Agricultural Research and Education as related to the creation of a prosperous India

By

M.S. Swaminathan
Indian Agricultural Research Institute
New Delhi

I. Introduction:

It is well known that a dynamic agricultural development programme needs also to be supported by a dynamic research programme. The birth pangs of an agricultural revolution are in many cases more painful and more difficult of mitigation than that of an industrial revolution. Changes in the micro-environment of the plant which are essential for increased production also favour pests and pathogens. Double and triple cropping which is the only way of increasing production under conditions where the total land availability as well as well as the supply of essential inputs are not very elastic, brings in its wake serious and threatening problems such as the accumulation and spread of nematodes, the origin of new diseases and the depletion of the micro-nutrient status of the soil. Thanks to the work done at the Indian Agricultural Research Institute in cooperation with many state research institutes and the Rockefeller Foundation under all-India coordinated projects during the last few years, new vistas in crop production have opened up. It is hence likely that a certain degree of complacency might set in while evaluating the needs of agricultural research in the next few years. We have, before us, however the lessons of the developed nations, which have gone through these phases of agricultural growth and it is essential to benefit from them lest we take the country to the brink of an agricultural disaster rather than of an agricultural revolution. Short-sightedness now will land us in serious trouble and would prove to be also extremely expensive in the long run. Intensive culture of potatoes in Ireland led to the famous potato famine of the last century. A similar disaster has already taken place in the Nilgiri hills in India. Paddy blight is gaining momentum and the same is the case with alternaria disease of wheat and root wilt of coconut. Accentuated research is necessary not only to foresee these probable dangers and control them before they become menacing, but also to take advantage of the scientific explosion which the world has been witnessing during the past decade. Almost any problem can be solved now provided we have a research programme to match the magnitude and complexity of that problem.

In ~~a developing nation like~~ India the land has been under cultivation for several thousands of years. The high rate of loss of organic matter in the soils due to severe summers coupled with depleted fertility resulting from prolonged cultivation and various forms of erosion have depressed the basal fertility of the soils of such areas to very low levels. The varieties cultivated in such poor soils have been chosen largely on account of their adaptive characteristics and not on the basis of their productive ability. Due to a lack of integrated planning, the introduction of individual inputs like water has in many cases done more harm than good by creating problems of alkalinity and salinity. Only after a particular damage is done, is there usually a realisation of the importance of dealing with the consequences of different developmental measures on the basis of an action-reaction analysis. In a crop like rice, which is cultivated mostly in irrigated lands, excess of water rather than the lack of it seems to be a more important limiting factor as regards yield. Agricultural research hence calls for a consortium of talents and approaches.

To enhance agricultural production and to sustain the increased production over a long period of time, it is essential that a deep insight into the factors limiting crop yields is gained. The factors should be studied both individually and collectively. The new problems which may crop up when agriculture gets oriented along highly productive lines should be anticipated and watched, so that remedial measures become available before any of them poses a serious threat to the maintenance of high yields. For this it is essential to have an adequate number of well-staffed and well-equipped agricultural research Institutes. A dynamic research programme is a pre-requisite for a dynamic production programme.

II. Present State of agricultural research in India

a) Trained personnel: There are nearly 520 Agricultural Research Stations in India, out of which about 480 are run by the State Departments of Agriculture. The remaining comprises the Research Institutions and their Regional Stations managed by the Indian Council of Agricultural Research. There are 8 Agricultural Universities and 70 Agricultural Colleges. In the field of animal husbandry, there are 85 research stations and 19 veterinary colleges. Many of these stations and colleges are very small and ill-equipped and recently efforts have been initiated to reduce the number of stations and have a fewer number of good and well-supported Institutes. Research on most of the crops has been organised on an All-India basis with both the Central and State Institutions cooperating in the programme. There are nearly 5000 B.Sc. Ags. 820 M.Sc. Ags., and 80 Ph.Ds., produced each year by the Agricultural Colleges and Universities. About

1200 B.V. Scs., and 100 M.V.Scs.,are also produced each year. Thus, quantitatively a large number of trained persons are being produced each year. However, due to difficulties in getting equipment, books and modern teaching aids, it has not been possible to maintain even an average standard of education at all the colleges.. There is hence an urgent need for improvement in quality.

b) Equipment: Equipments of all types which can hasten the progress of research and increase the validity of the conclusions drawn, are extremely scarce in Indian laboratories. Critical physiological and biochemical experiments have to be conducted under controlled conditions of temperature, humidity and intensity and wave length of light. In annual plants, the number of generations that can be grown during a year can be trebled, if suitable facilities exist. Likewise, the generation time can be reduced in perennial plants if facilities for tissue and embryo culture are available.

