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Towards An Evergreen Revolution In Agriculture

M.S. Swaminathan

The term 'Green Revolution', coined by Dr William Gaud of the US Department of Agriculture in 1968, has come to be associated not only with higher production through enhanced productivity, but also with several negative ecological and social consequences. There is also frequent reference to the 'fatigue of the Green Revolution', due to stagnation in yield levels and to a larger quantity of nutrients required for producing the same yield as in the early 1970s. Experts have been warning about an impending global food crisis due to increasing population, increasing purchasing power leading to the consumption of more animal products, increasing damage to the ecological foundations of agriculture, declining per capita availability of land and water, and the absence of technologies that can further help to enhance the yield potential of major food crops.

Should we therefore assume that as we enter a new century we will not have the benefit of new technologies which can help farmers produce more food and other agricultural commodities from less land and water?

We believe we are now in a position to launch an 'Evergreen Revolution' that can help increase yield, income and livelihoods per unit of land and water, if we bring about a paradigm shift in our agricultural research and development strategies. The Green Revolution was triggered by the genetic manipulation of yields in crops such as rice, wheat and maize. The Evergreen Revolution will be triggered by farming systems that can help produce more from the available land, water and labour resources without either ecological or social harm. Thus, progress can be achieved if we shift our mind-set from a commodity-centred approach to an entire cropping or farming system. This does not mean that we should decelerate our efforts in crop improvement research. But research should be tailored to enhance the performance and productivity of entire production systems. The transition from the fatigue of the Green Revolution to an Evergreen Revolution involves a shift from a crop-centred to a systems-based approach to technology development and dissemination.

Let us take, for example, the prospects for 'super-rice', capable of yielding over 10 tonnes of rice per hectare[1]. Such a rice plant will need a minimum of 200 kg of nitrogen per hectare, together with other macronutrients and micronutrients. Addition of such nutrients solely through mineral fertilisers will lead to serious environmental problems; hence, the introduction of legumes in the rotation becomes important.

Scientists now have unique opportunities for designing farming systems to achieve the triple goals of more food, more income and more livelihoods per hectare of land, provided we harness the tools of eco-technologies resulting from a blend of traditional knowledge with frontier technologies. Such tools include biotechnology, Geographic Information Systems (GIS) mapping, space technology, renewable energy technologies (solar, wind, biomass and biogas), and management and marketing technologies.

We can enter a century of hope only if we abandon the old concept of a crop-centred Green Revolution and replace it with farming systems and frontier technologies-centred Evergreen Revolution.

Industrial countries are responsible for many global environmental problems such as potential changes in temperature, precipitation, sea level, and incidence of ultraviolet radiation. While further agricultural intensification in industrialised countries will be ecologically disastrous, the failure to achieve agricultural intensification and diversification in developing countries – where farming provides most of the jobs – will be socially disastrous. This is because agriculture, including crop and animal husbandry, forestry and agro-forestry, fisheries, and agro-industries, provides livelihoods to over 70 per cent of India's population. The smaller the farm, the greater is the need for higher marketable surplus to increase income. As many as 11 million new livelihoods will have to be created every year in India and these must come largely from the farm and

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rural industry sectors[2]. Importing food and other agricultural commodities will thus have the same impact as importing unemployment.

Those who advocate going back to the old methods of farming ignore the fact that only a century ago when the population of undivided India was 281 million, famines claimed 30 million lives between 1870 and 1900. The famine eradication strategy comprising the following steps is perhaps the most important achievement of post-independence India:

- Enhanced production and productivity
- Better distribution through public distribution systems
- Adequate grain reserves
- Purchasing power enhancement through various employment generation and guarantee schemes
- Special intervention programmes for children, pregnant and nursing mothers, and old and infirm persons.

