3rd

SOUVENIR

MS SWAMINATHAN AWARD
2009

Emerging Trends in Indian Agriculture

RETIRED ICAR EMPLOYEES ASSOCIATION
HYDERABAD - 500 007 A.P. INDIA

Correct Citation

Souvenir - 3rd M S Swaminathan Award 2009
Emerging Trends in Indian Agriculture
RICAREA, 2009

Edited by

M V S Sastry and **J Venkateshwar Rao**

Published by

M.V.S. Sastry, President on behalf of Retired Indian Council of Agricultural Research Employees Association (Regn. No. 5959 of 1997), 7-1-636/10, Model Colony, Hyderabad-500 038.

Website

http://www.ricarea.org

Printed at

Heritage Print Services Pvt. Ltd.
B-11/9, IDA, Uppal, RR Dist.-39
Ph : 2720 6458

Contents

सत्यमेव जयते
अर्चना दत्ता (मुखोपाध्याय)
विशेष कार्याधिकारी (जन सम्पर्क)
Archana Datta (Mukhopadhyay)
Officer on Special Duty (Public Relations)

राष्ट्रपति सचिवालय
राष्ट्रपति भवन
नई दिल्ली - ११०००४
President Secretariat
Rashtrapati Bhavan
New Delhi - 110004

MESSAGE

The President of India, Smt. Pratibha Devisingh Patil, is happy to know that the Retired ICAR Employees Association, Hyderabad is organising the Third M.S. Swaminathan Award on November 14, 2009 and bringing out a Souvenir "Emerging Trends in Indian Agriculture" on the occasion.

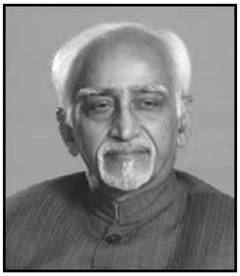
The President extends her warm greetings and felicitations to the organisers and the participants and wishes the Award Presentation Ceremony every success.

A. Datta

Officer on Special Duty (PR)

भारत के उप-राष्ट्रपति के विशेष कार्य अधिकारी
JOINT SECRETARY & OFFICER ON SPECIAL DUTY
TO THE VICE PRESIDENT OF INDIA
नई दिल्ली / NEW DELHI - 110001
TEL.: 23016422 / 23016344 FAX : 23012645

सत्यमेव जयते



MESSAGE

Hon'ble Vice President of India is happy to know that the Retired ICAR Employees Association, Hyderabad is organizing the Third M.S. Swaminathan Award function on 14th November, 2009 and bring out a souvenir on the theme 'Emerging Trends in Indian Agriculture' on this occasion.

Vice President of India extends his greetings and good wishes to the organizers and the participants and wishes the souvenir and the award function all success.

New Delhi
29th September, 2009

(P. HARISH)

S.N. Sahu
Director
Tel: 23014208

प्रधान मंत्री कार्यालय
नई दिल्ली - ११०१०१

PRIME MINISTER'S OFFICE
New Delhi - 110101

MESSAGE

The Prime Minister is happy to know that the Association of the Retired employees of the Indian Council of the Agriculture Research is presenting the Third M.S. Swaminathan Award on 14th November 2009 and bringing our a Souvenir on the theme 'Emerging Trends in Indian Agriculture'.

On this occasion the Prime Minister extends his greetings and good wishes to the organizers and participants for the success of the award giving function.

October 5, 2009

(S.N. Sahu)

सत्यमेव जयते

PRESS SECRETARY TO GOVERNOR
ANDHRA PRADESH

RAJ BHAVAN
HYDERABAD-500 041

21st October, 2009

MESSAGE

The Governor of Andhra Pradesh is pleased to convey his best wishes for the success of M. S. SWAMINATHAN SECOND AWARD FUNCTION being organized by the Retired ICAR Employees Association on 14th November, 2009, at Hyderabad and for bringing out a Souvenir on the theme of "Emerging Trends in Indian Agriculture".

Press Secretary to Governor

CHIEF MINISTER OF AP
MESSAGE

सत्यमेव जयते

डा. मंगला राय
सचिव एवं. महानिदेशक
DR. MANGALA RAI
SECRETARY & DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली ११० ११४
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
TEL : 23382629; Fax: 91-11-23384773; Email: mrai@icar.delhi.nic.in

MESSAGE

I am very pleased to know that the Retired ICAR Employees Association is organizing the Third M.S. Swaminathan Award function on 14 November 2009.

Retired persons, more appropriately knowledge tanks in the respective fields, if tapped properly can make any nation prosperous and healthy.

This Association at present is every befittingly serving as a pool of resource-persons for scientific and extension bodies, bringing awareness of latest developments among farming community and general public, and from time to time recognizing and felicitating outstanding scientists.

I wish the Association all the success in future.

Dated the 7 October 2009
New Delhi

(MANGALA RAI)

M S Swaminathan Award - A Foreword

The Retired Indian Council of Agricultural Research Employees Association (RICAREA) was formed in 1997 to promote and further the ideals and objectives of the Indian Council of Agricultural Research (ICAR), by providing services to Governmental Agencies, NGOs, Public & Private enterprises, and farming community. The association is also serving as a pool of resource persons for scientific and extension bodies, besides bringing awareness of developments in science and technology among the farming community and general public. At present the Association has a membership of 319 (250 Life Members and 69 Annual Members).

As part of the activities RICAREA in association with Nuziveedu Seeds Pvt Ltd., Hyderabad, Andhra Pradesh has instituted a prestigious National Award in the name of the living legend Prof M.S. Swaminathan. This award carries a Cash prize of Rs.1.7 lakhs, Gold Medal and a Citation. There are several prizes/awards/endowment awards being conferred on agricultural scientists by ICAR and other agencies. But these awards are given on the basis of specific age groups, discipline, team work, etc. and carry less prize money. We may say here that this is the highest recognition to an agricultural scientist for his life time achievements and contributions to Indian agriculture and the prize amount is also the highest at present.

The first M.S. Swaminathan award for the biennium 2004-2005 was presented to leading Poultry Scientist Dr Genda Lal Jain on 27th October 2005. The second M.S. Swaminathan award for the biennium 2006-2007was presented to Dr B S Prakash NDRI Scientist on 3rd November 2007. On both the occasions Souvenirs with articles from leading scientists of different crops, disciplines were released.

In response to our letters we have received 26 nominations from eminent scientists from all over the country covering agricultural sciences (22), animal sciences (2), fisheries sciences (2) for the 3rd M.S. Swaminathan award for the biennium 2008-2009.

The Selection Committee under the Chairmanship of Dr R.S.Paroda unanimously selected Dr S.Nagarajan, Former Director, Indian Agricultural Research Institute, and Presently Chairman, Protection of Plant Varieties and Farers' Rights Authority, New Delhi to receive the Third MS Swaminathan award. His work on wheat pathology has made significant contribution on society in terms of enhanced yields.

This Souvenir third in series is brought out to mark the occasion of the Third MS Swaminathan award presentation. This is a collection of 25 invited articles apart from the article of the awardee Dr S Nagarajan. with the theme "Emerging trends in Indian Agriculture."

The Association conveys its gratitude and sincere thanks to Smt Pratibha Patil, Hon. President of India, Shri Mohammad Hamid Ansari, Hon. Vice President of India, Dr. Manmohan Singh, Prime Minister of India, Sri Narayan Dutt Tiwari, His Excellency, the Governor of Andhra Pradesh, Dri K. Rosaiah, Hon. Chief Minister of Andhra Pradesh for their Messages and blessings.

On behalf of the Association we would like to thank Sri M.Prabhakara Rao, MD Nuziveedu Seeds and Members of RICAREA. We thank the support and encouragement given by the advertisers which enabled to bring out this Souvenir in record time.

I hope that the Souvenir with articles from specialists belonging to major fields of agriculture would serve as a reference guide.

M.V.S.Sastry & J.Venkateswara Rao
Retired ICAR Employees Association

About RICAREA

The genesis of Retired Indian Council of Agricultural Research Employees Association (RICAREA) was initiated in 1994 by late Dr K V Poornachandra Rao, Retd. Joint Director, NEH Complex, Manipur who discussed issues regarding medical facilities for retired employees from ICAR with Sri J R K Rao, Drs N G P Rao, S V S Shastry, V V S Murthy, R Seetharaman, J Venkateswarlu and M V S Sastry. Subsequently a few more retired employees joined this group and prepared a list of all retired ICAR employees settled in Hyderabad and organized informal meetings to discuss various issues related with retired employees' welfare. One of the main issues regarding extension of 'medical facilities' emerging from these meetings was sent as representation to ICAR and concerned Minister.

After two years of informal meetings, members felt the need to register the body and thus the present Retired Indian Council of Agricultural Research Employees Association (RICAREA) was formed on 13-09-1997 with full complement of office bearers with Dr. E A Siddiq as its President. The Association was registered in Hyderabad under the Andhra Pradesh (Telangana areas) Public Registration Act 1350 Fasli (Act I of 1350 F 0 on November 22, 1997 with Registration No. 5959 of 1997).

Objectives of the Association

- To serve as a pool of resource persons for scientific and extension bodies.
- To bring about awareness of developments in science and technology among the farming community and general public.
- To safeguard the general welfare and to provide a forum for sustaining professional?) interest of the members.

Later on the Association also took up the cause of recognizing and felicitating members on completion of 75 years.

At present the Association has a membership of 319 (250 Life Members and 69 Annual Members) from all over the country.

Annual Day

Since 1998 Annual Day is organized and members participate with their families. A custom was started from 2001 onwards to invariably invite an eminent person from public life as Chief Guest for the function. The list of luminaries who graced the annual days were Dr D. Bala Subramaniam (2001), Justice G Raghuram (2002), Gen. K.V. Krishna Rao (2003), Dr Kakarla Subba Rao (2004), Dr Y.L. Nene (2005), Dr A. Appa Rao (2006), Dr A.Panduranga Rao (2007).Dr A.V. Guruva Reddy (2008) and Dr Palle Rama Rao (2009).

Members felicitated on completion of 75 Years

Every year RICAREA felicitates the members who enter their Platinum jubilee year.

List of members felicitated on completion of 75 years:

- Drs/s Sarvasri
  2001: J S Kanwar, Karlapalem S Murty & J Suryanarayana.
- **2002:** I V G Krishna Murty, V V S Murty, D S Sastry, P Madhusudan.
- **2003:** N Ganga Prasada Rao, R Seetharaman, V Ravindranath,

P Satyanarayana, V Joseph & Y Sathi Raju.

- **2004:** M V Rao, S V S Shastry, Kuchimanchi S Murty, A V Subbayya, B R John, V Soundara Rajan & M Surya Rao.
- **2005:** N C Gopalachari and S Krishna Murty.
- **2006:** M V S Sastry, KV Subba Rao, D V Reddy, P V Anantaraman, P S Krishna Murty, D Seshagiri Rao & V Appa Rao.
- **2007:** S Chittaranjan, G Sreerama Murty, K V Raman & S Srinivasan.
- **2008:** G V G Krishna Murty, I M Seshagiri Rao, M Nageswara Rao, R Brahmanandam, R A Hodlur, C C Panduranga Rao, K V Satyanarayana and T Appa Rao.
- **2009:** G S R Murthy, P V Subba Rao, D V Seshu, N J Mudholkar, M Subrahmanyam, C R Padalia, J Bhimsen Rao, G Narasimha Reddy, R V Vidyabhushanam, S R Gawali, K Madhusudhana Rao, G Annamachari, D S Murthy and R D P Mohana Rao.

Welfare Activities

One of the aims of the Association is to take up matters related to healthcare with the concerned authorities. To improve the understanding of the members regarding healthcare a few lectures were arranged on health matters in collaboration with corporate hospitals. On 03-09-2006 lectures by Dr K Sailaja on Secrets of healthy lungs, and Liver care by Dr Asha Subba Lakshmi were arranged. Sri C V Rao Engineer talked on Energy conservation. Dr. A Panduranga Rao gave a talk on Emergency health care. Dr. A V Guruva Reddy gave a talk on Arthritis of Knee & Hips --- Facts and Myths.

Information about Association

To cater the needs of the members located in different places including foreign countries, a website was launched a few years back to disseminate information about all activities of RICAREA to members as well as other interested organizations and persons. The url is www.ricarea.org which is updated regularly with complete data of members. Many members have contributed for the growth of this association. We place on record our fond memories of those departed but left an indelible mark on the growth and development of our Association. Among them are: Drs/S/Sri. B. Venkateswarlu, P V Ramana Murthy, K V P Rao, M J Balakrishna Rao, T.P.Sriharan, N S Rao and M Someswara Rao. Drs P.V.Subba Rao, V.Nageswara Rao, M.Bangarayya and R Mallikarjuna Rao are also significantly contributing. These are the few names which come to our mind when we talk of the Association. The members who are actively associated and still contributing to the overall health of the Association are: Drs/S/Sri. M V Rao, N G P Rao, V V S Murthy, V Jayamohana Rao, J R K Rao, J Venkateswarlu, K.Vidyasagar Rao, S.Indira, J.Venkateshwar Rao, K.Purnachandra Rao, Vijay Singh, P.Kumaraiah, G.Nagaraj, M.Naga Raju, Y.S.Ramakrishna and S S Narayanan. The Executive Body of the Association is able to function efficiently because of the whole hearted support and help received from its members.

M V S Sastry

Dr. Norman Ernst Borlaug - The man who gave peace to the Hungry world through food

M.V. Rao

A hungry person listens neither to reason or religion, nor is bent by any prayer and where hunger rules, peace cannot prevail.

-Senaca (3000BC)

Through his technologies and dedicated and committed efforts Dr. Norman Ernst Borlaug increased food production in general and wheat production in particular and helped many countries in the world like Asia, Latin America and Africa to increase their food production by several folds and saved millions of people from hunger and famines. Born in a humble Norwegian family of migrants to America he lived and was brought up in harsh conditions. His early education up to eighth standard was in a one teacher one room school. He had to work as a daily wager and later on when he went to college as a waiter in a restaurant for which he was given only lunch and supper as remuneration**.** He graduated as a botanist and got his M.Sc and Ph.D degrees specializing in Plant Pathology and Plant Breeding in University of Minnesota,USA. Besides being good in studies he was also a good wrestler and baseball player of distinction in both school and college and captained the teams. He worked for some time as a forester in a lonely remote forest area where his food supplies used to arrive once in a week. During war time he worked as a biochemist in E.L. **Dupont** Company at Delaware. His teachers at Minnesota, like the world famous pathologist Dr. E.C. Stakman recognized the talents, competence and skills of Dr. Borlaug and recommended his name for appointment in 1942 as a pathologist in a newly initiated programme in Mexico by the Rockefeller Foundation to work on wheat. This programme later got upgraded in 1944 into the International Maize and Wheat Improvement Centre (CIMMYT). All his active life was spent here in Mexico developing varieties and technologies in wheat which brought Green revolutions round the world in several countries. India is one of the major beneficiaries of his dwarf varieties. After retirement he moved to Texas A&M University, USA but continued his invaluable service as an advisor to CIMMYT wheat programme till his last moment. He lived up to a ripe age of 95 years (born on 25^{th} March 1914 and expired on 12^{th} September 2009). Several awards, rewards, honorary degrees of 50 universities and highest honors were showered on him all over the world. He was the first agricultural scientist who received the Nobel Prize for Peace and American Congress Gold Medal. The Government of India honored him with Padma Vibhushan. Several Institutions, laboratories, roads in cities were named after him. Several books were written on Dr. Borlaug extensively covering his contributions to prevent famines, starvations and hunger which led to world peace. The citation of the Nobel Peace Prize committee at the time of its offer Dr. Borlaug states: "The world has vacillated between fear of two catastrophies - the population explosion and the atom bomb. Both posed a mortal threat. In this intolerable situation, with the menace of doomsday hanging over us, Dr. Borlaug comes onto the stage and cuts the Gordian knot. He has given us a well -founded hope, an alternative of peace and of life – the green revolution.”

It will be pertinent at this juncture to take note of Dr. Borlaug’s views while accepting the Nobel Prize for Peace. “There can be no permanent progress in the battle against hunger until the agencies that fight for increased food production and those that fight for population control unite in a common effort. Fighting alone, they may win temporary skirmishes but united they can win a decisive and lasting victory to provide food and other amenities of a progressive civilization for the benefit of all mankind.” In the same vein he continued “If you desire peace, cultivate justice, but at the same time cultivate the fields to produce more food, otherwise there will be no peace.”

The above statement shows the real nature and goal of Dr. Borlaug. He was intensely interested in fostering peace; reduce hunger and starvation in the world. He was extremely humane in his outlook and approach. World over Dr Borlaug is considered as a great fighter not as in war to kill people, but to save millions of people from hunger, starvation and death. He will be remembered for generations to come as a person deeply concerned about human happiness, dignity, wellbeing and peace.

For the information and guidance of Scientists, Policy Makers and Administrators I would like to quote some of the statements of Dr. Borlaug which I noted in my last 50 years of association with him :-

1. For Plant Scientists who are involved in giving results to the society: Plants speak. They speak in such a low voice you have to be near them to hear. If you are sitting far off in air conditioned rooms you can never listen to their voices.
2. We have only one Doctor i.e. Sun God. If you are working in the Sun in the fields the sun God will take care of your health and you will never fall sick.
3. Always aim for the stars. Even if you cannot reach them, at least you will get the star dust on your fingers and hands.
4. Agricultural research without application is only a hobby and application without research is folly.
5. Constructive good work is the best medicine God has ever given to man. So go on doing good work.
6. Technology alone cannot bring revolution in farming; it should be supported and backed up with appropriate policies, administrative support, prices and inputs to the farmers.
7. For generation of technology and its successful transfer to the end –users: multidisciplinary team work is most essential.
8. Bureaucracy is the biggest hurdle for progress. If one is firm in his conviction he should cut across the bureaucratic hurdles and push the programmes.
9. Responsible biotechnology is not the enemy, starvation is.
10. If the farmer is pinching your material in the field be happy and do not discourage him. This means he likes your new varieties and technologies and this is the best way of extension.
11. Arm chair theoratians and planners and other sooth sayers talk in gullible terms about lack of growth of food grains production, in spite of bumper harvests. The only way to convince that there is progress is by making

them carry the extra bags of food grains on their backs from the field to the market places. After carrying few bags then they will say "oh! There is progress."

12. Organic farming is good for certain high priced horticulture crops, and for improving soil health, texture and hydraulic conductivity. It cannot improve yields significantly. Organic material like dung cannot replace chemical fertilizers for boosting up food grain production. You require 4.7 billion tones of organic to compensate for 70 million tones of chemical fertilizers. Where is this quantity of organic material and where are the cattle and the enormous extra land that is needed to feed the extra cattle?

13. If I am a Parliament Member in India after every one hour I will get up and say more inputs and more inputs to the crops to increase food production.

There are many other instances of his exemplary life to quote. The amount of encouragement Dr. Borlaug gave to young people all over the world to become good scientists and leaders is enormous. Thousands of young scientists were trained by him. He strongly believed that "the mark of a true leader is not to create more followers but build more leaders." He was very firm in his conviction "without aggressive agricultural research programmes, the world will soon be overwhelmed by the population monster."

The contribution of Dr. Borlaug to India's food security, through his dwarf wheat varieties, production, protection technologies and transferring of technologies through talks and demonstrations are enormous and incomparable. India has emerged as the 3rd biggest food grain producer, and 2nd biggest producer of rice and wheat in the world, it is because of the seed of Green Revolution he planted. India is fortunate to have top ranking scientists, administrators, policy makers with strong input supply agencies and very hardworking farming community. Indian scientists greatly improved and refined the original varieties and technologies of DR. Borlaug and took the Green Revolution to new heights. Having been associated with the Indian wheat program in various capacities since 1952, I know the enormous value of Dr. Borlaug's help since 1963 till he breathed his last. He was interested in India's progress and food security. The first impact of his technologies was felt in 1967-68 in the rise of wheat production by four million tons from 12.4 million tones of earlier highest record of 1964-65, to 16.3 million tones. There was no place for storing the extra wheat because India was living on field –to- mouth or ship –to -mouth condition. Prime Minister madam Indira Gandhi released a postal stamp "Wheat Revolution 1968" to mark the start of the Green Revolution. India never looked back it, steadily increased its wheat production to unprecedented 80.7 million tons in 2008-09 and buffer stock storage of 25million tons of wheat. India could withstand shocks of excessive rains, droughts, floods etc. because of the security on the food front.

Dr. Borlaug used to visit India every year, sometimes twice a year and work in the wheat fields with scientists, travel extensively in the wheat growing states and address and interact with lakhs of farmers. Leaving aside the scientific talents of Dr. Borlaug he used to play a critical role in influencing political leaders, policy makers, administrations for making available to farmers, inputs, favorable prices, technology transfer etc. He was bold, frank and rigid in expressing his views and was disdainful of bureaucratic controls and unproductive publications. Everybody in India right from the top echelons of Indian political and scientific system to the farmers used to await the visit of Dr. Borlaug for his advice, assistance, guidance and inspiration.

Dr. Borlaug's efforts to banish hunger and give food security are not only confined to India but to all developing countries of the world particularly of Asia, Latin America and Africa. His technologies were also exploited in developed countries of North America, Europe and Australia. The very fact that he accepted the responsibility to work as Vice Chairman and later Chairman of the Sasakawa Global 2000

Foundation to reduce hunger in the famine stricken countries of Africa shows his concern for humanity. His Excellency The President of India Dr. K.R. Narayanan in his Republic Day message some years back said, "India's two greatest achievements after independence are, one is maintenance of democracy and the other is the Green Revolution." This summarizes the role of Dr. Borlaug in the Indian context.

As homage in memory of Dr. Norman Borlaug the Scientist, Planner, Policy Maker, Encourager of talent and, above all a great humanist who always thought of the welfare of people of the world, is to fix his goals in our mind and follow his footsteps and work for everlasting peace. The saying "the only thing you take with you when you are gone is what you leave behind" fits very aptly to Dr. Borlaug and the whole world will remember him for generations to come for what he left behind. At the sad demise of this great human being on the 12th September 2009, we all pray to Almighty God to give peace and solace to the departed soul of Dr. Norman E. Borlaug.

Norman Borlaug Memorial

Rudder Auditorium, Texas A&M University

6 October 2009

Memorial Address

by Prof M S Swaminathan

I feel privileged to have been invited to speak at this memorial designed to celebrate the life and work of Norman Borlaug, who has been aptly referred to by the Nobel Peace Prize Committee as the greatest hunger fighter of our time. I have had the privilege of knowing Dr Borlaug and working with him for nearly 50 years. I first heard him in 1953 outline an innovative strategy for combating wheat rusts at the University of Wisconsin, Madison. From 1963 onwards he visited India in March every year to see the wheat crop. During his extensive travels by road, he used to stop frequently, talk to the farmers and examine the state of the health of the plants. Plants and farmers became his life long friends and companions, and eliminating the wheat rust menace became his unrelenting mission.

Dr Borlaug started his research career in agriculture in Mexico at a time when the world was passing through a serious food crisis. During 1942-43, nearly 2 million people died of hunger during the great Bengal Famine. China also experienced widespread and severe famine during the 1950s. Famines were frequent in Ethiopia, the Sahelian region of Africa and many other parts of the developing world. It was in this background that Borlaug decided to look for a permanent solution to recurrent famines by harnessing science to increase the productivity, profitability and sustainability of small farms.

The work he did in Mexico during the 1950s in breeding semi-dwarf, rust resistant wheat varieties and its extension to India, Pakistan and other countries during the 60s brought about a total transformation in the atmosphere in the possibility of achieving a balance between human numbers and the human capacity to produce food. Developing nations gained in self-confidence in their agricultural capability. He disproved the prophets of doom like Paul and William Paddock and Paul and Anne Ehrlich. Paul and William Paddock even advocated the application of the "triage" principle in the selection of countries which should and should not be saved from starvation through American assistance. India was listed in such an analysis as a nation which can never feed itself.

The introduction of Mexican Semi-dwarf varieties of wheat in India in the early 1960s helped not only to improve wheat production, but also led to the union of brain and brawn in rural areas. The enthusiasm generated by the new technology can be glimpsed in the following extract from an article I had written in the Illustrated Weekly of India in 1969 :

"Brimming with enthusiasm, hard-working, skilled and determined, the Punjab farmer has been the backbone of the revolution. Revolutions are usually associated with the young, but in this revolution, age has been no obstacle to participation. Farmers, young and old, educated and uneducated, have easily taken to the new agronomy. It has been heart-warming to see young college graduates, retired officials, ex-armymen, illiterate peasants and small farmers queuing up to get the new seeds. At least in the Punjab, the divorce between intellect and labour, which has been the bane of our agriculture, is vanishing”

The five principles Borlaug adopted, in his life, to quote his own words, were

- Give your best
- Believe you can succeed
- Face adversity squarely
- Be confident you will find the answers when problems arise
- Then go out and win some bouts

These principles have shaped the attitude and action of thousands of young farm scientists across the world. He applied these principles in the field of science and agricultural development, but I guess he developed them much earlier in the field of wrestling, judging from his induction into the Iowa Wrestling Hall of Fame in 2004.

Having made a significant contribution to shaping the agricultural destiny of many countries in Asia and Latin America, Borlaug turned his attention to Africa in 1985. With support from President Jimmy Carter, the late Ryoichi Sasakawa, Mr Yohei Sasakawa and the Nippon Foundation, he organized the Sasakawa-Global 2000 programme. Numerous small scale farmers were helped to double and triple the yield of maize, rice, sorghum, millet, wheat, cassava and grain legumes. Unfortunately, such spectacular results in demonstration plots did not lead to significant production gains at the national level, due to lack of infrastructure such as irrigation, roads, seed production and remunerative marketing systems. This made him exclaim, “Africa has the potential for a green revolution, but you cannot eat potential”. The blend of professional skill, political action and farmers’ enthusiasm needed to ignite another green revolution as in India was lacking in Africa at that time.

Concerned with the lack of adequate recognition for the contributions of farm and food scientists, he had the World Food Prize established in 1986, which he hoped would come to be regarded as the Nobel Prize for food and agriculture. My research centre in Chennai in India is the child of the first World Food Prize I received in 1987. Throughout his professional career, Borlaug spent time in training young scholars and researchers. This led him to promote the World Food Prize Youth Institute and its programme to help high school students work in other countries in order to widen their understanding of the human condition. This usually became a life-changing experience for them.

When Mahatma Gandhi died in January 1948, the then Prime Minister of India, Jawaharlal Nehru said, “The light has gone out of our life, but the light that shone in this country was no ordinary light. A thousand years later, that light will be seen in this country, the world will see it, and it will give solace to innumerable hearts. For that light represented the living, eternal truth, reminding us of the right path, drawing us from error, taking humankind to freedom from hunger and deprivation”. The same can be said of Norman Borlaug. His repeated message that there was no time to relax until hunger became history will be heard so long as a single person is denied opportunity for a healthy and productive life because of malnutrition.

Norman Borlaug was a remarkable man who was supported by a remarkable family – wife Margaret, son William and daughter Jeanie and lovely grandchildren. His wife Margaret who died in 2007, to my mind, is the unsung heroine of the green revolution. Without her unwavering support, Borlaug might not have accomplished nearly so much in his long and demanding career.

In the Indian spiritual text Bhagwad Gita, sometimes referred to as the Bible of Hinduism, there is a saying that the divine manifests itself in various forms, whenever there is acute suffering or injustice on Earth. I feel it will be appropriate to consider Borlaug as one such messenger who came to the rescue of those struggling for their daily bread. I am saying this because Dr Borlaug was not only a great scientist but also a humanist full of compassion and love for fellow human beings, irrespective of race, religion, color or political belief. This is clear from his last spoken words on the night of Saturday 12 September 2009, Earlier in the day, a scientist had shown him a nitrogen tracer developed for measuring soil fertility. His last words were "Take the tracer to the farmer". This life long dedication to taking scientific innovation to farmers without delay set Borlaug apart from most other farm scientists carrying out equally important research.

I was privileged to be present when he was awarded the Congressional Gold Medal in 2007. On that occasion he pointed out that between the years 1960 and 2000 the proportion of "the world's people who felt hunger during some portion of the year had fallen from about 60% to 14%". The latter figure, he went on, still "translates into 850 million men, women and children who lack sufficient calories and protein to grow strong and healthy bodies". He added "the battle to ensure food security for hundreds of millions of miserably poor people is far from won". This is the unfinished task that Norman Borlaug leaves to scientists and political leaders worldwide. It will be appropriate for the Norman Borlaug Institute for International Agriculture to become the flagship of the movement for a world without hunger.

Before I conclude I have the privilege of announcing that the Government of India, in recognition of Dr Boalaug's monumental contributions to food security and rural prosperity, has decided to institute a Norman Borlaug Chair at the Indian Agricultural Research Institute, New Delhi.

Creating, protecting and managing intellectual wealth – and the Indian seed industry

S.Nagarajan

India because it is big has been able to produce intellectual elite of considerable size and competence and to develop a tradition of public debate on national issues

- Gunnar Myrdal, 1967

Preamble

Plant breeding efforts in India were initiated almost a century ago, by publicly funded institutions to develop superior crop varieties. In the early half of the last century these public good efforts were considered as efforts to enhance the livelihood security of the poor farmers. Seeds of the varieties developed were multiplied in the Government seed farms and were made available to farmers at concessional rates. By 1960s, when new high yielding varieties were developed seed corporations were started as government undertakings at federal and state levels. The Seed Act, 1966 was passed around the same time to prescribe quality standards, labeling procedures etc.

Crop Genetics emerges as new business

When the developing countries were rejoicing on the speed and success of the "Green Revolution" and the manner it fuelled the economic growth of nations, the West got the final proof for what the "Crop Genetics" can contribute to the seed industry. Soon, a global strategy emerged. Around the world many pesticide and seed industries merged to consolidate their capital and technology to become a formidable force (Nagarajan, 2007) to match national and international crop research systems. The outcome was obvious within two decades. The Bt cotton hybrids promoted by one of the seed giant, transformed the production system, reduced pesticide usage, improved fiber standards and above all it received overwhelming support from the growers. The seed company converged the technology wrapping it in a hybrid cotton seed; protected its intellectual -wealth through a series of patent, plant variety protection, trade mark and secrecy steps. The company was smart to quickly accord franchise to national companies through agreements, deals, and agency rights ensuring the flow of royalty (profit) to them.

The recent International Treaty on Plant Genetic Resources for Food and Agriculture has also made sure that royalty flows to the third party, in this case the FAO, to take up several activities. The TRIPs related patent requirements are to be properly understood by the Indian seed industry. There will be "no free lunch" any longer; patents, exclusive rights, benefit sharing and royalty have all come to stay with the seed business.

Biodiversity is the brick for variety breeding

There is an urgent need to conserve the biological diversity, sustainable use of its components and provide an

Chairperson, Protection of Plant Varieties and farmers' Rights Authority,Government of India, New Delhi. E Mail : *chairperson-ppvfra@nic.in*

equitable sharing of benefits arising out of the use of biological resources. In the International Convention on Biological Diversity held in Rio de Janeiro in 1992, it was agreed that biological resources are sovereign rights of nations. Since there was no common International Treaty, the Indian Parliament enacted the Biological Diversity Act 2002 to safe guard our interest on biological resources. It is worth remembering that India is one of the major centers of evolution of several life-forms. This vast wealth of India is a vital input for the growth of pharmaceutical, seed and several other industries. While extracting plants / genes / Indigenous knowledge and several elements from the keepers of biological diversity our industries should make sure that benefit sharing accrues to the hereditary conservers / improvers / perpetuators of this natural wealth. This will also make sure that using molecular tools big companies do not mine the farmer conserved genes that govern heat tolerance, quality characters, water usage efficiency, saline tolerance etc, so abundantly present in materials.

