long term goals. It helps the humans to understand various processes of the earth’s eco-system so that humans can make their activities compatible to earth’s eco-system. Sustainable agriculture is thus an approach to reduce external inputs in favor of managing on-farm resources.

Conway (1997) elaborates; agricultural sustainability is the ability of an agro-ecosystem to maintain productivity in the face of stress or shock like pest attack, soil salinity, drought etc.



Pretty (1998) defines “Put simply, sustainable agriculture is farming that makes the best use of nature’s goods and service whilst not damaging the environment. It does this by integrating natural processes such as nutrient cycling, nitrogen fixation, soil regeneration and pest predators into food production processes. It minimizes the use of non-renewable inputs (pesticides and fertilizers)”.

Famous agricultural economist John Ikerd [USDA: 1999] defined sustainable agriculture as “capable of maintaining their productivity and usefulness to society indefinitely. Such systems must be resource-conserving, socially supportive, commercially competitive, and environmentally sound.”

The idea of sustainability holds ambiguities and nuances that are sometimes difficult to resolve and “doing sustainable agriculture is a less complicated endeavour than defining it” (USDA:2007, based on an annotated bibliography of 200 references from 50 to 2007 AD).

**PHILOSOPHY OF SUSTAINABLE AGRICULTURE**

It is evident from all these definitions that sustainable agriculture has been practiced since times immemorial, and encompasses a number of approaches described as; Organic farming, Biodynamic farming, Biological farming, Nature Farming, Permaculture (permanent agriculture) etc. The common thread however is an opposing worldview to the commercial model of agriculture. The competing paradigms are:

- Centralization vs. Decentralization
- Dependence vs. Self dependence
- Competition vs. Community collaboration

- Dominance over nature vs. Harmony with nature
- Specialization vs. Diversity
- Exploitation vs. Restraint.

The philosophy of sustainable agriculture is thus based on the following components:

- Understanding nature’s processes and using the biological cycles efficiently
- Efficient use of non-renewable resources
- Environmental quality
- Social and economic equity
- Economic viability

A farm that emphasizes short-run profit, but sacrifices environmental quality, would not be sustainable in the long run. Likewise, pursuing environmental quality without ensuring viability of short-run returns also would be unsustainable. A farm that is very productive but uses large quantities of non-renewable resources like fossil fuels or a non-rechargeable aquifer, to achieve and maintain productivity would also not be considered sustainable in the long run. Sustainable agriculture thus has become an umbrella concept encompassing indicators like environmental soundness, economic viability and social acceptability. John Ikerd, Agricultural Economist of the University of Missouri opines that “The best way to communicate the meaning of sustainable agriculture is through real-life stories of farmers who are developing sustainable farming systems on their own farms”.

**MYTHS ABOUT SUSTAINABLE AGRICULTURE**

David Norman et al (1997), highlighted the common myths:

Myth 1: Sustainable agriculture means going back to what our

grandparents did.

Sustainable agriculture seeks to combine some of the wisdom of past practices, like crop rotation and green manure crops, with careful use of current technology.

Myth 2: Adoption of sustainable agriculture will inevitably involve losing money.

Conway and Pretty proved that overall farm productivity is high in those farmsteads following sustainable agricultural practices.

Myth 3: Sustainable agriculture increases soil erosion because of greater use of tillage.

Sustainable agriculture practitioners must meet conservation compliance guidelines but can emphasize methods of soil conservation over others.

**SUSTAINABLE AGRICULTURE: AN OPERATIONAL DEFINITION**

Sustainable agriculture is low-input farming, based on a reduction, but not necessarily elimination of chemical fertilizers and insecticides. Locally available botanicals are used effectively to manage the pests. Farmers adopt these practices to reduce costs, reduce chances of chemical poisoning and to minimize impact on environment. Sustainable agriculture should be practiced both in irrigated and rain fed systems as this approach is gentler and also beneficial to the ecosystem as a whole. The underlying idea is that farming enterprise becomes profitable (1) if the input costs can be reduced (2) if the productivity goes up or (3) if the price realization in the market is favorable covering costs of cultivation. The first option is the easiest as it is in farmer’s control. Sustainable agriculture, thus is situation specific, and has spatial (space) and temporal (time) dimensions.



### WHY SUSTAINABLE AGRICULTURE?

Agricultural production can be increased either by bringing more land under cultivation or by increasing the use of agrochemicals to improve productivity. The arable land is finite. Negative marginal utility has already set in and additional usage of agrochemicals is not improving the yields proportionately. It has also been established that use of agrochemicals has unleashed ecological problems. The devastation brought by such agriculture has catalyzed a search for alternatives. Another factor is the increasing energy cost per kilogram of crop produce. This is because of the fact that the world has taken fossil fuels for granted, even though reserves are finite. Sustainable agriculture could possibly show some alternative path(s). Examples of sustainable agriculture exist all over the world seeking acceptance and waiting to be researched for distilling their secrets.

### SUSTAINABLE AGRICULTURE - AN EXAMPLE

Sustainable agriculture empowers

communities. Sustainable agriculture is location specific, and thus requires a flexible policy frame work as one size does not fit all.

