THE STORY OF GREEN REVOLUTION IN INDIA*

BY

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I feel privileged to have this opportunity to pay homage to the memory of Dr. Rajendra Prasad who was the President of the Indian Society of Agricultural Statistics for 16 years from its inception. The topic I have chosen to speak on this occasion is perhaps an appropriate one in view of Rajen Babu's keen interest in agricultural and rural development not only when he was our Union Minister for Food & Agriculture and the President of India, but also during the days of struggle for Freedom. More than anybody else he truly represented the rural peasant of India.

2. Agriculture in India had all along been more a mode of living than a commercial enterprise. By and large, traditional or subsistence-agriculture was practised, which was characterised by low productivity resulting in backwardness and poverty in the rural areas. Most of the inputs were produced on the farm and the output was barely sufficient to meet the farmers' own needs. Meanwhile, the population explosion came about significantly increasing the number of persons depending on the limited land resources.

3. After Independence agricultural development received attention in the successive Plans. Production of foodgrains increased from about 60 million tonnes in 1949-50 to about 89 million tonnes in 1964-65. Impressive though this increase was, it was still inadequate to meet the growing needs of the rapidly increasing population and rising standards of living.

4. During this period, imports of foodgrains had to be stepped up and the target of self-sufficiency in foodgrains seemed

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elusive. Then came the crises of 1965 and 1966 as a consequence of one of the severest droughts of the Century. Steep fall in foodgrains production, scarcity conditions over large parts of the country and rising prices led to widespread distress. Some foreign observers even predicted that millions would die of starvation. The Prophets of Doom were proved wrong. We could meet the situation with prudent management of available supplies and generous assistance of friendly countries by way of gifts and imports of cereals on concessional terms. It is during this period of crisis that simultaneously with efforts to meet the food scarcity the new strategy for agricultural development was adopted to increase our food production through the application of science and technology. With the adoption of the new strategy the fortunes of Indian agriculture have taken a new turn of late and has given rise to a new feeling of confidence and hope of attaining self-sufficiency in foodgrain production within a foreseeable future. An era of Green Revolution in the Indian agriculture has started. Last year, production reached the level of 100 million tonnes of foodgrains and this year last year's record is likely to be excelled.

5. The genesis of the Green Revolution makes an extremely interesting and even exciting story. Till recently, the average wheat yield had been not more than 13 quintals per hectare even in areas with assured irrigation facilities and very much lower in the rainfed areas. Scientific research for improvement of wheat dates back in India to the early years of this Century. The work done under the leadership of Sir Albert Howard at the then Imperial Agricultural Research Institute led to the development of certain new varieties which yielded about 3 tonnes per hectare under propitious conditions of weather and good management. Greater attention was paid in later years to the development of varieties resistant to the rust diseases, which took a severe toll of wheat crop in many years. Still, all these notable researches did not result in high enough increase in yields. This has been due to the fact that the tall Indian varieties lodged under good conditions of soil fertility and their long duration of growth and development, exposed them to high temperature during the critical stage of grain development. It, therefore, became evident that considerable increase in wheat yields could only be achieved by introducing short-term dwarf wheats which are capable of responding positively to good management and high doses of fertilisers and because of short-duration, they would escape the soil and atmosphere drought of early summer months.

6. With a view to developing dwarf wheat varieties suitable for cultivation in India, leading Agricultural Research Organisations, notably the Indian Agricultural Research Institute, introduced in 1963 a broad spectrum of dwarf wheat germplasm from Mexico, thanks to the generous help and cooperation of the Rockefeller Foundation and the Mexican Ministry of Agriculture. The exotic varieties were tested in all the wheat growing regions of the country during 1963-64 and 1964-65, and also subjected to extensive physiological, pathological, chemical and agronomic tests. Two purely Mexican varieties, Lerma Rojo and Sonara-64, were adopted for cultivation in irrigated areas. A large quantity of 18,000 tonnes of high yielding varieties of wheat seeds were imported from Mexico which facilitated their cultivation over large areas in North India. At that time there were doubts and reservations regarding the wisdom of importing such large quantities. It was feared that we might be taking undue risks in introducing these high yielding varieties of wheat and paddy which had not been tested adequately for pest and disease resistance. But as one who was responsible for taking decisions during those crucial days, I knew that there was very little choice before the country. The risk involved was worth taking and we took a calculated risk, which had paid very rich dividends. Along with the introduction of the Mexican varieties the process of evolving new varieties was initiated. In fact, most of the imported varieties were adapted and even improved in several respects by the Indian scientists. New varieties like Kalyan Sona, Sonalika, Safed Larma and Chhoti Larma were also later released for cultivation under irrigated conditions.