Creating wealth through innovation

Nature has provided different types of floral biology, sexuality and multiplication pathways in plants that can be innovatively used. Perennial crops like temperate fruits, mango and orchard crops are grafted on root stocks that enhance the performance of the scion. Private plant breeders in western countries have come out with superior root stocks for specific variety and both are required to get the desired performance. This therefore enhances the royalty of the tree breeder and like hybrid, provides inbuilt safety from infringers. Similarly, heterocious plants like papaya, date palm etc, provide another option; pollinators are essential in fruit crops and are to be planted at a given density as without good supply of pollen fruit shape and size gets distorted. The nature offered systems can be improved, innovated and taken-up for opportunistic marketing. One has to learn from the manner fruit industry grew in California and Florida of USA and the Mediterranean nations.

The Secret

The institutions involved in such capital intensive future product development based research must patent the gene / trait under appropriate legal provisions leaving no fringes of the discovery to be infringed by anyone to produce a “look alike” product. It is better to develop such high value transgenic as hybrid, and park the gene in question in the mitochondria of the cell so that along with pollen, the trait cannot spread to any other plant. This double safety though involves upstream research is possible to accomplish. The industry can keep the material under “secrets” by holding back the B line (maintainer line).

Trade Mark

The “Trade Mark”, is an essential marketing and product identification strategy. Trade Mark should not become generic, must be registered in all countries where the product is to be sold and is to be used without a long discontinuation. Based on the business module adopted by the company, their IP strategy should be framed. Having a registered Trade Mark, followed by crop identification and denomination of the variety, can be adopted by seed companies to have proper hold on their biological assets.

Patent

Recombinant technology based products as validated gene sequences, gene constructs, promoters, reporters, special synthetic chemical media, staining materials, array of equipments that are designed and developed for such studies are all patentable under the Indian Patent Act 1970. Patents are exclusive rights granted to the inventor, which he has a right to enjoy for a given period of time and after which, it automatically comes under public domain or when the inventor does not wish to retain the patent. The patent holder rights can be purchased by anyone indenting to develop a commercial product using that knowledge or wishing to use it in any other form. Therefore the seed industry should get patent for priming and application procedure, seed coating, pelleting improvement, etc. This will prevent others using such systems and imitating their seed.

Biosafety requirements

When gene or a combination of genes normally not present in a given plant genera is inserted at a designated site of another plant DNA and if that gene(s) is able to express the special trait in the now embedded plant system, then the plant thus produced is a transgenic. Since the introduced gene sequence carries with it other DNA appendages, and that the pollen of the transgenic can get freely dispersed under natural conditions, it has become necessary to conduct experiments to validate the ecological and biological safety of the transgenic. For this purpose the Department of Biotechnology of the Government of India has prescribed "Biosafety Guidelines" to experiment with these materials under containment conditions. The Institution's Biosafety Committee is meant to oversee that the norms are not violated and steps are taken to ensure assurance to the society that there is no negligence during the process of product development.

Protection of Plant Varieties in India

It is never an infringement of plant breeders' rights granted under PPV&FRA to use the variety for further breeding, provided that it is not repeatedly used for the production of another variety, or an essentially derived variety. The PPV&FR Act 2001 is in force from 2005 and, from February 2007 registration for twelve species got started. As of now more than 30 species of plants covering a large number of cereals, millets, grain legumes, vegetables, oil seeds, spices and sugarcane are open for registration as new variety, extant or as essentially derived variety as the case may be. Several procedural details have been notified in the Gazette of India. The Plant Variety Journal of India published every month by the Authority is the Gazette for this Act where office order, public notice, applications accepted by the registrar for DUS testing, extant varieties granted registration are published to enable aggrieved party file their objection seeking a redressel from the registrar who has the powers of a Magistrate for this Act. Several RTI information have been sought, objections have been filed, enquiries made and judgments spelled. In other words, the law on PVP has been implemented meeting the TRIPS requirements. The rights granted under the Act are comparable to that of UPOV 1978 provisions including the clause dealing with farmer retention of seed. The farmers' right to compensation and his prerogative over the conserved biological resources have been suitably reflected in the Act. This exclusive right granted to the breeders / institutions will encourage greater investment in such activities. The rights grated to the breeder of the variety can be sold, transacted, leased or disposed in any manner and on completion of the registration period the material will be under public domain. Also if any one other than the initial breeder uses the material for deriving the essential characters of the variety, then he is to take prior approval from the initial breeder. And this gives the latter to exercise his rights on benefit sharing.

Law on Innovation in public funded systems

The Bayh-Dole Act of USA transformed their economic growth by linking the innovations of the public funded institutions with the industry which is poised towards product development and delivery system. Impressed by the public-private partnership that got triggered leading to market dominance by some of the well managed companies in India, the Innovation Bill 2009 is now under consideration by the parliament. Every public funded institution shall have to put in place an IP management structure and develop appropriate institutional frame work to transfer innovations for product development. It is recognized that business opportunities are available through IP and will drive major changes in our current style of handling agriculture, food and food processing.

How do we do it?

Marker aided selection in plant breeding using the information generated by genomic studies is going to dominate future agriculture and crop breeding. Many capital intensive seed companies of the west have already blocked several genes discovered during genomic studies covering rice, wheat etc. Therefore seed industries of the developing countries should collectively face these new Czars. Wherever reliable, closely linked, co-segregating markers are available for within genera variation, inter or intra species crossing and varietal development programme can be accelerated. Such an approach will reduce the variety development time by half. These are simple routine techniques and several markers are now available under public and private domain. Using multiple markers and high through-put machines thousands of DNA samples from segregating plant can be analyzed and only those where the gene in question has been integrated can be rapidly advanced and families can be field evaluated to select the one that would meet the market demand.

Many of these modern approaches are necessary for the seed industry and individually they may find it difficult to do. So the Seed Association of India should call for interested Indian seed companies, to invest in a Consortium with limited liability, and that consortium should run a "Plant Biotechnology service center for Indian seed industry". Each consortium member then pay a fees to get their plant DNA analyzed, or get their MAS done, fiber or oil quality validated, seed quality tested; each on a payment basis. The Board of Directors of the consortium should run this as private company dedicated to the cause of the member seed companies. Keeping high degree of confidentiality on the coded material taken for testing is very essential. By coming together the Indian seed companies can emerge as a formidable force and such bold decisions should be quickly taken if the industry is to survive and flourish.

Creating technology clusters

Evidence tends to suggest that clustering is a new trend in India in the agricultural biotechnology area, where knowledge and skills are diffuse, complicated and actively protected. Success of the cluster depends on the availability of innovation center, which can extend an array of functions to the members of the cluster. The BioValley model launched in USA is one of the largest clusters, backed by comprehensive government strategies. In India, capital intensive science is taken up by public funded systems. Seldom they accommodate start-up companies in their campus by extending incubators, nor by any agreement transfer their innovations to Indian seed companies. As a result despite heavy research expenditure by the Central Government the type of cutting edge knowledge and products that are necessary are not available to Indian companies and they are compelled to shop outside the country under exasperating royalty clauses. The Seed Association of India should take on new role and responsibilities to make our seed companies become global. Indian seed industry should not have myopia and short-sighted fly by night approach, but aspire to be a global player as Wipro or TATA.

The purpose of me, harping on this topic is to prevail on the seed industry that doing business as usual would no longer help and the industry must promote innovative research on seed development to withstand global pressures.

I would like to conclude by thanking the RICAREA, and Nuziveedu Seeds, Hyderabad for presenting me with the 3rd Dr.M.S.Swaminathan Award on 14 November 2009. On this birthday of our first Prime Minister of India Late Jawaharlal Nehru, I wish to convey my good wishes for a robust seed industry, accelerated growth of agriculture and prosperity to the Indian farmer.

Suggested Reading

Butler.S.C. 2005. A guide to UK and EU plant variety rights. Cambridge University Press, Cambridge, UK.125pp

Cullet,P. 2005. Intellectual property protection and sustainable development. LexisNexis Butterworths, New Delhi, 462p.

Krattiger, A., R.T.Mahoney, L.Nelsen, J.A. Thompson, A.B.Bennett, K.Satyanarayana, G.D.Graff, C.Fernandez, S.P. Kowalski. 2007. Executive guide on Intellectual Property Management in Health and Agricultural Innovation: A Hand Book of Best Practices.). Vol 1: 214p., MIHR (Oxford, UK), PIPRA (Davis, USA), Oswaldo Cruz Foundation (Fiocurz, Rio de Janerio, Brazil) and bioDevelopment – International Institute (Ithaca, USA).

Nagarajan, S. 2007. Knowledge, innovation, intellectual property rights and technology cluster. University News. 45: 20-24.

Nagarajan, S. 2008. Intellectual property rights as an option to promote excellence in Agriculture. 38th Lal Bahadur Shastri Memorial Lecture, IARI, New Delhi. 16p.

Nagarajan. S. 2008. Benefits that would accrue, obvious. The Hindu survey of Indian agriculture. p122 - 125

Nair,L. R., R.Kumar. 2005. Geographical indications. A search for identity. Lexis Nexis – Butterworths, New Delhi. 359pp.

Myrdal, G. 1967. Asian Drama – An inquiry in to the poverty of nations. Vol 1: 705 Pelican Books Ltd. England.

Climate Change, Crop yield and Food Security

M S Swaminathan

At the G8 Summit held in July 2009 at L'Aquilla, Italy, an agreement was reached that all nations should reduce greenhouse gas emissions by 40% by the year 2020, so that the rise in mean temperature can be limited to 2 C. At the current level of emission, the rise in temperature may go up by 4 C by 2100 or even earlier. A rise in temperature by 2 C may do good to agriculture in the northern latitudes, since this will help to extend the growing season and thereby increase the yield of the crops of those regions. In contrast, the average duration of crops will be reduced in the tropics and sub-tropics, thereby reducing yield.

The late Prof S K Sinha and I studied the impact of a rise in temperature by 1 C in wheat and rice twenty years ago. We observed that in North West India, which is the heartland of the green revolution, the duration of wheat and rice will be reduced by a week. This in turn will reduce yield by 4 to 5 quintals per ha (*S K Sinha & M S Swaminathan, Deforestation, Climate Change and Sustainable Nutrition Security : A Case Study of India. Climate Change, 19: 201-209:1991*). Numerous other studies which followed our publication have confirmed our finding and have highlighted the serious threat to food security arising from global warming. What are some of the steps we should take to insulate to the maximum possible extent our crops and food security system from the adverse impact of climate change? I shall deal with five of them.

1. More Crop and income per drop of water

Most of the rainfall during the South West Monsoon period occurs within 100 hours. Therefore rain water harvesting and storage both in the aquifer and in tanks and reservoirs becomes very important. Simultaneously we should promote increased water use efficiency. In 2007, the Ministry of Water Resources of the Government of India initiated a Farmer Participatory Action Research Programme in over 2000 villages all over the country to assess the impact of water saving technologies, like the System of Rice Intensification (SRI) in rice. I have been chairing the National Committee providing oversight to this programme. The results of the last 2 years have shown that yield and income can be increased by 50 to 100 % in most crops by using water saving technologies.

In the Union Budget for 2009-10, an additional Rs.1000 crore has been provided for the Accelerated Irrigation Benefit Programme. I would suggest that 5% of the allocation for all irrigation projects should be reserved for increasing irrigation water use efficiency. Efforts to augment supplies must be accompanied with steps to minimize demand. In rainfed areas, which constitute 60% of the cultivated area, low water requiring but high value crops like pulses and oilseeds should be promoted.

Member of Parliament (Rajya Sabha), Chairman, M S Swaminathan Research Foundation, Chennai. Email: chairman@mssrf.res.in / msswami@vsnl.net

2. Small Farm Management Revolution

Over 80 percent of our farms are below 1 hectare in size. It will be extremely difficult for small and marginal farmers to face individually the adverse impact of climate change leading to a higher frequency of drought and floods. An immediate need is the introduction of management techniques which can confer on farmers with small holdings the power and economy of scale. Cooperatives have enabled us to climb to the first position in the world in the area of milk production. Decentralized production needs to be supported by key centralized services for enhancing small farm productivity and profitability.

There are now over 2.2 million Women's Self-Help Groups (SHGs) linked with banks. The plan is to enroll atleast 50% of all rural women as members of SHGs during the next 5 years. We need a similar movement to promote a **Small Farmers' Self-Help Group Movement**. Incentives like group credit and group insurance should be introduced to stimulate the growth of Small Farmers' SHGs. Water and climate management as well as post harvest technology can be improved enormously if a farm families in a village or watershed work together in certain areas of farm operations. Producer oritented marketing will then become easy.

3. Grain Storage

The Government of India has a grain reserve of over 50 million tonnes of wheat and rice. **In an era of climate change, grain reserves will prove to be our most precious asset.** Just as grain reserves are important for food security, seed reserves are important for crop security. To the extent possible, Panchayats should be enabled to set up local level community seed, grain and water banks. In addition we should establish in about 50 locations in different parts of the country, the most modern Grain Storage Structures, each with a capacity of holding a million tonnes. In this way, a national grid of grain silos can be established. This will help to prevent both panic purchase and distress sales. At present, grain mountains and hungry millions co-exist. Still there is pressure to export rice and wheat on the ground that we are incurring high storage losses. It is high time that we build the most modern storage structures, so that post harvest losses can be eliminated. This will help to avoid situations where we export just because we have proper storage.

4. Mission for Coastal Zone Protection

We have a coast line of 7500 Kms in addition to the Andaman and Nicobar and Lakshwadeep group of islands. The tsunami of 26 December 2005 was a wake-up call. We should take anticipatory steps to protect our coastal communities. In addition to nearly 10 million fisher men, women and children living near the shore, over 25% of our population live within 50 kms of the shoreline. Therefore a National Mission on Coastal Ecological and Livelihood Security should be added to the 8 missions currently included in the National Action Plan for Climate Change.

5. Strategic Research

Designing crops for a warming India should be an important anticipatory research programme. Based on computer simulation models on different weather probabilities, varieties of crops and agronomic practices should be developed. Novel genetic combinations for resistance to biotic and abiotic stresses as well as high per-day productivity will have to be created using recombinant DNA technology.

Every calamity presents also an opportunity for new innovations. An innovative Small Farmers' Self-help Groups based agriculture is the answer to the threat of reduced crop yield and uncertain food security arising from adverse changes in climate.

Intensive Efforts Needed for Food and Nutrition Security

R.S. Paroda

After Green Revolution, we thought that we had achieved self-sufficiency and solved our problem of food security. Somehow, the things have changed and there are many challenges and concerns that require our immediate attention. In this context, I draw your attention to the "Vision Statement" adopted by all the science academies in India and released by the Hon'ble Prime Minister Atal Bihari Vajpayee during the Indian Science Congress held in January, 2001. Its theme was on food, nutrition and environmental security. We need to continuously discuss this issue as we move along. In India, the ever increasing population in fact nullifies all our efforts. Every year we add one Australia to our population needing additionally 4 to 5 million tons of food grains. Many countries don't have such challenge, even China is now better off in that context. We have 16% of total population sustaining on only 2.8% of global land. It is anticipated that we may even surpass the population of China by 2020. We have to realize that India also has almost half of the livestock population than that of our human population. No where else this type of pressure per unit land is being faced currently.

Over the years, per cent GDP from agriculture sector is declining. This indeed is a good sign since industrial growth in the country is showing upward trend. However, it is well established that unless we have 4% growth rate from agriculture, expected 8% industrial growth would not be possible. So, agriculture is the backbone for India's overall development. In rural India, almost 60% of our people are dependent on agriculture alone. Dr. Swaminathan, Father of Green Revolution has often highlighted the importance of agriculture for national food security.

In mid 60s, India was considered a basket case. We seemed to have progressed considerably, thanks to the science based Revolution such as: changing the plant type concept, by making them respond better to higher inputs and giving higher productivity. We had also been fortunate to have the holy alliance of the NARS (National Agricultural Research System) supported well by the policy makers, International Agricultural Research Centers such as CIMMYT and IRRI, and above all our highly intelligent and hardworking farmers.

The green revolution enabled us to feed our population, which is still increasing @ 1.6%. At one time, we were importing more than 10 million tons of foodgrains under PL-480. During past 50 years, we have witnessed unprecedented progress, increased agricultural production at growth rate of 4.5%. Yet the concern is of economic and ecological access to food. Unfortunately, we have not been able to increase buying power, which is why the poverty issue is of major concern.

In the past five decades, there had been steady rise in the prices of most of

Chairman, Trust for Advancement of Agricultural Sciences (TAAS) andFormer Director General, ICAR and Secretary, DARE. Email: raj.paroda@yahoo.com

the industrial products. On the contrary, in agriculture, prices of foodgrains have shown a declining trend, which made the life easier for our people. We have also been able to reduce poverty by 40%. At the same time, life expectancy got doubled from 32-64 years since we became independent. We are aware that despite all these achievements, there are new concerns globally. MDGs (Millennium Development Goals) have drawn our attention towards eradication of poverty and environmental sustainability. Unfortunately, the extreme poverty resides in South Asia. We cannot feel proud on this account despite having done much better on food front. We need to ensure better income for our people and see that they are above poverty line and have easy access to food.

The present global concerns are about 180 million children severely underweight for their age, over 800 million chronically undernourished children, 400 million women of child bearing age being anemic and over 200 million children being vitamin A deficient. Thus, nutrition security has become a major concern which needs to be addressed. Also the poverty concentration is maximum in the South Asia. Yet the donor organizations appear to be laying major emphasis on Africa. Asia is not taken seriously just because we had witnessed Green Revolution. Though around 200 million people are still below poverty line (getting less than dollar a day), yet our per capita calorie consumption is higher than many countries in Africa and parts of Latin America. At the same time, we need to move forward from present availability of around 2000 kcal per person to a level of about 2500 or 2800 kcal. This would demand an expansion of our food basket so as to reduce dependence on cereals. We have also been experiencing factor productivity decline on account of second generation problems of Green Revolution such as: salinity, lowering of water table and increased incidence of pests and diseases.

Lately, due to policy changes, the buffer stocks have also depleted. From over 58 million tons in 2002, our buffer stocks went down to almost 15 million tons. Due to global decline in production of foodgrains, the prices per ton of wheat and rice had touched all time high ($400 for wheat and $900 for rice) by late 2008. This has obviously affected the consumers badly.

Lately, the foodgrains are also being diverted as feed, thus making their availability even more difficult. We in India are fortunate due to being vegetarian. Our protein demand is mainly through pulses, vegetables and fruits and not meat. Lately, USA is diverting its maize production to the level of 33% towards bio-fuel production, which appears to be ethically wrong.

Climate Change is also affecting us. It is known that from 1920 to 2000, average global temperature has risen by almost 1 degree, which is expected to rise by another 4 degrees if no corrective measures are taken. Imagine what will happen if that really happens. Impact of climate change is now real. Emission of green house gases (GHG), leading to global warming, more intense tropical cyclones, faster wind speeds and heavy precipitation are all a reality. Contraction of Himalayan glaciers by almost 17 kms in the last 10 years is another reality. As stated earlier, the world cereal production has also been affected adversely in the recent past due to drought in Australia, Canada, US and other developing countries. Recent studies predict that 2250 million tons of cereals will be produced this year but most of this increase is going to be from the developed countries.

In India, the prices are going up, buffer stocks are depleting and imports from developed world are on rise. We must, therefore, think seriously to remain self sufficient. As such, the subject of this seminar to have self-sufficiency at the national level is indeed very important.

We had to import wheat in 2007-08, for the first time after Green Revolution period. We produced around 4 to 5 million tons of wheat each year for over a decade upto 2002. Somehow, during the last 6-7 years, our production has remained stagnant. Fortunately, the minimum support price (MSP) for wheat was increased from Rs. 750 to Rs. 1000 per ton in 2007, which resulted in increased wheat production by almost 3 million tons just in one year. So, the issue of sufficient production and self sufficiency depends on right policies. In recent years, demand for other commodities is growing much faster than cereals, which is a fairly good sign.

We need to reorient our research for development strategy through twin pillar approach. This will require a paradigm shift of not only having germplasm improvement (good varieties and hybrids) but also improved natural resource management. Also we need to consider socio-economic aspects and policies around diversification of agriculture.

It is a matter of concern that over the years, the use of germplasm for breeding new varieties of different crops has gone down. This trend is rather global and that's why a global initiative on plant breeding has been initiated by FAO through the support of Gates Foundation with the aim to reverse this trend. It is apparent that some complacency in plant breeding has come. It is because people think that biotechnology can solve all the problems. It is important to understand that biotechnology can supplement but can not replace plant breeding efforts. In eighties and nineties, Indian wheat program recorded an annual genetic gain of one per cent per annum. Lately, this is stagnating since release of variety PB-343. The challenge is how to improve the yield further. The same challenge is also now with The International Maize and Wheat Improvement Center (CIMMYT). In this context, advances through hybrid technology are encouraging. Our scientists both in public and private sector came forward to give hybrid technology first in to the world in cotton, pearl millet, castor and pigeonpea.

In case of rice, China was first to release hybrids which now covers 53% area giving more than 58% rice production. An yield gain of 1 t/ha could be achieved through this technology. Now China is developing super hybrid rice targeting yield level of 15 t/ha. This kind of effort is needed in India where rice productivity is still below 3 t/ha. Private sector can play a major role, since public sector has not been able to deliver expected output in case of hybrid seed production. We have 42 million hectare area of rice but hybrid rice area is only 1.2 m ha. Hence, we need to move forward. In the USA, single cross hybrid maize technology provided higher productivity (7 to 8 tons). The Bt hybrid maize can now yield upto 12 tons/ha. Though new technologies are available, yet there is need to make available the seeds of these hybrids to the end users.

It was for this reason, a mission project on hybrids was initiated under the National Agricultural Technology Project (NATP), which resulted in the release of single cross hybrids of maize for the first time. As a result, our maize production doubled in last one decade. However, the area under hybrid maize, particularly single cross and quality protein maize (QPM) hybrids, is much low. Why can't it be 70 - 80%? Why is it still 25%? We need to understand the reasons and move forward. For this, we need to strengthen Public Private Partnership (PPP).

PPP is essential for future growth in agriculture. For this, we need to provide enabling environment and government should come out with proper policies and incentives to be put in place for those who perform. There is an obvious need for building mutual trust. This is indeed a grey area for which we need to sit across the table and discuss successful models of PPP and have better understanding. Currently, total acreage under GM crops is around 140 m ha. Presently in India, we have only Bt cotton. In Philippines, Bt corn has already been released as a food crop. Recently, in India, both Bt brinjal and Bt corn have been permitted for field tests. In future, I do not know whether there will again be a resistance for acceptance of transgenic technologies. In any case, these technologies are required in country's interest. Even the Europeans are importing Bt cotton, soybean and corn for use as animal feed. I don't know why there should be any concern for release of GM food crops in India, if testing procedures are in place. Partnership of *Mahyco* with *Monsanto* coupled with enabling environment created by ICAR and DBT (Department of Biotechnology) both for testing and release led to release of Bt cotton in India. In last 5 years, area has increased from no where to around 8 m ha under Bt cotton. In my opinion, there is no better example than this for such a faster adoption anywhere in the world. As a result, the cotton area increased, production almost doubled and productivity also increased. Currently, cotton export alone is fetching India worth 1.4 billion dollars per year. Before Bt cotton technology, we practically had no tangible cotton export.

There is another approach for enhancing food and nutrition security. This is new area - new crop approach. We all know that both rice and sugarcane were not grown before in the north. Groundnut was not grown in Gujarat, which is currently number one state. Potatoes were not grown in the Indo-Gangetic plains before. Maize in eastern India now gives more than 8 to 10 tons of productivity. Chickpea, a crop of North India, can now be grown in Tamil Nadu because of short duration varieties. So, the research has led to a number of achievements in different commodities and crops. For example, pigeon pea is being grown in North and West, due to release of hybrids and short duration varieties. Niche for soybean could be found in Madhya Pradesh which is now number one oilseed crop in the country. Dr. Barwale raised a very pertinent point as to why we are exporting soybean which can otherwise help in ensuring nutritional security. Therefore, until we make use of it as a food source, we better continue with current export of soybean meal worth over US$ one billion per annum.

Finally, we need to move forward and do research in up-stream areas of strategic importance. We have to make sure that our knowledge gets translated into products that can benefit the end users. This is what we call translational research for which we need to work with the farmers in a participatory mode, as was demonstrated through Integrated Pest Management (IPM) in rice in Indonesia. This led to increased rice production and decline in pesticide consumption by 50% within 5 years. We have to understand the problems of our farmers and integrate their traditional knowledge with that of the scientific one. We have to make sure that they are able to use their resources judiciously; just alternate furrow irrigation in cotton can reduce water use by 30%. We need innovative technologies. A decade ago no one thought that in rice-wheat production system one could use zero-till drill and have conservation agriculture. Today, over 2 m ha area in the Indo-Gangetic plains is under zero-till. This success could be extended to a potential area of 8 m ha under rice-wheat in India.

My mention of all these is to convey that we should look for newer options such as precision farming, which is possible through efficient farm mechanization. Farmers are even adopting lazer leveling to improve water use efficiency (WUE). That's where again private sector's role becomes important.

Somehow, over the years, our extension system has also become weak. The dissemination losses are higher due to less competent people involved in extension services. In this context, private sector can again play an important role. For example, establishment of agri-clinics through creation of technology agents who can provide them much needed vocational training for custom hire services to the farmers is an important aspect. The role of NGOs is also to be encouraged in this regard.

It is indeed heartening that recent World Bank report has clearly brought out that there can not be sustained and inclusive development unless high priority and required funding support is given to agriculture. Fortunately, therefore, agriculture has come again up-front despite being neglected in the recent past. We definitely need more capital investment in agriculture, as we did soon after independence. We created a lot of good infrastructure like highest dam, longest canal, and best fertilizer factories in the co-operative sector, markets/*mandis* and so on. This could be possible since almost 18% of our GDP was spent for capital investment. Unfortunately, over the last 2 decades, this support has declined to almost 9%. Now we expect the private sector to come forward in building the much needed infrastructure. For this, Government has also to provide enabling environment to catalyse the private sector.

India is also blamed for providing subsidy to our farmers. It must be understood that agricultural subsidy in India is linked to productivity, whereas in the developed nations much higher support is provided for storage, marketing and also the export. Our subsidy is currently, around 6.5%, whereas, upto 10% is acceptable limit by the World Trade Organisation (WTO). Hence, needed support to resource poor farmers must continue in the overall interest of our nation.

Let me conclude by stating that we need not be complacent. We need to continue scaling up our efforts both up stream and out stream. We have to see that technologies reach quickly to the end users. We must build stronger partnership among public and private institutions to ensure this goal. For this, we need policy makers to provide enabling environment and needed support to catalyse the process as a matter of high national priority. All these will help in accelerating the productivity growth in agriculture to achieve both food and nutrition security on a long term basis.

Climate Change and Rainfed Agriculture

B.Venkateswarlu

1. Background

Nearly 80 m ha of India's 143 m ha net sown area is rainfed. Rainfed area falls mainly in arid, semi-arid and dry sub-humid climate zones. About 15 million ha area lies in the arid region which receives <500 mm rainfall; another 15 million ha is in 500 to 750 mm rainfall zone, 42 million ha is in 750 to 1150 mm rainfall zone and the remaining 25 million ha receives >1150 mm rainfall per annum. About 74% of annual rainfall occurs during southwest monsoon (June to September). This rainfall exhibits high coefficient of variation; with frequent droughts. Over 87% of coarse cereals and pulses, 55% of upland rice, 77% of oilseeds and 65% of cotton are cultivated under rainfed farming.

Despite the development and adoption of several new technologies, the productivity growth in many of these crops has remained stagnant in recent years. Farmers are encountering new challenges in terms of rising production costs, uncertain markets and more recently, increased climatic risks. Though rainfed areas contribute only 40% of the food grains, it has remained a priority area for the Government of India in the context of equitable growth of disadvantageous areas. Therefore, rainfed agriculture continues to receive high priority in terms of research and development support at the national level.

2. Key Issues in Rainfed Agriculture

The productivity levels of dryland crops like millets, pulses and oilseeds at farmers' level still remain low at about 1.0 t/ha although large number of technologies developed by the National Agricultural Research System showed that yields up to 2 t/ha can be achieved on farmers' fields. These yield gaps are largely due to a number of bio-physical and socio-economic constraints. Primary among them are weather uncertainties in drylands and degraded soils. Aberrations in South-West monsoon which include delay in onset, long dry spells and early withdrawal, all of which affect the crops, strongly influence the productivity levels. Soils in drylands are not only thirsty but also hungry. Wide spread deficiencies of macro and micro nutrients occur due to loss of nutrients through surface soil erosion and inadequate nutrient application. The replenishment of the nutrients in cropping cycles is not adequately done due to poor resource base of farmers. The risk of crop failure and poor yields always influence farmers' decision on investing on new technologies and level of input use. The infrastructure, credit and market support are also relatively weak in these areas. Non-remunerative and unstable market prices due to globalization and rising labour costs have further affected the profitability of dryland agriculture in the country

3. Climate Change Trends

Rainfed agriculture as such is risk prone. The recent trends in climate are increasing this risk further and likely to make key production systems more vulnerable. Long term data for India indicates that rainfed areas witness 3-4

Director, Central Research Institute for Dryland Agriculture, Hyderabad
Email: director@crida.ernet.in / vbandi_1953@yahoo.com

drought years in every 10-year period. Of these, 2-3 are of moderate and one may be of severe intensity. However, so far no definite trend is seen on the frequency of droughts as a result of climate change. For any R&D and policy initiatives, it is important to know the spatial distribution of drought events in the country.

3.1 Rainfall

According to IMD, no significant trend is noted in the summer monsoon rainfall over the country on all India basis. However, significant changes were noted at the sub-divisional level. Three sub divisions, viz., Jharkhand, Chhattisgarh and Kerala show significant decreasing trend and eight sub divisions viz. Gangetic West Bengal, West Uttar Pradesh, Jammu & Kashmir, Konkan & Goa, Madhya Maharashtra, Rayalaseema, Coastal Andhra Pradesh and North Interior Karnataka show significant increasing trends.

Most of the dryland crops like millets, pulses and oilseeds are grown during kharif. Therefore, summer monsoon rainfall plays a significant role in determining the productivity levels of these crops. Analysis of relationship between anomaly of kharif rainfall and crop production by IMD indicate that deficit rainfall has more impact compared to above normal rainfall. However, recent experiences across the country indicate even in drylands which receive low to medium rainfall, excess rainfall (high rainfall event on a single day) could cause heavy damage to crops.

3.2 Temperature

Another important weather variable which affects dryland crops is the temperature. Last three decades saw a sharp rise in all India mean annual temperature. Though most dryland crops tolerate high temperatures, rainfed crops grown during *rabi* are vulnerable to changes in minimum temperatures. Analysis of data for the period 1901-2005 by IMD suggests that annual mean temperature for the country as a whole has risen to **0.51^{o}C** over the period. It may be mentioned that annual mean temperature has been consistently above normal (normal based on period, 1961-1990) since 1993. This warming is primarily due to rise in maximum temperature across the country, over a larger part of the data set. However, since 1990, minimum temperature is steadily rising and rate of its rise is slightly more than that of maximum temperature.