Punukula, a village in Khamman District, Andhra Pradesh, which is about 600 hectares in geographical area with 189 households, was yet another village in Andhra Pradesh, till recently. Punukula experienced pesticide poisoning because of resistant cotton pests and the resultant high usage. The manifestations were ill-health and reduced profits because of disproportionate expenditure on pesticides. Center for Sustainable Agriculture, Hyderabad showed Punukula a path of non-insecticidal pest management using Neem seed (*Azadirachta indica*) and garlic clove sprays. Punukula's success reflects a paradigm shift, from "chemical input centric" to "knowledge centric" model, where farmers manage pests and target them, when they reach certain threshold levels and during vulnerable stages of pest's life-cycle. Capacity building enabled farmers reclaim their past knowledge. The input-costs plunged from about INR 6000 to 1200 per acre, when Punuku-

la farmers switched to Neem seeds and garlic cloves from pesticides. Thus INR 24,00,000 (4800 savings per acre x 500 acres cotton) was saved as no chemical pesticides were purchased. This money earlier was leaving the village economy. The savings on human health are substantial but difficult to calculate. But sustainable agriculture is not easy to practice. While one can easily buy a can of pesticide, botanical pesticides are not commercially available and are labor and time intensive to prepare. Despite these irritants, Punukula's experience is spreading, demonstrating the strength of this methodology. Society for Elimination of Poverty, a Government of Andhra Pradesh Society, which implements the National Rural Livelihoods Mission in the state, is spearheading this approach all over the state, especially in rain fed areas.

### SUSTAINABLE AGRICULTURE: HAS IT LOST ITS APPEAL?

If/When sustainable agriculture is good both for the people and environment, why has it lost its appeal? There are no easy and direct answers available in the literature. Often cited explanations are population pressure, degraded eco-systems, colonialism and monocropping, availability of miracle seeds with their attendant agro-chemicals to quickly improve yields, and so on. Globalization which promotes interdependence and trade obviously promotes commercial agriculture which is based on mono-crops.

Indian Agriculture is an interesting example. Our agriculture was subsistence oriented, and landlords leased out land to tenants. East India Company and later British State ensured maximum revenue from land. India was important

for the British in early 19th century as it supplied hides, oil, dyes, jute and cotton required for industrial revolution. Mono-crops were raised at the cost of sustainable agricultural practices. As India embraced mono-cropping and industrial crops, peasants became vulnerable and droughts and famines gripped the country, since eco-systems got disturbed and the finely balanced soil fertility was lost. Bengal famine (1943) was largely the result of rural commercialization and rising prices for food grains.

Independent India began its quest for more production and productivity with the Intensive Agricultural Districts Project in 1960, which later paved the way for green revolution technologies in 1967-68. Gunnar Myrdal in 1960 argued that the best option for India was labour intensive agriculture as was demanded by peasants in Telangana at that time. But the Indian leaders favoured Green revolution technologies, as they were an easy option, and offered the prospect of quick results as the country was going through worst food shortages. Green revolution worked, and India unlike many developing countries attained food security by creating support services around rice and wheat, but with ecological costs. Ecology took a beating, as India had to feed its millions. Cheap and adequate food has always been a necessity for rulers, be it Chinese emperors or modern nations. Food has always been an instrument for ensuring legitimacy of governments.

While we require enough food to keep the country going, not all tracts can produce food as efficiently as the irrigated areas. Of about 140 million hectares of net cultivated area in India, about 55 million

hectares are irrigated, producing 60 per cent of the food output, and about 50 per cent of our irrigated area is dependent on ground water. Our skewed policies like free power are wrecking our aquifers, and India has attained the dubious distinction of largest user of ground water in the world! Irrigated agriculture would continue to provide India the food security, but "business as usual" approach must change and principles of sustainability must be designed and incorporated. Rain fed areas constitutes about 85 million hectares and produce about 40 per cent of our food grains. Virtually all the millets, pulses and oil seeds are produced in these areas. Despite the best efforts, irrigated area will not increase beyond a limit. Hence rain fed areas should not be neglected. Somehow in these 60 odd years, since we got independence, rain fed areas always got a cold shoulder. They were administered with the same policy frame work and support services that were used for irrigated agriculture. Yes, that approach was quick and simple, and was based on external inputs - high yielding seeds, pesticides, fertilizers, irrigation and support prices - to encourage farmers to produce more. But, the technology and system fatigue is pronounced in green revolution areas. Time is therefore ripe now to renew our efforts, put all our research together and begin evolving a policy for rain fed areas, as they hold the potential to bring the second green revolution, especially with mineral rich millets and very valuable oil seeds and pulses.

Pretty and Hine (2001) in their "SAFE-World" report mention that 8.98 million farmers follow sustainable agriculture on 28.92 million hectares in 52 countries,

compared to 100,000 hectares a decade ago. Sustainable agriculture is the most relevant approach in rain fed areas, and these areas must not wait perpetually. It is like the proverbial "idea whose time has come", as robust examples exist, and all we need is the will and focus to research and mainstream them.

Prof. Jonathan Foley (2011) of the University of Minnesota opines that the world can be fed well and the food production can be doubled by 2050 if we (1) stop expanding agriculture's footprint [stop consuming more tropical land], (2) close world's yield gaps, (3) use resources more efficiently, (4) shift diets away from meat, and (5) reduce food wastage. Foley also advocates for a "networked" food system [a system which is sensitive to nearby climate, water resources, ecosystem and culture and connected through an efficient system of trade]. "Networked" food system helps certifying foods based on how well each one delivers nutrition and food security and limits environmental and social costs. This would help public choose products that push agriculture into sustainable direction. Thus "networked" food system is obviously based on the principles of sustainable agriculture.

Conway (1997) evangelizes "The way forward lies in harnessing the power of modern technology, but harnessing it wisely in the interests of the poor and hungry and with respect for the environments in which we live. We need a shared vision based, above all, on partnership, among scientists and between scientists and the rural poor".

Yes, Sustainable Agriculture is the way forward. ♦

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# Market-led Extension: Present need of the farming community

In the last few years, India has been witnessing tremendous increase in food grain production. Thanks to our farmers, whose hard work and perspiration synchronized with the technology developed by the efforts of scientists and dissemination endeavour of the extension workers. Till today, our extension efforts are production oriented, which has resulted in the sufficient food for the country. With time, India has increased production, but the farmers have decreased. Farmers have been quitting the profession and moving away from agriculture.