While famines have been prevented, widespread undernutrition prevails among the economically underprivileged. Since non-food factors such as health care, environmental hygiene and literacy play an important role in promoting sustainable food security at the level of the individual, we should revisit our strategy along the following lines. First, sustained physical access to food will involve a transition from chemical- and machinery-intensive to ecological farming technologies. Second, the emphasis on economic access underlines the need for promoting sustainable livelihoods through multiple income-earning opportunities. Third, environmental access involves, on the one hand, attention to soil health care, water harvesting management and the conservation of forests and biodiversity, and, on the other, to sanitation, environmental hygiene, primary health care and primary education.

If the political vision to implement this mission is forthcoming, population stabilisation can be more readily achieved. The prediction of the French philosopher, Marquis de Condorcet, made in 1795, that population will stabilise itself if children are born for happiness and not just for existence will then come true.

The emphasis on the individual is important, since the household is often not a homogeneous unit. Women and girls tend to suffer more from undernutrition than men and boys. The 'Human Development Report' contains distressing data on the growing feminisation of poverty[3]. To give operational content to such a concept of food security, we should initiate a Hunger-free Area Programme (HFAP) with the following objectives:

- Ensure sustainable availability of food by maintaining the growth in food production over population growth through the development and dissemination of eco-technologies, supported by appropriate packages of services and public policies. Eco-technology involves blending ecological prudence and technologies of the past with the best in frontier technologies, particularly biotechnology, information technology, space technology, renewable energy technology and management technology. Without eco-technological empowerment, farmers will not be able to produce more food and other agricultural commodities on an environmentally sustainable basis from fewer land, water and energy resources.

- Sustain the productivity of the natural resource base by conserving and improving the ecological foundations essential for continuous advances in crop and animal productivity.

- Ensure adequate household incomes through promotional social security, such as accessing assets, employment, and organisational and marketing empowerment. Agricultural programmes should aim at more food, more jobs and at more income. Integrated attention to farm and non-farm employment and value-addition to primary agricultural commodities will be necessary to enhance income and rural livelihood security. Above all, we should ensure that macro-economic and global trade policies do not destroy micro-enterprises supported by micro-credit.

- Provide entitlement to food for the vulnerable groups through protective social security measures such as employment guarantee and food for nutrition programmes.

- Introduce a National Food and Livelihood Security Act with the concurrence of the National Development Council for the purpose of paying integrated attention to important issues. These include conserving land, water, forests and biodiversity, and protecting the atmosphere; enhancing productivity through eco-technologies; improving distribution to eliminate endemic hunger; maintaining adequate food security reserves; strengthening the techno-infrastructure for better post-harvest technology; expanding the coverage of sanitary and phytosanitary measures; and developing efficient research, education, extension and marketing systems to take full advantage of emerging opportunities in international trade and to ensure that research and extension designed to promote the good of the public receive adequate support.

NEW STRATEGY

New technologies supported by appropriate services and public policies have helped prove doomsday predictions wrong and have led to the agricultural revolution (the Green Revolution) becoming one of the most significant of the scientific meaningful revolutions of this century. Four thousand years of wheat cultivation led to Indian farmers producing 6 million metric tonnes of wheat in 1947. The Green Revolution in wheat helped surpass in four years the production accomplishments of the preceding 4,000 years, thus illustrating the power of technological changes[4]. There are uncommon opportunities now to harness the power of a new social contract among science, society and public policy to address contemporary development issues like the growing rich-poor divide, feminisation of poverty, famine of jobs, human numbers exceeding the population supporting capacity of ecosystems, climate change and loss of forests and biodiversity.

Fortunately, modern information technology provides opportunities for reaching the 'unreached'. Computer-aided and Internet-connected 'Virtual Colleges' linking scientists and women and men living in poverty can be established at local, national and global levels for launching a knowledge and skill revolution. This will help create better awareness of the benefits and risks associated with Genetically Modified Foods, so that both farmers and consumers will get better insights into the processes leading to the creation of novel genetic combinations[5].

THE YIELD REVOLUTION

India's current position in the world in a few major crops is given in the table. In several crops, and more particularly in wheat, our farmers have

made striking progress. In 1947, we produced a little over 6 million tonnes of wheat; in 1999, our farmers harvested over 72 million tonnes, taking our country to the second position in the world in wheat production.