There is urgent need for research on the design of efficient agricultural implements. The three main implements used in Indian farms - the country plough, sickle and hand hoe - were designed probably at the dawn of agriculture and are extremely inefficient in energy utilization. They need to be replaced as fast as possible. Also, the design and improvement of implements have to be dovetailed with breeding and agronomic research. For example, experience during the past two seasons ~~have~~ has shown that in the case of dwarf varieties of wheat, germination is poor if the seeds are sown below two inches from the surface of the soil. In the normal practice of sowing, the seeds fall at a depth of 4 to 6 inches. Hence, seed drills capable of sowing at different depths have to be designed and distributed.

c) <u>Research in relation to the improvement in the level of nutrition of the population</u>: One aspect of this problem relates to dietetics. Traditional food habits die hard and introducing a balanced diet in a question of both education and economics. The other part which is amenable to modification by research is the improvement of the quality of the principal cereals and grain legumes and production of more fruits, eggs, milk, fish and meat. For example, studies at the Nutrition Research Laboratory at Hyderabad have shown that unlike in the United States, pellagra in India is associated with the consumption of Sorghum (Jowar). In the development of pellagra the excess of leucine plays an important role. In the United States pellagra has been associated with the deficiency of tryptophan in maize. It has been found that a gene known as Opaque-2 increases greatly the content of lysine in the grain. Thus, through genetic manipulation it has been possible to control pellagra in the United States. If Jowar strains low in leucine are developed in India, pellagra can be likewise controlled. This is just one example to show how an important nutritional disease can be eliminated through identifying the casual factor and rectifying the deficiency by breeding.

Proteins are in short supply in most of the under-developed countries. In India the vegetarian habit of a considerable proportion of the population adds to the difficulty in ensuring a proper protein balance in the diet. Genetic studies have shown that there are strain differences in protein content. Also, by spraying urea at the time of grain development it is possible to enahnce the protein content to a great extent. This problem will have to be studied both from a quantitative as well as qualitative angle, since as already indicated, deficiencies or excesses of specific amino acids could have undesirable effects. The grain legumes also need to be studied critically from a quality aspect as well as for yielding ability. There is much scope for improving the quality of the feeds and fodder fed to cattle and poultry so that the plant-animal-man food chain may gain in both quantity and quality. At present only very limited facilties exist at the Indian Agricultural Research Institute, New Delhi, for studying problems relating to quality. It is obvious that if the aims of improving the level of nutrition of population are to be achieved, there should be a considerable expansion in the staff and facilities available for work on quality.

III. Recent research in relation to the yield potential of crops

In a 4-hectare plot in the Botany Division of the Indian Agricultural Research Institute, yields of the order of 6 tons of wheat, 6-7 tons of maize, 5-6 tons of jowar and about 4 tons of bajra per hectare have been obtained during the last two years. It appears possible now to get a minimum of 5 tons of grains per hectare by growing two crops a year if facilities for irrigation and adequate quantities of fertilizers are available. The implications of this development with regard to agricultural production are obvious. To produce 100 million tons of food grains, the country ought to need only 20 million hectares if all the results of scientific work can be adopted on such an area.

The principal ingredients of the scientific revolution in production possibilities are the following:

a) Evolution of varieties and hybrids with great genetic potentialities for yield:

Many of these varieties or hybrids have been developed during the last four years under All-India coordinated projects sponsored by the Indian Council of Agricultural Research and carried out in collaboration with the Rockefeller Foundation. Besides hybrids of maize, jowar and bajra, high yielding varieties of wheat and rice are also now available. These new strains are very efficient in the utilization of both solar energy and chemical energy in the form of fertilizers. In addition, they are resistant to lodging and hence can profit fully from irrigation.

b) Optimum plant population per acre:

This is a very important factor in determining the ultimate yield obtained. The slogan most relevant to India today is 'Reduce the density of human population in our homes and increase the density of plant population in our fields'. The ideal plant population per acre in the case of maize, jowar and bajra are respectively 20,000, 55,000 and 40,000. If a good plant population is to be maintained, out-moded irrigation practices have to be changed.