In India, there is no dearth in technology, but the problem is to make these technologies location specific, suitable to the needs of the farmers, customised enough to fit in. Farmers are completely unaware about the price-demand situation, resulting in distress sale of products. Now-a-days, consumer preferences have also changed, a new segment namely, "ready to eat" is in demand. But, this requires a relevant type of commodity, with predetermined quality and set standards. Under this situation, farmers should know the demand of the customer with regard to particular commodity in terms of their grade and standard. To solve this, an upgraded version of extension system is required. An extension system, which can solve the problems of the farmers by providing them location specific technology, price and demand scenario of different commodities in various markets, need of the customer, training on quality aspects, grading and standardization of the commodity etc. This type of extension system is known as Market-led Extension, a beta version of production oriented extension, which deals in terms of rupees to rupees, with sole objective of profit maximization to the farmers; transforming every farmer into an entrepreneur.

Market-led Extension is the blend of agricultural extension and agricultural marketing. The role of Market-led Extensionist starts right from the selection of commodity

by the farmers and ends with their disposal in the suitable market, and helps the farmers in realising best price of their product.

## POTENTIAL OF MARKET-LED EXTENSION

Market-led Extension can help the farming community in many ways:

- Enhance the farmer's share in consumer price
- Augment the capacity of the Indian farmers to compete with the global farmers
- Make the farmers competent enough to export their produce
- Develop a conducive climate, where a farmer can build up a farm according to the market demand
- Consumer can avail the product at less cost with desired quality

## REQUIREMENTS OF MARKET-LED EXTENSION

The needs of Market-led Extension can be accessed from two point of views, i.e., extension agency perspective and farmer's standpoint.

### EXTENSION AGENCY PERSPECTIVE

There is a need of dramatic change in many aspects of the extension agency to prepare themselves for Market-led Extension. Some of the areas are:

#### • Development of Market Intelligence Cell

Market for agricultural commodity is very volatile. It varies dramatically according to the price and demand of the commodity. It makes the farmers sceptical about the crops to be grown. So, to understand the market scenario in a precise manner, there is a need to develop a Market Intelligence Cell in every state. It will work as a nodal centre of the state for understanding the market and provides regular updates to the farmers on prices of different commodities. Mobile phones can be properly harnessed for this purpose.

#### • Training of the Extension Personnel

Extension agents are the key professionals for



Market-led Extension. They require special training on many aspects such as - grading and standardization of commodity, quality improvement of the produce, marketing analysis etc.

#### • Regular update on national and international market policy

Government policy regarding market, both at national and international level changes regularly. Extension agents should understand these policies satisfactorily, analyse its pros and cons, and make the farmers aware about market opportunities or threats.

#### • Skill development on Information and Communication Technology

Information and Communication Technology can be properly exploited for the Market-led Extension. Market analysis requires handling of a large amount of data, which cannot be done manually. So, skill development on the Information and Communication Technology front will help the extension agents to keep themselves updated, and also provide relevant information to the farmers at the right time.

#### • Spirit of profit maximization

The motto of our extension system till today was "service to the farmers". But, it only shows half the story.

"Service to the farmers with profit maximization" should be the new motto of extension fraternity. Spirit of profit maximization should be inculcated among the extension agents through appropriate motivational technique, so that they will work for the benefit of the farmers.

#### FARMER'S STANDPOINT

If Market-led Extension has to succeed, then it is not only required to change the extension agency perspective, but also that of the farmer's. Some of the dimensions, where farmers require change are:

#### • Change in techniques of production

Market-led Extension works according to the demand of the market. If market requires a specific commodity with relevant quality, then farmers have to satisfy this need. It requires well defined and structured production techniques to produce the specific commodity. So, they have to change their traditional cultivation practices, if they want to harvest the market opportunity created by the demand of the customer.

#### • Formation of Commodity/Farmer's interest Groups

Farmers who have similar resource

bases and are growing the same crop can be grouped together and Commodity/Farmer's interest Groups can be formed. It will help them to bargain for inputs as well as their produce. Market-led Extension agents can provide the required services to the group. Here, extension agents should be competent enough in mobilizing the farmers for group formation.

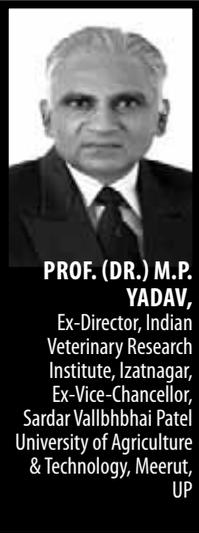
#### • Training on quality aspects

In the present era of globalization, the Indian farmers have to compete with the global farmers. If they want to stay in the business, they have to improve their quality because overseas markets are very conscious about quality. So, Market-led Extension agents should provide training on quality aspects of different commodities to the farmers.

#### • Entrepreneurship development

"Risk taking" and "need for achievement" are the primary qualities of an entrepreneur. Through Market-led Extension, farmers are transformed into entrepreneurs. So, farmers should be trained in these directions for cultivating the right attitude and motivation.

