1

Genesis and Growth of the Yield Revolution in Wheat

2013 marks the fiftieth anniversary of the commencement of a yield revolution in wheat in India, caused by a modification in plant architecture and physiological rhythm. The wheat revolution represented a significant landmark in India's agricultural history. Its genesis and growth have been analysed earlier. Here, the steps that led to the wheat revolution in India have been briefly summarized.

The Bengal Famine (1942–43) provided the backdrop to India's independence. The average yields were below 1t/ha in wheat and rice. As a result of the tall and thin straw, the then cultivated varieties were not responding well to fertilizers or irrigation. Dr K. Ramaiah, the first Director of the Central Rice Research Institute (CRRI), Cuttack, proposed that one should transfer genes for fertilizer response from *japonica* to *indica* rice varieties. This was the beginning of the breeding of high-yielding varieties, which subsequently led to 'the Green Revolution'. I worked at CRRI on the *indica-japonica* hybridization programme for sometime in 1954, before joining the Botany Division (later named by me as the Genetics Division) of the Indian Agricultural Research Institute (IARI), New Delhi. Dr B. P. Pal, Director of IARI and an eminent wheat breeder, agreed to my desire to work on semi-dwarf and fertilizer-responsive varieties of wheat using multiple research strategies, including radiation-induced erectoides mutants, on the lines of the work done by Professor A. Gustafsson in Sweden on developing the erectoides mutants of barley. Dr Pal warmly supported the proposal and mentioned that breeding wheat varieties, which can respond to fertilizer application was the need of the hour. Unfortunately, all the semi-dwarf strains the author produced by different approaches had also reduced panicle size and hence a lower yield potential.

In 1955, I learnt from Dr H. Kihara, the famous Japanese wheat scientist, that Dr Gonziro Inazuka of the Norin Experiment Station had semi-dwarf varieties with long panicles (i.e., without any pleiotropic effect) and that these were being used by Dr Orville Vogel in Pullman, Washington State, USA, in his winter wheat breeding programme. I wrote to Dr Vogel and he was kind enough to send seeds of the semi-dwarf variety *Gaines*. He, however, also wrote that being a winter wheat, *Gaines* may not flower in Delhi. He, therefore, suggested that I approach Dr Norman Borlaug in Mexico who had incorporated the same dwarfing genes in a spring wheat background.

Dr Borlaug had entered some of his semi-dwarf material in the International Wheat Rust Nursery trials organized by the US Department of Agriculture (USDA). Dr M. V. Rao and I studied this material in 1961 at the IARI and were very impressed with the new plant type. I, therefore, requested Dr Borlaug to send a wide range of breeding material containing the *Norin* dwarfing genes. He promptly offered to send the seeds and expressed a desire to visit India to study the growing conditions before making a set to send to us. It took more than a year for the visit to materialize. He finally came to Delhi in March 1963, when he and I travelled all over the wheat belt in North India. Several of my colleagues like Dr S. P. Kohli, Dr M. V. Rao and Mr V. S. Mathur also accompanied him in some of the trips.

At the end of the field trips, I decided on the following roadmap: Dr Borlaug would send by September 1963 about 100 kg seeds of each of the four Mexican semi-dwarf strains, namely *Sonora 63*, *Sonora 64*, *Mayo 64* and *Lerma Rojo 64-A*, selected on the basis of their good performance in Pakistan. I also requested him to send a wide range of segregating material (F2 to F7) so that one could make selections possessing resistance to the prevailing races of wheat rusts (stem, leaf and stripe rusts) as well as desirable culinary properties. I gave high priority to the genetic checkmating of wheat rust races. I explained to him that selection from crosses made in Mexico will help in purchasing time, since the quantity of wheat imports under the US PL480 programme was increasing each year (it reached a level of 10 million tonnes in 1966).

The seeds from Mexico arrived in early October 1963. I immediately arranged their sowing at Indore, Kanpur, New Delhi, Ludhiana, Pant Nagar and Pusa (Bihar). Thus, a multi-location trial was organized in the very first year of this programme. Agronomic research was also started immediately under the overall guidance of Dr O. P. Gautam at the Agronomy Division of the IARI, since it was clear that changes in several agronomic practices like depth of sowing, time of first irrigation, etc., would be needed in the case of the semi-dwarf strains. The agronomic practices needed in case of the new plant type were standardized within a short time. Similarly, plant pathologists, led by Dr R. Prasada and Dr L. M. Joshi, identified rust-resistant strains and biochemist Dr A. Austin assessed the chapati-making quality of the new varieties. Dr Borlaug was full of praise for this inter-disciplinary teamwork, particularly for the speed with which India developed new varieties from the segregating populations sent by him. The segregating material helped one breed outstanding semi-dwarf varieties like *Kalyan Sona* and *Sonalika*, possessing amber grains and good yield potential. In contrast, the Mexican dwarf wheat had red grains. *Kalyan Sona* and *Sonalika* proved to be very popular with farmers. Consumers liked their chapati-making quality. Since then, hundreds of high-yielding varieties of *Triticumaestivum*, *T.durum* and *T.dicoccum* have been released by wheat scientists working under the All India Coordinated Wheat Improvement Project sponsored by the Indian Council of Agricultural Research (ICAR).