c) Optimum fertilizer dose:

For getting more yields it is obvious that more nutrition has to be given to the soil. To get the types of yields mentioned earlier, it is necessary to apply about 80-100 lbs. of nitrogen, 50 lbs. of phosphorus and 30 lbs. of Potash per acre. When yields are high, the other elements like sulphur, zinc and boron which are normally not needed also get depleted in the soil. Hence in areas where an intensive cropping pattern is followed, it would be advisable to supply these micro-nutrients. It would be prudent to apply a basic dose of micro-nutrients as a routine procedure, rather than commence their application after their need becomes obvious though foliar and other symptoms.

d) Pest and disease control:

The kharif crops like maize, jowar and bajra are badly affected by various insect pests. For producing high yields, it is necessary to adopt proper plant protection measures. Hybrid jowar, in particular, is susceptible to heavy damage by insects.

e) Time of application of fertilizers and irrigation:

Where heavy doses of fertilizers are being applied, it is important that 75% of the dose of N is given at the time of sowing. Growing vigorous young seedlings, rather than rejuvenation of old plants should be the aim. Irrigation at the time of grain development is essential for high yield in wheat. While this cannot be done with a tall strain, dwarfs permit such a practice. Wheat yields are generally low even in irrigated lands in north India, because of the fact that the crop is seldom irrigated during the month of March when temperature rises rapidly and grain development is in progress.

Recent releases:

Jowar: Two different hybrids named: CSH-1 and CSH-II, have been released for cultivation. CSH-I is suitable for the early and medium duration kharif areas and for the irrigated summer tracts. It was produced by crossing a male sterile line called Combine Kafir 60 with a yellow endosperm Feterita known for its high carotene content. This is a short variety which will be ready for harvest in about 3 months and is capable of yielding 4-5 tons per hectare. The second hybrid named CSH-II is suitable for cultivation in the mid-late kharif tracts all over the country. It was developed by crossing male sterile Combine Kafir 60 with a yellow endosperm Hegari strain. It takes about 110-120 days to mature and has white pearly grains. It is medium tall growing about 6' in height. It gives 30-40 per cent more yield than CSH-I and about 6 tons per hectare can be easily obtained. To get maximum yields, the right combination of fertilizer dose and population density has to be evolved.

Bajra:- This crop is one of the poorest yeilding in our country and has been traditionally associated with both poor soils and poor farmers. A hybrid named HB-I was released early this year. This hybrid was developed by the Punjab Agricultural University, Ludhiana. It takes about 75 days to mature and gives yields of about 4 tons per hectare. Over 300 hybrids are currently under trial and a new hybrid developed at the I.A.R.I. is very promising. In addition to hybrids, promising varieties are also being developed and seeds of one dwarf variety which can yield about 3-4 tons per hectare are being multiplied.

Maize:- Ganga-3, a hybrid released last year particularly for cultivation in rotation with rabi crops like wheat, is becoming extremely popular in the country. It can give about 6 tons per hectare. In addition to the eight already released hybrids, very promising synthetics or complexes are now being developed since the farmer can keep his own seeds of these strains unlike in the case of hybrids where he has to purchase the seeds each year. Some of the complexes developed in India have proved to be the best yielders in countries like Thailand and Indonesia.

Fodder crops:- The Pusa Giant Napier grass which has already spread all over the country can now be profitably rotated with the Pusa Giant Berseem which is a man-made strain. Pusa Giant Berseem released this year for cultivation was produced by artificially doubling the chromosome number of normal berseem. The berseem which our farmers grow has 16 chromosomes, while Pusa Giant Berseem has 32 chromosomes. This is the first strain to be released in India by the technique of artificial chromosome doubling. Berseem gives fodder throughout the winter months while Pusa Giant Npaier gives fodder throughout the summer months. It is essential that such high yielding fodder crops are grown by our farmers in a small area in their land so that the cattle can have adequate green fodder throughout the year.