Change is the rule of nature. Everything has to change within a given span of time. Extension system too is not an exception. Market-led Extension is the hope and new vista for the extension functionaries and farming community. It will help farmers to understand the market situation and needs of the customers, and accordingly plan things. If farmers have to grab market opportunities aroused due to globalization, they have to transform according to the demands. Here, Market-led Extension will help in realising their share. Now, the time has come, where we have to revisit our extension system. ♦



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## Policy Imperative for Holistic Agricultural Development and Food Security

**A**griculture has dominated our culture, particularly in rural India, since centuries after the dawn of civilization. 'Uttam Kheti Madhyam Ban, Adham Chakri Bhik Nidan' (Agriculture is the best profession followed by business, service, and begging, which is the lowest) was the motto in ancient India, when agriculture was considered the noblest profession. Agriculture is producer of both wealth and health. Pandit Nehru, first Prime Minister of India, aptly said that 'Everything can wait, but not agriculture'. Mahatma Gandhi also identified himself as 'a farmer from Sabarmati', while making entry in the visitor book of NDRI at Bangalore. After independence in 1947, India ventured on the path of development, and in due course of time became a developing country. It was soon realised that if the country has to attain the status of a developed nation, there has to be a growth rate of two digits on a sustainable basis at least for more than a decade. Planning Commission kept a target of 4 per cent growth for agriculture sector in Five Year Plans for more than past 15 years, but the targeted growth in agriculture could not be achieved during the last three decades. In fact, the agriculture GDP fluctuates from year to year and between Plans due to monsoon uncertainties and other factors.

While agricultural GDP growth rate was 2.4 per cent during the 10th Plan, it ranged around 2.5 to 3.0 per cent per annum between mid and late 1990s. Lately, it has improved to 3.7 per cent for the first time during 11th Plan. Crop production, however, had an annual growth rate of 1.4 per cent during 1996-97 and 2010-11. For India to become a developed nation, the agriculture sector as a whole should grow at a minimum of 4 per cent. Thus, to enable the agriculture sector to attain 4 per cent and plus growth, its sub sectors having higher growth potential, namely livestock, animal husbandry, poultry, fishery and horticulture need to grow at minimum of 6-8 per cent.

The growth rate in livestock sector has been always about 4 per cent. Considering these seminal facts, the Planning Commission has targeted a growth rate of above 6 per cent for the livestock and fisheries in the 12th Plan, so that it can compensate the lower growth rate (less than 2 per cent) in crop agriculture.

Interestingly, exports from agriculture sector have also picked up in recent years in the competitive global market and economy. Since two years, India has been leading globally in the export of rice. During the year 2012-13, the country exported agricultural commodities amounting to Rs 2.31 lakh crores. The total



imports for agricultural commodities were to the tune of Rs. 1 lakh crore. Thus, the agricultural exports were in excess of Rs. 1.31 lakh crores than the imports. When compared to other sectors having import value of Rs. 24.46 lakh crores against the exports value of meagre Rs. 16.34 lakh crores, the performance of agriculture sector has been encouraging and significant. India is largest exporter of buffalo meat. Total meat exports from India were to the tune of Rs. 15,000 crores in value. Meat exports from India have increased by 37 per cent in 2010-11 and 40 per cent in 2011-12. Fish exports alone value Rs. 14,500 crores. Total exports from agriculture increased by 11 per cent during 2012-13.

There was a time during 1960s, before the advent of Green Revolution, when we had to import large volumes of wheat and rice from abroad to feed our population. Now, the situation has changed, and the country is net exporter of food grains. India exported rice worth Rs. 34,000 crores and wheat worth Rs. 11,000 crores in 2012-13. Besides wheat and rice, other major commodities being exported from agriculture sector include meat, fish, dairy and poultry products, honey, spices, vegetables, fruits and flowers. The export value of spices has reached Rs.15,500 crores. During 2012-13, India exported cotton worth Rs. 20,000 crores and sugar valuing Rs. 8,000 crores. In total food production, India is now third in the world (2012-13). In milk production, India has been reigning on the top position in the world since more than a decade and has touched a new record of 133.79 million tonnes (mt) in 2012-13. Our annual egg production has reached 71 billion.

The above progress in agricultural production has been possible as a result of new innovations and technologies developed by the scientists, enabling policies of the Government and hard work of our farmers. A number of schemes sponsored by the Central and State Governments, including National Horticulture Mission (NHM), National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY), Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) and other missions



launched from time to time, have been instrumental in boosting agricultural production in recent years.

The policies of the Government should aim to enhance the productivity and production of food grains, fruits, vegetables, spices, pulses and oil seeds, milk, eggs, meat and fish to sustain and promote the health and productivity of livestock and humans through hygienic and organic production, ensuring sustainable environment. At times, the government policies contradict with the social, political, economic and scientific needs and compulsions. For example, provision of free electricity and water for the farmers by some states, though beneficial for the farmers and helpful in increasing agriculture production,

leads to wastage of water and power, the two important natural resources, thus causing ecological imbalances as well as higher expenditure. On the other hand, more subsidies on micro-irrigation based sprinkler and drip systems is a better policy which will conserve water for posterity. The scheme of providing higher prices on the produce and subsidy on seeds for pulses under NFSM have encouraged farmers to grow more pulses, which require less water and result in reduction in the use of fertilizer as these crops fix nitrogen in the soil, thus reducing the use of chemical fertilizers. As a result of the favourable policies of the government, the country has produced a record production of pulses to the tune of 18.45 mt in 2012-13. Similarly, use of resource conservation technologies, like zero till, laser levelling, ridge/ furrow irrigation, and raised bed sowing not only save energy, seed, water, and fertilizer, but also enhance the production of the crop and net profit for the farmers. These technologies reduce the carbon foot print of agriculture, thus ensuring healthy environment, besides mitigating the climate change. These innovative policies, practices and technologies will ensure higher production along with conserving natural resources.