7. The record bumper wheat crop to the tune of about 16·5 million tonnes harvested in 1967-68, as compared to 12·3 million tonnes in 1964-65, was in a very large measure due to these high yielding dwarf wheat varieties. In parts of the Punjab, farmers harvested an average wheat yield of 47 quintals per hectare, a figure approaching the national average of the Netherlands which has the world record. The Government of India, therefore, befittingly commemorated the phenomenal wheat crop of 1967-68 by releasing a special postage stamp on the 17th July, 1968. The wheat output in 1969-70 reached the high level of 20 million tonnes and the prospects for the current year are even brighter.

8. The Green Revolution in India which is largely the result of a breakthrough in wheat production, is neither a stroke of luck

nor an accident of nature, for, the success of new strategy is based on sound research. In the case of wheat, half-way round the world, in Mexico, new high yielding dwarf varieties were designed, bred and developed after two decades of aggressive research. The original source of dwarfness was the Norin 10, an extremely dwarf variety from Japan. Along with the breeding of the new varieties, the production technology which permitted these varieties to express their high genetic grain yield potential was also developed. With proper cultivation practices, these new dwarf varieties could yield twice or thrice as much as the old tall varieties.

9. Originally, the dwarf varieties imported from Mexico carried a wider spectrum of disease resistance than the local Indian types that they replaced. The newer Indian varieties are even better in resistance and are of a different genetic type than the original introductions. This great diversity reduces the danger from disease epidemics although such dangers cannot be eliminated. Even developed countries like the USA are not free from such unexpected and destructive epidemics. A southern leaf blight of maize affected large areas of USA during the summer of 1970. The only protection against such epidemics is through varieties developed by intelligent, persistent and diversified breeding programme coupled with a broad disease surveillance system and a sound plant pathology programme to support breeding programme.

10. While we regard the phenomenal increase in wheat yields as the main component of the Indian Green Revolution, other cereal crops also have played a crucial role in achieving this revolution. Of these, special mention should be made of maize, sorghum, bajra and paddy.

11. The beginning of last decade saw the development and cultivation of hybrid maize capable of yielding over 5 tonnes per hectare. However, hybrid maize cultivation was impeded often by lack of good quality seeds which have to be made available for sowing season after season. The difficulty was ingeniously overcome by the plant breeders by evolving strains called 'composites' which combine the good traits of many races and varieties, through a long drawn process of selection so that they breed true over generations yielding about 5 to 7.8 tonnes per hectare and possess a fair degree of resistance to diseases.

12. Some of the improved varieties of Sorghum capable of yielding 6 to 7 tonnes per hectare were released for general cultivation during the middle sixties. Moreover, these varieties matured early and are adapted to wide environmental conditions. They also yield as much as 2 to 3·5 tonnes per hectare even under low rainfall conditions due to their early maturity. Hybrid bajra was also simultaneously released. These varieties matured early and were capable of producing stable yields of about 2·5 tonnes per hectare.