3.3 Extreme events

More than seasonal rainfall, the distribution is more important for dryland crops grown during *kharif*. Long dry spells have significant negative impact on fodder and grain production indirectly affecting the livestock production. Extreme events such as cold waves, heat waves, floods and high intensity single day rainfall events were on increasing trend from the last decade. For example, the 2002 drought across the country during *kharif*, the heat wave of May 2003 in AP, extreme cold winter in North during 2002-03, prolonged dry spell during July 2004, abnormal temperatures during March, 2004 and January, 2005 in North, floods during 2005, cold wave during 2005-06, unusual floods in Rajasthan desert and drought in North-East in 2006 and abnormal temperatures during January-February, 2007 in North are some of the extreme weather events which had significantly impacted agriculture. Excess rainfall during peg development stage during *kharif* 2008 has resulted in poor pod formation in groundnut in Rayalaseema districts of Andhra Pradesh. High intensity storms in a short time also have negative impact on dryland crops. Most models predict that these extreme events will further increase in future.

4. Coping with Climate Change

Though climate change impacts agriculture globally, developing countries like India are more vulnerable in view of the fact that majority of the population depend on agriculture, leading to excessive pressure on natural resources and poor coping mechanisms. The key projected effects of climate change are reduction in yields of crops like wheat, rice, shifts in cropping zones, sharp changes in water resources availability over time and space, decline in livestock productivity and migration of fish. Improved technologies and new policy initiatives are needed to enable farmers cope with climate change impacts. A few adaptation and mitigation approaches along with researchable and policy issues are summarized below:

The crop based technologies include growing crops and varieties that fit into new cropping systems and seasons, development of varieties with changed duration that can over winter the transient effects of change, development of varieties for high temperature, drought and submergence tolerance; evolving varieties which respond positively in terms of growth and yield to high CO_2. In addition, varieties with high fertilizer and radiation use efficiency and also novel crops and varieties that can tolerate coastal salinity and salt water inundation are needed. One of the important strategies would be to revisit the germplasm collected so far which has tolerance to heat and cold stresses but not made use in the past due to low yield potential.

Improved agronomic and crop production practices like adjustment of planting dates to minimize the effect of temperature increase-induced spikelet sterility can be used to reduce yield instability, by avoiding the flowering period to coincide with the hottest period. Adaptation measures to reduce the negative effects of increased climatic variability may include changing the cropping calendar to take advantage of the wet period and to avoid extreme weather events during the growing season. Improved crop management through conservation agriculture, crop rotations and intercropping, integrated pest management, supplemented with agroforestry and afforestation schemes will be an important component in strategic adaptation to climate change.

4.1 Policy imperatives

Apart from technological interventions, a sound policy framework and political will are required to battle climate change impacts on agriculture. The policy should address the issues of redesigning social sector with focus on vulnerable areas/ populations, introduction of new credit instruments with deferred repayment liabilities during extreme weather events and weather insurance as a major vehicle to transfer risk. Government should identify and prioritize adaptation options in key sectors (storm warning systems, water storage and diversion, drought/ pest warning systems and infrastructure needs). State level institutions should be strengthened; a dedicated cell should be set up in each state on close monitoring and take up quick remedial measures in the event of an extreme weather event in agriculture and help in settling insurance claims. Emphasis should be given on tapping financial resources to strengthen adaptation efforts at state level. The capacity of local institutions e.g., SHGs, banks and agricultural credit societies should be strengthened to come up with new way of financing climate related risks at village/block level. Public-private partnership in promoting investments on infrastructure markets, information and communication can help deal with climate risk to a large extent.

Impact of climate change on plantation crops

George V. Thomas, K. V. Kasturi Bai and S. Naresh Kumar[1]

Climate change has emerged as a major challenge influencing agricultural production in the country. In recent times the pace of climate change has accelerated as a direct result of industrialization, deforestation, population growth, and various other anthropogenic activities. Climate change can also lead to increase in global temperature which will cause extreme weather events such as change in the amount and pattern of precipitation, glacier retreat leading to rise in sea level, changes in agricultural yields etc. resulting in major economic losses on one side and poverty on the other. As per IPCC reports, atmospheric concentration of CO_2 will further rise leading to increased temperatures. Unless corrective measures are taken, climate change is likely to become more rapid and have an adverse and extreme impact on life on earth. Thus it is important to study the adaptation capacity of plants which are scavengers of atmospheric CO_2 so as to choose suitable crops or cultivars which can thrive under such conditions.

Intensive agriculture and excessive use of external inputs have lead to the degradation and depletion of natural resources like soil, water and plant which in turn adversely affect the agricultural production and profitability. It is a known fact that crops and trees are natural carbon sinks and conservation agricultural practices help in carbon sequestration. The New Delhi declaration on conservation agriculture during February 2009 stressed the conservation of natural resources based on the three principles: minimum mechanical disturbance to the soil, permanent organic cover on the soil surface and a diversified sequence or association of crops.

Climate change and plantation crops

Plantation crops, being perennial in nature, have to face the impact of climate change even during a single generation or in a standing crop. Hence it is important that the impact of climate change is understood well. Plantation crops mainly coconut, rubber, tea, coffee, cashew, oil palm *etc.* are grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and high humidity. All these crops are of high economic value contributing substantially to the agricultural exports at global and national levels. These are grown in large areas in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, West Bengal and Assam. The plantations provide sustenance to the millions of people. Weather variables such as rainfall, evapo-transpiration, temperature, solar radiation, sunshine hours, relative humidity and wind velocity influence the yield potential of these crops.

Impact of climate variables on coconut, arecanut and cocoa

Coconut palms, as rainfed crops, are exposed to drought of different intensities and durations in various parts of the

Central Plantation Crops Research Institute, Kasargod-671 124, Kerala,
[1] Division of Environmental sciences, IARI, New Delhi- 110012.
Email: sicpmt@yahoo.com / georgevthomas@yahoo.com

country. Characterization of drought in different agro-climatic Zones in India viz; Western ghats high rainfall zone (Kidu-Karnataka), Western coastal area - hot sub-humid-per-humid (Kasaragod - Kerala; Ratnagiri - Maharashtra), hot semi arid (Arisikere - Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh) indicated variations in length and number of dry spells in each zone bringing about the different intensities of drought. In view of long duration of 44 months between the initiation of inflorescence primordium and ultimate nut yield, with about 70% period of pre-fertilization and only 30% by fertilization/ post-fertilization phases, any fluctuations in dry spell occurring during important stages of floral/fruit development would reflect on nut yield and the impact can be seen from the year of drought till four years. The coconut palm experiences moisture stress when exposed to irradiation above 265 Wm^2, temperature of 33°C and vapour pressure deficit of 26 m bar, aggravated by soil water deficit during the period.

The arecanut is grown under irrigated conditions and generally more than 50% of variation in yield is due to climatic differences. It is grown under different agro-climatic conditions. The most important climatic factors that influence the growth and development are altitude, relative humidity and rainfall. But extremes of temperature and wide diurnal variations are not conducive for healthy growth. A 12 year data of weather variables indicated that the yield is influenced by relative humidity, evaporation and rainfall.

Though cocoa is grown under wide climatic conditions, its yield potential is higher in arid tropics where the climate shows relatively little variation throughout the year, especially in terns of temperature, solar radiation and day length. In India it flourishes mainly under shade. The yield was significantly correlated with the number of rainy days in the previous year and, sunshine hours and maximum and minimum temperatures of the current year. Relative humidity, temperature, sunshine hours, rainfall and rainy days showed maximum correlation with yield during the five months lag period, coinciding with flowering period. Most of the cocoa growing areas lie below 300 m. However, cocoa can be grown successfully up to a height of 1100-1200 m provided the temperature is congenial during flower production. Cocoa can be grown within 20° of the equator. However, over *75%* of the world's cocoa lies within 8° of the equator.

Climate change studies in coconut

Studies conducted at CPCRI on impact of climate change on coconut indicated general warming trends in most of the coconut growing areas. Coconut productivity increased over past 50 years except recent declining trends in plains of Karnataka and Coimbatore district of Tamil Nadu due to consecutive droughts. In Coimbatore district the coconut productivity was reduced to the tune of about 3500 nuts/ha/year for 4 years. Loss due to 1996 cyclone in Andhra Pradesh was to the tune of 6200 nuts/ha/year in East Godavari district and by ~4100 nuts/ha/year in West Godavari district for 6 years. Impact assessment and climate change future projections in different scenarios indicated that plains of Karnataka, Eastern TN, coastal Andhra Pradesh, Pondicherry, West Bengal and Assam in decreasing order are found to be hot spots as per different HadCM3 model scenarios.

For the first time a coconut simulation model was developed. Using coconut simulation model, yields were simulated for 13 agro-climatic zones represented by 16 centres. These areas contribute over 90% to the coconut production. Simulations for yield projections were done for HadCM3 climate change storylines viz., A2a, B2a and A1F for 2020, 2050 and 2080 scenarios. Analysis based on coconut simulation model studies indicate that coconut productivity is projected to go up to 10% during 2020, 16% in 2050 and 36% in 2080 over current yields only due to climate change in west coast of India. However, in east coast yields are projected to decline by about 2% in 2020, 8% in 2050 and 31% in 2080. Spatial variations exist for these projections. Yields are projected to go up in Kerala, Tamil Nadu (if irrigation is continued to be provided), Karnataka, and Maharashtra while they are likely to decline in A P, Orissa, parts of Karnataka, T N and Gujarat. However, situations may vary if future irrigation sources are limited particularly in irrigated areas as in Tamil Nadu and Karnataka.

Response of elevated CO_2 and temperature on coconut, arecanut and cocoa

Effect of elevated CO_2 and temperature on coconut, arecanut and cocoa studied in open top chambers indicated that seedlings grown under elevated CO_2 had higher root dry matter, specific leaf area, chlorophyll a/b ratio, collar girth, shoot height, shoot dry matter and leaf area. Seedlings exposed to elevated temperature had high shoot height, root length, collar girth and root dry matter and volume as compared to the chamber control. The shoot and root dry matter in cocoa and arecanut seedlings was more in those exposed to elevated CO2 over control chamber.

In coconut elevated CO_2 and temperature caused significant reduction in leaf stomatal density. However the reduction in stomatal density did not influence the net photosynthetic rate, indicating significant adaptation strategy by coconut to changing climate. Further, biochemical parameters indicated that the elevated CO_2 caused increased accumulation of proline in leaf tissue in spite of maintenance of high leaf water potentials. On the other hand, elevated temperature caused only a slight increase in proline concentration, despite the reduced leaf water potentials. These results suggest greater role for proline in coconut adaptation to high CO_2 concentrations. Observations on epicuticular wax, proline and scavenging enzymes such as super oxide dismutase, poly phenol oxidase, peroxidase and catalase clearly showed the response of coconut cultivars to different treatments.

Carbon sequestration and carbon stocks

The carbon sequestration in coconut above ground biomass varied from 15 to 35 CO_2/ha/year depending on cultivar, agro-climatic zone, soil type and management. Sequestered carbon stocked in to stem was in the range of 0.3 to 2.3 CO_2/ha/year. Standing C stocks in 16 year old coconut cultivars in different agro-climatic zones varied from 15 to 60 CO_2/ha/year. Annual carbon sequestration by coconut mono-plantation is higher in red sandy loam soils and lowest in littoral sandy soils. In areca - cocoa system the CO_2 sequestration ranged from 5.14 to 10.94 Mg/ha/ year in arecanut sole plantations while in cocoa it ranged from 1.38 to 2.66 Mg/ ha/year. Hence, coconut, arecanut and cocoa can be strong candidates for carbon sequestration under Clean Development Mechanism.

Socio-economic analysis on impact of drought in Coconut growing area

It has been observed that more than two lakh palms died and about six lakh palms were severely/partially affected due to drought in Coimbatore and

Tumkur districts. Farmers who adopted soil moisture conservation practices or drip irrigation could reduce the drought impact and improve coconut yields. Hence soil moisture conservation is the only adaptive strategy to reduce the climate change impact on plantation crops.

Simulation models in plantation crops

Even though simulation model in perennial crop like cocoa has been reported, the model is not yet validated for Indian conditions and suitability for climate change studies. In coconut, simulation model has been developed based on the generic crop model InfoCrop that simulates various annual crops in tropical and subtropical regions. The InfoCrop-coconut model was calibrated and validated with data compiled from published studies comprising many physiological, agronomical and nutritional experiments conducted between 1978 and 2005 in diverse geographic locations throughout India. The treatments included various water and nutrient regimes and varieties of coconut. The genetic coefficients used for calibration and validation were generated from field experiments conducted during 1995-2005. Simulated trends in phenological development, total dry mass and its partitioning, and nut yield agreed closely with observed values. The model adequately simulated the effects of various factors like management practices, soil and nutritional factors on coconut growth, dry matter, partitioning and nut yields.

Carbon sequestration and high density multi species cropping system (HDMSCS)

Productivity of land can be increased by adopting high density cropping system. The principle of multistoried cropping is to use the basic production inputs such as light, water and nutrients to the maximum extent with minimum soil deterioration. This is attained by growing suitable crops having different canopy patterns and root systems. A variety of crops are grown in the interspaces of coconut and arecanut ranging from short season annuals to perennial tree species. Biomass production of various crops in a cropping system gives a rough indication of their compatibility. The beneficial changes in rhizosphere of the main crop and intercrops not only improve the soil micronutrients, but also result in increasing yields considerably besides helping in carbon sequestration. Utilization of land, airspace and inputs with maximum sustainable returns are the advantages of HDMSCS.

Conclusions and future thrust

Efforts are being made to understand the impact of climate change in all the plantation crops. No valid models are available for the exhaustive studies and hence studies are required to develop simulation models suitable for climate change studies. Plantation crops offer to be good candidates for carbon sequestration and carbon trade. Recent report of the Panel meeting of the plantation crop workers held at CPCRI, Kasaragod, on “Carbon sequestration in plantation crops and trading under Clean Development Mechanism” clearly showed that all the plantation crops with an estimated area of 4.764 m. ha in India, with cumulative CO_2 sequestration potential of 146.05 M. tones can reduce emissions effectively. However, currently under CDM, plantation crops are not included for carbon trade. Keeping future possibilities on inclusion of plantations for carbon trade, studies on carbon sequestration potential of plantation crops need to be intensified.

Aquaculture in the Context of Climate Change and Declining Capture Fisheries Production

M. Vijaya Gupta

Introduction

We are passing through an era of increasing population, food shortages and declining agriculture productivity. This will be exacerbated in the coming years by the global warming and climate change that will have a major effect on terrestrial and aquatic resources directly and on the human population indirectly and could result in catastrophe, if no remedial measures are taken. Global human population has grown from 1.5 billion in 1900 to 6.4 billion now and it is expected to reach 9 billion by the year 2050. The Millennium Development Goals (MDGs) adopted in 2000 set a target of reducing hunger and malnutrition population to half by 2015. At that time, 1.3 billion were living in poverty and 800 million were food insecure. While some progress has been made in reducing the proportion of hungry and malnourished population, there is an increase in absolute numbers due to increasing population as food production could not keep pace with increasing population. It has been estimated that 852 million or 14% of global population are hungry and of these 690 million are in Asia-Pacific with 260 million in India. Micronutrient deficiencies or hidden hunger in one form or other is affecting more than 2 billion people globally. Fifty seven percent children suffer from vitamin A deficiency. India is home to 40% of world's under-weight children. Fifty percent of hungry are in small-holder farming households and 20% among rural landless (Millennium Task Force on Hunger 2004). In this context fisheries could play an important role in contributing to nutritional and livelihood security to millions of poor in the country.

Fish Production and Demand

India is the third largest producer of fish in the world and second largest producer of fish from aquaculture. Though India is recognised as third largest consumer of fish in the world, which is due to its large population, per capita consumption of fish at 9kg/head/year (among non-vegetarians) is one of the lowest in the world. In the year 2005-06 India produced 6.3 million tons of fish, of which 3.2 million tons from the inland sector. It has been estimated that by the end of XI plan period (2012) the demand for fish and fish products would be in the range of 9.74 million tons which would increase to 11.86 million by 2020, to meet the demand of increasing population, changing dietary habits and increasing income levels. Capture fisheries production from the marine and inland waters has stagnated or declined over the years due to over capacity, over exploitation and anthropogenic pressures. This would be further exacerbated by the global warming and climate change which is expected to result in rising water temperatures that are likely to reduce the up welling of food supplies that pelagic fish depend on, and the increased carbon dioxide in the atmosphere will increase the acidity

World Food Prize Laureate/ Former Assistant Director General, WorldFish Center, Penang, Malaysia. Email: guptamo2000@yahoo.co.in

of water bodies, adversely affecting aquatic life.

The recent Stern Review on the Economics of Climate Change concluded that "For fisheries, information on the likely impacts of climate change is very limited". Hence, it is necessary to step up research to fill the knowledge gaps and make the sector resilient and productive in spite of climate change.

Aquaculture, the Saviour

In view of the meagre chances of increasing production from capture fisheries, the increasing demand has to be met from aquaculture. Long coast line and vast inland waters in the country offer excellent opportunities for aquaculture – both marine and freshwater. Increased aquaculture could not only meet the domestic demand, but also contribute to increasing potential for export. However, to harvest the potential, a number of initiatives have to be taken by both research and development institutions/organisations as detailed below:

Mariculture

Mariculture is presently contributing 80,000-100,000 tons, mostly by shrimp farming. While technologies have been developed and disseminated for farming of mussels, edible oysters, clams, etc, unfortunately, the country could not make progress in farming of finfish. Recent attempts at breeding and culture of seabass (*Lates calcarifer*) have shown encouraging results and the research institutions have to work on a priority basis for developing technologies for breeding and culture of a number of high value species such as groupers, snappers, etc. which have potential for export. Further, marine fish being mostly carnivores, farming of these fish will be more expensive in terms of capital investments and operating costs. This to a large extent will deter the participation of coastal poor, unless initiatives are taken to make them partners in the development of this sector.

Freshwater Aquaculture

Freshwater aquaculture is already contributing substantially to the country's production. Country's vast freshwater resources could contribute much more than the present production and contribute not only to increased production, but also improving and creating livelihoods for the rural poor. However, the research institutions, developmental agencies and policy makers have to address some issues that constraint development.

Need for bridging gap between research and development:

The yield gap between research production and farmers' production is quite wide and needs to be bridged. For e.g., research has indicated production potential of 10-15 tons/ ha from farming of carps in ponds and farmers in Andhra Pradesh have attained these production levels. But, the average production in the country is estimated at only 2.5 tons/ha and even these low productions according to some are high estimates. This clearly indicates the need to look for new technology transfer/ dissemination strategies taking advantage of the ICT and the involvement of civil society organisations.

Research for species diversification and control of alien species:

In spite of a large number of potential species for aquaculture, so far the research and production systems have concentrated only on few species – mostly carps. Consumers and farmers are looking for new species for farming and consumption and in the absence of diversification; farmers have taken course to bringing in alien species from across our borders. While in the short term they benefit the increased production, but in the long term introduction of these alien species without any assessment of their potential impact on native biodiversity is likely create problems. In view of this instead of continuing research on the same species year after year, we should look at new indigenous species and develop technologies for their breeding and culture.

Non-conventional aquaculture resources:

Besides pond aquaculture which has been the major contributor to aquaculture production, there are other aquatic resources where farming of fish along with capture fisheries could be undertaken. For e.g., the country possesses 3.15 million ha of reservoirs with very low average production of less than 50 kg/ha. Through proper management and commitment of all those involved, the production could be easily increased to over 200 kg/ha, if not more. Also landless poor could be involved in farming of fish in cages in these reservoirs. While research in this area has been going on for a number of years in many research institutions, the technology is yet to be perfected and commercialised. In addition to the reservoirs, over a million ha is under oxbow lakes and flooded lands where capture based culture fisheries could be practised involving landless poor in the area.

Need for seed certification:

While seed certification procedures have been developed for commercial crops, the same is lacking in the case of fish. Often fish seed from the hatcheries is worse than the wild seed due to decades of inbreeding in hatcheries. There is urgent need to finalise seed/hatchery certification procedures which have been drafted in recent time and implement them without any further delay.

Safe guarding interest of small farmers:

The emphasis being placed by both domestic and export markets on increasing product standards in terms of food safety, quality, traceability, certification and ecolabelling will make it difficult for the small farmers who lack knowledge and access to technology to comply with the standards. Raising of market standards should not form a barrier or additional impediment for entry of products in to major markets by the small producers. In this regard, the government needs to enhance the ability of small farmers through training, legislation, codes of practice, certification, traceability schemes, etc., to comply with trade and market access requirements for producing safe and quality products by undertaking best management practices. A comprehensive study to assess the impacts of market standards including assessment of costs (need for additional infrastructure, increased implementation capacity and better technical knowledge) and benefits of complying with these standards is urgently needed.

Policy support:

While some of the states have come up with fisheries policy, at a country level we lack a clear policy with regard to fisheries development and safeguarding the interests of the farming/fishing community. States, where the fisheries policies are in place, lack resources (financial and human) to implement these strategies. What is needed for these policies, plans, strategies, etc., to bear fruits is, allocation of adequate resources – financial and human for implementation of plans and strategies.

If aquaculture is to be encouraged to contribute to nutritional and livelihood security, this needs to be treated on par with agriculture for tax benefits, incentives such as subsidized tariff for power and water, fertilizer subsidy as given for land crops and insurance for crop loss, etc.

The Outlook

Excellent opportunities exist for the aquaculture to bridge the gap between supply and demand in the years to come without harming the environment when planned and implemented well and contribute to nutritional and livelihood security. It is necessary to judiciously under take intensification without damage to the environment and bring in to production the marginal lands which are not suitable for agriculture.

Along with efforts at increasing production which will not be sustainable unless there is market demand, it is necessary for the government and the concerned agencies to bring awareness among the population of the health benefits of fish; organise the sector for the availability of fish under hygienic conditions and develop value added and easy to cook foods.

Rain-Proofing Rice Cultivation

B.C.Viraktamath[1] and J.S.Bentur[2]

'Water is the elixir of life' and all living forms including plants depend on it for their survival. Rainfall is the ultimate source of water supporting surface and under-ground water for irrigation. Total amount of water (H2O) is constant and therefore, it is very important to devise ways and means of judicious use of this precious resource. Rice production scenario at national level during the period 2001-09 can be described as 'steep fall and steady recovery' phase. The year 2001-02 registered a record high rice production of 93.34 million tons (Mt). During 2002-03 rice production plummeted to a low of 73.5 Mt. However, this trend steadily recovered back with production of 93.35 Mt during 2006-07. Due to good monsoons, the country witnessed a record production of 99.6 Mt during 2008-09. However, severe drought that occurred during this year may have negative impact on rice production by pulling it down by almost 10 Mt. This scenario clearly indicates the vulnerability of rice cultivation to the vagaries of monsoon. Analysis of production constraints for the period highlights over-dependence of rice cultivation on timely arrival and normal distribution of monsoon. A fall of 20% in total rainfall across the country during 2002-03 resulted in a fall of 23% in rice production. With 75% of normal rainfall during June-July this year, the area planted to rice in kharif has dropped by 6 million ha. Normal kharif rice area in the country is about 39 million ha with an average production of 75 Mt. It is predicted that present drought spell may reduce rice production by 15%, i.e. by 10-15 Mt. To add to the miseries of the farmer, this year an unprecedented flood in southern states of AP and Karnataka during first week of October damaged standing rice crop on nearly one M. ha. Thus it is evident that rice cultivation is over-dependent on rainfall. How this problem can be addressed through research and extension efforts is the theme of this article. Developmental part involving creation and maintaining irrigation facilities, watershed or rain water management are not considered in this article.

Need for rain-proofing rice cultivation

We are now experiencing the ill effects of climate change through erratic rains, frequent floods, long spells of drought, etc. Water is becoming a critical limiting factor in rice cultivation. Fresh water availability will be drastically reduced in future and one has to produce 'more crop from every drop'. New varieties need to be developed to resist the floods. These threats have to be tackled both by genetic and management approaches.

Genetic approach

Development of drought and submergence tolerant varieties can help farmers overcome some of the problems associated with delayed monsoon and flash floods. Conventional breeding approach has resulted in development of several drought resistant rice varieties like Tulasi, Anjali, Annada, Heera released from the central committee. Some of the popular recent drought tolerant rainfed upland varieties released by different states are Varalu (AP), Luit (Assam), Vandana (Bihar), Danteswari (Chhattisgarh), GR-9 (Gujarat), Birsadhan

[1] Project Director, [2] Principal Scientist, Directorate of Rice Research, Rajendranagar, Hyderabad 500 030, viraktamath123@rediffmail.com

201 (Jharkhand), Amrut (Karnataka), Harsha (Kerala), Improved Ambemohar (Maharashtra), Heera, Vandana (Orissa), Vaigai (TN), Narendradhan 118 (UP), Jaldi Dhan 15 (West Bengal), etc. While these varieties are primarily for rainfed upland areas, their performance under drought prone rainfed lowlands has also been satisfactory. Like in case of drought, flood or submergence tolerant rice varieties have also been developed and released for cultivation either under semi-deep or deep water ecologies. These include Nalini, Jitendra (Central Release), Padmanath (Assam), Vaidehi, Sudha (Bihar), Jaldubi (Chhattisgarh), Hemavathi (Karnataka), Prabha, Varsha dhan, Durga (Orissa), Jalamagna, Jalpriya, Jalnidhi (UP), Ambika, Neeraja(WB) etc.These varieties are bred for areas where water logging and prolonged stagnation is a common occurrence. However, varieties have not been specifically developed for normal rainfed shallow lands for flash floods and transient submergence for a period of 3-10 days.

Thus conventional breeding efforts did not give highly satisfactory results. More recent efforts of transgenic research appear to be promising. DREB1 and TSP genes are able to confer salt and drought tolerance when transferred to rice cultivars. Efforts are under way in development of transgenic rice using these genes through transgenic approach.

Under the genetic engineering technology, efforts are being made at a few institutions such as Delhi University, IARI, New Delhi and DRR, Hyderabad to develop transgenic rice against abiotic stresses like drought, salinity and submergence. Engineering rice for improved flood tolerance through alterations in the levels of PDC and ADH proteins has been reported and transgenic rice plants, which over-express PDC sub-units, have been identified. At PAU, genes which confer water use efficiency such as Gly, Dreb and Zad and then their combinations would be made to develop a new gene that will be further transferred into traditional crop varieties. Drought tolerant rice is also under development stage in the genetic background of IR64 with trehalose biosynthesis (TPSP) gene. Confirmed transgenic lines are expected after 2-3 seasons.

Development and successful testing of 'Swarna sub1' and, 'IR64 sub1' using marker assisted selection has shown the utility of submergence tolerance gene 'sub1' derived from a traditional flood tolerant rice FR13A and of the marker technology for rice improvement. These rice lines have been developed by a team of international scientists from IRRI, Philippines, Cornell, USA and national scientists from India, Bangladesh and the Philippines. Swarna sub-1 has been released for cultivation in the states of Orissa, Bihar and West Bengal. The scientists are now introducing sub-1 gene into the background of few more popular varieties.

Hybrid rice

Many of the rice hybrids have greater tolerance to drought and salinity. Extensive evaluations have shown wider adaptability of hybrids like KRH2, Sahyadri and DRRH2 under limited water condition. Few hybrids like PSD3, KJRH2 are the two hybrids found to perform better under aerobic cultivation. Two of the hybrids developed from Central Rice Research Institute, Cuttack viz CRHR28 and CRHR29 are suited for rainfed shallow lands. Thus popularizing these hybrids and evaluation and development of more hybrids for water limited cultivation will be highly rewarding.

Cultural Approach

Late transplanting due to delayed monsoon is a common unavoidable approach for the farmers. Some of the available varieties have been found suitable for such practice. Even 30-45 day old seedlings can be transplanted with marginal loss in the yield. In case of flash flood causing damage to just transplanted young plants or plants in tillering stage, replanting using the surviving plants by uprooting and tiller separation is advocated. This will help in increasing the plant population and thereby reduce yield loss.

System of Rice Intensification or SRI is a method of cultivation that aims at minimum use of seeds and water. Studies suggest saving of up to 40% in irrigation water. Recent studies carried out at several locations across the country indicated that SRI practice resulted in 7-20% higher grain yield, higher root volume and dry mass while reducing requirement of seeds by 80%, water by 29% and crop growth duration by 8-12 days. However, SRI was found to be genotype dependent as varieties having better tillering ability responded well.

Direct seeding of either dry seeds or sprouted seeds in puddled soil has been developed as a cultural practice in areas where there is delayed monsoon and/or labor shortage for transplanting. This method will also reduce the crop duration by 1-2 weeks and thus saves water.

Studies have shown that the drum seeder method of seeding significantly increased grain yields (4.90 t/ha) compared to broadcasting (3.70 t/ha). The drum seeder may be recommended as an alternative to transplanting due to low cost, reduced duration, higher cost/ benefit ratio in areas of controlled water and weed management. Of the 23 rice cultivars/varieties tested under direct seeding, Tulasi, Krishnahamsa, lET 9994, lET 9219, lET 9691; Nidhi, Triguna, IR64 and Vikas performed well and were found to be suited due to their early vigor and better root development. Variety having better culm strength, greater anchorage, early growth vigor, better root proliferation, medium tillering and higher panicle weight are more preferred for direct seeding.

Under normal irrigated conditions with good control over water supply, alternate wetting and drying is being recommended as water saving technology. Field is irrigated once hairline cracks develop on the soil surface. Studies have shown that such rotational irrigation increases rooting depth and more dry matter production as compared to continuous submergence. However, water stress at panicle initiation and flowering stages reduced the grain yield when compared to stress at tillering stage. Intermittent flooding decreased the nutrient supply from the soil by 10-11% for N, 7-28% for P and 8-12% for K over continuous submergence, and resulted in 13-28% increase in water use efficiency. The Hybrid (Sahyadri), performed better than HYV (Krishnahamsa) under deficit irrigation irrespective of crop establishment methods (SRI and conventional) but required higher (12%) N application to record equivalent yields.

‘Aerobic rice is becoming one of the practical options to combat the water crisis. Under this system, rice will be grown like any other ID crops such as wheat and maize. Under this system, rice is direct seeded in unpuddled soil and irrigated as and when necessary. Thus rice is grown with just 50% of the water as compared to transplanted rice.

The whole world is concerned about the climate change which is enormously affecting agriculture including rice cultivation. ‘Water crisis’ both in terms of deficit and excess would affect rice production. These problems could be tackled within genetic and management approaches. ‘Rain proofing’ rice by developing drought and flood tolerant varieties by deploying both conventional and biotechnological tools could be one approach. Secondly, innovative management approaches like adopting SRI, Aerobic, Zero tillage, FIBR methods. The research efforts in this direction would certainly help the rice farmers to face the challenge of climate change in the coming years.

Quality Protein Maize (QPM) for Nutritional Security

H.S. Gupta

Maize occupies an important position in world economy and trade as a food, feed and industrial grain crop. Millions of people worldwide are dependent on maize as a staple food through economic necessity, and derive their basic needs of protein and carbohydrates from it. In the developing world, maize is an important source of both human and animal nutrition.

The main structural component of the maize endosperm is starch, a complex carbohydrate that constitutes on an average 71% of the grain and is a source of concentrated energy. Bulk of the protein in a mature maize kernel is in the endosperm and germ; but, the germ protein is superior in both quantity and quality. The endosperm protein is deficient in lysine and tryptophan, and therefore, maize needs to be eaten with complementary protein sources such as legumes or animal products. As per the World Health Organization, almost half of the 10 million annual deaths of children under age five could be attributed to protein malnutrition.