The policies adopted in finance allocation in the developmental schemes between central and state governments also need to be innovative. For example, the foot and mouth disease control program (FMD-CP) of the Department of Animal Husbandry Dairying and Fisheries (DAHD&F), Government of India, presently in operation since 11th Plan, funded by the Central Government on 100 per cent basis,

has been very successful as compared to the previous schemes, where the expenditure on vaccination was shared between central government, state government and the livestock farmers or between central and state governments, which invariably resulted in delays and even non-utilization of the available funds. The RKVY scheme is based on innovative funding policy, where the extent of funding is decided on the basis of the performance as well as financial contribution of the state for this project. Thus, it ensures active involvement of the state governments. Under RKVY, there is flexibility of deciding the projects in consultation with the state in all sub-sectors of agriculture covering research, infrastructure development, value addition, marketing etc., depending on their need without predetermined prescription. This flexibility has proved another innovation in planning and funding for better performance. Another scheme of the DAHD&F, GOI, namely ASCAD (Assistance to States for the control of animal diseases) is a flexible scheme, where any disease in a particular state can be covered including FMD. This enables the state governments to undertake vaccination against important diseases prevalent in the area, besides strategic approaches, for example, some states which are partly covered under FMD-CP, also prefer to include FMD vaccine under ASCAD so as to effectively control this serious disease condition having far greater impact on the health, production and productivity of cattle, buffaloes, goats, sheeps and pigs. For increasing

livestock production (milk, meat, eggs, fish) providing equal treatment to livestock, poultry and fishery at par with crop agriculture for electricity and water charges, loans, insurance etc., is possible through innovation in the policy environment.

Minimum support price (MSP) provided by the government on wheat and rice by organizing government managed purchase and direct payment to the producers, has encouraged the farmers to step up the production of these staple food crops. However, the subsidy on urea



has been responsible in more use of nitrogen as compared to potassium and phosphorus, thus leading to imbalance in NPK composition of the soil, and organic carbon depletion which are responsible for more leafy growth, lodging, disease susceptibility, yield reduction and soil degradation due to over mining of nutrients. MSP on rice has also expanded rice cultivation to non-traditional areas, such as Western Uttar Pradesh, Punjab and Haryana, thus resulting in excess water use, depleting water table and increased cost of cultivation. Similarly, MSP on sugarcane coupled with wheat and rice, has promoted sugarcane-sugarcane, wheat-sugarcane and

wheat-rice crop rotations which are both water and labour intensive and lead to micronutrient deficiencies due to excessive nutrient mining from soil resulting in soil degradation due to excessive use of chemical fertilizers, insecticides and pesticides. Thus, subsidies on wheat, rice and sugarcane production are partly responsible for the above problems being faced in Indo-Gangetic plains, where farmers are reluctant to quit these crop rotations for economic gains at the cost of deterioration of soil health leading to soil fatigue, low factor productivity leading to stagnation in the productivity of wheat and rice in recent years.

Haryana surpassed Punjab in wheat productivity to become number one in the country in 2011-12 by producing nearly 52 quintals per hectare. Government sponsored compulsory seed treatment and timely sowing of the crop along with cotton, guar and pulses as inter crops in place of rice, have been responsible for this accomplishment. Surprisingly, MSP for milk has so far eluded most of the states except Karnataka and Rajasthan. To keep a balance between the profit margin to the dairy farmers and reasonable consumer price of milk, subsidy on milk is provided by the government in several developed countries. Considering the perishable nature of this commodity, an innovative way has been suggested in India by providing subsidy on per litre of milk sold to the Cooperative and/ or other Milk Federations / Dairy Societies. The payment to the producers will be channelized through these Federations / Cooperatives. While

the policy will ensure fair price and better profit to dairy farmers, it will provide a boost to milk production, ensuring nutritional security for the vegetarian population at the same time. The incremental benefit on per unit of milk extra produced, will be imminent as well as on daily basis as a result of improved nutrition, health coverage and management of dairy cows on account of more profit to the milk producers. It will also encourage more milk procurement and reduction in the overall cost in the processing of milk. The regular income from milk to the farmers has distinct advantage as compared to the crop husbandry, where return on inputs comes after several months, only twice or thrice in a year.

The livestock sector, in general, has shown higher growth rate in last few decades as compared to the growth of agriculture sector as a whole or the food grain crop sector. Among the components of livestock sector, fisheries and poultry have shown much better growth rate ranging from 10-15 per cent. Dairy sector has also witnessed a growth of 4-5 per cent. Incentives/ subsidy on area specific mineral mixture, drugs for deworming for young calves, vaccines and diagnostics will ensure better health, growth, reproduction and enhanced production of animal produce, including milk, meat, wool, eggs and animal power for agricultural operation and transportation purposes.

By 2050, India will become the most populous country in the world surpassing China. We need to at least double our food production by 2030. However, under the negative impact of climate change and global warming, there are increasing concerns such as production uncertainties for food grains and

other agricultural commodities. For every one degree centigrade rise in temperature (terminal heat), wheat yield is likely to fall by 4 per cent. It will enhance the frequency as well as intensity of food price hikes in future, which will hurt the poorest people, the most, in the developing countries. Unfortunately, India has one-fourth of the world's population under this category facing malnutrition. About 40 per cent children in India are malnourished. India is in the midst of major economic, social and political transitions. Increasing trend of population mobility from rural to urban areas within and across the states after independence has been one of the contributing factors for these demographic transitions. People are shifting from agriculture to diversified occupations and enterprises. Entitlement to subsidized food items is part of social protection.

The Government of India is considering passing a National Food Security Bill which will provide people the right for food. The Bill is before the Parliament for consideration. If passed, it will provide legal right to people for food entitlement. The proposed Bill has provision to provide five kilograms of rice, wheat or coarse cereals per month per person at heavily subsidized prices to nearly 840 million people and 35 kilograms of food grains per person per month to another 250 million people in the poorest category. The requirement of food grains and other protein rich food items, such as pulses, fats/ oils, milk etc., for ensuring nutritional security of our 120 crores population has essentially to be met from home production. To meet this challenge, we need to pursue Climate Smart Agriculture (CSA), which implies sustainably increased agricultural

productivity and incomes through policy support, besides enabling technical and financial environment. The ultimate objective of CSA is to pursue climate resilient agriculture, and reduce the greenhouse gases (GHGs). The CSA being site specific takes into consideration its multiple objectives for meeting diverse social, economic and environmental concerns. While reduction in GHGs aims to reduce the carbon foot print of agriculture, industry and other activities on the planet contributing to GHGs production, now there is increasing realization to reduce the Food Foot Print by ensuring minimum wastage of food grains during production, transportation, storage, cooking, till serving on the plate.