Pusa Giant Napier, an outstanding perennial grass hybrid, evolved at the Division of Botany, has established itself as a high forage yielding crop under irrigated conditions throughout the country. It gives 2500 to 3000 quintals per hectare per year of green matter. It contains 25 per cent more protein and 12 per cent more sugar than the Napier grass. However, the hybrid is susceptible to cold wdather and does not show much vegetative growth during the winter months in northern India. In order to make up for this non-productive period, Pusa Giant Berseem, has been tried as an inter crop in the fields of Pusa Giant Napier. The tetraploid variety gives 40 per cent more green fodder than the normal diploid berseem. It is estimated that the introduction of Pusa Giant Berseem in rotation with Pusa Giant Napier would not only result in an additional 800 to 1000 quintals of green fodder per hectare per year, but would also ensure outflow of green fodder from the same plot throughout the year. Pusa Giant Berseem can also be expected to provide a protective cover against incidence of frost, to which the Napier grass is susceptible. Furthermore, the introduction of the legume is expected to increase the productive capacity of the Pusa Giant Napier fields, by restoring soil fertility.

Wheat:- The dwarf Mexican wheats introduced into India in 1963 by the I.A.R.I., have undergone extensive testing all over the country during the past two seasons. Two of them, Lerma Rojo and Sonora 64, have been found to be sufficiently promising as to warrant their large scale cultivation under heavy manuring, where lodging becomes a limiting factor in yield. The Ministry of Food and Agriculture arranged for the import of 250 tons of seeds of these two varieties during 1965, and the seeds have been sown in Government Seed Farms and by progressive farmers particularly those belonging to the National Tonnage Club. Lerma Rojo is a medium-late, semi-dwarf variety with a high degree of resistance to all the rusts, while Sonora 64 is a dwarf and early variety which is ideal for being grown in rotations like paddy-wheat, cotton-wheat etc. Sonora 64 is highly resistant to black and brown rusts and will not lodge even when grown in soils fertilized with about 200 lbs. of nitrogen per acre. It is the most lodging resistant variety now available. In addition to these two varieties, the varieties N.P.846, N.P.818 and N.P.202 suitable for cultivation in the hilly regions were also approved for release during ~~this year~~ 1965. These hill wheats are highly resistant to rusts and if they are grown widely in all our hilly areas, the problem of rusts in the plains will become very much reduced. Another interesting development during 1965 is the removal of the red colour, from the grains of the Mexican dwarf wheats, by treating them with atomic radiations. For getting the maximum yields from the dwarf wheats, irrigation during the month of March is a must. The seeds of these varieties should be sown rather shallow (not below two inches), since otherwise the seedlings will not emerge from the soil.

<u>Possibilities in genetic manipulation of fertilizer response:</u>

That there are varietal differences in the relative efficiency of utilization of Nitrogen are obvious from several studies, ~~data from one of which are given in Table 7~~. Since the application of fertilizers and water will shift the micro-environment of the plants in a direction which is favourable also for the growth and spread of pathogens and pests, a high degree of genetic resistance should be built into varieties which are recommended for cultivation in irrigated and fertilized soils. This brief account would be sufficient to indicate that such genetic engineering can be done quickly and effectively now.

IV. Need for a dynamic research programme

The above outline of some recent research would be adequate to show that through the development of suitable varieties or hybrids and of agronomic and manurial practices best suited for bringing out the yield potential of the strain, it is possible to achieve very high yields. The ultimate yield obtained depends upon several interacting and inter-dependent factors. Therefore, there is need for integrated research as well as for adequate arrangements for the supply of the various production inputs. Intensive agriculture brings in its wake new problems in the form of new diseases and pests as well as deficiencies of micro-nutrients in the soil. For example in the Punjab where there has been a large improvement in the yields of crops like rice, wheat and maize during the last few years, deficiency of sulphur in the soil has started to act as a limiting factor on yield. Virus diseases are becoming a menace in many crops and the damage is very severe particularly in the case of perennial plants like coconut, cardamum and several forest trees. Nematodes are spreading and are assuming epidemic proportions in certain areas. Intensive research on these aspects is hence a must if we are to maintain a high level of productivity.

One aspect of research which has a special possibility in the tropics and sub-tropics is the study of the photo-synthetic ability of crop plants. It is well known that the efficiency of utilization of solar energy by most plants is very low and that even a slight improvement in this efficiency on a field scale will result in considerable gains in production. The morphological, genetic and physiological attributes which could result in increasing the efficiency of utilization of solar energy need critical study. Problems of this type are many and have to be carefully isolated for evolving priorities in research. In plantation crops like rubber, the experience already gained in Malaya suggests that hormone injections could stimulate greater yields. The spread of Arabica coffee in India is dependent upon the evolution of disease resistant strains. Physiological research relating to quality aspects in tea is another urgent need. Extensive hybridisation between the two jute yielding species Corchorus olitorius and Corchorus capsularis can give rise to ideal varieties.