The high position we occupy in the production of several crops is to a considerable extent due to the large area covered under those crops. As will be evident from the data in the table, our position in productivity is, however, unenviable. In a way, this is a blessing since the yield gap represents an untapped production reservoir, from which we can derive benefit in the coming decades.

The position in pulses illumines the pathway for a new strategy in agriculture. We occupy the first position in the world in both area and production of pulses, but the 118th position in productivity. A major reason for our low average yield is the cultivation of pulses mostly under conditions where soils are both thirsty and hungry.

A Pulse Technology Mission now exists and it will be prudent to link it to the watershed development movement recently launched by the government. Our experience in organising Pulse Villages in the dry districts of Pudukkotai and Ramanathapuram in Tamil Nadu, India, indicates that we can make rapid progress in improving the production and productivity of pulses, provided the farming families of the village/watershed cooperatively undertake the harvesting of every drop of rain water. There will be no cooperation in water harvesting unless there is equity in water sharing. This is where high value but low water requiring crops play an important role in ensuring that the resource-poor farm men and women get maximum income from the available water.

Productivity improvement will be possible only if we pay greater attention to improving the efficiency of input use, particularly nutrients and water. To cite just one example, our cotton yields are less than 20 per cent of the yields achieved in several other countries such as Egypt and the USA. However, we are using 25 times as much water to raise a tonne of cotton as compared to that done by California. Normally, to produce 1 tonne of grain, about 1,000 tonnes of water may be needed but in most cases we are using much more[6].

To bridge the gap between actual and potential yields prevailing at the currently available levels of technology, we have to undertake a multidisciplinary analysis in different regions and farming systems. For example, in rice, which occupies the largest area among food crops, the opportunities for rapid progress are great. The growing availability of rice hybrids increases the prospects for rapid progress in productivity improvement.

WHEAT

We now occupy the second position in the world in wheat production. We grow bread, *durum* (macroni) and dicoccum wheats. In order to meet the needs of our growing population, it will be necessary to produce about 110 million tonnes of wheat by 2020[7]. This is entirely feasible both because of the untapped yield potential in several wheat growing areas and because of the possibility of introducing hybrid wheat. Our aim should be to become the number one country in wheat production by 2010. We should also produce in the Himalayan region hard wheats to satisfy the needs of automatised bakeries.

If we enable farmers with appropriate technologies, services, prices and markets, our average yield can go up to 42 quintals per hectare from the present 27 quintals per hectare. Yield improvement should be our goal in every crop and farm animal. This will be possible if our farm families can be helped to improve the efficiency of use of water, nutrients, plant protection chemicals, and post-harvest technology.

RESOURCE MANAGEMENT

The future of small farm families belongs to taking agriculture to precision, which involves the use of the right inputs at the right time and in the right way. Biotechnology will play an important role in all the following six

TABLE
India's current position and goal

Crop	Area (1,000 hectare)		Production (million tonnes)		Productivity (kg/hectare)	
	India	Highest	India	Highest	India	Highest
Wheat	25122 (3)	China 29001	72.0 (2)	China 109.005	2493 (32)	Ireland 8997
Rice	42700 (1)	India	82.2 (2)	China 190.100	2811 (51)	Ukraine 7444
Maize	6150 (5)	USA 29602	8.66* (9)	USA 236.604	1408 (105)	UAE 18636
Sorghum	11700 (1)	India	10.50* (2)	USA 20.39	897 (51)	France 6182
Potato	1089 (3)	China 3502	17.94* (6)	China 46.05	16478 (51)	Ukraine 43966
Pulses	25604 (1)	India	14.8 (1)	India	608 (118)	France 4769
Cotton	8300 (1)	India	14.0 (3)	China 18.75	922 (57)	Israel 4527
Sugarcane	3870 (2)	Brazil 4826	289.7 (2)	Brazil 324.435	65892 (34)	Peru 121361