The policy approach to agriculture since 1990s focussed on extending subsidies on major inputs such as fertilizer, power, and water, coupled with MSP incentives, rather than capacity building in irrigation, power and rural infrastructure. As a result, the production base has shifted from low cost regions to high cost ones, thus resulting in increase in the cost of production, regional disparities and additional burden on the storage and transportation of food grains. The need of the hour is to strictly follow environmentally sound cropping patterns and animal husbandry, besides effective control over unrestricted mining of ground water. For lasting inclusive growth, India needs a movement away from agriculture to non-agriculture sectors and within agriculture a movement away from food grains alone. Creation of off employment opportunities, commercialisation, value addition, resource conservation, and diversification should be the main planks of reforms in agriculture which should go in parallel with rural reform agenda. ♦

**A. SUBBA RAO**

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## Conservation Agriculture for Carbon sequestration and Sustaining Soil Health

**A**ccelerated atmospheric CO<sub>2</sub> concentration of 397 ppm, which is increasing at the rate of 2 ppm/year has resulted in unprecedented global warming. Evidently, climate change models predict decreased precipitation in many of the world's cropping regions and, as a result, substantial land area devoted to rainfed agriculture is likely to become less productive, unless there are major changes in the geographical locations where major crops are grown. Such reduction in productivity may be minimized by novel crop management techniques and introduction of improved genotypes with enhanced resilience to abiotic stresses. The 4x4 assessment of climate change scenarios for 2030s [through Regional Climate Model Had RM3-(Hadley Centre Regional Model Version 3) for A1B scenario] further confirms that the overall warming of all the regions in India. The net increase in annual temperatures in 2030s with respect to 1970s ranges between 1.7°C and 2.2°C, with extreme temperature increasing by 1-4°C, with maximum increase in coastal regions. The extreme maximum and minimum temperatures are also projected to increase in 2030s with respect to 2070s.

Widespread residue burning in the country coupled with intensive tillage accelerates oxidation of soil organic carbon which is otherwise vital for sustainable soil quality and food production systems. Rising atmospheric

concentrations of GHGs like CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> are global threats to the future of human civilization. Agricultural activities around the world contribute about 15-18 per cent to the annual emissions of these greenhouse gases. Research during the past few decades has demonstrated the significant contribution that conservation agricultural systems can have on reducing emission of greenhouse gases, as well as sequestering carbon in soil.

Therefore, conservation agriculture (CA) practices in the arid and semi-arid regions of India have to be understood in a broader perspective. It aims at a system of raising crops in rotation without tilling the soil, while retaining crop residues in the soil surface with three key principles:

- minimum (mechanical) soil disturbance,
- maximum (permanent) soil cover/residues and
- appropriate (diversified) crop sequence/rotation.

### SPREAD OF CONSERVATION AGRICULTURE

Crop residue retention through conservation agriculture (CA) is able to revert the soil degradation process like soil erosion, compaction, surface sealing, through the system of raising crops in rotation without tilling the soil while retaining crop residues in the soil surface. Due to fertilizer price rise and declining native mineral sources, there is an urgent need



Widespread Residue Burning



Crop establishment under residue retention

to re-use the crop residues left in the field. World-wide CA is being adopted on more than 117 m ha area, whereas in India, it is expanded to only upto 2-3 million ha. If the total land under CA reaches 3.5 million hectares, the saving in diesel alone would be 120 million litres in addition to savings of water, labour and protection of soil from degradation processes.

### CONSERVATION AGRICULTURE

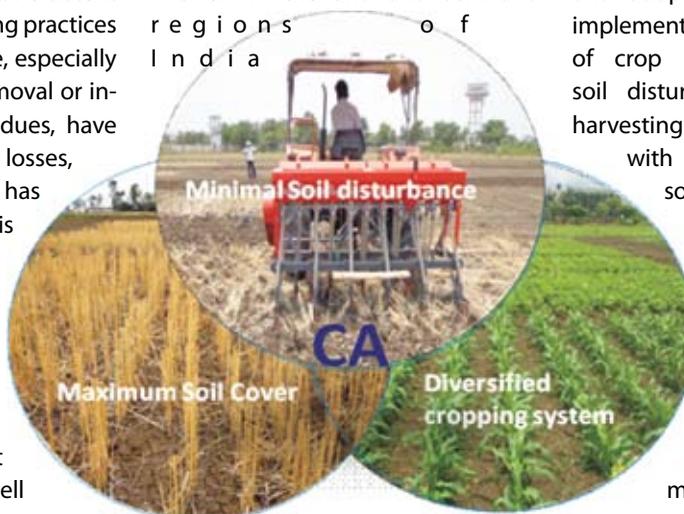
Human efforts to produce ever-greater amounts of food leave their mark on our environment. Persistent use of conventional farming practices based on extensive tillage, especially when combined with removal or in-situ burning of crop residues, have magnified soil erosion losses, and the soil resource base has steadily degraded. Land is becoming a diminishing resource for agriculture, in spite of a growing understanding that future of food security will depend upon the sustainable management of land resources as well as the conservation of prime farmland for agriculture. The main threats to soil resource are soil erosion, loss of organic matter, soil compaction, soil sealing etc. It has been realized worldwide that crop residue retention on soil through conservation agriculture (CA) is able to revert the soil degradation process. As the food demand is ever increasing due to population explosion coupled with fertilizer price rise and declining native mineral sources, there is a need to reuse the crop residues left in the field as well as other options for reviving the agriculture sector's growth.