Research in the field of animal sciences has to strike fresh paths and for this, it needs both additional facilities and know-how. Experiments on the control of sex determination in cattle through techniques like semen density-gradients are extremely important to a country like India where beef is not widely consumed and as such, selective production of females would be preferable. In silk worms, techniques for sex determination at the cocoon stage would be valuable, since in this way the males alone can be reared.

V. Formulation of sound land-use policies

This is an extremely important aspect needing very careful study since a sound land use pattern has to be evolved both on the basis of maintaining the long term productivity of the soil and of self-sufficiency in essential food requirements. In the past, the cropping patterns had often tended to follow an unscientific trend. For example, the yield of sugarcane in the tropical part of India is nearly twice as that of the sub-tropical part. Nevertheless a large part of the area under sugarcane in the country is in the sub-tropical

VII. Agricultural Education

As mentioned earlier, we have now over 70 Agricultural Colleges in the country and 8 Agricultural Universities. There are 19 Veterinary Colleges. During 1964 nearly 5,000 B.Sc. Ag's., 820 M.Sc. Ag's and 76 Ph.D's were produced by these Institutions. In animal science, about 1,200 B.V.Scs. and 100 M.V.Scs were produced. If all these graduates are to subserve any useful purpose, we must improve the quality of the agricultural graduates as well as in-grain into them a love for practical farming and familiarity with the latest production techniques. It might be useful to assign a group of 30-40 students to a specific village for an entire crop season during the last year of their formal education and to assess their performance on the basis of a specific achievement. Unless agricultural graduates learn agriculture and not merely about agriculture, their utility and effectiveness would be very low.

VIII. Requirements:

The pace of progress of agricultural research is very slow by modern research standards. The work is bound up with seasons and an abnormal season leads to the loss of a year from the point of view of research. It is hence necessary to provide more sophisticated and efficient research tools in the hands of agricultural scientists. Efforts should hence be made to provide the following:

(a) Equipment needed for carrying out the work speedily and on a scale commensurate with the needs. Machinery for land development, equipment for creating controlled environment and modern biochemical and radiochemical instruments are particularly needed.

(b) Requirements in the form of books, chemicals and other needs such as travel for participation in scientific symposia. A survey has already been made of the badly needed equipment for some of the major research Institutes in India and it would be desirable to make such an assessment as essential part of the projections for the Plan period. Steps should be taken to find means of providing the equipment and facilities indicated as essential by the survey.

If we organise agricultural research on a scale commensurate with the needs of the diversity and extent of our agriculture, we can lay the foundation for obtaining high yields on a sustained basis.

B.Lal/

Table 1

Performance of Indian Sorghum hybrid in Brazil

Variety or Hybrid	Yield of dry seeds kg/Ha
MS x IS 3691 (C.S.H.$_2$)	3,669
MS 630	3,353
RS 608	3,224
DEKALB 81-5 x 11	3,134
NK 221	3,122
RS 610	3,103
KS 652	2,986
NK 125	2,843
MS x IS 532	2,743
DEKALB C 44B	2,719
LINDSEY 788	2,551
SD 451	2,526
DEKALB E 56 A	2,479
SD 503	2,361
TEXAS 660	2,200
SD 441	1,938
SH 10	1,350
DEKALB SX-11	1,295
SD 102	1,009
Is 1056	898

Table 2

Yield performance of some maize materials from India in South-East Asia

Pedigree	Indonesia				Thailand	
	Bogor		Wonosoho		Prabuddabat	
	Kg/ha	% of local	Kg/ha	% of local	Kg/ha	% of local
ETO AMARILLO X DORADO DE TEQUISATE	5592	134	4231	117	3018	122
ETO X FERGUSON YELLOW DENT	6987	168	2010	56	-	-
SYNTHETIC 2	6510	157	3050	85	-	-
COMPOSITE B 1	5978	144	2953	82	3143	124
COMPOSITE A 1	-	-	-	-	3143	124
GANGA 101	5557	134	3704	103	-	-
GANGA 2	6365	153	3514	97	-	-
DECCAN	6264	151	4080	113	-	-
LOCAL	4156	100	3605	100	2500	100

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