Production figures for India are 1998-99 estimates taken from the Economic Survey. For the rest of the world, production figures correspond to the year 1996.
Figures pertaining to productivity and area correspond to the year 1996. Figures in parenthesis indicate rank.
** 1996 production figures used for these items.*

major components of integrated natural resources management and precision farming:

- Integrated Gene Management
- Efficient Water Management
- Integrated Nutrient Supply
- Soil Health Care
- Integrated Pest Management
- Efficient Post-harvest Management

Eco-technology based precision farming can help cut costs, enhance marketable surplus and eliminate ecological risks. This is the pathway to an Evergreen Revolution in small farm agriculture. It is now widely realised that the genes, species, ecosystems and traditional knowledge and wisdom that are being lost at an increasingly accelerated pace, limit our options for adapting to local and global change, including potential changes in climate and sea level. The Global Biodiversity Assessment estimates that about 13 to 14 million species may exist on our planet[8]. Of this, less than 2 million species have so far been scientifically described. In particular, our knowledge of soil micro-organisms is still poor. Also, biosystematics as a scientific discipline is tending to attract very few scholars among the younger generation.

Another important paradigm shift witnessed in recent decades in the area of management of natural resources is a change in the concept of 'common heritage'. In the past, atmosphere, oceans and biodiversity used to be referred to as the common heritage of humankind. However, recent global conventions have led to an alteration in this concept in legal terms. Biodiversity is recognised under the Convention on Biological Diversity as the sovereign property of the nation in whose political frontiers it occurs.

Under the UN Convention on the Law of the Sea, nations with coastal areas have access to a 200-mile Exclusive Economic Zone (EEZ)[9]. For example, the ocean surface available to India under the EEZ provision is equal to two-thirds of the land surface available to the country. The Climate Convention and the Kyoto Protocol provide for both common and differentiated responsibilities to countries[10]. Thus, the global commons can be managed in a sustainable and equitable manner only through committed individual and collective action among nations.

While we have some knowledge of variability at the ecosystem and species levels, our knowledge of intra-specific variability is poor, except in the case of plants of importance to human food and health security. The Global Biodiversity Assessment warns, "unless actions are taken to protect biodiversity, we will lose forever the opportunity of reaping its full potential benefit to humankind". What kind of action will help us ensure not only the conservation of biodiversity, but also its sustainable and equitable use? In my view, we must foster an Integrated Gene Management System in every state of the country.

The Integrated Gene Management System includes *in situ*, *ex situ* and community conservation methods[5]. The traditional *in situ* conservation measures comprising a national grid of National Parks and protected areas are generally under the control of government environment, forest and wildlife departments. The exclusive control of such areas by government departments has often led to conflicts between forest dwellers and forest dependent communities, and forest officials. The non-involvement of local communities in the past in the sustainable management of forests has resulted in a severe depletion of the forest resources in India. It has become clear that sole government control alone will not be able to protect prime forests or regenerate degraded forests

CONCLUSION

Attention to on-farm and non-farm employment with particular emphasis on women and landless labour families will be essential to provide access to food to the economically disadvantaged population. A massive investment in post-harvest technology and sanitary and phytosanitary measures and spreading awareness of food safety standards will be necessary to achieve both value-addition to primary products as well as to expand home and international trade in agricultural commodities.

Planning of agriculture in villages around towns and cities will help increase farmers' income and rural employment considerably, since urbanisation is accompanied by greater demand for horticultural and animal husbandry products. Above all, we must step up our efforts to attract and retain educated youth in farming through spreading science-based precision farming techniques which are both intellectually stimulating and economically rewarding.

The author is Director, M.S. Swaminathan Research Foundation, Chennai.

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ANNOUNCEMENT

On behalf of the Nutrition Society of India, I am pleased to announce that the Federation of Asian Nutrition Societies (FANS) at its recent meeting in Seoul, Korea, has unanimously accepted India's offer to host the IX Asian Congress of Nutrition-2003, under the Presidentship of Dr C. Gopalan.

B.S. Narasinga Rao
President
Nutrition Society of India

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