Discovery and Initial Use of *opaque2* Mutation

In the 1920s in a Connecticut (USA) maize field, a natural spontaneous mutation of maize with soft, opaque grains was discovered, which was eventually named as *opaque2 (o2)* (Singleton, 1939). In 1964, Dr. Oliver Nelson's team at Purdue University, USA, discovered that the homozygous recessive *o2* allele had substantially higher lysine (+69%) in grain endosperm compared to normal maize (Mertz *et al*., 1964). It was further determined that this mutation results in 2-3-fold increase in the level of two amino acids, lysine and tryptophan in comparison with normal genotype. The increased concentration of these two essential amino-acids (normally deficient in the maize grain endosperm) effectively doubles the biological value of maize protein (Bressani, 1991) with the considerably profitable result that only half the amount of *o2* maize (relative to normal maize), needs to be consumed to obtain the same biologically usable protein (FAO, 1992). In addition, other amino acids such as histidine, arginine, aspartic acid and glycine showed increase, while the decrease was observed for some amino acids such as glutamic acid, alanine and leucine. Decrease in leucine is considered desirable as it makes leucine-isoleucine ratio more balanced, which in turn help to liberate more tryptophan for niacin biosynthesis, and thus helps in combating pellagra.

With the discovery of the nutritional benefits of the *o2* mutation, breeding programmes in several countries began to incorporate this gene through backcrossing, leading to *o2* cultivars. However, the direct use of the *o2* mutation in breeding programs soon receded after the discovery of serious negative pleiotropic effects of this mutation, including vulnerability to storage pests and diseases, unattractive and chalky grain texture, reduced yields etc., thereby severely limiting its practical use in the breeding programmes.

Director, Indian Agricultural Research Institute, New Delhi – 110 012.
Email: hsgupta@lycos.com / director@iari.res.in

Combining *opaque2* with Endosperm Modifiers

During the process of converting normal maize populations to *o2* versions, partially hard endosperm (i.e. vitreous) or "modified" grains was observed by many researchers including breeders at CIMMYT in Mexico. Separations of such grains when encountered began as early as 1969 by Dr. John Lonnquist and provided a new way to development of *opaque2* varieties with hard kernels (Bjarnason and Vasal, 1992; Vasal, 2000; Prasanna *et al*., 2001).

At CIMMYT, the modified kernels were classified into different categories and laboratory analysis was carried out to study the effect of the degree of modification on biochemical characteristics (Villegas *et al*., 1984). A few *o2*-converted population were then identified which had usually a high frequency of modified kernels. The breeding procedures followed for the incorporation of genetic endosperm modifiers along with o2 gene were reviewed in detail by Prasanna *et al*. (2001). This led to the birth of the "Quality Protein Maize" (QPM). The term 'QPM' now refers to maize homozygous for the *o2* allele, with increased lysine and tryptophan content and without the secondary effects of the soft endosperm (Vasal, 2001).

The *Opaque2* (*O2*) gene was cloned using a transposon tagging strategy with the maize mobile genetic elements, *Spm* (Schmidt *et al*., 1987) and *Ac* (Motto *et al*., 1988). The *O2* gene encodes a transcription factor required mainly for the expression of 22 kDa α-zein-coding genes and a 32-kDa albumin gene *b-32.* Lower α-zein content in *o2* endosperm results in protein bodies that are about one-fifth to one tenth the normal sizes, which is presumed to alter packing of starch grains during seed desiccation, thereby conferring a characteristic soft texture to the kernel. With the reduction of α-zeins in the endosperm due to *o2* mutation, there is usually a concomitant increase in the level of γ-zeins (Habben et al., 1993).

The mechanism(s) by which the endosperm modifier genes convert the starchy endosperm of *o2* to a normal phenotype is still not completely understood, but some important clues have been obtained through analysis of biochemical changes in modified *o2* endosperm. Studies suggest that the products of the modifier genes interact with α-zein mRNA transcripts and enhance their transport from the nucleus or increase their stability and translation. The overproduction of γ-zein appears to enhance protein body number and result in the formation of more vitreous endosperm. Endosperm modification is polygenically controlled. *

Nutritional Significance and Economic Benefits of QPM

QPM offers tremendous benefits in the nutrition of monogastric animals including humans, since the two limiting amino acids (lysine and tryptophan) cannot be synthesized through metabolism in them. In animal nutrition, QPM can provide a cheaper way of obtaining a balanced animal feed. The protein quality of QPM was evaluated using nitrogen balance technique in several studies, where QPM proved its superiority over the normal maize with respect to apparent nitrogen retention and biological value. These studies concluded that nitrogen balance and retention were higher with QPM, especially at lower levels of total protein intake. Moreover, unlike normal maize, young children can consume QPM in amounts needed for the positive nitrogen balance that is required for growth. Recovering malnourished children fed QPM further showed the same growth as those fed modified cow milk formula (Graham *et al*., 1990). Thus, QPM has added advantage of being superior in protein quality and higher in food and feed efficiency as compared to conventional maize (Krivanek *et al.*, 2007). Use of QPM as poultry feed leads to early development of broilers, saves energy and feed, and also the extra cost incurred on lysine and tryptophan fortification.

The other nutritional benefits of QPM include higher niacin availability due to a higher tryptophan and lower leucine content, higher calcium and carbohydrate, and carotene utilization (De Bosque *et al.*, 1988). Further, QPM grains can be transformed into edible products without deterioration of its quality or acceptability, and can be used in conventional and new food products. In Guatemala, it was demonstrated that *o2* maize had 90% of the nutritive value of milk protein in young children. Children in Colombia suffering from Kwashiorkar, a severe protein deficiency disease, were brought back to normalcy on a diet containing only *o2* (Bressani, 1990).

Spread of QPM Cultivars

The QPM hybrids released in many countries, including India, are mostly either superior or at par in productivity with their similar duration normal maize hybrids. Therefore, cultivation of QPM provides an opportunity to the farmers to produce nutritionally superior maize grains and increase productivity and profitability, one from the high-value cereal grain product and the other from use of feed and fodder in livestock industry.

Initial QPM breeding efforts at CIMMYT focused on conversion of a range of subtropical and tropical lowland adapted, normal endosperm populations to *o2* versions through backcross-recurrent selection procedures, with a focus of accumulating the hard endosperm phenotype, maintaining protein quality and increasing yield and resistance to ear rot. Several QPM composites and hybrids possessing different ecological adaptations, maturity, grain colour and texture were developed and released worldwide in the last 10-15 years (Prasanna *et al.*, 2001; Gupta *et al.*, 2009).

In India, a nutritionally superior *o2* composite with hard kernel texture, designated as 'Shakti-1' was released in 1997. Since 1998, intensive efforts were made at different centres in the country, particularly at Karnal, Dholi, Almora, Hyderabad, Delhi and Ludhiana, resulting in development of QPM germplasm and release of a series of QPM hybrids. The first white grained QPM hybrid 'Shaktimaan-1' (a three-way cross hybrid using CIMMYT QPM lines) was released during 2001 by Rajendra Agricultural University, Dholi (Bihar). 'Shaktimaan-2' (a single-cross hybrid with white grain) was released by the same University during 2004. The first yellow grained single cross hybrid 'HQPM-1' was released by CCS Haryana Agricultural University, Uchani (Karnal), during 2005, followed by the release of 'Shaktimaan-3' and 'Shaktimaan-4' during 2006, 'HQPM-5' during 2007 and 'HQPM-7' during 2008. 'Vivek QPM 9', developed by Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, was released during 2008. Thus, a series of eight QPM hybrids were developed and released so far; all these hybrids, except 'Vivek QPM 9', were based on CIMMYT QPM lines (adapted to Indian conditions). All the seven hybrids developed at Dholi and Uchani Centres are of full season maturity, while Vivek QPM 9 is of early maturity and it was developed through marker assisted breeding.

Molecular Markers and MAS in QPM Breeding

To hasten the pace of progress of QPM cultivar development, and most importantly, to diversify the genetic base of QPM cultivars in the country, it is important to convert some of the highly diverse and agronomically elite non-QPM inbred lines into QPM versions and derive more heterotic QPM hybrid combinations. The recent developments in plant biotechnology, including molecular mapping and marker-assisted selection (MAS) offer a choice of options for introgression of the target gene(s) in the genetic background of elite varieties of major crops. MAS refers to the manipulation of genomic regions that are involved in the expression of traits of interest using molecular markers. The PCR based molecular markers help in targeted 'foreground selection' of segregating/ backcross progenies possessing the desired gene(s), besides shortening of the breeding cycle significantly through rapid recovery of recurrent parent genome using 'background selection'. Micro satellite or Simple Sequence Repeat (SSR) markers are particularly useful in undertaking MAS in crop plants like maize.

The cloning and characterization of the *o2* gene, followed by detection of three SSR markers (*phi057*, *phi112* and *umc1066*) within the gene (Lin *et al.*, 1997), led to effective differentiation of the *O2* and *o2* alleles (Bantte and Prasanna, 2003; Babu *et al.*, 2005). These *o2*-specific SSR markers offer tremendous advantage in molecular marker-assisted conversion of non-QPM lines into their QPM versions. 'Foreground selection' for the *o2* allele using SSR markers and 'background selection' (using markers polymorphic between the donor and recurrent parents) aid in recovering individuals with desired genotype at the target locus, besides high levels of recovery of recurrent parent genome, within 2-3 backcross generations. This programme can thus be implemented in a cost- and time-effective manner as compared to that based on phenotypic selection alone (Dreher *et al.*, 2003).

One of the successful examples of MAS for maize improvement is the utilization of *opaque2*-specific SSR markers in conversion of the normal maize lines into QPM lines with enhanced nutritional quality (Babu *et al.*, 2005; Gupta *et al.*, 2009). The parental lines of 'Vivek Hybrid 9' (CM145 and CM212), developed at VPKAS, Almora, were converted into QPM versions through transfer of *o2* gene using MAS and phenotypic screening for endosperm modifiers. The MAS-derived QPM hybrid, 'Vivek QPM 9' has been released in the year 2008 for commercial cultivation in zones I and IV in India. Vivek QPM 9 shows 41% increase in tryptophan, 30% in lysine, 23% in histidine, 3.4% in methionine, coupled with 12% reduction in leucine, as compared to Vivek Hybrid 9. Domestic consumption of such QPM grains will help in reducing protein malnutrition in the hills. In view of this, F_1 hybrid seeds of Vivek QPM 9 are being produced in large scale for distribution in Uttarakhand and other parts of the country. Vivek QPM 9 can potentially replace Vivek Hybrid 9 as well as composites without any yield loss in these areas (Gupta *et al.*, 2009).

The approach outlined above was also used to develop QPM versions of several elite, early maturing inbred lines adapted to the hill regions of India. Besides, QPM versions of six elite inbred lines, which are the parents of three single-cross hybrids, PEHM2, Parkash and PEEHM5 have been recently developed by the Maize Genetics Unit, IARI, New Delhi, through the ICAR Network Project on Molecular Breeding. A Network Project has also been recently sanctioned by the Department of Biotechnology (DBT), Govt. of India, for conversion of several important Indian maize inbred lines into QPM versions.

The genetic make-up of the QPM materials necessitates their cultivation in isolation from normal maize, as any contamination with *O2* allele will be apparent in the form of normal transparent kernels in contrast to the marble-like appearance of *o2* kernels. As isolation distance of 300-400m is adequate; with the increase in the number of border rows, this distance can be suitably reduced. Even in the absence of isolation, the farmers planting 2-4 ha can save the seed from the middle of the field, whereas the rest of the crop can be used as nutritionally superior grain.

Recent investigations into the improved protein quality of the *o2* mutant and the genetic mechanisms that can suppress its starchy kernel phenotype provide new insights to support the continued improvement of QPM. Chief among these developments are the use of transgenic approaches to improve nutritional quality and the discovery that an important component of modified endosperm texture in QPM is related to altered starch granule structure (Gibbon and Larkins, 2005).In addition, set of 'amino acid modifiers' could affect the relative level of lysine and tryptophan content. The lysine content of normal maize is around 2%, whereas it is approximately 4% (of the total protein) in QPM, with a range 1.6–2.6% in normal maize and 2.7–4.5% in QPM. Three genes associated with lysine level have been mapped to locations on chromosome 2, 4 and 7, besides several major *o*2 modifier-QTLs on chromosomes 1, 7 and 9. Therefore, it is possible to get favourable responses to selection for endosperm texture modification as well as relative content of the essential amino acids, if they are monitored efficiently, during the QPM breeding programmes.

Conclusions

The opportunities for implementing breeding for improved nutritional quality in crops like maize have increased tremendously in the recent years. Significant strides have also been made, particularly with regard to MAS for generating QPM versions for elite inbred lines and identification of genes/QTLs influencing diverse quality traits in maize. Yet, the application of molecular tools to accelerate breeding for improved nutritional quality in maize has barely begun, and there is vast potential and need to expand the scope and impact of such operations. Breeders will want to avail molecular tools to more efficiently add value to new maize cultivars, for example, by enhancing their nutritional or biochemical qualities for use as food, feed, and industrial material.

Simultaneous with the technological advances, there is a need for effective policy interventions both at the Central and State levels for widespread popularization and adoption of technologies such as QPM by the farmers, enhancing the possibilities for consumption of nutritionally-rich products by all sections of the society, and incentives to those who contribute to the nutritional security of the nation. A National Symposium on "Quality Protein Maize for Human Nutritional Security and Development of Poultry Sector in India" was organized at New Delhi on May 3, 2008. Salient among the recommendations of this Symposium are as follows:

Since QPM hybrids are basically bred by public sector institutions, and public seed producing agencies are unable to cope with the production of seed of these hybrids, a Public-Private Partnership model should be adopted to achieve the seed production and area coverage targets.

Currently, utilization of maize as food crop is only 25% whereas its use for animal and poultry feed is almost 60%. Hence, increasing area under QPM could lead to improved human nutrition and availability of low cost feed for which internal demand is increasing very fast. This would demand use of diverse maize products and food habits through popularization of various maize recipes. Also, QPM could be a cheaper source of protein for children and can be used effectively as mid-day meal for which the Bihar State has taken the lead.

Poultry sector has a potential for growth at about 15% p.a. as compared to the present 11-12% and also as an export industry. QPM for poultry is an industry demand and should be satisfied in the overall interest of the country.

In view of the best available quality feed for poultry, it is necessary to provide incentive (at least 10 % higher price than normal maize) to the QPM growers to accelerate and strengthen the QPM in the country. Some of the State Departments of Agriculture (e.g., West Bengal) have taken initiatives for seed production of QPM hybrids and their dissemination through public-private partnership in view of the ever increasing demand of poultry feed.

Cooperative Farming in Rainfed Areas

J. Venkateswarlu

Preamble

Any development is meaningful only when the needs of the poor are satiated. The rainfed areas are the abode of 80% of the poor and 65% of the livestock. To achieve sustainability in development, community has to be involved. The classic example comes from SERP (IKP) of Govt. of A.P. wherein 3,40,000 farmers from SHG's (mostly women) in about 3,000 villages brought 5,61,200 ha under Non-Pesticidal Management (NPM) of crops (examples: cotton, pigeonpea, and chillies). SERP provided the needed training only.

Setting

The rainfed areas in the state (about 60%) are ecologically and economically disadvantaged. There is high spatial variability in soils, with multiple slopes, variable depths and texture. Soil organic matter is continuously depleting. The rainfall (main source of water) also varies temporally and spatially. With global warming it is becoming more unpredictable with high intensities and long dry spells. Thus the rainfed areas are not only thirsty (moisture stress) but also hungry (nutrient inadequacies). Over half of the farmers in rainfed areas do not have draft for agricultural operations and any source of irrigation.

To bring such a heterogeneous community under co-operative farming would be a Herculean task. But nothing is impossible.

It is important to realize

- Smallholders are the repository of agro-biodiversity, the lifeline for sustainability
- Small farms are more efficient
- They cool the climate better than commercial / large farms
- Livestock enterprises (particularly milch animals) are growing with smallholders
- Other non-farm enterprises are on the rise

Selection of Areas

It could be contiguous or scattered. But the first option would be better for initiating the programme. And watershed areas already covered under the Ministry of Agriculture (NWDPRA, RVP and FPR) and Ministry of Rural Development (IWDP, DPAP and DDP) programmes may be considered. Advantages are two fold. First, there was considerable effort to improve the natural resources (land, water, vegetation). Second, much effort was made in developing community-based organizations (SHGs, UGs).

To start with, watersheds noted for their good performance may be considered for the purpose with about 150-300 farmers as a unit.

Some awareness on management of natural resources, sharing of usufructs money management, conflict resolution, group discussions and decisions, group action / implementation, etc already exist in the watershed areas.

Existing Models

Several models are available in

Director (Retired), Central Arid Zone Research Institute, Jodhpur.
Email: jagarlapudi34@yahoo.co.in

community farming. From personal visits and experiences three models are cited. One such comes from Lonzhau Province of China. Here 200 ha area covered with 20 bore wells are farmed by 100 farmers. Each farmer is allotted 2.0 hectares out of which 1.0 hectare is to be put under food crops (rice, wheat) to supply targeted food grains to the Government kitty. The Government provides the needed inputs on subsidy. The other 1.0 ha can be planned with crops (including vegetables) of the choice of the farmer, but with the overall approval of the community and with due consideration of available water for the year. The inputs for this 1.0 ha are to be acquired by the farmer from the existing channels. Both the people and the Government are happy.

The second option is from Turkmenistan (then under USSR) where the members of the commune are allotted land to grow food crops, fruits, cotton and others as decided by the commune. Each of the farmers is paid monthly some compensation. In order to avert laggards, it is planned to pay additionally for their achievements in terms of yield and quality.

The third is from arid West Rajasthan. In Jaisalmer district there are about 500 *Khadins* that used to supply the needed food grains to the people of the entire district after meeting their personal needs.

Khadin is a low-lying area wherein rainwater is stored across a bund. Size varies from 50-100 ha. Rainwater from the upper reaches collects in this low-lying area during the monsoon period (rainfall varies from 100-180 mm/ year). The area remains under water during *kharif* season. By late October to early November the water percolates into the soil and even recharges the groundwater. Once the soil with stored water is ready for sowing crops like chickpea followed by wheat are taken up as *rabi* crops.

Each *Khadin* is owned by a homogenous group of farmers (generally same caste). The group owns the land. They together till the soil and grow crops. They share the final produce. Excess is sold.

When the system was attempted by Govt.of Rajasthan in the neighboring Pali district, it failed. On investigation, it was found that the groups of farmers were heterogeneous and needed adequate training and back stopping.

Proposal

In the watershed selected from out of the completed watershed areas, the following points may be considered as watershed plus activities.

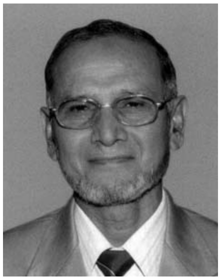
1. Improve the soil productivity at the cost of the budget
2. Encourage the SHGs to be federated and identified as a cooperative
3. Let the farmers decide the crop production plans, keeping in view the rainfall and available water from wells / bore wells and minor irrigation sources
4. Provide the costs towards infrastructure needed for
    a. Life saving irrigation for rainfed crops
    b. Pressurized irrigation systems for high value crops
5. Encourage participatory irrigation systems for groundwater as well
6. Farmers may grow food crops (Cereals, pulses) at least in half of their holding for which Government may provide subsidy for the inputs (including draft). For the rest of the holding the farmers may decide as a community to grow crops of their choice for which Government may encourage Bank loans through federated SHGs.
7. While the procurement of food grains

(in excess of farmers' needs) be done by the Government, the produce from non-food crops be sold to external agencies through MoU for which Government / Panchayat stands as a third party assurance. Best would be encouraging farmers to take up organic production (cotton, medicinal plants for green pharmacy, fruits and vegetables). Their internal and external (export) demands are ever increasing. Further the system is eco-friendly.

8. As regards milch animals, the milk producers be the members of the federation and directly supply milk and milk products through the Cooperatives. The same approach may be adopted, if poultry is taken as another enterprise.

Pulses Production in India

Masood Ali



Present Scenario

India is the largest producer of pulses in the world with 25% share in the production. The major pulse crops are chickpea (39%), pigeonpea (21%), mungbean (11%), urdbean (10%), lentil (7%) and fieldpea (5%). The important states are Maharashtra (20%), Madhya Pradesh (17%), Rajasthan (11%), Uttar Pradesh (11%) and Andhra Pradesh (11%), together accounting for 79% of the total production. During 2007-08, the total production was 14.76 million tonnes from an area of 23.63 million hectares with an average yield of 625 kg/ha. The 3rd Advance Estimate for 2008-09 show a drop in production mainly due to shortfall in area (0.63 million hectare) and in productivity on account of unfavourable weather for *kharif* pulses. However, the area and production of *rabi* pulses increased significantly but could not compensate the loss in production. The pulses production is not keeping pace with the domestic requirements and consequently the nation has to import 1.5 - 2.8 million tonnes annually, which is a matter of serious concern.

Regional Shift

A significant regional shift in area of pulses has been witnessed during post-green revolution period. In North India, the area reduced from 10.83 million ha in 1971-75 to 8.60 million ha in 2005-08, while in central and South India it increased from 11.34 million ha to 15.01 million ha. This was more conspicuous in chickpea, where it decreased from 5.1 million ha to 2.06 million ha in North and increased from 2.39 million ha to 5.2 million ha in central and South India.

Trends in Area, Production and Productivity

The area under chickpea has increased from 6.5 million ha in 1991-93 to 7.3 million ha in 2006-08. Similarly in pigeonpea, the area increased from 3.60 million ha to 3.63 million ha. In Andhra Pradesh, the chickpea area has increased from 71,000 ha to 0.58 million ha and productivity from 621 kg/ha to 1397 kg/ha yielding a 16 times increase in production. In Maharashtra, the chickpea area increased from 0.57 million ha to 1.24 million ha and the production from 0.29million to 0.96 million tonnes. In Karnataka, the chickpea area increased by 2.7 times and production by 4.4. times during this period.

In case of pigeonpea, the area increased from 0.33 million ha in 1992-93 to 0.45 million ha in 2006-08 in Andhra Pradesh, 1.01 million ha to 1.14 million ha in Maharashtra and 0.47 million to 0.62 million ha in Karnataka. This was mainly due to increased productivity. Presently, mungbean and urdbean occupy 3.77 and 3.24 million ha area in the country, which were around 3.00 million ha of each in 1990-93. This, coupled with positive growth in productivity has led to increase in the production to 1.56 and 1.52 million tonnes in mungbean and urdbean. Rajasthan has shown an impressive growth in area from 0.37

Former Director, Indian Institute of Pulses ResearchKanpur- 208 024 (U.P.)
Email: masoodali53@rediffmail.com

million ha to 0.93 million ha due to development of short duration, yellow mosaic resistant varieties with higher productivity. Maharashtra followed this trend. In case of urdbean, Uttar Pradesh has shown progressive increase both in area and production. There was positive growth in area, production and productivity of lentil in Madhya Pradesh and Uttar Pradesh, the major lentil growing states. Area under lentil has increased from 1.18 million ha to 1.50 million ha while production has increased from 0.74 million tonnes to 0.94 million tonnes in the same period.

During the period 1991-93 to 2006-08, highest increase in productivity of chickpea was recorded in A.P. (124%) followed by Karnataka (63%), Maharashtra (52%) and Gujarat (40%). In pigeonpea, A.P. (109%), Karnataka (103%), Maharashtra (64%) and Gujarat (27%) showed marked improvements. Madhya Pradesh reflected significant growth in lentil and fieldpea. There was more than 20-40% increase in productivity in urdbean in M.P. (24%) and Maharashtra (28%), and in mungbean, in A.P. (22%), U.P.(18%), M.P.(10%) and Maharashtra (11%).

Major Constraints

The major constraints that limit the realization of potential yield of pulses include biotic and abiotic stresses besides socio-economic factors prevalent in the pulses growing areas. *Fusarium* wilt coupled with root rot complex is the most widespread disease followed by Ascochyta blight mainly in the cool and humid climate of the North-West Plain Zone and Botrytis grey mould in North-East Plain Zone causing substantial losses to chickpea. While fusarium wilt, sterility mosaic, phytophthora blight and alternaria blight cause substantial losses to pigeonpea, mungbean yellow mosaic virus, cercospora leaf spot and powdery mildew are the important diseases in both mungbean and urdbean. In lentil, rust, powdery mildew and wilt cause considerable yield loss. Powdery mildew is the most important and widely spread foliar disease of dry peas throughout the country. In the recent years, rust is also appearing as the most important disease in northeast plains. Among key insect pests, gram pod borer *(Helicoverpa armigera)* in chickpea and pigeonpea, pod fly in pigeonpea, whitefly, jassids and thrips in mungbean and urdbean, aphids in lentil and stem fly in dry peas cause severe damage to the crops. Weeds also cause substantial loss to pulses. Nematodes have emerged as a potential threat to the successful cultivation of pulses especially in light textured soils.

Among abiotic stresses, terminal drought and high temperature at terminal stage and cold as well as sudden drop in temperature coupled with frost and foggy weather during the reproductive phase of crop inflict major yield losses and instability in production. Consequently, pulses are perceived as marginal farmers' crops laden with high risk and poor yield. This perception discourages farmers to invest in requisite inputs vital for its successful cultivation. This is further compounded in the absence of favourable market intervention in the form of minimum support price and efficient procurement mechanism besides lack of liberal credit policy.

Technology in shelf

Research and development efforts made by the Indian Council of Agricultural Research in association with State Agricultural Universities have resulted in development of over 570 improved varieties of different pulse crops and remunerative production technologies. Some of the proven technologies are highlighted below:

Improved Varieties: About 304 varieties of different pulse crops having high yield, resistance to key diseases, larger seed size, appropriate duration have been released since 1992 for cultivation in various agro-climatic zones. Many of these varieties have yield potential of 2.0 to 2.5 t/ha in chickpea, pigeonpea and field pea; while in mungbean and urdbean, the yield potential is 1.0 to 1.5 t/ha. A large number of frontline demonstrations conducted in different zones have shown mean yield gain of 24%, 23.6%, 24.3%, 20.3% and 21.9% in chickpea, lentil, pigeonpea, mungbean and urdbean respectively due to improved varieties over local cultivars.

Ridge/Raised Bed Planting: *Kharif* pulses, especially pigeonpea, suffer heavy losses due to water stagnation, resulting in poor plant population and seed yield. Ridge planting of pigeonpea has been advocated especially in North East Plain Zone (Eastern U.P., Bihar, Jharkhand, West Bengal) to ensure desired plant stand of the crop, minimize the incidence of Phytophthora stem blight, ensure quick disposal of runoff and also to economize the use of supplemental irrigation, if needed. The technology involves making ridges and furrows by tractor/bullock drawn ridge planter at 60 cm spacing and sowing seed in the centre of the ridge. Frontline demonstrations of ridge/raised bed planting in this Zone have clearly shown 17-20% yield advantage over flat bed sowing. Raised bed planting is becoming popular with the availability of low cost raised bed planters. Ridge planters now available need to be popularized through community services.

Bio-fertilizers: Pulses are endowed with unique ability of biological nitrogen fixation, which enables them to meet their own N requirement besides improving soil fertility. However, this phenomenon occurs with adequate population of *Rhizobium* bacteria, which are low in stressed soil of rainfed areas where pulses are grown. Phosphorus solubilizing bacteria have been identified to improve availability of phosphorus to the plant. Field experiments and frontline demonstrations on bio-fertilizers have clearly shown that seed inoculation with *Rhizobium* and PSB improved productivity of pulses by 11-21%. The technology involves inoculation of seeds with *Rhizobium* culture @ 25 g/kg of seed and PSB 10-12 hours before sowing. These are the least expensive inputs, needing popularization on large scale.

Foliar Spray of Urea: In rainfed areas, pulses generally suffer with inadequacy of N at the reproductive phase due to moisture stress and degeneration of root nodules. Foliar spray of 2% urea helps in improving N content of leaves making them photosynthetically more active. Frontline demonstrations on chickpea, lentil, mungbean and urdbean in different regions have shown spectacular increase of 13-20% in their productivity. This proved to be one of the simplest and low cost technologies for improving production of pulses.

Sulphur Application: A comprehensive study on fertility status of pulse growing regions has shown that out of 135 districts, 87 showed 20-60% deficiency in sulphur. This has gradually developed as these crops are generally deprived of organic manures, besides continuous cultivation without addition of S containing fertilizers, leaching losses and heavy demand for S. Presently in many areas, response to S is more prominent than P. Soil application of 20 kg S/ha through SSP, gypsum or pyrite depending upon soil condition have shown encouraging results. Therefore, S should become important component of integrated nutrient management. Farmers are fully convinced with the beneficial effect of S fertilization but non-availability of these fertilizers is the major constraint. It is therefore, imperative to promote production of SSP, which meets the requirement of both P and S, and also ensure availability of gypsum and pyrite in S deficient districts. This technology has shown 15-24% yield advantage in different pulse crops.

Weed Management: Amongst various production inputs, weed management has been found as the most critical input for *kharif* pulses and second most important in *rabi* season as weeds cause substantial yield losses. Pre-emergence application of pendimethalin @ 1.0 to 1.25 kg a.i. per ha has been found quite effective in controlling seasonal weeds. Frontline demonstrations of this technology have shown 24-33% yield advantage and therefore, need popularization immediately.

Seed Priming: Most of the *rabi* pulses like chickpea, lentil and lathyrus are grown on residual soil moisture. At that time, the moisture will be limiting factor in seed zone for proper germination due to early withdrawal of monsoon. Under such conditions, seed priming (soaking seeds for 6-8 hours in water) has proved quite beneficial in improving plant stand and early vigour, resulting in higher yield. This simple technology needs to be advocated among farmers.

Remunerative Cropping Systems: With the advent of high yielding and short duration varieties, new cropping systems with high productivity and monetary returns have been developed both for rainfed and irrigated areas, which are popular with the farmers. Among such systems, rice-wheat-mungbean for intensification of rice-wheat system and short duration pigeonpea-wheat and rice- late sown chickpea for the irrigated areas of Punjab, Haryana, Delhi, central and western U.P., rice-lentil for the eastern U.P., Bihar, West Bengal and M.P., and rice- *rabi* urdbean/ mungbean in rice fallows of coastal peninsula have been found efficient and remunerative. These systems have potential to increase pulses production on a sustainable basis.

Integrated Wilt Management: *Fusarium* wilt is a serious problem in pigeonpea, chickpea and lentil causing substantial yield losses. Host plant resistance is the best option. However, non-availability of seeds of wilt resistant varieties and existence of pathogenic variability call for integrated approach of wilt management involving summer cultivation, seed dressing with fungicides like carbendazim, thiram and *Trichoderma* which are compatible with *Rhizobium,* promoting intercropping of pigeonpea with sorghum, chickpea with linseed and appropriate crop rotations.A glaring example of containing pigeonpea wilt was well demonstrated in Maharashtra. There is need to ensure fungicide treatment of seeds being sold to farmers, adequate production and distribution of *Trichoderma* and creating awareness on the wilt resistant varieties.

Integrated Management of *Helicoverpa:* Gram pod borer *(Helicoverpa armigera)* is the key pest of pigeonpea and chickpea causing 25-30% yield losses. At present, there is no variety showing resistance to this dreaded insect pest in any of the pulse crops. In view of this, low cost bio-intensive IPM modules have been developed which involve timely sowing to exploit host avoidance phenomenon, intercropping with mustard, barley and linseed in chickpea and sorghum in pigeonpea, use of trap crops like *Vicia sativa* and African giant marigold, use of Nuclear Polyhedrosis Virus (NPV) @ 250 LE/ha or *Bacillus thuringiensis* (*Bt*) @ 1-1.5 kg/ha, and erection of perches @ 20-30/ha to attract insectivorous birds. Spraying with 5% Neem Seed Kernel Extract or Achook @ 1.25 l/ha or need based use of chemicals like 0.07% endosulfan or 0.004% fenvelarate at 15-20 days interval is recommended. There is need to popularize IPM technologies and ensure availability of pheromone traps, *Ha*NPV and neem based products. A prediction model for *Helicoverpa* in long duration pigeonpea has been developed that is based upon minimum temperature (>5^0C) around 7-8 standard weeks, rainfall during 1-9 standard weeks and base moth population (more than 15 moths during 5-7 standard weeks). The combinations of all these factors could lead to severe infestation of *Helicoverpa* whereas one of the factors indicate low occurrence of the pest.