'Conservation Agriculture' (CA) has been proposed as a widely adapted set of management principles that can assure more sustainable agricultural production.

The CA is aimed to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as economically, ecologically and socially sustainable agricultural production. It can also be referred to as resource efficient or resource effective agriculture." (FAO).

### KEY PRINCIPLES OF CA

The CA in the arid and semi-arid regions of India



should to be understood in a broader perspective. The term, CA, refers to the system of raising crops in rotation without tilling the soil, while retaining crop residues in the soil surface that has three key principles.

Minimal soil disturbances enable through no-till/reduced tillage  
Maximum soil cover/residues  
Diversified crop sequences/rotations.

The CA system constitutes a major departure from the past ways of doing things. These CA principles are applicable to a wide range of crop production systems from low-yielding, dry, rainfed conditions to high-yielding, irrigated conditions. However, the techniques to apply the principles of conservation

agriculture will be very different in different situations, and will vary with biophysical and system management conditions and farmer circumstances. This implies that the whole range of agricultural practices, including handling crop residues, sowing and harvesting, water and nutrient management, disease and pest control, etc., need to be evolved and evaluated through adaptive research with active farmers' involvement. The key challenges relate to the development, standardization and adoption of farm machinery/ implements for seeding amidst of crop residues with minimum soil disturbance; developing crop harvesting and management systems with residues maintained on soil surface; and developing and continuously improving site specific soil, crop, nutrient and pest management strategies that will optimize the benefits of the new systems.

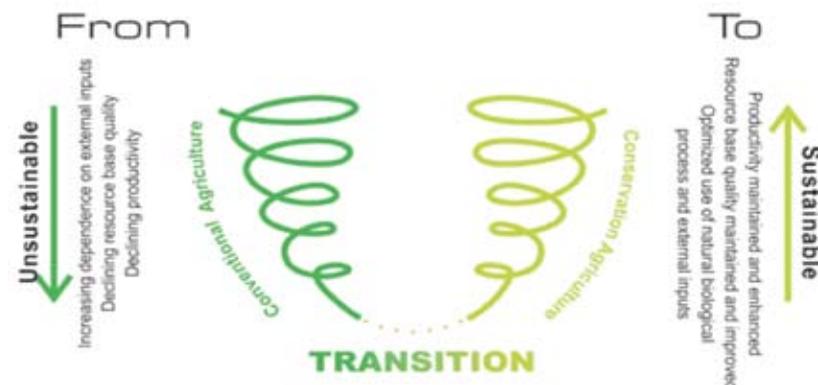
In contrast to the homogenous growing environment of the IGP, the production systems in semi-arid and arid regions are quite heterogeneous in terms of land and water management and cropping systems. These include the core rainfed areas which cover up to 60-70 per cent of the net sown area and the remaining irrigated production systems. The rainfed cropping systems are mostly single cropped in the Alfisols, while in Vertisols, a second crop is generally taken on the residual moisture. In Rabi black soils, farmers keep lands fallow during kharif and grow Rabi crop on conserved moisture. Sealing, crusting, sub-surface hard pans and cracking are the key constraints which cause high erosion and obstruct infiltration of rainfall. The choice and type of tillage largely depend on the soil type and rainfall. Leaving crop residues on the surface

**Conventional Agriculture**

- Repeated Tillage
- Crop residue burnt/removed
- Limited crops / varieties

**Conservation Agriculture**

- No tillage
- Crop residue left on soil surface
- Variety of crops in spatial/ temporal sequence



*Conventional Agriculture vs Conservation agriculture  
(Adapted from <http://www.conserveagri.org>)*

in CA is a major concern in these rain-fed areas due to its competing uses as fodder, leaving very little or no residues available for surface application. Agroforestry and alley cropping systems are other options for CA practices. This indicates that the concept of CA has to be adopted in a broader perspective in the arid and semi-arid areas. Experience at IISS showed that reduced tillage in soybean-wheat system is a suitable option for growing soybean and wheat crops in Vertisols with saving of energy and labour. This system over a period of time also improves soil organic carbon, physical and biological properties.

**CHALLENGES IN ADOPTION OF CONSERVATION AGRICULTURE**

The CA systems are quite different from the conventional practices. This implies that the whole range of agricultural practices, including handling crop residues, sowing and harvesting, water and nutrient management, disease and pest control, etc. need to be evolved and evaluated. The key challenges relate to the development, standardization and adoption of farm machinery for seeding amidst of crop residues with minimum soil disturbance; developing crop harvesting and

management systems with residues maintained on soil surface; and developing and continuously improving site specific crop, soil, and pest management strategies that will optimize the benefits of the new systems. Application of the nutrients to crops amidst of crop residues in the system taking into account the nutrient requirements and the nutrient residues left by the previous crop as well as developing customized fertilizers for CA system are the challenging tasks ahead of us. Crop residues left on the fields undergo decomposition processes and releases nutrients over a period of time/season, and thus the nutrient contribution of residues must be worked out over a number of seasons for discounting them in working out the appropriate fertilizer doses.

**CROP RESIDUE MANAGEMENT**

The main threats to soil resource are soil erosion, loss of organic matter, soil compaction, soil sealing etc. It has been realized worldwide that crop residue retention on soil through conservation agriculture is able to revert the soil degradation process. India is second only to China in fertilizer nitrogen and phosphorus consumption. Currently about 38 per cent of

the total fertilizer consumption is fulfilled through imports. The imports of total finished fertilizers have gone up to 21.7 million tonnes (Mt) in 2010-11 from 3.6 Mt only in 2000-01. During 2007-08, it was estimated that about 23.01 Mt of fertilizer has been consumed. In order to meet nutrient demand of the country, there is an urgent need to reuse surplus crop residues of 141 Mt left in the field. About 93 Mt of crop residues are burnt on-farm in the country.