13. Although paddy has been one of the major foodgrain crops in the country being cultivated over some 35 million hectares, its average yield is only 1·1 tonnes per hectare (in terms of rice) in contrast to over 4 tonnes in Japan. As in the case of wheat the tall Indian variety of paddy is mainly responsible for the low yields as these varieties lodged under heavy fertilisation. Therefore, in mid-sixties, the dwarf *Indica* variety, Taichung Native-1 and the variety IR-8 developed at the International Rice Research Institute, Philippines, which is popularly known as the "miracle rice" in many parts of South East Asia, were introduced into the country. These short duration dwarf varieties are capable of yielding 8 to 10 tonnes per hectare. However, they suffered from a marked susceptibility to diseases and their grains were initially rather coarse and glutinous, thus affecting their consumer appeal which led to some marketing problems in some of the major rice producing States. Nevertheless, these dwarfs opened up new possibilities of increasing low rice yields. Efforts are being made by the Indian scientists to evolve high yielding varieties of paddy with better quality, short duration and greater resistance to pests and diseases, under the All-India Coordinated Rice Research Project. So far 15 new varieties have been released, some of these to suit upland areas, others to suit water-logging conditions and still others with better quality of grain. Rice is a more sensitive crop—sensitive to its environment. It is more exacting in its requirements of water. It is grown mostly in the kharif season in coastal areas with erratic monsoon. Although many varieties suitable to upland areas or rabi/summer cultivation have been evolved, satisfactory varieties suitable to kharif season have yet to be evolved. Also varieties with greater resistance to pests and diseases particularly blast, blight and tungro virus have yet to be bred into these varieties. Research currently in progress under the All-India Coordinated Research Scheme promises to yield results in a year or two.

14. In fact, these high yielding dwarf exotic varieties of wheat and rice formed the main basis of the High-Yielding Varieties Programme launched by the Government of India. The programme was originally expected to cover 32·5 million acres by 1970-71— a target which is likely to be exceeded.

15. It is evident that the significant breakthrough in yields of many important food crops would have been impossible but for the efforts of dedicated teams of research workers all over the country. The efficient dissemination of this knowledge among the farmers and winning over their cooperation is the most crucial factor that has brought about the Indian Green Revolution. In this context, the Intensive Agricultural District Programme initiated by the Government of India in 1961, the National Demonstration Programme launched in 1965 and the High-Yielding Varieties Programme now being implemented played significant role to dispel the apathy and suspicion of the farmers and win them over to whole-heartedly cooperate in bringing about this heartening change in the Indian agricultural scene. The remunerative prices offered to the cultivators is also a favourable factor. The change of attitudes in the Indian farming community which is the result of a healthy dialogue between the farmer and the scientists through extension workers is, perhaps, the most remarkable as well as the most important result of the Green Revolution, since the continued success and consolidation of our future agricultural advancement would essentially depend upon this factor. This, in short, is the remarkable and the fascinating story of the beginning of the Indian Green Revolution.

16. Never before in the history of agriculture has a transplantation of high yielding varieties coupled with entirely new technology and strategy, been achieved on such a massive scale in so, short a period of time and with such great success. The success of this transplantation is an event of great scientific and social significance.

17. In the words of Norman E. Borlaug, "The All-India Coordinated Wheat Improvement Programme taken up by the Indian Council of Agricultural Research, which is largely responsible for the wheat revolution in India has developed as one of the most extensive and widely diversified wheat research programmes in the world. Its success had generated confidence, a sense of purpose

and determination. Current agronomic research on wheat in India equals the best in the world. The breeding programme is huge, diversified and aggressive. Already it has produced several varieties which surpass those originally introduced in Mexico in 1965."

18. The revolution in wheat and rice production in India not only greatly increased food production but it had also many indirect effects on both the farmer and the economy. The Green Revolution has also made the Government improve many of its public services by way of communications, storage, etc., marketing and processing facilities, agricultural credit, etc.

19. However, it is not out of the way for me to point out the problems and difficulties which baffle or elude the scientist, the administrator and the farmer, since the gains of the currrent agricultural transformation have to be consolidated and enhanced in view of the importance of agriculture in the Indian economy and the fact that agriculture employs 70% of the country's working population and contributes nearly to half the national income.

20. While a quantitative assessment of impact of Green Revolution will be of interest to many, specially to the agricultural statisticians, we may not lose sight of some of the main lines of approach for intensification of the current Green Revolution. As you all know, the nutritional problem in India forms part of a large and intricate complex. In addition to a quantitative increase in food production, improvement in nutritive quality of our food crops also needs to be brought about. New cropping patterns and agronomic practices designed to give optimum results under varied agro-climatic conditions in the country and to suit different holdings have yet to be evolved. While a beginning has been made in this direction, much more remains to be done.