Integrated Management of Nematodes: Plant parasitic nematodes like root knot and cyst nematodes are posing serious threat to many pulse crops especially in the light textured soils. They also predispose crop plants to wilt and damage root nodules. Integrated management that involves summer ploughing, seed treatment with neem seed powder or smearing seeds with neem oil and appropriate crop rotation provide effective control of nematodes.

IIPR Mini Dal Mill: A low capacity *dal* mill, popularly known as IIPR *Dal Chakki,* having milling capacity of 80-125 kg per hour for different pulse crops has been designed at the Institute. In this mill, all the three milling operations, dehusking of grains, splitting of dehusked kernels and cleaning of finished product take place simultaneously in single pass. A cyclone separator provided in the mill separates powder and husk fraction from the milled product, resulting in the cleaned finished product. The machine operates on 1.5 hp single-phase power supply and gives 75-82% *dal* recovery with minimum breakage. Its design has been released for commercial production. The *Chakki* has become very popular with the farmers for value addition and small entrepreneurs for employment generation.

Oilseeds in India: Present Status and Suggested Road Map

D.M. Hegde

India has one of the largest vegetable oils economy in the world, next only to USA, China, Brazil and Argentina. The diversity of oilseeds found in India is not seen anywhere else in the world. In addition to all the annual oilseeds, a wide range of other minor oilseeds of horticultural and forest origin, in particular coconut and oil palm are grown. The country also produces substantial quantity of vegetable oils from rice bran and cottonseed. One or more of oilseeds are grown in every state of the country. However, Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu and Uttar Pradesh account for nearly 90% of their area and production.

Progress in oilseeds production

The area, production and productivity of oilseeds registered an annual compound growth rate of 1.60, 3.02 and 1.41% between 1950 and 2008 respectively. There was 2.65, 5.69 and 2.15 times increase in these parameters during the last 58 years. These achievements under predominantly rainfed conditions are even higher than the production increase in total food grains. It is worth recording that 4.6 times increase in total food grains was achieved with the highest national priorities to this group and was relatively under much more favourable farming environments, particularly irrigated lands right from the first five year plan. The net per capita production of edible oils increased from 3.5 kg during 1951 to 8.1 kg during 2008 while that of food grains from 132.4 kg to just 170.3 kg during the same period.

There has been large regional variation in oilseeds production during the last 25 years. Only a few states like Haryana, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal increased their production both through area expansion and productivity improvement. Gujarat increased oilseeds production mainly through higher productivity. In Punjab, oilseeds production declined by nearly 50% mainly in response to sharp drop in its area, while in Orissa, both area and productivity decreased sharply leading to large decline in production. The major states like Andhra Pradesh and Karnataka have not achieved any noteworthy success in oilseeds production.

The oilseeds sector has become a net earner of foreign exchange during 2007-08 after a gap of nearly a decade (exports and imports are Rs. 12875 and Rs. 11147 crores respectively) although the country imported 5.2 million tonnes of vegetable oil constituting 36% of national needs. This trend is being continued during 2008-09.

Demand projections

Vegetable oils consumption is both income and price elastic. The per capita consumption has increased from less than 3 kg/year at the time of independence to nearly 12 kg/year during 2007-08.

Project Director, Directorate of Oilseeds ResearchRajendranagar, Hyderabad-500 030.
Email: dmhegde@rediffmail.com

As per the projection of DAC-Rabo Bank, the per capita consumption is likely to rise to 12.60, 14.57 and 16.38 kg/year by 2010, 2015 and 2020 respectively. This amounts to a vegetable oil requirement of 14.8, 18.3 and 21.8 million tonnes by the respective periods for a projected population of 1175, 1256 and 1331 millions. it is equivalent to 44.8, 55.5 and 66.0 million tonnes of oilseeds respectively, provided that the proportion of different oilseeds remains constant in the coming years. If one assumes 20% of vegetable oils from crops other than annual oilseeds, such as coconut, oil palm, rice bran, cotton seed, tree borne oilseeds etc. then we need to produce about 55 million tonnes by 2020 to achieve near self-reliance in vegetable oils. Considering that oilseeds production during 2007-08 amounted to about 29.76 million tonnes, the country needs to almost double their production in the next 11 years requiring an annual growth rate in excess of 6%, which will indeed be a tall order.

Issues in oilseed sector

The major issues/concerns in oilseeds are continued dependence of oilseeds on rainfed production system leading to wide year to year fluctuation in production, non-availability of quality seeds of improved varieties/hybrids, poor crop nutrition-both suboptimal use of major nutrients and minimal use of secondary and micronutrients, new biotic threats in different oilseeds for which there are currently no effective management options, weak transfer of technology, highly inefficient processing, inadequate marketing support, non-remunerative and unstable prices and usually unfavourable trade policy.

There is need to adopt multipronged strategy to meet the challenges of oilseeds production in the years to come. This involves enhancing their production through area expansion and productivity improvement through better adoption of currently available improved technology, value addition to oilseeds and oils to increase their competitiveness, higher recovery of oil through efficient processing, overcoming the constraints of domestic marketing of oilseeds and its products and liberalizing trade in India's oilseeds economy.

Area expansion

The expansion of oilseeds area during the last two decades was a major source of growth in their production. Nearly 45.3% of the increased production was contributed by area expansion and 54.7% by productivity improvement during the period 1985-86 to 2007-08. The area increase came where the oilseed crops were superior options to traditional crops. Farmers always searched for technological options and practices, which brought them higher returns and readily responded to various economic incentives. The area expanded in favour of those oilseed crops which have either shown a higher growth rate of productivity due to technological development as in rapeseed-mustard or whose relative prices with competing crops have moved in their favour as in sunflower or higher growth rates in productivity were combined with higher prices resulting in sharp increases in total profitability as in soybean.

There is a limited scope to bring additional area exclusively under oilseeds as the demand for land for producing other remunerative crops will continue to rise due to population increase and rising living standards. However, it becomes imperative to search for newer approaches to expand their cultivation under different cropping/farming situations. Oilseeds have an edge over other crops in terms of price and relative primal production under environmental stress conditions.

Extending cultivation to underutilized farming situations such as in rice-fallows of eastern India where 15 million hectares is under low land rice is one such possibility. In India about 45 million hectares are available with widely spaced crops (cotton, sugarcane, maize, pigeonpea, etc.) where introduction of oilseeds as intercrops is possible. In addition, these can also be intercropped in less remunerative, traditional staple food crops whose replacement is not possible as in wheat in peninsular India. Newer areas and seasons for cultivation of oilseeds is the grey area to be exploited. Further, under limited water availability for the second crop of rice or in tail end areas of canals, oilseeds are better options where, sunflower, sesame and groundnut can be harvested well with less than fourth of water needs of rice. Oilseeds perform well in saline areas than cereals or pulses. Considerable potential exists for expansion of area under oilseeds in rice-based cropping systems. There is an urgent need for diversification of rice-rice and rice-wheat cropping systems by introduction of oilseeds for conservation of resources and better sustainability.

Sunflower and sesame may also be better options under contingency planning where the season for regular crop is not conducive or when this has failed. These can fit well as catch crops between two regular crops. Value addition to some of the main and by-products of oilseed crops will further increase their competitiveness and help expand the area. This will also arrest constant decline in area observed in some minor crops like safflower and linseed in recent years. It must be possible to reach a target of at least 33 to 35 million hectares by the year 2020 under oilseeds if concerted efforts are made with appropriate policy back up along with scientific adjustments in cropping systems.

Improving oilseeds productivity

The productivity of all oilseeds in India is just 50-60% of the world average with the exception of castor and only 15-25% of the productivity observed in the country. With limited scope to bring additional area under oilseeds, bulk of the future increases in their production have to come primarily from land-saving technologies, highlighting a combination of high yielding varieties/ hybrids, balanced and integrated crop nutrition, efficient crop management, integrated pest management and mechanization.

Crop ecological zoning: There is widespread cultivation of most of the oilseeds with varying productivity levels in different districts. Crop ecological zoning is an important strategy for their efficient production. Delineating efficient zones for each oilseed crop helps in realizing potential yields with high input use efficiency. Only 4 districts contribute 33% of groundnut area and 37% of sunflower area in the country. Likewise 9 and 12 districts contribute 31% of mustard and 41% of soybean area. All our efforts for increasing the productivity of oilseeds need to be dovetailed to these zones. Support services like input supply, marketing and processing have to be linked. Besides strengthening of research and extension systems, these zones also help in addressing tasks of getting over infrastructural shortcomings faced by the farmers.

Quality seed supply: Availability of quality seeds of improved varieties and hybrids is grossly inadequate and is one of the important constraints to enhance oilseeds production. As on today, more than 670 varieties/hybrids have been developed and notified for seed production which have shown up to 40% yield superiority over the local cultivars with better resistance to insect pests and diseases. During 2007-08, out of 614 varieties notified, only 290 were in seed chain. Out of those also, only a few select varieties were dominating the seed indent with the result, that many new varieties suited for specific conditions are not finding their way to farmers' fields. While there is enough breeder seed production in most of the oilseed crops, further seed multiplication through foundation and certified seed production are the key constraints for availability of quality seed at farmers' level. The seed replacement ratio for all annual oilseed crops put together is only 8-10% ranging from <1% in niger and linseed to 69% in sunflower. Even in major crops like groundnut, it is only 2%. With the exception of castor and sunflower where hybrids are ruling with private sector involvement, the seed production is primarily left with public sector agencies with many limitations.

Irrigation: Annual oilseed production in the country is faced with high degree of variation, as nearly 72% of the oilseeds area is rainfed and subjected to uncertainties of moisture availability. With the exception of rapeseed-mustard (72.1%) and castor (63.6%), the irrigated area in other oilseed crops varies from less than 1% in safflower and niger to 1.7% in soybean, 6.3% in sesame, 8.3% in linseed, 19.6% in groundnut and 24.9% in sunflower. The production of oilseeds can be stabilized and significantly increased by extending irrigation facility. The water requirement of oilseeds in general, is low and they respond remarkably to limited irrigation input at critical stages. Sometimes productivity of crops like safflower can almost be doubled with just one protective irrigation.

Nutrient supply: Oilseeds are energy rich crops but they are mostly grown under energy-starved condition. The low or no use of plant nutrients is one of the most important factors for their low productivity. Their need in general, is high for all the nutrients including micronutrients for producing higher yields. Some of the cropping systems involving oilseeds may remove as much as 400 to 800 kg/ha/year of N, P_2O_5, K_2O under high productivity conditions. The estimated NPK removal by oilseed crops during 2007-08 was 3.94 million tonnes while the contribution to nutrient uptake by fertilizers was only 14.5% leading to continuous mining of soil in these areas even with present low productivity. Apart from good response to major nutrients, there is growing deficiency of secondary and micronutrients such as S, Ca, Zn, Fe and B due to intensive cropping using high analysis fertilizers. The limiting secondary and micronutrients need to be applied along with NPK for achieving desired yields.

Groundnut and soybean being legumes, occupy more than 50% of oilseeds area and they can greatly be benefited from use of appropriate *Rhizobium* cultures economizing N fertilizer use. These crops in sequence with other non-legumes can help in saving N fertilizer to the extent of 30 to 40 kg/ha. Since the average consumption of plant nutrients is very low and still lower in oilseeds, the residual fertility build up due to legumes is obviously a major contribution, which must be exploited fully for increasing oilseed production.

Biofertilisers like *Azotobacter*, *Azospirillum* and phosphorus solubilising microorganisms can also play an important role in achieving economy in chemical fertiliser use. Seed treatment with *Azotobacter* and *Azospirillum* can save 20 to 30 kg N/ha in crops like sesame, mustard, sunflower and safflower even under rainfed conditions. These biofertilisers need to be promoted in different oilseeds along with *Rhizobium* for leguminous crops.

There is need for practicing fertilizer

management on a system basis rather than on an individual crop or field basis for achieving higher efficiency and economy, leading to greater sustainability. Specific attention needs to be given to harness the residual effects of fertilizers containing P, K and S. Sound fertilizer management for intercropping system meeting the nutrient needs of component crops will go a long way in enhancing productivity of the system.

Efficient crop management: Oilseeds are cultivated for commercial purpose and their by-products at field level are of little value with the exception of groundnut. Profitability lies in efficient crop management, mainly with non-cash or low cost inputs. Such practices are: adoption of proper crop rotation to improve soil health and to reduce pest build up, soil and moisture conservation measures, timely planting, adequate plant stand, timely weed management, need-based plant protection with bioagents and biopesticides, promotion of plant growth promoting rhizobacteria like *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphorus solubilising microbes etc. These will have great influence on productivity and sustainability of oilseeds production.

Integrated pest management: Oilseeds are affected by a large number of insect pests and diseases that cause considerable yield loss. Many pests have become limiting factors in oilseeds production, as no effective and economic measures are currently available for their management. IPM practices have been standardized involving resistant varieties, biocontrol agents, biopesticides and need-based use of chemicals. The additional benefit with IPM package adoption ranged from Rs. 2500/ha in linseed to Rs. 7600/ha in castor.

Farm mechanisation: The opportunity time for carrying out many field operations for oilseeds is very limited especially under rainfed conditions. Out of these, planting in optimum time is most crucial for getting the desired plant stand and expected yield. There are a large number of very efficient farm implements both bullock drawn and tractor drawn, specially designed for oilseeds which need to be made use of on a much larger scale to achieve efficiency and economy in many farm operations. In cases where it is not possible for individual farmers to own these implements, these must be made available on custom hire basis. The selective farm mechanization can make a significant impact on productivity of oilseeds apart from enhancing input use efficiency ultimately leading to increased competitiveness of oilseeds.

Effective technology transfer

For increasing oilseeds production, besides generating new technologies, concerted efforts are needed to transfer the existing technologies from research laboratories to the farmers' fields through efficient and effective technology transfer programme. The data generated from nearly 26700 frontline demonstrations organized by the Directorate of Oilseeds Research, Hyderabad during the last two decades in the farmers' fields across various crops, seasons and situations clearly indicate the possibility of enhancing oilseeds production to a great extent. Different components like improved varieties, nutrient management, need-based plant protection, weed control, irrigation management and thinning etc. have profound influence on the productivity of different oilseed crops. There exists a commercially exploitable yield reservoir to the tune of nearly 80% of the national production that could be harnessed by the adoption of currently available improved technologies.

Value addition to oilseeds and oils

Oilseeds are sources of oil, protein,

sugar, minerals and even nutrients. Although oilseeds in general, have good composition and quality, their domestic utilization as well as larger exports are hindered due to certain limitations and toxic factors. We must overcome these limitations for better value realization. Instead of exporting direct items like oilseeds, oil and oilcakes, India should export value-added products. Currently, castor oil and other related products worth about Rs.2000 crores are exported annually without any significant value addition. A conservative estimate indicates that, foreign exchange of about $ 6 billion can be earned if value-added castor oil and its products are exported. There are uncommon opportunities to add value to different oilseeds and oils, which must be fully exploited to enhance the competitiveness of these crops. A large number of high-value products can also be obtained from by-products of processing industry. Quality of cakes and meals of all oilseeds can be upgraded by removing anti-nutritional factors and contaminants and their utilisation base can be broadened by developing processing technology for value-added food products. Provision of appropriate storage structures can overcome problems like pesticide contamination in sesame seeds, which is a major roadblock in increasing sesame seed exports. Similarly, aflatoxin development in groundnut has to be avoided by adopting effective production and storage technologies.

Policy options for oilseed sector

The remarkable progress India could achieve in oilseeds sector during initial years of technology mission would not have been possible without an appropriate policy backup from the Government. If the country has to turn near self-reliant in vegetable oils sector in the coming years, a comprehensive policy framework for the entire sector taking into consideration various demands and interests of all the stake holders (consumers, industries, farmers, traders) with diverse interest is a pre-requisite. The policy must stimulate balanced growth of vegetable oils sector, which can be sustained over a long run. Some of the major elements of this policy framework are:

- All traditional oilseeds are reserved for small-scale sector with inefficient processing set up. There is need to decontrol all these oilseeds from small-scale sector to enhance efficiency of processing.
- There is a very large processing industry with low capacity utilization (5% in *Ghanis* to 45% in refineries attached to *Vanaspati* units) leading to high cost of processing with both farmers and consumers as the losers.
- India's domestic price support programme has often favoured production of crops that compete for area with oilseeds. Support price index in recent years has distinctly moved in favour of rice and wheat unlike in oilseeds.
- Effective market intervention by NAFED to give price support to oilseeds was not forthcoming in many years and in several regions leading to distress sales and low realization from oilseeds by the farmers.
- The trade policy changes were very unstable and quite often were not favourable for domestic oilseed sector.

The government after a careful analysis should give a direction whether India should aim at self-reliance and self-sufficiency or go for need-based imports without unduly disturbing the food and nutritional security. Oil is critical for the health of our public, industry and farmer. After this, we should take steps to implement the policy. The policies should be balanced between availability of oil to the consumers in reasonable quantities and affordable prices on one hand and on the other promote domestic production without resorting to uncontrolled imports to safeguard the interests of the grower, employment, industry and health of our people. This demands a coordinated approach, frequent consultations and avoidance of pressures of interested groups and lobbies, before decisions are taken and directions issued. The decisions and directions have to take into consideration both short-term and long-term issues because the country has seasonal, annual and perennial crops and a big industry base, where substantial investments are made. The decision-making should be based on international scenario, WTO obligations, trade relations, comparative advantages of prices of commodities, whether raw or refined, either to import or export.

To sumup, the oilseeds policy framework has to promote the goals of economic efficiency and social equity through creative combinations of policies, which puts a premium on science and technology. Public policy should support private sector in providing inputs and services to the farmer, the processor and the trader. The tariff policy should strike an appropriate balance between the promotion of domestic production and of export, while safeguarding the interests of consumers through reasonable imports.

Scope for Exalted Status of Cotton in 21st Century

S. S. Narayanan

Cotton & International Year of Natural Fibres

The United Nations Food & Agriculture Organization declared that 2009 be celebrated as the Year of Natural Fibres and accordingly in all major countries including India, international and national level conferences have been organized and many more are likely to come. The Indian Society for Cotton Improvement and the Indian Fibre Society under the auspices of the ICAR, New Delhi conducted a very successful international Conference on Natural Fibres at Mumbai from 16-18 April 2009 with large participation by scientists and stakeholders. Among the scores of natural fibres from plant and animal origin used in textile industry and other purposes, cotton commands the top position in the conventional and technical textiles apart from certain non-textile uses. India ranks first in total area under cotton with around 9.5million hectares (5% of the total cultivated area), second in total production (5.35million tonnes out of a global output of 24 million tonnes) and consumption in textiles (cf.75% in textiles and 20% as exports), and relatively a lower position in productivity in the global situation. The Indian Cotton Advisory Board estimated 31.5 million bales of production for 2007-08 and 29.0 million bales for 2008-09. These were against a total demand of 32.6 and 28.0 million bales including mill and non-mill consumption and exports respectively for the years. There is still an estimated stock of 6.0 million bales at the end of 2008-09.

Indian Textile Industry

Textile and clothing industry is one of the largest and most important industries in the Indian economy in terms of output, foreign exchange earnings and employment. This contributes 4% to the country's GDP and 14% to the industrial production. With US 12.7billion US$ textile exports and 9.7billion US$ garment exports in 2007-08, the industry contributed around 12% to India's foreign exchange earnings. The industry provides employment in manufacturing sector to 33.17 millions, besides in forward and backward linkages of the industry. Over 50 % of the production in the textile value chain gets exported. Ministry of Textiles has targeted an annual growth of 16% for the industry to reach US $115billion by the end of the 11th Five Year plan besides securing a 7% share in global trade and has a potential to employ 45million people by 2012. The export earnings are estimated to increase to US$ 55billion by 2012. Indian T&C market is estimated at INR 2.55 Trillion in 2007-08 with exports amounting to 35% of the T&C earnings.

Cotton & Textiles under Multilateral Trade

Reports released in June 2009 from multilateral organizations like the World Bank, IMF, WTO and ADB had highlighted the collapse in demand due to economic

Former Director, CICR, Nagpur & Research Advisor (Cotton) in NFCL, NARDI, VIBHA & JK Seeds; Consultant (Cotton) in German Seed Project in UN-FAO Afghanistan; QRT Member for CICR-AICCIP & CIRCOT. Email: narayananss@rediffmail.com

downturn. Widespread recession has crippled the economic activities across the globe and caused an acute loss of business. Efforts are on way to bring about acceptable solutions soon. Textile demand dropped dramatically, cotton stocks rose to unmanageable levels and cotton acreage tumbled putting several segments of the world-wide cotton community to suffering in the past cotton year. The year 2010 is likely to be a turnaround period in the industry as per the Cotton International (May-June 2009 issue). The Secretariat of the International Cotton Advisory Committee had forecast that 2009-10 world cotton production would continue to decline for the third consecutive season to 23.6 million tons. World cotton mill use is forecast stable at 23.7million tons in 2009-10, while cotton imports are expected to increase to 7.3million tons. World ending stocks are expected to decline slightly to 12.5million tons by the end of July 2010. Dr. Peter Pascal Lamy, the Director General of the World Trade Organization had pleaded that completing the Doha Round talks would help pull the global economy out of recession unleashing new trade flows and confidence at this moment of crisis. WTO chief is confident that the top U.S.A. and Indian trade representatives agreed to "reset" the stalled Doha Round of trade liberalization talks during a bilateral meeting on the sidelines of a conference of agricultural exporters in Indonesia. He had stated that 80 % of the global deal was done. Let us fervently hope that multilateralism in trade will succeed at the end paving way for a brighter future for cotton and T&C.

Reframing National Policy on Fibres & Textiles

It is Rs.22,000 Crores industry in India and with a right package for cotton and textile industry by the government as well as the stakeholders. In the textile value chain, the employment and cotton utilization potential can be enhanced dramatically in the next five years. Technical textiles represent another area in the extension and diversification of cotton use. To make the industry competitive globally, there is an urgent need for reframing the National Fibre Policy to suit the present and future demand scenario especially to tone up the man-made fibre sector without affecting the cotton production and cotton textile sector and focus on assured market potential areas globally for cotton and cotton textiles and also organic products and finishes. The budget announced for 2010-11 also contains considerable provisions for supporting the cotton farmers and the textile industry.

New Technology Miracles in Cotton

Recent achievements in cotton production scenario in India are due to bold introduction of the transgenic Bt-hybrid cottons from 2002-03, thanks to ICAR-AICCIP-DBT-MoEF of Government of India efforts to adopt all safety testing mechanisms and measures and ensuring that the new gene technology is available to all cotton farmers in all cotton growing regions and states. Till 2008-09 crop season, 280 Bt-hybrids by over 30 Private Seed Companies and one Bt-variety (by CICR) in BG-I (Cry1Ac MON531, Cry1Ac Event-1 of JKAG, Nath Seeds' fusion gene Cry1Ac +Cry1Ab) and BG-II (Monsanto Cry1Ac and Cry2Ab stacked) have been approved for cultivation. The area covered by Bt-hybrids is more than cf. 95 per cent of the tetraploid cotton area, while there is no released Bt-cotton available for the diploid desi cotton area, which has also shrunk due to coverage with upland cotton Bt-hybrids. Area under Bt-cotton has increased substantially in all the nine States and occupies 6.90

million ha, accounting for 73 per cent of total cotton area. A new transgenic "Wide strike®" by Dow Agro-Sciences for more effective bollworm management, competing herbicide technologies especially "Round-Up Ready Flex" and also abiotic stress technology especially for drought resistance are likely to make entry into cotton farming system in India sooner or later. In insect resistance itself, the scientists are looking beyond Bt-source.

Cotton Genomics & Fibre Quality Improvement

International Cotton Genome Initiative (ICGI) is very much concerned about implementing Genomic studies involving various cultivated and wild species genomes of Gossypium in major laboratories in important cotton research centres of the world. Cotton fibers are specialized seed hairs (trichome) that are virtually unrivaled in the plant kingdom as perhaps the longest plant cell trichome morphogenesis. Using developing cotton fibers as a unique model system, and understanding the molecular mechanisms that determine the fiber phenotype and important agronomic traits, it will pave the way for the genetic improvement of cotton using molecular approaches in near future. Biotechnology can create quality enhancements in cotton textiles, although the realization of the improvements will be in the 8 to 10 year time frame. In the shorter term (5-6 years), opportunities exist to create value through the application of biotechnology to increase yield and reduce costs, benefiting technology and farm segments. Barriers to commercialization exist within each segment of the cotton value chain, including development of enabling technology, global acceptance and regulatory environment. Biotechnology opportunities in cotton should be availed off to support existing capabilities in textiles and agricultural production scenario. what research and innovation can do for the cotton and textile industry can be judged in the near future by activating research, innovation & adoption of technologies suited to the new agricultural economy and biotechnology products in cotton are likely to play an increasing role.

Benefits to Cotton Farmers in India & World-over

In India in 2008, 5 million small farmers, (up from 3.8 million farmers in 2007) benefited from planting 7.6 million hectares of Bt- cotton, equivalent to a high adoption rate of 82%. Benefits will vary according to varying pest infestation levels in different years and locations. However, on average, conservative estimates for small farmers indicate that yield increased by 31%, insecticide decreased by 39%, and profitability increased by 88% equivalent to US$ 250 per hectare. In addition, in contrast to the families of farmers planting conventional cotton, families of Bt-cotton farmers enjoyed emerging welfare benefits including more prenatal care and assistance with at-home births for women, plus a higher school enrollment of their children, a higher percentage of them were vaccinated. Taking adoption by trait, from the genesis of commercialization in 1996 to 2008, herbicide tolerance has consistently been the dominant trait. Cotton has and continues to hold good potential for value creation through the application of genetic engineering. A total area of 7.6million hectare is likely to be covered in 2009-10 with Bt-hybrid cotton. The cotton growers are reported to have saved an average of Rs.2250/ per acre in last year and from 2002-08 cumulatively saved around Rs.10, 325 crores by using less pesticide. Many farmers are reported to have switched over more to double gene technology BG-II this year (BG-II in 4.0 million and BG-I in 3.6million hectares) for better protection from bollworms and also to get higher yields. Bt-cotton has demonstrated its potential benefits and it is time to look beyond Bt-cotton.

Climate Change & Water Management

'More crops per drop' is the slogan of the FAO and other eminent agronomists and breeders. Field-level water management, rainfed agriculture with water harvesting and supplemental irrigation, soil and water conservation practices, watershed management, improved water use efficiency, appropriate technologies for field scale implementation, conservation tillage, alternative crops and cropping systems, improved nutrient management (fertilization) coupled with improved seeds and pest management including IPM + IRM are required in abundant measure in the slowly encroaching global warming scenario to sustain crop production.

Favourable Polices on Seed and PVP

The Seed Act (1966) has been revised in tune with changing laws in various areas like Protection of Plant Varieties and Farmers' Rights Act, 2001, Biodiversity Act (2002) and other miscellaneous provisions so as to enable better service to the farming community and adequate support for the effective performance of the private Seed Industry and a congenial atmosphere for the Public sector-Private Sector Seed Industry cooperation and collaboration. The New seed Bill has undergone many revisions and may be approved by the current Parliament. The PPV&FRA aims at encouragement to the development of new varieties, protection of Breeders' Rights and Farmers' Rights and stimulate the development of a competitive and complementary seed Industry. PPVFRA covers all plants except microorganisms. Registration of plant varieties under the Act is voluntary, but registration will help the healthy growth of industry and promote scientific approach to agricultural advancement. New, Extant (those registered under the Seed Act, 1966, varieties of common knowledge, those in public domain and farmers' varieties) and essentially derived varieties (EDVs) are accepted for registration with a set period of protection, as 15 years for agricultural plant varieties. Any variety proposed for PPVFRA registration should exhibit Novelty, Distinctiveness, Uniformity and Stability with a demonstration of the potential attributes as claimed in the variety submitted for registration by the DUS test. A National Seed project Website has been established by the Division of Seed Science & Technology at IARI and this NSP Net provides all-encompassing information to farmers, seed industry and other users.

Need for Dynamic Policy and Effective Implementation

There has been a substantial progress in Indian cotton economy in recent years in terms of productivity gains and fibre quality and yet the textile and clothing industry of the country has not been able to leverage this advantage for improving its cost competitiveness because of lack of other desirable policy interventions of the government taking into account the concerns of all the stake holders. Even though a higher MSP was offered to cotton growers last year, the real benefits of the price increase went to traders. The Government of India and State governments have only implemented certain recommendations of the National Commission for Farmers with Dr. M. S. Swaminathan as Chairman and the technical and technology aspects of the recommendations should be implemented on a mission-mode approach in the current and successive plans to accelerate the tempo of cotton research, establish a concrete extension machinery and strengthening of the quality input supply system in all cotton growing states and also ensuring an incentive based pricing system remunerative to cotton farmers and without jeopardizing the interests of various segments of the cotton textile industry. CITI Vision for 2020 and beyond is very clear and the industry is expected to make a leap forward. All stakeholders have a joint responsibility to work unitedly for common goals of making India the number ONE country in Cotton production and textiles in the next few decades.

International Actions on Cotton & Textiles

The international Cotton Advisory Committee located in Washington USA has proposed to discuss various aspects concerning with the welfare of cotton farmers, fair trade policies and cotton promotion in its next meeting this year to be held in South Africa. The sole purpose is to help the positioning cotton as a solution to global problems such as policies to enhance food security, role of biotech cotton, government responses when agricultural prices are below the cost of production, facilitating Small Holder Cotton Production, stakeholder relations to move cotton forward, government policies to ensure that cotton production is viable and sustainable, cottonseed and value addition etc., outlook for supply-demand and prices of cotton and inputs, overcoming the impediments to progress in Multilateral Trade Negotiations (WTO), Bio-safety regulations, implementation and consumer acceptance, the impacts of social and environmental standards and demand for Cotton and Textiles etc. There will also be discussions on the role of organic cotton in the cotton industry, best practices in instrument testing, progress towards harmonization of Trade Rules, the impact of Carbon trading on Cotton Industry, enhancing Demand for Cotton Products, best practices in cotton ginning and the role of organizations in the cotton economy.

Conclusion

The international organizations and national governments have realized the fact that more active and positive support should be bestowed on cotton and textile economy for stability, clothing and food and feed security needs (edible oil and protein for humans and livestock), better and more prosperous rural livelihoods, employment generation and GDP enhancement. Thus cotton will be an important crop and textile commodity among all natural fibres and also synthetics in the 21^{st} century.

Need for Integration of Indian Agriculture with Global Agriculture

S.M. Ilyas

1. Introduction

It is often postulated that Indian agriculture is slowest to respond to changes in economy and has been taking long time to integrate with global agriculture. In fact this premise is not true as very concrete efforts have been taken to use best technology and practices as well as the codes and standards of quality. This is largely due to emergence of a large middle class which is conscious of quality and is willing to pay for it at a competitive cost. India has all possibilities and capabilities to emerge as food basket of world.

But there are challenges which are no less formidable. The country has been making great strides in economic field and has emerged as one of leading economies of the world, contribution to GDP by the agricultural sector has gone down. Presently, the growth rate of agriculture is around 2 per cent and its contribution to GDP is less than 18 per cent. The spectre of large scale pulse and edible oil import is looming large, forcing the top planners to once again focus on agriculture. The agriculture, which was not supposed to wait, has been waiting helplessly for too long. The huge responsibility of developing and transferring technologies for doubling food production by 2020 is on all, but specifically on scientists. The development of cost effective technologies and their fastest transmission and absorption by end users is the challenge which has to be met squarely.