Rice-Wheat and Soybean-Wheat are the dominant cropping systems in many parts of our country, where the residue left on the field during harvesting of wheat or paddy poses serious impediment to sowing of the next crop as well as greater challenge to the farmers to recycle them. One of the easiest and quickest ways to remove the residue is 'burning'. Thus, residue burning is a prevalent practice in many parts of the country. By and large, soil application of crop residue involves either as mulch on soil surface or incorporation of raw residue in soil or mixing of burnt ashes in the soil.

**RESIDUE BURNING: A NUISANCE OR PANACEA TO THE FARMERS**

Worldwide, many farmers conduct burning of field crop residue for a variety of real and perceived benefits, such as timeliness of field operations, reduced cost associated with residue management, increased crop yield and better control of weeds and diseases. Nevertheless, residue burning causes considerable loss of organic carbon, nitrogen and other nutrients by volatilization, which may affect soil microorganisms detrimentally. Residue burning is a quick, labour-saving practice to remove residue that is viewed as a difficulty by farmers. However, residue burning has several adverse environmental and ecological impacts. The burning of



dead plant material adds a considerable amount of carbon dioxide and particulate matter to the atmosphere and can reduce the return of much needed carbon and other nutrients to the soil. So this practice needs to be discouraged and curtailed.

In comparison to burning, residue retention, either as mulch or incorporated in soils, increases soil carbon and nitrogen stocks, provides organic matter necessary for soil macro-aggregate formation. Crop residues in general serve a number of beneficial functions, including soil surface protection from erosion, water conservation and maintenance of soil organic matter. Large amounts of residue in the soil surface have traditionally been viewed as a nuisance, and have been associated with mechanical planting difficulties, poor crop-stand establishment, decreased efficacy of herbicides, release of growth-inhibiting allelopathic compounds, and ultimately results in yield reduction. Therefore, crop residues, particularly wheat residue, are commonly burned or plowed under followed by discing to prepare a seedbed for double-cropped soybean.

Crop residues returned to the soil maintain organic matter levels, and crop residues also provide substrates for soil microorganisms. As microbes use or decompose crop residues and soil organic matter, carbon dioxide is given off as a by-product of soil respiration. Therefore, it is reasonable to believe that residue levels might affect soil surface carbon dioxide fluxes. Microbial and root activities are dominantly influenced by soil moisture and temperature. Environmental fluctuations of temperature and moisture are in turn affected by residue management practices, such as burning and tillage. For example, burning removes residue and the insulating effect of a residue cover on the soil surface causing temperatures to increase, which can stimulate microbial activity and soil respiration, and enhanced fluctuations in soil moisture and temperature.

#### **CARBON SEQUESTRATION AND SUSTAINING SOIL HEALTH**

Carbon sequestration can be defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the

atmosphere. The terrestrial carbon pool has been a source of atmospheric carbon dioxide, ever since the beginning of settled agriculture. Conversion of natural systems to agricultural ecosystems often leads to depletion of the terrestrial carbon pool because of deforestation, biomass burning, drainage, and soil cultivation. In general, relatively less biomass carbon is returned to the soil in agricultural ecosystems than in natural ecosystems. Many long-term studies have shown that continuous cropping results in decline of soil organic carbon, although the rate is climate and soil dependent, and can be restored by the choice of soil management practices.

The soil organic carbon is vital for sustainable soil quality and food production systems. It can be better stored/sequestered through conservation tillage practices in crop land soils in comparison with conventional tillage practices. Though relative increases in soil organic carbon were small, increases due to the adoption of zero tillage were greater, and occurred much faster in continuously-cropped than in fallow-based rota-

tions.

Conservation agriculture as defined by the Food and Agriculture Organization of the United Nations, provides alternatives that can address not only some of the challenges posed by erosion, but also some of the challenges presented by climate change and the high energy costs projected for the future. Carbon sequestration is highly related to soil and management systems. Switching from conventional tillage to either, no-tillage or to conservation agriculture, would increase the net carbon sequestration potential of agricultural lands. Carbon sequestration through CA is important in climate change adaptation efforts, since it contributes to so many soil functions and properties that are related to productivity. For example, carbon sequestration helps to improve soil properties, such as soil structure and aggregate formation, which contributes to increase in avail-

able water holding capacity. From a soil fertility point of view, carbon sequestration increases the cation exchange capacity (CEC) of soils and is a key for storage of essential crop nutrients such as nitrogen, phosphorous, sulphur and other macronutrients and micronutrients.

Various researches on the impact of tillage practices and crop rotation have demonstrated that no-till and permanent vegetation are more effective in storing carbon in the soil. The use of crop rotation and conservation tillage, in addition to effective manure and nitrogen management systems, contributed significantly to improving soil carbon status. The key principles of conservation agriculture are also in sync with management options that can be used to sequester carbon and to help mitigate and adapt to climate change.

Alternative residue management

options (depth of incorporation, optimum size of residue retention) must be developed to minimize or eliminate the tradition of residue burning. Simultaneous and permanent application of all three principles of CA helps in synergy effects which enforce the effect of single practice, while eliminating the disadvantages of each technology applied in isolation. Such permanent application leads to a long term change in the agro-ecosystem and makes the production system increasingly resilient to external factors, increasing the parameters of sustainability of the production systems. Conversion of conventional practices into conservation agriculture practices helps in sequestration of soil organic carbon, and enhanced soil health results in mitigation of climate change effect, besides, better soil aggregation, nutrients cycling, and reduction of soil erosion and nutrient losses. ♦

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