21. Conditions which results in luxuriant plant growth are favourable for the outbreak of pests and diseases also. This calls for intensification to battle against new diseases and pests that are likely to crop up, through adoption of scientific plant protection measures.

22. The adoption of the new technology is likely to bring in its trail new post-harvest problems—these are problems of plenty.

As such there is a need for developing a suitable post-harvest technology to meet the challenge of the situation. Suitable storage facilities congenial to Indian conditions have to be provided to suit the requirements specially of the small and medium farmers. Processing facilities need to be expanded and organised on modern lines. Greater transport facilities are to be arranged for taking the inputs to the farmer and taking the output to the markets.

23. Progress means change and change gives rise to new problems. Modernising Indian agriculture through transformation of traditional agriculture will definitely create new problems. What is necessary is to anticipate the problems and to take remedial measures to meet those problems. This requires that the scientific research has to be placed on a sound footing and that the scientists should be of the highest calibre so that they could meet the challenges that might be posed by the new technology. I am glad to say that after the reorganisation of the Indian Council of Agricultural Research, the research base in the country has improved considerably. Earlier there used to be a large number of small research schemes undertaken by different Central and State institutions, each one not knowing what the other was doing. This has been replaced by all-India Coordinated Research Programmes for each of the major crops and for the major disciplines under which all aspects of a programme are looked after in a unified and co-ordinated way and at different stations. This has resulted in more efficient and effective research effort, which has earned the appreciation of the world scientists.

24. Agricultural scientists have an important role to play in this transformation. In fact, it is a great recognition given to the agricultural scientists when Dr. Norman G. Borlaug, an agricultural scientist, received the Nobel Prize for Peace this year. There can be no peace when there is hunger and malnutrition all round. The hunger and malnutrition can be eradicated only through increase in agricultural production in a wider sense including animal husbandry and fisheries which contribute to the provision of a balanced diet.

25. The Green Revolution has been confined to the irrigated areas alone and the lot of the farmers of the unirrigated areas remains more or less unameliorated. Even in the irrigated areas the small farmers have been lagging behind. It is needless to point

out that the revolutionary change in agricultural scene has accentuated the already wide socio-economic gap that existed between the farmers of these more fortunate regions and those of areas largely dependent on the vagaries of monsoon, as also between the large and small farmers. The small farmers can also adopt the new technology, but the only constraint is resources. If the Government provides credit, for investment on suitable terms, they also could, participate in the agricultural prosperity. The Government have started new programmes for setting up Small Farmers Development Agencies to make arrangements for the provision of credit, etc.

26. With regard to the rainfed areas, appropriate technology to suit these areas has to be developed taking into consideration topographical features, soil characteristics, rainfall pattern, etc., as expeditiously as possible. Even here, there is scope for applying known technology and the Government have taken up pilot projects for dryland agricultural development. Simultaneously, a coordinated research scheme has been started for evolving suitable techniques for adoption in these areas.

27. One of the major tasks of the National Commission on Agriculture is to make a comprehensive review of the current progress and problems of agriculture and make recommendations for modernising it with a view to promoting the welfare and prosperity of the people. The Commission would no doubt examine what further steps are required in terms of scientific research, administrative arrangements, institutional reforms, etc., for achieving results similar to those achieved in the case of wheat in respect of other crops and for extending the application of science and technology in other spheres, like animal husbandry, poultry, fisheries, forestry, etc. The problems are no doubt complex, but what is needed now is for the Government to take specific policy decisions in regard to certain critical areas of agricultural development and enforce them unflinchingly. We in the National Commission on Agriculture have accordingly selected certain priority areas for study and appraisal. These include: the arrangements for further application of science and technology to agriculture, control on quality of seeds and fertilisers distributed to the farmers, supply of credit, particularly to the small farmers and tenants, land reforms, and also pilot projects for creating employment potential. In these

efforts, we seek the cooperation of scientists in every sphere and, I am sure, agricultural statisticians who have assembled here have an important role to play in the formulation, progressing and evaluation of agricultural development programmes and thus contribute to the success of the developmental efforts in the agricultural sector.