Since post-WTA, the Indian economy has to be integrated with the world economy, there is a need to devise suitable policies, strategies and road map for transforming our agriculture to enable its early integration with global agriculture, with due safeguards for our farmers/producers and consumers.

2. Major challenges to Indian agriculture

- Natural resource base is shrinking as a result of degradation from intensive cultivation with high external inputs.
- Arable lands are being taken out of production @ 1% per annum for urbanization, infrastructure development and leisure activities.
- Per capita share of resources is fast dwindling through population growth, especially in already vulnerable areas.
- Nutrient mining, organic matter depletion and soil erosion from insufficient inputs and resource extractive practices have become a major threat to food security. The NPK ration recommended by the scientists have no takers in many parts of India, micro-nutrients are mostly ignored. A downward spread of poverty – environmental degradation – low productivity is increasing leading many people into perpetual deprivation.

Former Director, National Academy of Agricultural Research Management,
presently Project Director, Distance Education, National Institute of Rural Development,
Rajendranagar, Hyderabad 500 030, Email: syed@nird.gov.in

- Low and stagnant productivity is widespread. Agriculture has become a non-profitable proposition. If given alternative, 40 per cent farmers will leave agriculture.
- 57 per cent population dependent on agriculture in India, contributing less than 18 percent to GDP. Engagement of too many people directly in agriculture causes low productivity and cost incompetitiveness.
- Global warming and climate changes triggered by accelerated industrialization, intensification of agriculture, infrastructure and unsustainable lifestyles is a major threat to agriculture and food security.

The silver lining is, however, that people spend about 40% of their income on food- a great opportunity for food production and trade.

The Indian National Agricultural Research System (NARS), which had hitherto largely included the ICAR Institutes and State Agricultural Universities, is itself undergoing a transformation. And to-day ,the NARS also encompasses others which are involved in agricultural research. The private sector is now investing in agricultural sectors and many corporate and MNCs are in fray. In this process of expanding family, paradigms in agriculture are shifting quite fast.

3. Nature of Innovation and Innovation Practices in Agriculture

- Research is an important component – but not always central component of innovation.
- In the contemporary agriculture sector, competitiveness depends on collaboration for innovation.
- Social and environmental sustainability are integral to economic success and must be reflected in intervention
- Market is not sufficient to promote interaction – the public sector has a role to play.Interventions are essential for building capacity and fostering the learning to enable a sector to respond to continuous competitive challenges.
- Organization of rural stakeholders is a central development concept. It is a common theme in innovation system development and in numerous agricultural and rural development efforts.
- Actors that are critical for coordinating innovation systems at the sector level are either overlooked or missing.
- A wide set of attitudes and practices must be cultivated to foster a culture of innovation
- Enabling environment is a key component of innovation capacity.

4. Global Scenario

- Dramatic yields during the past 50 years have made food cheaper and more widely available than ever before.
- Income growth will replace population growth as the major challenge to world food production capacity in this century.
- The growth in demand for grain for animal feed will outstrip the demand for grains used in human foods.
- A complete view of productivity changes includes the value of all inputs, not just land.
- The exceptional productivity growth of the past 50 years is the result of agricultural research in the 19^{th} and 20^{th} centuries.
- Agricultural innovations will have to be adapted to local agro-ecological conditions.
- Private investment in agricultural research and development is substantial

and concentrates on commercially attractive technologies. It has been heavy in seed sector.

- The impact of agricultural research occurs after a considerable lag, but the returns are impressive.
- WTO has impacted the agricultural production and trade policies of countries. Efforts are on to integrate nation's agriculture with global agriculture.

5. Pathway to Integration with Global Agriculture

Basically, the globalization entails integration of economies and societies through cross-country flows of information, ideas, technologies, goods, services, capital, finance and people. It leads to economic interdependence of countries through increased trade and widespread diffusion of technologies. Apart from these and many other advantages, there are a number of ill effects as well including its impact on indigenous agriculture and industries. It provides greater access of goods at competitive prices to consumers but tends to neglect rural sector.

India need not be extremely defensive and inward looking, as our agriculture has demonstrated strength which needs to be appropriately used to compete in world market, otherwise it will be a case of missed opportunity (*Swaminathan,* 2007). Indian agriculture can and should take lead as the leading producer and trader of farm produce (in both raw and processing form, desirably latter

5.1 Following pathway is suggested :

- Strengthen comparative and competitive advantages of our agricultural produce. This requires a world-class functional infrastructure for input supply, transport, storage, processing, packaging and retailing. Consumer is becoming quality conscious, is ready to pay and has options.
- Farmers / producers should be encouraged with incentives like subsidies, soft credit and assured with timely supply of quality inputs(seeds, fertilizer, chemicals, water, equipment and energy etc).
- To offset the rise in the prices of farm produce due to export, the Public Distribution System (PDS) will require revamping so that it meets the demands of weaker sections of society appropriately.
- To develop and / or adopt cost effective technologies for production of high quality produce at competitive cost. The technologies should be latest, at par with the best and should be transferred only after merciless testing. The transfer of technology process needs to be more innovative so that the gap between the generation and absorption is minimized. In the whole process, all the stakeholders, not scientists alone, should be involved closely.
- To enable small and marginal farmers to get maximum returns from their small holdings by developing alternate farming systems encompassing agriculture, horticulture, livestock and fisheries.
- Encouraging good production practices to promote quality of raw produce as per international standards. There is a need to train farmers in the production and handling of quality produce.
- Regulate use of chemicals by encouraging greater use of bio- fertilizers bio-pesticides so as to achieve the permissible MRLs (maximum residue limits) as levied by importing countries.
- Promote value chains by strengthening each node so that all weak links in the soil to plate systems are

removed. This will necessitate good understanding of forward and backward linkages and closer involvement of all stakeholders.

- Market intelligence and support will need a major transformation. The number of middlemen between producer and consumer needs to be brought down to minimum (from present 5- 7 to 2- 3).
- Since India is both exporter and importer of farm produce, a closer watch over compliance of codes and standards needs to be ensured.
- Harmonization of our codes and standards for safety and quality with international codes and standards is essential. India should insist that all countries should put their quality-safety requirements on the website of WTO. There should be zero tolerance for safety.
- Agro-processing is an important instrument for agricultural and rural development as it will convert Indian consumer markets from produce market to product market. It can attract huge FDIs which could be allowed in agriculturally backward areas.
- Development of agro-processing will also lead to diversification and make our farmers more cost and quality conscious.
- Indian agricultural policy needs to suitably safeguard the interest of crops, people and regions which are likely to be affected by globalization.
- Increase public investment in agricultural research especially for undertaking researches on frontier areas like climate change, bio-technology and nano-technology, information and communication technology (ICT), byproduct utilization, product and process development, remote sensing (GIS and GPS) etc. so as to generate globally competitive technologies, processes and products. The R & D system should become more responsive to emerging global challenges by triggering innovations. Indian institutions should be encouraged to collaborate with the best institutions of the world. We should also help the developing countries of Africa and Asia in improving their food production.
- In order to remain competitive and in fact ahead, there is a need to strengthen / develop our agricultural intelligence especially in the countries who are our existing / potential competitors. It will be useful to keep a tab on their strategies and moves so as to suitably devise / modify our response.
- Strengthen institutional mechanisms to safeguard our scientists and producers especially with reference to IPR, SPS and TBT issues.

6. Epilogue

Indian agriculture has to face the onslaught of cheaper and more innovative alternatives from competing countries. The challenges are real – we cannot wish them away. The silver lining is that we have faced many challenges before and have come out winner. So, the determination is there, the capacity is there (but it needs strengthening) and ambience is also favourable which provides needed flexibility for meeting the challenges. Of course in this process, the business as usual will not work. Our house has to be set in order by removing all constraints. There is a need to start bothering about quality, something which we had not considered worthwhile before. It is superior quality and competitive price which will win us any day.

Despite relatively cheaper labour, our cost of farm produce is still high because of low productivity, costlier transport and huge post-harvest losses. The productivity can be increased by timely operations, efficient input (seed, fertilizer and water) management, pest and disease control and weed management, timely harvesting / pricing at appropriate time and efficient post-harvest management. The farming being knowledge driven, the farmers need to be continuously empowered with latest knowledge through efficient learning process through ICT. There is no doubt that with farm friendly policies, enabling environment, cost effective technologies, capacity building, timely resource availability, efficient market support, our farmers / producers will rise to occasion and deliver the goods of required quality, and desired price, as he has always done. Let us support them whole hog, because that is the only way for food security , rural prosperity and national pride.

Gene Targeting in Higher Plants

P. Ananda Kumar

Plant molecular biology has revolutionized agriculture by facilitating introduction of foreign genes in crop species and expressing novel traits such as pest resistance, disease resistance, quality improvement etc., Transgenic plants are usually developed relying upon the genetic transformation techniques mediated by *Agrobacterium tumefaciens*, particle bombardment, protoplast uptake of DNA etc., The transgene integration mediated by these techniques takes place at random sites in the plant genome. The position of integration in the genome and the complexity of the integrated DNA influence the quality of transgene expression. Development of techniques that mediate transfer and integration of foreign genes at specific pre-determined locations obviates many problems associated with existing methods of gene transfer. Introduction of foreign genes via gene targeting based on the technique of homologous recombination offers many advantages such as precision gene integration, single copy transgene insertion and high expression of the transgenes. It would allow the construction of "safer" transgenic crops, which would not suffer from unknown "position" effects due to random integration.

Homologous recombination

Gene targeting in higher plants was first demonstrated in 1988 by Paszkowski *et al*. (1988) who performed targeting in tobacco by direct transfer of plasmid DNA into isolated protoplasts. Since then, the model dicot species tobacco and *Arabidopsis thaliana* have been targeted in similar experiments and the results have been promising. Kempin *et al*. (1997) used a recombination strategy in *A. thaliana* combining *A. tumefaciens*–mediated transformation, a targeting construct containing a kanamycin-resistance cassette for selection, and PCR detection of recombinants. In a later study, Hanin *et al*. (2001) tried to target the *A. thaliana* protoporphyrinogen oxidase (PPO) gene, which is involved in the syntheses of chlorophyll and heme. PPO protein is a target of a herbicide that can kill wild-type *A. thaliana*, but plants containing a mutated PPO gene become resistant to the herbicide. By selecting herbicide-resistant plants carrying the mutated PPO present in an introduced T-DNA, Hanin *et al*. (2001) obtained recombinants in which the wild-type gene was converted into the modified PPO sequence by gene conversion and recombined genes were integrated elsewhere in the genome. By combining *Agrobacterium tumefaciens*–mediated transformation protocol with stringent selection, researchers have succeeded in isolating gene-targeted plants with high efficiency in rice (Terada *et al*. 2002). They chose the Waxy gene, encoding granule-bound starch synthase, as a target because its mutation is easily detected by iodine staining of pollen and endosperm.

Transferring the enzyme machinery from organisms in which gene targeting works well is one of the novel strategies.

Director, National Research Centre on Plant Biotechnology, Pusa Campus, New Delhi 110012.
Email: polumetla@hotmail.com

It was reported that the expression of yeast RAD54 gene, a member of SW12/SNF2 chromatin remodeling gene family, enhances gene targeting in *Arabidopsis* by one to two orders of magnitude, from 10^{-4} to 10^{-3} in wild type plants to 10^{-2} to 10^{-1} (Shaked *et al*., 2005). These authors devised an ingenious GT assay by using a promoterless GFP gene inserted in an *Arabidopsis* cruciferin gene. Cruciferin is a seed storage protein; hence, integration of the GFP containing gene into one of the genomic genes should produce fluorescent seeds. Rad54 not only enhances targeting efficiency but also suppresses non-homologous recombination.

Li and his group reported that the transient expression of RecQ gene in rice embryogenic cell increases the homologous recombination efficiency as much as 4-fold. Further experiments revealed that this effect is influenced by the RecQ dosage. Stable expression of RecQ in rice dramatically increased the homologous recombination events 20 to 40-fold in leaf tissue from different transgenic lines (Lia and Li 2004).

In our laboratory, we demonstrated the homologous recombination-mediated targeted integration of *Bt cry1F* gene at *Flavonoid-3-glucosyltransferase* (anthocyanin synthesis pathway) locus in Brinjal (*Solanum melongena* L.) for resistance against its major insect pest 'Brinjal Fruit and Shoot Borer' (BFSB)(*Leucinodes orbonalis*). These transgenic lines showed complete protection against BFSB with consistent transgene expression in different pest sensitive tissues such as leaf, stem epidermis and fruit epidermis. The transgene integration did not show any significant influence on *Flavonoid-3-glucosyltransferase* (F3G) transcript level or anthocyanin pigmentation in transgenics (Shrivastava *et al*., 2009).

Cre-Lox system

Another reliable method to achieve the objective is by utilizing the *Cre-Lox* system (Kuhn and Torres 2002). The basic strategy of site-specific integration is to first develop a target line by obtaining a single-copy insertion of a *Lox* target construct into the plant genome. This step relies on random non-targeted integrations; and therefore involves searching for single-copy integrations in a large pool of transgenic lines. Once the target line is developed, it is retransformed with a *Lox*-integration construct. *Cre*-mediated interaction between the previously inserted *Lox* target site containing one half of the selection marker gene (ie, either the promoter or the coding region) and the newly introduced *Lox* site contributing the remaining half of the marker, results in the formation of a defined single-copy integration locus. There can be two different ways of providing *Cre* activity: (i) *cre* gene expression from a genomic locus, (ii) *cre* gene expression from a co-introduced plasmid. The target site contains only half of the selection marker gene and the other half is contributed by the integration construct. Site-specific integration of the integration construct leads to the formation of a complete and functional marker gene, allowing selection of the site-specific integration locus.

Cre-mediated site-specific gene integration has been performed successfully in a range of plant systems. A strategically important component of these methods is the use of mutant *Lox* sites. To stabilize the integration locus, mutant *Lox* sites that contain 4-6 base alteration in either the right or left inverted repeat. The strategy has been further improved by utilizing two complete *Lox* sites within a DNA construct, which prevents integration of plasmid backbone.

Zinc Finger Nucleases

The development of Zinc Finger Nuclease (ZFN)-mediated gene targeting provides molecular biologists with the ability to site-specifically and permanently modify plant genomes via homology-directed repair of a targeted genomic double-stranded break (DSB). ZFNs can be used to induce DSBs in specific DNA sequences and thereby promote site-specific homologous recombination and targeted genomic manipulation. Because zinc fingers can be directed to a broad range of DNA sequences and targeting is very efficient, gene constructs were made for custom-designed ZFNs that are designed to cut at specific DNA sequences at a preselected locus in the genome of plant species. A site-specific zinc-finger endonuclease has been successfully employed to induce site-specific mutations by non-homologous end joining in *Arabidopsis* (Lloyd *et al*., 2005).

Recently, Shukla *et al*. (2009) used ZFNs to modify endogenous loci in plants of the crop species *Zea mays*. Insertional disruption of one target locus, *IPK1*, results in both herbicide tolerance and the expected alteration of the inositol phosphate profile in developing seeds. Herbicide-resistance mutations were introduced into *SuR* loci by ZFN-mediated gene targeting at frequencies exceeding 2% of transformed cells for mutations as far as 1.3 kilobases from the ZFN cleavage site. More than 40% of recombinant plants had modifications in multiple *SuR* alleles (Townsend *et al*., 2009)

Future perspectives

Gene targeting provides a novel perspective on development of genetically modified crops with stable and predictable transgene expression. Major breakthroughs in the field of gene targeting in plants have taken place within the last decade, however the frequency of gene targeting in plants remains low. The current research on HR based gene targeting has been largely focused on demonstration of this technology in plant systems. In addition, the application of this technology may allow precise modification of any endogenous gene sequence that will be valuable in elucidating gene function. While such research will give us a greater understanding of functional genomics, the ultimate goal is to apply gene targeting in crop improvement programs.

Emerging Trends in Indian Agriculture

B.R. Barwale

Agriculture is a very important segment of the Indian economy as it not only provides food, fiber, oilseeds and raw material to the industry, but it also provides employment to a majority of Indian population. Immediately after independence we were dependent for food on domestic production and shortages were met by imports from the developed world, part of it as Public Law 480 supplies. Indian Institutions and universities were working to develop high yielding varieties (HYVs). However, success was limited. There were a few exceptions. IARI under the leadership of Dr. Harbhajan Singh bred yellow vein mosaic resistant okra variety which revolutionized okra production in the country.

In the late fifties, the Government of India through the ICAR signed an agreement with Rockefeller Foundation to improve the production of food crops. This resulted in the first four hybrid maizes, first hybrid sorghum and first hybrid pearl millet. Immediately after that, India began trials of the dwarf wheat varieties bred by Dr. Norman Borlaug and his team. Dr. M. S. Swaminathan laid the foundations of the programme in India. Simultaneously, dwarf rices were imported from IRRI by Dr. G. V. Chalam.

Out of the trials wheat varieties Sonora-64 and Lerma rojo were selected and rice variety Taichung Native-1 was approved for cultivation. These varieties were revolutionary and yielded many times of the existing varieties. Though they were not best suited to Indian food habits, were a great relief for our hungry nation. It made India self-sufficient in food production. This food production revolution came to be known as the "Green Revolution." In due course, in the early 70's, Dr. Chandrakantbhai T.Patel bred the cotton Hybrid H-4 for the first time in the world. It was produced by hand emasculation and pollination. This revolutionized cotton production in western India.

Later on Dr. Manmohan Attavar of Indo American Hybrids introduced hybrid vegetables, particularly tomatoes to the Indian agriculture. This was followed by introduction of hybrid cabbage and radish by Mahyco. Hybrid vegetables have revolutionized vegetable production in the country and have been accepted by the farming community and customers. Now there are hybrid vegetables in okra, tomato, eggplant, radish, cabbage, carrot, watermelon, muskmelon, and all sorts of cucurbits like gourds, etc. In spices, hybrid chillies are also revolutionizing chilli production in the country.

Meanwhile experimenting with genetically modified (GM) crops, the USA has approved GMOs of corn, soybean, cotton, etc. which gave great relief in terms of insect control in cotton and corn, as well as weed control in soybeans.India closely was watching the situation in the developed world. In 1995, Mahyco signed an agreement with Monsanto to incorporate Bt gene in cotton in 1995 and started the process of introducing bollworm resistance in cotton by adding the Bt gene.

With the dawn of the 21st century, the Government of India approved the first three hybrids of cotton in 2002.

The Bt cotton experience in India is

Chairman, Maharashtra Hybrid Seeds Co. Ltd. E mail Aban.Kapadia@mahyco.com

a remarkable story, which has clearly demonstrated the enormous impact that can be achieved by adopting genetically modified crops. In a short span of five years, cotton yield and profitability almost doubled, and insecticide application was almost halved, transforming India from an importer to an exporter of cotton. Acknowledging that infestations of cotton bollworm do vary with season, location and climatic conditions, it is estimated that big and small farmers cultivating Bt cotton will benefit from a 39% reduction in insecticides, 31% increase in yield, and an 88% increase in profitability, which is equivalent to about Rs.10,000 gain per hectare.

These gains in crop production are unprecedented. Significant environmental and socioeconomic benefits are being enjoyed by Bt cotton farmers including lower insecticide residues in the soil and aquifers and significantly less exposure to insecticides, with notable health implications. Thus, Bt cotton is already contributing to the alleviation of poverty of farmers.

Naturally the most important common element in all the above major developments was improved seeds and the willingness, indeed, the eagerness of big & small farmers to embrace, change and adopt these new technologies in order to quickly overcome production constraints and to increase their income to sustain their livelihoods and escape poverty. Indian Government has taken a purely science based approach. Indian Regulatory process decision is made on fair science basis.

The Indian population has increased considerably and in due course this will be the most populous country in the world. We have to feed a growing population and we have to provide sufficient nutrition. Thus, there is an urgent need to develop plant material that produces more and more nutritious food. Development of Golden Rice will surely contribute in a big way in enhancing nutrition, especially to women and children. Besides Golden Rice, the new crop in the pipeline is the nutritious potato with Ama 1 gene. In vegetables, Bt brinjal is foremost in line to be released shortly. It will provide control of fruit and shoot borer to a great extent.

With climate change it has become very important to have crops that shall perform even in adverse conditions. It has become very important to have crops which will survive better in drought and salt affected areas. It is also very important to have incorporated traits for nitrogen use efficiency.

We are very short of pulses. Pigeon pea is grown in a big way only in India. Perhaps because there is a market for it in India. Burma and Africa produce small quantities of it. A very desirable development has come out of the programme sponsored by Mahyco and other seed companies and ICAR with ICRISAT for breeding cytoplasmic male sterile lines which have been carried out successfully. The first hybrids are being tested all over the country. Efforts are on to provide Bt gene to control fruit borer which does great damage to fruit.

Bt gene has now been transferred into chick pea very successfully. The gene, which will resist aphids and white fly, has also been successfully incorporated in chick pea germplasm. These two traits combined should make the chick pea crop more productive and thus more profitable to farmers. This will improve the agronomy of the crop and increase in area too. Overall availability of these two pulses is going to greatly improve. Mahyco has developed a few F-1 hybrid wheat. The extensive efforts in this direction will bring sizeable productivity in wheat too.

I conclude saying that the only solution for India's food and other agricultural production is putting more and more science into agriculture, in crop breeding, in agronomy and in GMOs.

Future is Bright for Indian Seed Industry

M.Prabhakar Rao

Indian Seed Industry which started with the establishment of National Seeds Corporation in 1963 has matured in mid 70s with the Private sector entrants. It got boost after the announcement of New Seed Policy by the Union Government in 1988 which allowed the entry of large business houses like Hindustan Lever Ltd, JK group etc., and some Multi Nationals.

The growth has got accelerated in early 2002 with the introduction of Bt cotton hybrids, Maize single cross hybrids, hybrid rice, etc. As per International Seeds Federation estimates India's seed market size was about Rs 6000 Crores in 2007 and reached to about Rs 7000 Crores in 2008, nearly 17% growth in a single year. During the same period the global market has grown by 12.5%. India's Seed market in global context was ranked 9th in 2007 and in 2008 it became 5th sharing with Japan and Germany.

The share of public Sector in the market is estimated at Rs 2000 crores (<30%) and private sector at Rs 5000 Crores (>70%). The professionally managed PUCs are planning a major growth in their business and their share may reach 35% in the expanded market size of Rs 12000 Crores by 2014. By then it is estimated that India will rank No.3 behind USA and China. This requires an average annual growth rate of less than 15%, which is easily possible.

The Optimism arises from the following facts:

1. Hybrid Cotton seed demand will continue to grow as more and more area coming under high density planting with close spacing made possible by erect plant types.
2. Single cross maize hybrid seed acceptance is growing and these will occupy about 60% area in next 3 years.
3. With the PPV & FR Act in place, private sector is now investing in R&D to develop better open pollinated varieties in important crops like wheat, rice, soybean, mustard, etc.
4. The Seed Replacement Ratio will improve dramatically with the raising of farm income and profitability.
5. New Biotech traits will further boost the Seed market value.

We know that this will not happen automatically by itself. The Industry needs to take several proactive steps to ensure the bright future. Two most important areas are Research and Extension.

Research

The Companies should actively undertake R&D activities to generate area specific Hybrids or high yielding varieties addressing the local needs in terms of biotic and abiotic stress tolerances, output quality, duration, etc. apart from yield. These also should take up the responsibility of developing suitable cultivation practices for each product to go with. There is great need to use biotech tools like Marker Associated Selection to cut the gestation period in developing new products through conventional breeding. We should also

Chairman & Managing Director, Nuziveedu Seeds Private Ltd

encourage Public-Private Partnership in the area of Research whereby the industry can sponsor Research Projects with National and International Research Institutes to utilize the wealth of knowledge, experience and skills of scientists and the infrastructure facilities. The process has started with ICRISAT, NBRI, IARI, etc. but more needs to be done.

Extension

Extension to take new products and technologies from Lab to Land is the most important driver for Industry growth. It is high time that all Agri-Input suppliers come together and join hands in popularizing the new technologies be it seeds, new molecules or nutrient solutions. We should initiate action in bringing together major Agri-Input Associations like Fertilizer Association of India, National Seed Association of India and Pesticide Manufactures and Formulators Association of India (PMFAI) to form an active cell to take up extension work at National level in association with the Government Extension systems and SAUs. I would like to give two examples of recent innovations in cultural practices of Rice and Hybrid Cotton, where extension plays a major role in farmers' adoption.

1. Lower Seed rate in Paddy Cultivation

In growing varietal paddy, traditionally the farmers are using 30-32 kg of seed per acre. NSPL through its innovation-oriented R&D programs experimented with a lesser seed rate per acre in varietal paddy and has pioneered a concept to increase the profitability of the paddy growing farmers. After several large scale in-house trials and experiments, NSPL developed the concept of 10 kg per acre as the seed rate.

This concept is being explained to the farmers as under:

- No. of hills per acre = 1,80,000
- 2 seeds to be planted per hill in varietal paddy
- Total no. of seeds required per acre=1,80,000*2=3,60,000
- 1000 seed grains of paddy weigh 22-24 g
- 3,60,000 seeds weigh 7.92 kg (3,60,000/1,000*22)
- @ Statutory minimum germination level of 90%, the seed requirement is 9kg/acre.(7.92/90*100)
- Taking cognizance of seedling mortality due to improper handling during transplanting, we recommend 10kg/ acre as against 30 -32 kg/ acre seed rate used earlier.

It is worth noting that in India, with 44 million hectares of land under rice cultivation, this concept has potential to save nearly 2.2 million tons (50 kg seed saved/hectare x 44 million hectare) of grain per year which can be used to feed our burgeoning population. In the first year of the commercial launch of the Innovation, NSPL could save more than 16,000 Metric tons of paddy seed which could be used as food grain.

More importantly this practice will speed up adoption of new varieties / quality seed thereby improving the Seed Replacement Ratio (SRR) in a short period as the farmers will use fresh quality seed every time because of lower seed rate and higher commodity prices, resulting in overall increase of rice productivity. The Industry can have reasonable margins for quality seed by charging a small premium.

2. High Density Hybrid Cotton Cultivation

NSPL, after several in-house experiments and trials, developed the concept of increasing farm yields by increasing the plant density by reducing the spacing between the plants in Bt Cotton hybrids. Erect plant type is suitable for higher

State	Normal practice		NSPL Concept		Yield Increase Kg/ha
	Spacing cm x cm	No. of Plants per acre	Spacing cm x cm	No. of Plants per acre	
AP	90 x 90	4840	90 x 30	14520	625
Maharashtra	90 x 90	4840	60 x 60	10890	943

plant population per acre leading to higher yields. The University trials confirmed these results as shown above:

This concept is being extensively promoted by NSPL through field work, field days, field visits in addition to widespread communication through press, hoardings, posters, etc. The integrated approach of lab to land/ market introduced has resulted in the large number of farmers adopting this practice. Today about 35% farmers are adopting this innovation. We expect 70% Cotton cultivation in India will follow this practice in next 3 years. While due to better Bt hybrids, India has replaced USA to take the position of 2nd largest cotton producer in the world. By adopting this agronomic Innovation, India can become No.1 cotton producer.

Another area of great interest will be Direct Sowing of Rice (DSR). This practice will save precious water and cut down on labour costs without compromising on yield. While the above two technologies have been tested and perfected to be taken to the farming community, the DSR is being tested and modified.

All the Agri-Input Industries will benefit from joint extension work. While the seed demand growth will benefit the Seed Companies, the demand for fertilizers and other nutrients will also grow due to these practices. The demand for new molecules for seed treatment and herbicides in DSR cultivation will benefit the agri-chemical Industry.

It is the duty of all of us to ensure the desired agricultural growth in the country which is rather sluggish now. As a Nation with 65% population depending on Agriculture for their livelihood, we cannot afford to be complacent. I am sure working together we can build a very bright future for the Industry while safeguarding the country's Food Security.

Biofuels – Safe & Renewable Sources of Energy

G.Nagaraj

India's present consumption of petroleum and related products is around 110-120m tonnes. More than 76% of this quantity is imported at a huge cost of around one lakh crore rupees. Petrol is a fossil fuel obtained from the earth through mining. Organic matter under high pressure and temperature in the absence of oxygen gets converted into hydrocarbons (petrol) inside the earth. Globally it is available at a few locations like the Arabian countries. It is a non-renewable resource and is getting depleted year after year.

Major energy sources

Modern human being is heavily dependent on energy. He utilizes different forms of energy like electricity, heat and light for his comfortable living. These different forms of energy are inter-convertible. Transport sector is the major consumer of energy. Petroleum and natural gas are the major sources energy, accounting for about 55% of the global energy needs. Coal is the next important source of energy accounting for about 23% of energy. Both these sources are non-renewable and are getting depleted due to heavy mining and utilization. Further they are concentrated in a few pockets on the earth and under the control of a few nations. They are associated with health problems due to smoke and high carbon emission. These are also responsible for environmental pollution causing global warming. Comfortable living conditions on the earth for the living beings are thus getting disturbed.

Different energy sources:

Human being is on a search for safe and cheap alternate sources of energy. Luckily there are various types/ sources of energy that are available to him. The primary and a major source of energy is the Sun. We worship Sun as a God. It is nothing but an expression of gratitude. Scientifically, Sun is nothing but a mega nuclear fusion plant. Four hydrogen atoms fuse or combine to form a helium atom, releasing a huge quantity of heat and light energy. It is very cheap and available during daytime from the open skies. We need to convert the light to heat and electricity for further utilization. Photovoltaic cells can trap the energy. But there seem to be some problems relating to storage and transmission. Once these problems are resolved, the global energy needs can be easily managed.

The other forms of energy that are available are wind energy, hydro-energy, wave energy, geothermal energy, and nuclear energy. Wind and water are not constantly available. They are specific to locations and seasons as also have variations in intensity etc. Hence these forms of energy cannot be depended upon as regular sources. They can be harvested as and when they are available. Wave and geothermal energy are also beset with certain problems especially, initial investment and high cost of production.

Nuclear energy

Nuclear energy is an important source which is gaining importance. One kg of nuclear fuel can produce energy equivalent to burning of 3 tonnes of coal. Nuclear fuel has thus an edge over other forms of energy. Huge quantity of energy is stored in a tiny component of an atom, called nucleus. When the nucleus breaks or decays the stored energy is released at the expense of a very small mass of the nucleus. Elements like uranium and thorium occur naturally on the earth and are radio active. They spontaneously decay and release energy.

Retired Principal Scientist DOR (ICAR). Email: guttarla@hotmail.com/ guttarla@yahoo.co.in

Uranium-235 is the radioactive element mainly utilized for production of nuclear energy. Uranium-235 atom is bombarded with neutrons under controlled conditions in atomic reactors to produce atomic/ nuclear energy. This atom occurs only as a small fraction of natural uranium. Hence it needs to be concentrated using special and costly techniques. Further uranium ore is present at a very few locations on the earth. Because of the health hazards (mutations, cancer etc.) associated with radioactive elements, its supply and handling are under strict safeguards. Nuclear reactors produce highly dangerous and more active radio-isotopes. Their disposal is another major costly affair. Also radio-isotopes can be misused for the manufacture of devastating nuclear bombs. Hence human beings are hesitant in utilizing the nuclear energy on a large scale.

Bioenergy

Plants on the earth absorb solar energy in the form of photons or light. The green matter namely, chlorophyll, in the leaves convert the light to chemical energy through photosynthesis. Among crops, sugar beet is highly efficient in harvesting solar energy at 4.3% followed by grass at 4.2%, sugarcane at 3.8% maize at 3.4% and rice and wheat at 2.9%. Part of this energy is consumed by human beings and animals as food and feed. The remaining portion, namely the agricultural residues (stem, leaf, roots etc.), is burnt to obtain energy. This has been the simplest and easiest traditional way of energy harvesting by the human beings. Bioenergy accounts for nearly 15% of total global energy.

Direct combustion of biomass can give 45-65% energy. Gasification of the same is a more efficient way of energy management. Fermentation of the biomass and its products to ethanol is another mode of production and use of energy. All these routes are being utilized by the humans to meet their energy needs. Wood and biomass, in general, can give 15-20MJ/kg energy. Ethanol can give 30MJ/kg while biogas produces 20MJ/kg. This is against 45MJ/kg by gasoline. Rural population prefers the biomass energy due to cheapness, renewable nature and easy availability. Biomass has a great potential in furnishing a safe and regular supply of energy. Further it is renewable and hence easily dependable. India has wasteland area of about 60m ha. This area can be utilized to grow trees or plants which can yield seeds with oil content ranging from 20-50%. Many trees like *Jatropha, karanj, neem, Simarouba* can be grown in wastelands and also as avenue trees. Plants like *Jatropha* start yielding from 4th year onwards, while other trees take 6-8 years to become economically useful. The seed yields range from 1.5-3.5 tonnes per ha per annum. From 60m ha even at a minimum yield of 2 tonnes seed per ha 120 m tonnes seeds can be obtained. Again at very low level of 25% oil in the seeds, we can derive 30 m tones of vegetable oil from the wastelands. This oil can be converted to its methyl ester, which we normally call as bio-diesel. One kg of oil is equivalent to 40 MJ energy. We can thus obtain one lakh twenty thousand crore MJ of energy from the waste lands, each year. This source of energy is renewable, safe and highly dependable. Also, waste land management for bioenergy can provide lot of employment to many unskilled as well as skilled persons. Even cultivated lands can be utilized to grow traditional and non-traditional oil plants to harvest energy. Thus vegetable matter especially the oil has a great potential in relieving the energy deficiency of this globe.

Municipal waste for bioenergy

India is producing 1,20,000 tonnes of municipal waste every day. Equivalent quantities of leaf litter and crop residues are also available. All this biomass can be converted to bioenergy by direct burning or through gasification etc. One kg of biomass can yield 15MJof energy. If 2,00,000 tonnes of biomass is available, energy equivalent to 300 crore MJ can be produced each day. Proper planning and management are needed to utilize this energy.

Oilseed Plants for Energy

M.V.R. Prasad

Intoduction

A look at the global market for agricultural products reveals that oil bearing crops enjoy a significant and increasing proportion both with regard to value and land use. Currently around 80% of total oil and fat production is utilized in the food sector, but oil seeds have an added attraction, compared with cereals and pulses, of being actual or potential medium – high value industrial feed stocks. The world wide consumption of vegetable food oils has been rising far outstripping the population increases, leading to an average increase in per capita oil consumption of 1.8% per annum. Apart from their use as sources of edible oil for culinary purposes, their products were put to use for a variety of non-edible applications, including as lubricants in simple machines, as sources of illumination in lamps, cosmetics, soaps and as massage oils. The demise of oil crops as major industrial feed-stocks began with the increasing large scale exploitation of coal and fossil-oil reserves during the late 19th and early 20th centuries. The increasing human population dictated expansion of the cultivation of oil bearing crops to meet growing needs of edible oils.

Vegetable Oils for Energy

The changing scenario with regard to the steadily depleting and non-renewable fossil fuels provides a powerful incentive for development of new types of oil bearing plant species. Such crops could serve as renewable sources of partially refined hydrocarbon based products for future. Most plant oils are already more complex than mineral oils when they are extracted. This eliminates the necessity for some of the costly and environmentally unfriendly processes needed for refining the mineral oils. Hence the oil bearing plants are non polluting "bio-refineries" or "bio-reactors."

Approach Not to Clash with Food and Commercial Crops

Due to burgeoning population, there is a need to ensure the production of plants that yield bio-diesel or straight vegetable oil for energy purposes. However, this approach should not encroach upon the soils used for growing food crops. Hence, the only option left is to exploit poor soils and waste lands for the production of plant species yielding oil for energy in the overall micro-panning for rehabilitation of such lands. Self Help Groups for landless people can be profitably involved in this activity in the ambit of Integrated Watershed Management programs. In this context, the National Mission on Bio-fuels too has identified around 13.4 million hectares for the production of plants of bio-fuel value.

Comparison of Some Oil Bearing Plants for Energy

An evaluation of the wide range of oil yielding plant species for bio-diesel production has indicated that Pongamia pinnata (a.k.a Mellittia pinnata) has all the desirable attributes that renders it suitable to be grown with profit under varied eco-systems. A comparison of Pongamia with another plant species viz., Jatropha curcas and oil palm indicates that ten year old Pongamia plantation yielded 18 tons of oil / ha as against 10.5 tons from oil palm and 9.5 tons from Jatropha of the same age. Yields above are based on results from plantations that are professionally managed with high quality plant genetics, adequate nutrition, proper harvesting techniques and high quality processing equipment. In view of the value of palm oil as important edible

Project Director (Retd.), Directorate of Oilseeds Research, Hyderabad.

oil, there is no justification for its use in the energy sector.

The relative merits and demerits of the two oil bearing perennial species viz., Jatropha and Pongamia are compared in this article.

Jatropha curcas: The source of Jatropha remains controversial, but it is highly probable that the centre of origin is Mexico and Central America. From the Caribbean, the species was probably distributed by Portuguese seafarers via the Cape Verde Islands and former Portuguese Guinea (now Guinea-Bissau) to other countries in Africa and Asia. It is now naturalized and widespread throughout the tropics. Jatropha curcas is a perennial, monoecious shrub or small tree up to 6 m high; bark pale brown, papery peeling; slash exudes a copious watery latex, soapy to tough but soon becoming brittle and brownish when dry; branches glabrous, ascending, stout with leaves alternate and palmate. After cross pollination the trilocular ellipsoid fruit is formed. The exocarp remains fleshy until the seeds are mature. Cooked nuts are eaten in certain regions of Mexico. The seeds contain up to 40% oil. J. curcas oil contains a toxin, curcasin. The albumen of the kernel is a poison, toxalbumen cursin, most abundant in the embryo. Another poison, a croton resin, occurs in the seeds and causes redness and pustular eruptions of the skin. Jatropha oil is an environmentally safe, cost-effective renewable source of non-conventional energy and a promising substitute for diesel, kerosene and other fuels. The inherent monoecious nature of the species is resulting in instability in floral sex expression as influenced by the environmental factors, principally temperature.The extent of genetic variability of the species is rather limited in India, due to it being an introduced crop.

Initially Jatropha was thought to be drought resistant that can grow under stark un-irrigated conditions and scanty rainfall. This however, was proved wrong since such populations of Jatropha grown under dry land conditions revealed that there was a need for irrigating them to obtain satisfactory yield levels. Added to this, the prevailing belief that Jatropha was relatively free from the menace of biotic stresses was found to be incorrect and misnomer. Several stands of Jatropha were attacked by a number of insect pests and diseases, whose management was indeed expensive. For example, powdery mildew, Alternaria blight, necrosis, leaf webber larvae, capsule borer and golden flea beetles are the common pests. Considering these factors, now it is becoming clear that production of Jatropha needs irrigations to the tune of 500 mm and the cultivation is not possible without plant protection. Propagation of Jatropha by rooted cuttings was considered an advantage. This, however, renders the plant vulnerable to drought due to the superficial fibrous root system of the rooted cuttings apart from lodging due to high wind velocity, which is very common.

Despite its potential for high quality bio-diesel, Jatropha needs genetic and agronomic tailoring before it could be exploited on a commercial scale. The need of the hour is an agronomic plant type of J. curcus. It is worth exploiting the related species viz., J. integerrima, J. gossypifolia etc., for the purpose. This kind of work is already in progress in some institutes.

Pongamia pinnata: This is a medium sized ever green leguminous tree, an Indo-Malaysian species, common on alluvial and coastal situations from India to Fiji, from sea level to 1200 m. Its common name in Hindi is Karanja . The tree has originated from India and occurs naturally or is naturalized from Pakistan, India, Sri Lanka, from south-east Asia to north-eastern Australia. The species is now found in Australia, Florida, Hawaii, India, Malaysia, Oceania, Philippines, and Seychelles. Its distribution is from tropical dry to moist zones through subtropical dry to moist forest zones. The tree withstands low and high temperatures and can come up very well under very low to very high rainfall situations. It is a hardy tree that mines water for its needs from 10 meter depth without competing with other crops and needs no irrigation, unlike Jatropha. The tree grows wild on sandy and rocky soils, in most soil types, and even with its roots in salt water. The tree produces attractive white flowers in abundance in racemes. It grows all over the country, from the coastline to the hill slopes. It needs very little care and cattle do not browse it. It has rich leathery evergreen foliage. Pollination is done by bees. Pongamia pods are thick and one seeded.

The seed contains around 25 to 30% oil that has excellent bio-fuel value. The abundant genetic variability of Pongamia in India is of great advantage. Historically Indians have developed a wide range of uses of it starting from its use in native medicine to cure a number of skin ailments and in agriculture as green manure and soil disinfectant. Pongamia oil has been used for lighting lamps and as a source of energy in running engines and automobiles in the decades of 1940s and early 1950s. In Warangal (A.P.), the Azamshahi Textile Mills, set up by the Nizam of Hyderabad in 1940, generated the power needs of the factory using non-edible oils like Pongamia oil until its recent closure; and it had surplus power left for the city's needs. In the 1930s the British Institute of Standards, Calcutta had examined, over a 10 year period, eleven non edible oils as potential 'diesels', among them was the oil from Pongamia. In 1942, the prestigious US journal, 'Oil and Power' had in an editorial eulogized karanja oil as technically a fit candidate to generate industrial-strength power. The people of Powerguda village in Adilabad District (A.P.) had planted 4,500 Pongamia trees in 2002 on the edges of their agricultural land. The village's Jangubai Self-Help Group sold the equivalent of 147 tons of carbon dioxide in emission reduction over 10 years for $645 from World Bank. The CO_2 emission reduction comes from the substitution of about 51 tons of diesel oil by bio-fuel produced from Pongamia, found in the local forest.

From the third year, an elite tree of Pongamia yields pods 5-8kg/tree. Production is average of 80kg / tree / year from year-10. The tree's yield continues to increase till its 25th year and productive till 60 years with a total life span of 100 years. Ten trees can yield 400 litres of oil, 1200 kg of fertilizer grade oil cake and 2500 kg of biomass as green manure per year. Pongamia oil can be directly used as a source of energy in engines and automobiles without any need for trans-esterification. It Can fix more carbon than is used in production of fuel - creating a truly "carbon negative" solution. It is resistant to drought, light frost, water logging, moisture stress and salinity. Honey bee culture can be taken up in good Pongamia plantations. Some pests such as leaf-miner, leaf galls, etc. have been noticed, but without any significant adverse effect on the yield.

Considering the impressive array of genetic variability that the country possesses for Pongamia, it is possible to select the Plus Trees of Elite Trees with enormous yield potential ranging from 80 to 100 kg per tree in its tenth year. The selected trees should be thoroughly evaluated and confirmed for their genetic superiority. These can be propagated by grafting their scions on a hardy root-stock. The technique of "soft-wood grafting" standardized for cashew tree propagation gives over 90% success rates in Pongamia too. Work on these lines has been carried out at Krishi Vigyan Kendra at Madanapuram in Mahaboob Nagar District (A.P.) in 2006 along with the selection and utilization of elite Pongamia tress under the guidance of the author. Some of the grafted plants have been furnished to "Ponnur Thanda" a tribal village in this District.

Development of Wastelands in India

J.V. Rao

Abstract

Wastelands mean degraded lands, which can be brought under vegetation with some special efforts. These are under-utilized and suffer from several problems. According to land sat imagery, nearly 50% of the geographical area is wasteland. These fall into three major categories occurring in forests to unculturable land. Continuous rise in human and livestock population and their demand for various products and faulty management practices are the major causes for degradation. Some of these lands could be realized for agriculture, forestry and rangelands. Alternate land use systems are the best options to provide sustainable land management, by arresting degradation and loss of productivity due to excessive/ faulty use. Likewise, several tree species are available which perform well even under constraints. When the needs of people are satisfied in respect of forest products, the dependence on forests would come down, thus leading to ecological restoration and conservation of land resource, which can be used for future farming apart from reducing unemployment and migration.

The Problem

About 175 M.ha out of 329 M.ha of our geographical area is degraded due to various reasons, and erosion itself causes an annual loss of 6000 M. tons of fertile top soil and 8.4 M. tons of nutrients.146 districts spreading in 19 states have been identified as having degraded lands. Nearly 83.2% of waste lands are in the states of Rajasthan, Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Orissa, Tamil Nadu, Karnataka and Uttar Pradesh. Soil erosion and land degradation account for nearly 126.6 and 47.0 M.ha area, respectively. It is reported that about 85 M.ha of the net cultivated area and 37 M.ha of the forest area are suffering from varying kinds of degradation like upland with or without scrub, degraded pastures, saline areas, etc. Degradation of forest lands is also due to growing demand for forest products, overgrazing, shifting cultivation, encroachments, urbanization, industrialization and poor management. The average annual loss of forestland is around 0.15 M.ha, leading to floods, water logging, erosion of fertile lands and silting of rivers and dams. Adverse ecological manifestations viz., global warming, enormous soil loss, repeated drought and floods and serious pollution problems are the results of deforestation. The National Forest Policy estimated total forest area as 75.18M.ha (22.8% of geographical area), but the land sat imagery shows this area as about 64.3M.ha (19.5% of geographical area).The Policy envisages the forest area to be at lest 33% of geographical area.

The reported cultivated area in India is around 142 million ha, of which, 60 percent (86 million ha) is rainfed. In the recent past, large cultivated area has been transformed into highways, rural roads, development of towns, industries and the like. This shows that the really cultivated area is much less than the reported area, which must cater to the

Principal Scientist (Agronomy) (Retired), CRIDA (ICAR), Hyderabad. Email: raojv@yahoo.com

growing food, fodder, timber and other needs of our burgeoning human and livestock population. Due to such effects, cultivation has been extended to marginal and degraded lands which are facing the problems of soil moisture shortage, low soil fertility and productivity.

Definition: Wasteland means degraded land which can be brought under vegetative cover with reasonable effort, and which is currently under-utilized and land which is deteriorating for lack of appropriate water and soil management practices or on account of natural causes.

Categories: The wastelands are divided into three broad categories covering all the forests to the unculturable lands: a) water logging, gully erosion, shifting cultivation, etc.b) wind erosion including shifting sand dunes, extreme moisture stress, coastal sand dunes, etc. and c) salinity and alkalinity.

Wastelands, which could be improved by the application of scientific, technological and other resources so as to provide economically and ecologically viable vegetative cover, may fall under private and public ownership.

Reclamation of such degraded lands and putting them to productive use for agriculture, forestry and rangelands is a multi-dimensional activity needing the attention of several agencies.

Opportunities

Soil and water conservation: Trees act as semi-permeable barriers to water movement and, mulch from trees reduces the raindrop impact and thus, helps in soil conservation. Microclimatic improvement is due to reduced wind speed and moderating air temperature. The combined effect of changes in radiation balance and surface wind pattern influences plant water uptake. Trees can increase water availability in the soil by reducing runoff and increasing infiltration, reducing evapo-transpiration through shading by canopy and litter and, increasing soil available water holding capacity through maintenance of organic matter. Soil fertility improvement is the result of addition of nutrient rich litter on a long term basis. Timber and fiber yielding trees/ plants like *Agave sisalana* also should be encouraged. *Acacia tortilis/ nilotica, Prosopis cineraria, Ailanthus excelsa, Azadirachta indica, Tecomella undulata, Zizyphus mauritiana* etc. act as good shelter belts/wind breaks to check soil erosion. Inclusion of leguminous and semi perennial forages is known to improve the organic carbon content of soils after at least 5 years of their establishment.

Improvement of problem soils: Trees ameliorate the problem soils by improving physical, chemical and biological properties. Leguminous trees like *Prosopis juliflora, Acacia nilotica, Casuarina equisetifolia, Sesbania sp.* ameliorate alkali soils at a much faster rate than non-leguminous trees, because of the buildup of organic matter, recycling of nutrients and moisture conservation. The compatible forage sp. with them are: Karnal grass*, Cynodon dactylon, Chloris gayna* and *Paspalum sp.* The most promising trees identified for agroforestry on reclaimed alkali soils are: *Populus deltoids* (Poplar), *Eucalyptus tereticornis/ hybrid, Acacia nilotica* and *Tectona grandis*. *Populus*-based agroforestry has been proved more remunerative because of its faster growth and high wood price compared to Eucalyptus and Acacia based systems.

Livestock improvement: Increasing livestock population and its poor health demands continuous supply of nutrient rich fodder in sufficient quantities. Since seasonal dry/green fodders are inadequate and poor in nutrition, there is a need to augment the supplies from alternate sources. Many fodder trees can be promoted on wastelands such as: *Leucaena leucocephala*, *Hardwickia binata*, *Albizia amara, Ficus sp.*, Acacias, Gliricidia, *Morus alba*, *Bauhinia sp.*, *Syzygium cumini*, *Ailanthus excelsa*, *Moringa oleifera*, *Dalbergia sissoo*, and *Zizyphus sp*. These can also be planted on field bunds, waterways or sparsely on good quality lands along with agricultural crops. The trees develop new flushes and fruits during spring to summer, rich in protein, minerals and thus form healthy nutrition along with dry fodders. Seeding of *Stylosanthes hamata/ scabra*, *Cenchrus ciliaris/ setigerus*, *Dichrostachys nutan,* Napier grass, Bhabar grass*, Dicanthium annulatum, Panicum maximum, Urochloa sp.,* Dinanath grass, siratro, and the like in the degraded lands helps in their stabilization and arresting erosion. After the trees and fodders establish well, controlled grazing can help in improving live weight gain/ sheep and number of lambings and general health of livestock.

Rainfed Horticulture: Most of the fruit crops can grow well in rainfed/ degraded areas. However, these can be mounted successfully on deep soils with good water holding capacity having well distributed rainfall pattern or with protective irrigation at active crop growth period coinciding with flowering and fruiting. When these are introduced in marginal soils, it is essential to adopt micro-site improvement, micro-catchment, contour trenches, and other related agro-techniques for better survival and establishment. Once they are established, they would strike deep root system and draw soil moisture from deeper layers of profile. Suitable fruit crops identified for dryland/degraded areas are: ber, custard apple, guava, *aonla*, *jamun, bael*, tamarind, *karonda*, phalsa, sapota, mango, pomegranate, passion fruit, sweet orange, fig, lime, papaya, drum stick, wood apple, chironji, soap nut.

Tree Borne Oilseeds: There is vast potential for Tree Borne Oilseeds(TBOs) from forests and wastelands, like sal, mahua, neem, simarouba, pongamia, jatropha, jojoba, cheura, kokum, wild apricot, bhikal, wild walnut, kusum, tung, salvadora,etc., which are collected and crushed for vegetable oils. There are nearly 300 species with oleaginous seed material; some are still to be exploited. The oil is mostly used in manufacturing basic oleo-chemicals, soaps and detergents, paints, lubricants, greases, biodiesel, medicinal uses etc., bedsides for edible purpose like margarine, confectionary and bakery products. The estimated potential is more than 5 million tons of TBOs with an oil yield of nearly 2 million tons. Currently only 0.8-1.0 million tons of seed is collected with an oil yield of 1.5 -2.0 lakh tons. Among the TBOs, sal, mahua, neem and pongamia constitute about 80% of the production. Sal is the major species, 90% of which occurring in Madhya Pradesh, Chhattisgarh, Bihar, and Orissa besides in foot hills of Himalayas. Mahua is grown in Uttar Pradesh, M.P., C.G., Gujarat and Andhra Pradesh while pongamia is distributed all over the country, mainly on the banks of rivers, streams, or sea coast. It is mostly seen in Karnataka, A.P., and Tamil Nadu. Pongamia is quite hardy, tolerates drought and salinity and is fast growing. Jatropha is a hardy plant well adapted to arid and semi-arid conditions grows on stony, gravelly, shallow and even calcareous soils mainly in the states of Gujarat, Rajasthan, M.P., Maharashtra, T.N. and A.P.

Vegetable oils and their methyl esters are considered as potential alternate fuels for diesel engines if they have a cetane index of methyl esters >35-40 and Iodine value of 80 to 145. Many TBOs like pongamia and jatropha possess these properties.

Alternate land use systems: These systems when implemented in wastelands**,**

offer potential advantages such as: increased utilization of space, effective utilization of off-season rainfall for their establishment and growth, improved soil physical, chemical and biological characteristics, enhanced nutrient cycling, increased productivity from tree and annual intercrops, potential reduction in soil erosion due to multi-storeyed canopy, reduction in extremes of microclimate, reduced risk of complete crop failure and the like. The economic and social advantages are: increased year round employment and income, variety of products, improved human and animal nutrition apart from reducing migration of rural masses. In this system, short duration arable crops preferably legumes can be raised in the interspaces of trees to provide seasonal revenue. Horti-pastoral systems also can be raised in waste lands for multiple uses.

The Approach

The vision of late Prime Minister Sri Rajiv Gandhi to rehabilitate 5 M.ha of wastelands every year in the country remained almost as a plan only. Had it been implemented truly in letter and spirit since then, probably today we would not have any constraint in solving the food and other problems of our increasing population. Nevertheless, it is not too late that we rise to the occasion and try to dedicate ourselves for boosting up the forest area in the country on par with other progressing countries through wasteland development programs.

The Govt. of India had initiated several programs like afforestation, social forestry with rural fuel wood plantations and operation soil watch for soil and water conservation in forests; block plantations on community lands, pasture development, tree patta scheme, livefencing, establishment of nurseries and the like. Some incentives also were initiated for promotion of vegetation development programs. The future programs must include development of wasteland maps based on aerial and space information, rehabilitation of wastelands, controlling desertification by plantations and other methods. The following steps are suggested for development of wastelands.

Several ICAR institutions are addressing the problems of degradation of natural resources and have achieved commendable solutions to tackle the issues. Relevant technologies already evolved at research stations must be made available to the farmers. The Ministries of Environment &Forests, Agriculture, Irrigation, Communication and Transport, Railways, Science& Technology and the like should make a joint program for this purpose. This would help in conserving scarce resources, avoiding duplication of efforts and finally making fruitful programs.

In problem areas, where water is the critical and scarce resource, farming system's approach is the best option integrating arable cropping with livestock production, alternative land use systems incorporating trees, wasteland development, and other similar options. Preference should be given to the fruit trees if protective irrigation is available since these are the best options for rehabilitating wastelands/degraded/marginal lands to effectively utilize off-season rainfall for their establishment and stable and sustainable production. Short duration arable crops preferably legumes may be raised in the interspaces of trees to provide seasonal revenue apart from improving plant/ human nutrition. Watershed approach is suggested for other agroforestry species.

The degraded forest lands can be reclaimed by situation specific silvi-pastoral models. The tree species must be selected based on the purpose: Amenity (recreation), protection of land, production, local needs and past experience and be multipurpose. Trees must be tolerant to droughts and extremes of temperatures and amenable to intensive lopping. Fodder yielding and other trees also can be promoted on contour/field bunds/ boundaries, waterways, along gullies, roadside, railway lines, and on degraded lands as block plantation or in ranges or sparsely on good quality lands where agricultural crops are grown.

Broadcasting of seeds of fodder crops is required in difficult- to- reach areas or planting of stem cuttings on hill slopes, low/high rainfall areas and poor soils. The selected species should be able to grow well in scanty/high rainfall, compatible with other crops and grow even under shade. However open grazing should be avoided since this would reduce the life of such establishments due to trampling and causes further degradation.

The complete involvement and dedicated effort on the part of researchers -development agencies - NGOs – farmers, community leaders, schools - local youth and industry, is essential to develop a sustainable package and for the success of wasteland development program to give a clean environment to the people. Farmers' participation also helps in protecting the plantations from destruction due to stray animals, fire, illicit cutting and such other activities. The village must be the lowest unit of our activity and farmers be motivated to take active part through demonstrations, training, traveling workshops, field visits, mass meetings, film shows, and distribution of literature.

The children should be encouraged to plant saplings on their every birthday and also people should plant saplings on the birthdays of National Leaders. It is more important to nurture the saplings than planting them till they establish well.

Development of new forest villages, construction of small dams, financial assistance, introduction of cottage industries, land to landless, establishment of orchards, construction of roads and similar measures are essential to fulfill the objectives and to improve the productivity of land/ forests.

A systematic approach for cultivation of TBOs in wastelands along with provision of infrastructural facilities like collection & processing centers, transport, storage, oil extraction, etc. would go a long way in augmenting self sufficiency in vegetable oils. TBOs can generate tremendous employment opportunities for rural people including tribal and other weaker sections. This would also help in maintaining eco-friendly environment besides earning huge foreign exchange from edible grade fat of sal, mango kernel, kokum, simarouba and mahua.

Presently pongamia seed oil is used as diesel substitute in electricity generation in rural Karnataka (Tumkur) and A.P. (Adilabad) and jatropha oil for tractors and water lifting devices in T.N. and Punjab. Some states also have introduced the oils of pongamia and jatropha for substituting up to 10% of diesel in road/ rail transport. Such examples should be extended further in every state to bring awareness on self sufficiency and to reduce the import burden of crude petroleum products. Most of the culturable waste lands are ideal for such oil yielding trees.

Wasteland development will also help in better utilization of highly degraded lands for promoting flora and fauna, wild life sanctuaries and the agro-eco-tourism centers besides protecting the environment.

Threats

The continuously growing human and livestock population demands huge outputs of various commodities from the limited resources to maintain lives at minimum level. The shrinking natural resources and their constant degradation, rising temperatures, highly irregular monsoonal behaviour, environmental pollution, degradation of forests, loss of soil and nutrients and unforeseen happenings are likely to hamper the progress of the nation if these are not attended to at right time and in a fitting manner before it becomes irreparable. In rainfed areas the problems of desertification are continuously increasing due to over exploitation of natural resources. The problems are generally location specific and get rectified with appropriate solutions. Most of the farmers are marginal to small and cannot meet their daily needs from meager resources. This might result in mass migration of rural folk to towns and cities. *If proper attention is not paid to restore our natural resources, the child born today will have less chance of getting adequate food to eat, space to live and pure air to breathe, in future.*

In the light of potential physical, economic and social advantages of wasteland development, every effort must be made to impress upon farming community and others to implement the suggested programs and the like in a mission mode. However, suitable marketing, pricing and such other issues must be addressed well. Success of wasteland development thus depends on whole hearted participation of community, R&D agencies, NGOs and funding.

According to Atharvana Veda, the Mother Earth nurtures all the living being of the world. It is our earnest desire to keep the green cover of the land ever lasting. Our salutations to the Mother Earth, the giver of all kinds of potent food grains and water.

Sustainable Food Security of Kerala, Role of Agro-biodiversity – A State-level Dialogue

R.D. Iyer

Introduction

During the inauguration of the NGO-Navasakti- a non profit organisation established at Karunagappalli in Kollam District of Kerala on January 29, 2009, in his Chairman's remarks, Prof.M.S. Swaminathan highlighted the significance of the Invocatory song, "Maithrim Bhajatha", composed by the Paramacharya of Kanchikamakotipeetam, and sung for the first time by Bharat Ratna M.S.Subbulakshmi at the U.N. General Assembly in New York. This song calls for fostering world peace and friendship among nations. Indeed the very foundation of peace and tranquillity of a nation is its food security, which can be achieved only through application of science and technology for agricultural transformation". He outlined four pathways of Transfer of Technology:

i) from **land to land,** that is, the success achieved by one farmer is emulated by others;

ii) from **lab to land**, technology developed by research institutes is adopted by farmers;

iii) from **land to lab,** farmer's successful technology is analysed by the lab for refinement or upgradation;

iv) **Lab to lab**, where technology is enriched by interaction between research institutions.

"However, to find solutions to problems of local nature, he said that Non-Govt Organizations like Navasakti Trust have a significant role to play. As a preliminary step, Navasakti, in collaboration with MSSRF and KAU had organized this State-level Dialogue on *'Sustainable Food Security of Kerala - Role of Agro-biodiversity'*, with the active participation of State Departments of Agriculture, Animal Husbandry & Fisheries, various Central Research Institutes and experts in the field. Based on the Dialogue an Action Plan was formulated for implementation by the State for achieving the objectives through conservation and utilization of agro- drudgery biodiversity".

The recommendations emerging out of each of the Sessions :i) Paddy Cultivation, Production & Consumption, ii) Sustainable Production of Fruits & Vegetables, iii) Dairy, Fisheries & Livestock Management, and iv) Gender Equality in Agriculture are reproduced here in the form of the *Thazhava Plan of Action.*

I: Paddy Cultivation, Production and Consumption

Prof. Swaminathan suggested for enlarging the *'Food Security Basket'* to include under-utilized crops, creating awareness, particularly among the younger generation. He indicated that Govt of India has initiated a National Programme entitled, *"Rashtriya Krishi Vikas Yojana"* with an outlay of Rs 25,000 crores for four years, for accelerating the pace of agricultural progress. We need to prepare specific project proposals for bridging the gap between potential and actual yields of major crops at the

Retd. Principal Scientist & Head, Crop Improvement Division, CPCRI, Kasaragod,
Jt. Mg. Trustee, Navasakti Trust, Vengattompalli, Thazhava-690523, Kollam Dt., Kerala
Email: rdiyer_1935@rediffmail.com

level of each District, using technologies currently available. This will involve attention to the following five areas of sustainable farming:

- Soil health enhancement
- Water harvesting and efficient water management
- Spread of appropriate environment-friendly technologies, both production and post-harvest, so that conservation, cultivation, consumption and commerce form a continuous chain
- Prompt availability of Credit and Crop Insurance.
- Assured and remunerative marketing, which is the major trigger for generating enthusiasm among farm families for the adoption of the Integrated Package.

It was felt that Kerala was an exporter of Rice during the 1850s, when only the elite consumed rice while the general population consumed diversified food crops. Now the spices attract more funds than rice, and there is mismatch between expenditure and income from Paddy cultivation, mainly due to the high cost and poor efficiency of labour output, and their mental attitude towards farming.

Rev.Fr. Thomas Peelianikkal, Exec. Director, Kuttanad Vikasana Samithi (recent winner of Karshakacharya Award), out lined the following **five** steps for the revival of Paddy cultivation

- Establishment of Seed Banks to meet the shortage of quality seeds to farmers at subsidized rates, and training of farmers to produce their own seed stocks.
- For Crop Insurance, proper assessment by State experts is needed, so that farmers are suitably compensated for crop loss due to natural calamities. Post-harvest Insurance should be backed up by adequate storage facilities like Paddy Shelters on high ground.
- Organic Farming and Shrimp farming need to be promoted. A sum of Rs.5000/- per ha for paddy cultivation is highly inadequate; at least Rs 50,000/- per ha should be allotted for reclamation of marshy lands for Paddy cultivation.
- Mechanization is the only answer for remunerative Paddy cultivation, and youth should be trained to operate and maintain farm machinery.
- Payment to farmers for Paddy procured by the State, should be made promptly without delay, and the least clerical hassles.

It was suggested for proper coordination between Govt. agencies and NGOs in the field, to realize the cherished aim of bringing 50,000 ha under Paddy cultivation.

II: Sustainable Production of Vegetables and Fruits

The wide gap between production and demand of vegetables and fruits in the State has led to imports from other States. Summer irrigation facility should be made available to augment production. Dissemination of database on vegetables and fruits calls for proper synergy between concerned Govt Departments to encourage vegetable and fruit production. It is also desirable to promote inter-cropping and utilization of fallow and wastelands for the purpose.

Inadequate marketing system is another bottleneck, compounded by the lack of storage facility for fruits and vegetables. Hence, a price support system is required to protect farmers from price fall, and the marketing facility should be extended to small towns for ensuring viability of the produce.

The lack of transfer of technology from lab to land is a major bottleneck. In this direction, the Horticultural

Mission in Kerala has made efforts to create awareness among farmers of its Schemes through the electronic and print media. The Credit Packages for farmers cultivating leased land must be availed. The Mission is also promoting and supporting SHGs in Horticulture.

It was observed that there has been a drastic shift in consumption pattern, from local leafy vegetables and tubers to onions, tomatoes and potatoes. Vegetable farming is done mostly on leased land by landless labour and hence the land tenure problem has to be addressed and leased land should be legalized. Vegetable & fruit cultivation in traditional areas, conservation of home/ kitchen gardens (by supplying seeds and organic inputs at subsidized rates) deserve every support, to capitalize on the current wave of interest in organic foods.

Nutrition Gardens involving school students and housewives must be promoted in order to achieve self-sufficiency in fruits & vegetables. The production units also must be set up near International Airports, to link up external & internal market chains. Kerala's unique land-races and ethnic vegetables should also find a place in the Mission.

III: Dairy, Fisheries and Livestock Management

Since milk production was declining, enhancement of the livestock population and ensuring their food security was suggested. Conservation of indigenous breeds like the ***Vechur*** cow should receive top priority. Concern over Food Security should emerge as a public mandate backed by public action.

It was felt that there is a shortfall in production of dairy, poultry, fisheries and livestock, although 83% of it was cross-bred. Hence a change in breeding policy and genetic upgrading of all animals and also their nutritional standards is called for. There is a need to set up small and medium units for milk production. Low productivity of inland fisheries was a cause for concern, and post-harvest losses need to be reduced besides arresting pollution of water bodies.

A stringent cross-breeding policy was suggested for genetic improvement. Special Milk Production Zones for pure-bred cattle areas like Idukki and Wayanad need to be established. Fodder cultivation by Panchayats should be encouraged and Fodder Banks be set up. Labour Banks of skilled milkers will help improve production efficiency, and a Pricing Commission will help stabilize milk prices, while a flexible loan scheme covering all sections of society will go a long way in enhancing milk production. Backyard Poultry should be encouraged and the high rate of VAT on

Chicken normalized. Exotic Poultry like quails and turkey should be encouraged and Poultry Farmer Service Centres established for disease surveillance and conserving native germplasm.

For achieving rapid development of the dairy industry, 12 steps are suggested as given below:

- Encourage non-conventional feeds
- Integration of Technology for achieving potential productivity
- Promote local production of fodder
- Provide concentrated feeds at subsidized rates
- Encourage goat-rearing for milk and meat production
- Strictly enforce real field service of technical staff
- Prepare Integrated Plan for next 10 years for potential areas
- Document and validate indigenous knowledge related to livestock management

- Prepare a Package for treating pollution associated with livestock production
- Constitute a District-level Expert Committee for guiding farmers
- Enhance budget outlay for Animal Husbandry, Dairy, Poultry & Fisheries Sectors.

The *Thazhava* Declaration on the Plan of Action for Sustainable Food Security of Kerala:

1. Kerala is an Agricultural Biodiversity Paradise, with a diversified food basket, involving rice, tapioca, yams & other tubers, vegetables, jack, mango and bananas besides fish (both marine & freshwater), and other animal products. The state has gone from a stage of export of rice to dwindled food basket during the past due to several reasons. To create an economic stake in conservation and provide social prestige to the Conservers, it is suggested that the state should institute **"Food Security Saviour Awards",** to recognize the following contributions :
    - Individual Farmers and Tribal families conserving the rich agro-biodiversity in their homestead "genetic gardens":
    - Tribal and farm families conserving a wide range of land-races in rice, tuber crops, vegetables and animal breeds like the *Vechur Cow.*
    - Panchayaths & Nagarpalikas who promote enlarging of the Food Baskets, by including under-utilized but nutritious food crops, in PDS, ICDS, and School Noon Meal Programmes.
    - Outstanding farm families contributing towards increasing productivity, profitability, and sustainability of rice-farming systems.
    - Those contributing towards preventing loss of traditional wisdom in relation to the enlarging of the Food Basket, and to saving the dying wisdom and orphan crops.
2. Kerala should launch a **"Bridge the Yield Gap Movement"** to help farmers fill the prevailing gap between potential and actual crop productivity, through mutually supporting technologies, services (like seeds), and public policies designed to ensure remunerative price for farm produce.
3. If farm Ecology & Economics go wrong, nothing else will go right in agriculture. Because of its varied topography and agro-ecosystems, the state should launch a **"Conservation Farming Movement"** to conserve and improve the ecological foundations essential for sustainable agriculture like land, water, biodiversity, and climate.
4. Global Food Security is getting worse due to the uneconomic nature of farming and deterioration of ecological conditions. Climate change resulting from global warming can pose a grave threat to Kerala's coastal communities, as a result of sea-level rise. Anticipatory research and measures should be undertaken to strengthen concurrently the ecological and livelihood security of families living within 50 km from the shoreline.
5. Unique agro-ecosystems like Kuttanad, where Paddy cultivation occurs below sea-level, and are designated as *Ramsar site,* should be developed into ***Special Agricultural Zones***, where conservation farming involving either Organic or Green Agriculture based on the methods like IPM and INS can be promoted. SAZ should be based on the integrated applications of the principles of Ecology, Economics, Social & Gender Equity and Employment Generation. Decentralized farm production should be supported by key centralized services in areas of salinity control and

management, plant protection, farm machinery, and post-harvest technology. The aim is to integrate the advantages of **Mass Production** technologies like land preparation, salinity management, harvesting, threshing, and storage, with **Production by Masses** approach involving the active participation of small holders in the production-marketing chain.

6. Kerala's agro-biodiversity conservation movement should be based on integrated attention to the **Conservation-Cultivation-Consumption-Commerce chain.** Kerala is ideally suited for mixed farming systems involving crop-livestock-fish integrated production systems as well as Agro-forestry. For Rice farmers, multiple livelihood opportunities through initiatives like the **Rice Bio-Parks** will have to be created for enhancing total household income.

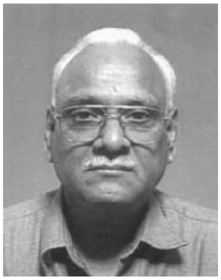
7. The National Policy for Farmers calls for an income orientation to farming. Due to the high male and female literacy, Kerala offers great opportunities for promoting knowledge-intensive farming systems, which are intellectually satisfying and economically rewarding. This is the only pathway for attracting and retaining educated youth in farming, which is a pre-requisite for Sustainable Food Security.

8. In order to promote Coordinated Action in conserving and utilizing Agro-biodiversity for Sustainable Food Security, a **Kerala State Coalition for Agro-biodiversity for Food Security** may be formed with the participation of Govt, Non-Govt, Tribal Farmer Organizations and Academic Institutions.

RICAREA: Similar such other locations in the country also may benefit from the excellent recommendations suggested above.

Fertility Management in Buffaloes

P.A.Sarma



Buffalo as domesticated animal mostly available in tropical and sub tropical countries. India possesses about 40% of the buffalo population in the world. In our country buffaloes constitute about one third of the total cattle population and is contributing about two thirds of our total milk production. It also significantly contributes to meat and leather production and earns substantial amount of foreign exchange to our country. No doubt it is unfortunate that cattle protagonists are often prejudiced against buffalo. In our country there is place for both these species (cow & buffalo) to help to free our population both from protein and calorie hunger.

Buffalo -an animal from tropics and tropical countries being scientifically not developed, very little is known about the neglected animal. All the time we applied the knowledge available about the cattle to the buffalo and probably it may be one reason, so far we could not fully exploit the animal's production potential. At present through the Endeavour of Central Research Institute on Buffaloes supported by ICAR, scientists are probing simultaneously in to the fields of feeding , breeding and management to reveal the secrets of the animal.

The major fertility problems of Buffalo are:

1. Delayed age at maturity
2. Post partum anoestrus
3. Repeat Breeding

Fertility management in Buffaloes

The following aspects need special attention to solve the problem to a possible extent and improve the fertility in buffaloes.

1. Optimum and better feeding and management will bring down the age at maturity.
   Experiments have shown that growth rate is faster in the buffalo calves between 5-12 months and 17-24 months of age while the gain in body weight in calves during 12-17 months of age is substantially low. 40% higher protein intake helped to get the heifers conceived at an age of 23-27 months. In order to get early maturity the heifers are to be fed at optimum level. The earliest we see the buffalo heifers attaining 250-270 kg body weight; they mature irrespective of their age. There are records that buffalo heifers have conceived at 18 months of age at NDRI, Karnal when 40 percent extra than NRC recommended protein level (for cattle) is provided in ration to buffalo heifer.
2. Heat detection: Heat detection is one of the important bottle necks in artificial breeding, all the more with the buffaloes owing to their silent nature of heat.
   The symptoms of heat(such as loss of appetite, excitement, bellowing, Swollen Vulva, Hyperemia, frequency of urination, opening of Cervix, mounting by teaser bulls,etc.) could be compared at various stages in buffalo cow. However, it should be noted that all

Director (Retired) Govt. of India, Former Professor, NDRI, Karnal---ICAR,Consultant , APLDA, Govt of Andhra Pradesh , Technical Advisor, VET CARE PROVIMI

symptoms may not be present in all animals and very close observation is needed to detect these symptoms.

Symptoms of heat in Buffalo cow are as follows: The heat period is of long duration 24-36 hours, external heat symptoms are less intense and silent, Mucus discharge is less marked and less in quantity, Bellow sharply, and for longer duration, exposition of teeth while bellowing is very characteristic with buffalo cow and Mounting other buffalo cows is seldom.

Teaser bulls for heat detection in buffaloes: Use of teaser bull will help to solve the problem of heat detection in buffaloes and therefore strongly recommended in the organized buffalo herds.

Teaser bulls could be prepared by one of the following surgical techniques keeping the principle to retain sex libido intact to tease the buffalo in heat but not reprocreat.

i. Vasectomy

ii. Penectomy

iii. Epididectomy

iv. Obliteration of prepuce

However the following aspects are to be looked in for obtaining better results by employing teaser bulls:

i. Use teaser bulls with good sex libido

ii. Have sufficient number of teaser bulls to give adequate physiological rest to the bull to recoup its libido before it is being paraded next time

iii. Remove the buffalo detected in heat from the sight of teaser to provide scope to detect other animals in heat if any in the herd.

iv. Train sincere, honest and painstaking persons for heat detection to obtain good result

v. Since it is considered a skilled job, don't change the heat detector frequently

vi. Be more careful between 6 pm to 6 am.

vii. Have close intervals between parades preferably once in 4 hours

viii. Maintaining heat expectancy charts coupled with use of teaser bull give better results

3. Post partum rest: Sufficient period of physiological rest is needed after calving to have satisfactory involution of the uterus for maintaining good fertility. About 45-60 days rest is sufficient after calving.

4. Use of best Quality semen: Don't use frozen semen with less than 40 percent post thaw mortality. Thaw frozen semen straws in water at 35 to 400C for minimum half minute to get good fertility. Use all sterilized equipment for A.I.

5. Optimum time for insemination: Unlike in the case of cattle delayed insemination is recommended in buffaloes for better conception rates. Insemination between 14-20 hours from the onset of heat is recommended for buffaloes to obtain better fertility.

6. Site for deposition of semen: Depositing half quantity of the semen taken at half to one centimeter ahead of cervix and remaining half in the mid cervix while withdrawing the A.I gun

7. Double Insemination: Giving two inseminations instead of conventional single insemination during heat proved more useful. Those detected in heat the previous night are to be inseminated both morning and evening of the same day. Those detected during day are to be inseminated

the same day evening and the next day morning.

8. Management: Efforts are being made by adopting managerial techniques to break the slogan 'Buffalo is a seasonal breeder". We can get the buffaloes into heat during summer months also. Summer breeding will help to augment the shortage of milk in lean season. Results at NDRI and elsewhere are giving hope in this direction. The following management practices will be helpful to breed buffaloes in summer:
   a. Feeding green fodder.
   b. By providing good showers at noon in summer to decrease the heat stress in buffaloes, which not only improve their production ability but also helps to get the buffaloes regularly to come to heat during summer and also prevent the possible embryonic mortality and thereby repeat breeding especially in summer season.
   c. Cutting down the day light have improved the summer breeding in buffaloes and shown good fertility rates.
   d. Especially in summer months by providing good showers or wallowing immediately after insemination and securing the buffaloes in shade on the day of insemination helped in getting better conception rates.

9. Routine examination of breedable stock will help to identify the problem buffaloes at the earliest possible and treat successfully.

10. Periodical disease testing programme against diseases like Brucellosis, TB, JD, Vibriosis, Trichomoniasis, etc will help the elimination of positive animals and to check spread of these diseases which have a direct impact on the fertility of the herd. Calf-hood vaccination against Brucellosis needs no emphasis in the fertility programme.

11. Good coordination and cooperation among the Manager of the farm, Veterinarian and A.I technician will play an important role in improving the fertility.

12. Keep the animal on positive energy balance both for better production and reproduction.

13. If the animals are to be confined and no grazing is possible prefer loose housing for buffaloes to improve fertility.

14. Plan the housing for buffaloes in such a way to protect them from the heat stress during summer.

15. Synchronization of oestrus in live stock though not improve the fertility, may help to eliminate considerably the need for heat detection which is said to be one of the bottlenecks in artificial breeding of livestock in general and buffaloes in particular owing to their nature of silent heat. This method of synchronization also helps to have planed calving during the lean season for milk and also facilitate various managerial aspects for the dairy farmer.

Let us not forget the buffalo in this cross breeding era and sincerely try to understand the secrets of this animal to exploit the hidden production potential of buffalo by improving its reproductive efficiency. Production depends on the reproduction of the animal.

Let us try to convert the "Possibilities" with the buffalo production into "realities."

Research Priorities in Poultry: Emerging Challenges and Opportunities

U.Rajkumar and R.P.Sharma

Poultry industry has witnessed a phenomenal growth from the traditional backyard venture to a dynamic commercial agri-based industry during the last 7-8 decades. The constant efforts in upgradation, modification and application of new technologies paved the way for the multifold and multifaceted growth in poultry and allied sectors. Development of high yielding layer (310-320 eggs) and broiler (2.2-2.4 kg at 6 wks) varieties together with standardized package of practices on nutrition, housing, management and disease control have contributed to spectacular growth rates in egg (4-6% per annum) and broiler production (8-10% per annum) in India during the last 30 years. The annual per capita availability also increased to 46 eggs and 1600g of meat, consistently with increase in productivity. However, it is far below the recommended level of consumption of 180 eggs and 10.8 kg poultry meat per person per annum by Indian Council of Medical Research.

The policy paper on livestock research (NCAP) puts poultry in third place in allocation of resources (10.05%) among the livestock sector, while nearly 80 % was for cattle and buffaloes. Though poultry sector is contributing substantially to the GDP, the allocation for research is meager.

India ranks third in egg production and fifth in chicken meat production in the world. The intensified growth of poultry sector can be attributable to the constant research efforts in the fields of breeding, feeding, health and management. The Poultry Industry is contributing about Rs.352 billion to the national GDP and providing employment to about 1.5 million people. International Egg Commission forecasts an increased demand of 12 million tonnes of eggs over the 59 million tonnes available in 2005 with a global demand of 70.9 million tonnes by 2015 (Watt Executive Guide, 2006). However, they had also forecast associated risks like spread of High Pathogenic Avian Influenza (HPAI), increased feed costs and political decisions. In addition, the availability of feed ingredients, emerging diseases, fluctuating market price of egg and broilers, etc. are the bottlenecks in further improving the poultry production.

To overcome the challenges and to find the solutions for the problems the poultry research has to be prioritized based the consumer and industry needs for sustainability of the enterprise.

The research priorities, challenges and opportunities are discussed in important areas such as breeding, Feeding, management and health.

Breeding

The primary objective of poultry breeding programme is to improve the productivity, i.e., growth rate in broilers and egg production in layers. During the last 5-6 decades, population genetic tools and selective breeding made a tremendous progress in poultry sector both in layers and broilers. The breeding goals are changing as per the needs of the industry, the performance of the birds are no more in terms of one parameter, but different parameters,

Project Directorate on Poultry, Rajendranagar, Hyderabad-500 030.
Emial: ullengala@yahoo.com / pdpoult@ap.nic.in

ultimately the economics and profitability is determining the selection criteria. In case of layers, it is no more the number of eggs, but the size, feed consumption and flock depletion; in broilers feed efficiency and depletion along with body weight counts (Kotaiah, 2006). Sometimes breeder performance is of top priority than the yield characters. The research prioritization should be based on the needs of the industry and consumers; ultimately the profitability from the enterprise determines the sustainability.

Improvement of Purelines

The elite strains of layers and broilers available in public and private sectors may be further improved with multitrait multilevel selection indices with high selection intensity. The private sector has achieved the desired production levels in layers and broilers using such methods. The purelines developed should be tested for their nickability and terminal crosses.

BLUP: The usage of best linear unbiased prediction (BLUP) is limited in poultry. BLUP method of selection can be compared with the existing Osborne index method of selection in layers. BLUP will be the best (being unbiased and having minimum variance) provided the analytical model used makes correct allowance for all important environmental and genetic biases. The general flexibility of BLUP allows the formulation of a mathematical model to represent each situation, making optimum use of all information on each individual and its relatives and simultaneously adjusting for systematic biases such as dam age, season, sex, etc.Genetic relationships between animals may contribute considerable information to the prediction of breeding values and can be incorporated into BLUP using the Numerator Relationship Matrix (NRM) (Henderson 1975). The genetic trend resulting from selection can be adequately accounted for in BLUP by the inclusion of the NRM and/or use of genetic grouping to represent sub-population differences over time. In addition, the inclusion of sires and maternal grandsires in a BLUP analysis, along with the use of the NRM substantially eliminates any biases due to non-random mating. A useful extension from the application of BLUP procedures is the possibility to compute 'estimates of annual genetic trend from predicted age group difference, providing a direct monitor of what is happening in practice. This method can be a better chance for the improvement of traits with low heritability such as feed efficiency, egg quality and disease resistance etc. which plays a substantial role in determining the economics of the poultry.

Rural poultry or Backyard poultry

The thrust area for public sector and Governmental organizations has been Rural/backyard poultry for the last 10 years. To improve the overall poultry production, the research efforts should concentrate on larger section of (70%) of our population residing in rural areas. This can achieve better production potential in rural germplasm besides accommodating the improved varieties of chicken developed specially for rural and tribal areas. This system will result in progressive improvement in poultry production with low input cost and status of the rural and tribal livelihoods. This is low capital and less labour intensive. It is diffused in rural areas and caters to the rural markets and generates employment in villages (Sharma and Chatterjee, 2006). It provides the nutritional security to the rural landless labourers by providing eggs and meat at their door steps. It has been an alternative or subsidiary income source especially for rural women. In recent past, rural/backyard/family poultry is gaining wider importance, Governmental organizations like Project Directorate on Poultry (PDP), Central Avian Research Institute (CARI) and Agricultural universities are concentrating on developing the suitable varieties for rural poultry. Some of the researchable issues to be addressed are:

- Development of region or zone specific varieties with the incorporation of local germplasm or improved germplasm
- Package of practices on feeding (nutritive requirements), health and mangement for the nursery period as well as subsequent free range management.
- Transportation for long distances
- Low cost housing, low cost feeds using locally available feed stuffs and minimum health cover.
- Testing the already available germplasm at various agro-climatic conditions across the country.
- Improving the broodiness in improved varieties.

Development of disease resistant lines

Development of specific disease resistant lines against important diseases (MD) should be given top research priority. Selection for diseases resistant against MD and *E.coli*, infection has been studied with variable results. However, more research efforts in this area are needed.

Selection for feed efficiency and immune competence

Feed efficiency and immune competence should be utilized in the formulation of the selection indices along with other important economic traits. Feed efficiency, humoral, cell mediated immunity and phagocytic index may be put together along with the growth and egg production in an index for selection of the parents. The expected progress may be slow, but the lines can survive under adverse environmental conditions.

Biotechnological tools

The long-term intensive selection programmes have lead to exhaustion of the genetic variability among the stocks and these tools could not address some of the issues regarding the traits that are expressed late in life, sex linked and low heritable. The extensive use of high yielding stocks has increased the probability of disease occurrence. These situations warrant for new modern biotechnological tools that can address the limitations of traditional methods. The research priorities in avian biotechnology are:

- Production of transgenic chicken
- Biopharmaceutical production for therapeutic proteins in egg and meat
- Marker assisted selection and molecular breeding
- Genome wide marker assisted selection
- Candidate gene approach to identify QTLs
- Development of recombinant vaccines for newly emerging diseases

Organic egg and meat production

This is the new emerging area in poultry sector where consumer preference is growing continuously for organic eggs and meat. The research should be more focused in this direction and its economic viability as commercial enterprise in the present scenario. However, backyard poultry to some extent may contribute to the organic egg and meat production in which there is no incidence of antibiotic residues as they are grown on natural food base. Denmark tops the organic egg production, followed by Austria and United Kingdom (Windshort 2005).

Feeding

Feed accounts for 65-70% of broiler and 75-80% of layer production cost. The availability and cost of feed ingredients is going to be the major concern for the poultry industry. Maize is the popular cereal used in combination with protein meal like soybean meal which generally determines the cost of compounded feed (Panda, 2006). Average increase in maize availability has been 3.8% per annum, which is far below the growth rate of egg or meat production. The shortage of maize may increase because of its use in ethanol production is rising steadily. Similarly, soybean meal production increase also not on par with demand. Thus, there is a need to explore the usefulness of other alternate energy and protein rich feedstuffs to maize and soybean meal.

In view of the large gap between the demand and availability of feed ingredients for poultry production, a holistic research approach is needed to meet the demand of ever growing poultry industry.

- Identification of new and alternate feed resources for poultry
- Utilization of structural carbohydrates and phytate phosphorus
- Agro-industrial byproducts and unconventional feed stuff
- Feed additives (probiotics, gut acidifiers, enzymes, etc.)
- Immuno modulation through nutrition

Disease management

Management of diseases plays an important role for the progress of the poultry industry. Vaccination is regularly practiced to protect the bird against diseases. In spite of all the measures, the poultry industry in India suffered a major set back last year due to the out break of Avian Influenza. The industry suffered serious trade losses following downfall in consumption of poultry meat and eggs for about 6 months.

To minimize the occurrence of disease in poultry the three most important components of disease control are Bio-security, Vaccination and Medication. Bio-security refers to all measures taken to secure prevention of all types of pathogens in poultry farms. Effective bio-security and implementation of successful hygienic procedures are increasingly dependent on Hazard Analysis Critical Control Point approach (HACCP). The principles of HACCP such as hazard analysis, critical control points, critical limits, correction, recording and verification should be strictly followed for analyzing risk assessment and risk management. Vaccination should be practiced regularly following the regulatory procedures. Priorities for effective disease management in making the poultry industry a sustainable enterprise are:

- Trans-boundary diseases which are not endemic to India (Avian influenza) may enter through germplasm and biological materials. Strict quarantine measures should be followed before allowing the material.
- Establishing and strengthening surveillance and monitoring system.
- Efforts are needed to develop new diagnostics and biological using genomic approaches for rapid and accurate diagnosis and effective control of poultry disease.
- Research on prevention and control of emerging diseases. Isolation of mutated strains and development of vaccines against the modified strains of the diseases.

Conclusions

The poultry sector in India, experienced several challenges in the past, but continues to excel because of the consumer demand for the poultry produce. With increasing demand for chicken egg and meat, the poultry production in India foresees further expansion and industrialization with continuous research efforts in frontier areas of poultry. Adoption of small scale poultry farming in backyards of rural house holds will enhance the nutritional and economic status of the rural people. The resources allocation for poultry research should be increased by 2-3 folds. With the advent of knowledge in different fields of poultry the future challenges will not be a hindrance and thus sees a bright future for poultry production in this country.

Emerging trends in Indian Fisheries

S. Ayyappan[1] and J.K. Jena[2]

Introduction

Indian fisheries are increasingly contributing to the nutritional security of the country, with the present production of fish and shellfish from capture fisheries and aquaculture being over 7.1 million tonnes. The country also has an important role in global fisheries as the third largest producer of fish in the world and higher enhancement levels as compared to world fish production levels.

Further, with an annual yield of over 4.1 million tonnes from the inland fisheries sector, India is next only to China in the area. Increase in production of finfish and shellfish from 0.75 million tonnes in 1950-51 to 7.1 million tonnes during 2006-07, demonstrating over 750% growth in the last five decades, is a testimony to the contributions of the sector. The share of inland fisheries sector, which was 29% in 1950-51, has gone up to over 55% at present.

While the marine sector is almost constituted by capture fisheries, aquaculture has been the principal contributor in inland fisheries sector, with a share of 77%. Besides providing livelihood security to over 14 million people, the sector has been one of the major foreign exchange earners, with revenue reaching nearly Rs. 8,000 crores in 2008-09 accounting for about 14% of the agricultural export. Producing 4.7% of the world's fish, India trades to the extent of 2.5% in the global fish market. The contribution of fisheries sector, at an annual growth rate of 4.5% is estimated at 1.07% to the GDP and 5.4% to the agricultural GDP.

A few questions that we would like to address at this stage are: Has a major maritime state like India been able to realize its potentials of fish production? Had there been overemphasis on marine fisheries in the past? Is our transition from catching fish to cultivation rather slow? Are we saturated in marine fisheries and are we under producing in inland fisheries? What are the major issues in different segments of fisheries? An attempt has been made to make projections and draw up an action plan for achieving the production levels.

Marine fisheries

Present features of Indian marine fisheries are excess coastal fishing capacity and overexploitation, unregulated open access, discards at capture/ indiscriminate capture of juveniles and sub adults, coastal pollution and environmental degradation, biodiversity loss due to both natural processes of climate change and anthropogenic pressures, increasing fishing costs and reduced profitability, poor infrastructure at fishing harbours and landing centers and linkages for domestic marking and underutilization of oceanic and deep sea resources, emerging inter and intra-sectoral conflicts.

A paradigm shift is necessary from increasing marine fish production to increasing profitability and sustaining the marine fishery resources through

[1] Deputy Director (Fisheries) Indian Council of Agricultural Research, New Delhi
[2] Central Institute of Freshwater Aquaculture, Bhubaneswar
Email: ayyapans@yahoo.co.uk/ ayyapans@icar.org.in/

management interventions. Reducing overcapacity in the mechanized sector and co-management, diversification of fishing towards underutilized deep sea and oceanic resources, fuel-efficient crafts, conservation and stock enhancement through promotion of marine sanctuaries, installation of artificial reefs and sea ranching, effective code of conduct for responsible fisheries, high value produce from the seas and eco-labeling, coastal and open sea mariculture and post-harvest handling, both on-shore and on-vessel, are required. These can be achieved in a time frame of 5-10 years by agencies, ICAR, DADF, MPEDA and MoEF.

In case of island fisheries, the present level of operation is only 10% of the tuna potentials in the Andaman & Nicobar and Lakshadweep islands. It is necessary to link with the prime markets in Japan, which requires infrastructure of deep sea fishing vessels, on-vessel chilling, processing facilities in the islands and exports and policy interventions for mid-sea transfer with observers on-board and vessel monitoring system. Agencies such as the DADF, MHA, MoEF and MoC need to interact and invest over a time frame of 5 years, in a PPP mode.

Mariculture in the country is in its infancy with only mussels, oysters and seaweeds being presently cultured in a few parts. Along with crab and lobster fattening, sea cage finfish farming has great potentials. This requires inputs in terms of seed of marine finfishes, sturdy cage designs and feeders and policy support for leasing of coastal waters, along with suitable processing and value addition to the produce, as otherwise they fetch low price in the domestic market. The time frame to realize the full potential is medium term (5-20 years) by agencies, ICAR, DADF, MFPI, State Fisheries Departments and Public-Private participation.

As regards coastal aquaculture, production is dependent only on exports and global price fluctuations and trade restrictions are affecting farming. With commercial farming confined only to *Penaeus monodon,* it is necessary to produce disease-free seed including SPF-shrimp seed and also diversify into other shrimps and finfishes. Indigenous feeds and farm feeds need to be encouraged along with properly evaluated probiotics and antibiotics in hatcheries and ponds, complying with regulations of the importers. There are new opportunities in the islands and domestic market needs to be explored with suitable cold chains and outlets. ICAR, DADF, MPEDA, NFDB and MoEF will need to work in the area to address the above over a time frame of 5-10 years.

Inland fisheries

With most rivers subject to intense anthropogenic stress, it is necessary to ensure environmental flows, river ranching, fish passes in the dams and protected fish habitats in order to restore them. Further, mesh size regulations and restrictions on non-selective gears and destructive fishing need to be enforced. The new model of canal fish culture would need to be institutionalized with defined ownership. Enhancement of productivity of reservoirs and other wetlands by 3-4 folds is possible with provision of rearing space and stocking of quality fingerlings. Community based fisheries management and integrated fisheries and eco-tourism are suggested for higher profitability. ICAR, DADF, NFDB, Ministry of Tourism and State Fisheries Departments may undertake the above in a time frame of 5-10 years.

With 40% of total fish production coming from freshwater aquaculture, there is ample scope for doubling the production. Diversification, improvement through selection, transgenic ornamentals,

Perspective

The projections of fish production from different segments are as follows:

Area	Production in 2008, million tonnes	Projected production in 2012, million tonnes	Projected production in 2022, million tonnes
Marine capture fisheries	2.91	3.00	3.13
Mariculture	0.01	0.03	0.12
Coastal aquaculture	0.14	0.16	0.34
Inland capture fisheries	0.85	1.20	1.70
Coldwater fisheries	0.00030	0.001	0.01
Freshwater aquaculture	3.22	5.60	7.40
Total	**7.13**	**9.99**	**12.11**
Export	0.62 (Rs.7,555 crore)	0.70 (Rs.12,000 crore)	0.82 (Rs.15,000 crore)

development of suitable models for different resources, water budgeting and projections of feed requirements, provision of quality seed and its certification, establishment of brood and seed banks, aqua-shops and small scale cold chains are required to be undertaken by ICAR, DADF, NFDB and State Fisheries Departments over a duration of 5-10 years.

With post-harvest losses in fish as high as 15%, it is necessary to provide post-harvest preservation and transport to markets. Most fish consumed in the country is fresh or chilled/iced and that processed is only about 10% of the produce, largely for export. On-vessel preservation facilities for marine and small scale cold chains for inland fisheries, ready-to-cook and ready-to-eat fish products, value addition for low value fish must be taken up, with an emphasis on domestic markets, with hygienic fish outlets and quality assurance measures. ICAR, DADF, MPEDA and NFDB could address these, largely in a PPP mode.

Policy issues in areas of deep sea fishing, uniform closed seasons and mesh regulations in states along east and west coasts, alternative livelihoods for fishers during closed seasons, provisions for culture of certain marine invertebrates like sea cucumbers, regulations on wild seed collections and destructive fishing, leasing of waters (both inland and marine), quarantine and regulated introduction of exotics, Fish/shellfish seed certification, ranching of water bodies and domestic markets with customized cold chains need to be addressed, mainly by the DADF, in consultation with other concerned ministries/departments, mainly the MoEF.