Based on analysis of the results of the multi-location trials conducted during 1963–64, I concluded that the time had come to launch a yield revolution in wheat based on semi-dwarf, fertilizer- and irrigation water-responsive varieties. I, therefore, proposed in June 1964 the organization of 1,000 national demonstrations in the fields of farmers with small holdings for introducing the new plant type to them. I emphasized that the demonstrations should be in the fields of resource-poor farmers, since the success of demonstrations in rich farmers' fields would be attributed to affluence and not to technology. The Ministry of Agriculture had some reservations about this approach, but the then Minister for Food and Agriculture, Mr C. Subramaniam, overruled the objections and approved the programme in August 1964. In the national demonstration plots, laid out during 1964–65, small farmers harvested 4 to 5 t/ha of wheat in contrast to less than 1 t/ha in the control plots. The success of the national demonstrations unleashed the enthusiasm of farmers and a small government programme became a mass movement.

In 1964, a National Tonnage Club of Farmers was organized, the membership of which was confined to farmers producing about 2 t/ha of wheat or other crops. Thus, the seeds of the yield revolution were sown in the minds and outlook of small farmers. In 1964–65, because of the success of the national demonstrations, the clamour for new seeds grew rapidly. I devised a two-pronged strategy for purchasing time in terms of seed multiplication. First, Jounti village in Delhi was organized as a seed village. Seed technologist Dr Amir Singh, who knew the villagers well, played an important role in convincing them that they should take to the production of seeds of the new varieties. The second aspect of the strategy was to get bulk quantities of seeds from Mexico: 200 and 18,000 tonnes of seeds of wheat vars *Lerma Rojo* and *Sonara 64* in 1965 and 1966, respectively. These imports were done as part of the 'purchase time' strategy. We then sent a team comprising Dr S. M. Sikka, Dr S. P. Kohli and Mr Vijayaraghavan to Mexico to purchase the seeds. They did a superb job and the seeds arrived by mid-September.

Wheat production reached a level of 17 million tonnes in 1968, in contrast to 12 million tonnes four years earlier. On my suggestion, Ms Indira Gandhi and the then Agriculture Minister Mr Jagjivan Ram released a special stamp titled 'Wheat Revolution' in July 1968. The stamp had a picture of the IARI library building, to symbolize the role of science in the transformation of yield potential in wheat.

In 1968, about four million tonnes of additional wheat became available due to the high-yielding varieties programme. Most of this belonged to the red grain Mexican wheat Var Lerma Rojo. The Agricultural Prices Commission recommended an addition of ₹ 5 per quintal for amber grain varieties. It was clear that such a difference would dissuade farmers from growing the Mexican varieties during the following year. I mentioned to Mr Tony Dias, the then Food Secretary, that India should announce a uniform support price for amber and red grain varieties. He was kind enough to take me to Minister Mr Jagjivan Ram to explain the reasons why one should have a uniform price. After hearing my arguments, Mr Jagjivan Ram announced in Parliament a uniform minimum support price of ₹ 65 per quintal for all wheat varieties. This decision played a catalytic role in spreading the new high-yielding varieties on a large scale during the *rabi* season of

Cambridge University Press
978-1-107-12311-3 - Combating Hunger and Achieving Food Security
M. S. Swaminathan
Excerpt
More information

1968–69 and in subsequent years. Meanwhile, I and others had intensified our work in developing new varieties with the desired culinary quality characters. Mr V. S. Mathur played a key role in the development of a range of very high-yielding and high quality varieties. The early coordinators of the All India Coordinated Wheat Improvement Project, Dr A. B. Joshi, S. P. Kohli and M. V. Rao, played an important role in getting the new material tested all over the country for their yield potential and disease resistance properties. Dr. Glen Anderson of Canada, whose services were provided by the Rockefeller Foundation, was a pillar of strength of the coordinated programme. After his initial visit in 1963, Dr Borlaug invariably used to come for seven to 10 days each year in March to study the progress being made both by scientists and farmers. His visits were a source of inspiration to all of us who worked with him.

An important factor in stimulating accelerated growth in wheat productivity and production was the unhesitating support given by political leaders to scientific ideas. Mr C. Subramanian was a pillar of strength throughout the three years he served as Food and Agriculture Minister (1964–67). Mr Lal Bahadur Shastri, through his slogan 'Jai Jawan Jai Kisan' highlighted the critical role of farmers in not only feeding the nation but also in safeguarding its sovereignty. It was, however, Ms Indira Gandhi who clearly saw the link between food self-sufficiency and India's ability to adopt an independent foreign policy. She was also responsible in getting the television programme 'Krishi Darshan', aimed at disseminating information on new agricultural technologies to the farmers. The programme was launched in January 1967. It played an important role in ushering in the Green Revolution. The programme is still running and helping in improving agricultural productivity.

These few examples provide a flavour of the atmosphere prevailing in the 1960s with reference to the interaction between scientists and political leadership. Ms Indira Gandhi's decision to build up substantial grain reserves, often against the advice of the Planning Commission, helped India take an independent view on important issues, including the decision to carry out nuclear implosion tests at Pokhran in1974 and 1998.

The term 'Green Revolution' refers to all crops where there has been a yield breakthrough. India's High-Yielding Varieties Programme, initiated in 1967, included wheat, rice, maize, *jowar* (sorghum) and *bajra* (pearl millet). It must be emphasized that the Green Revolution became possible only because of synergy between technology, public policy and farmers' enthusiasm. Public policy with reference to input and output pricing, and assured and remunerative marketing was absolutely essential to get the economics right and thereby sustain farmers' interest in producing more. This also became clear from the somewhat disappointing results of Dr Borlaug's efforts in Africa, where there was no arrangement for procuring the surplus grains from farmers at an assured minimum support price, thus underscoring the fact that high-yielding varieties alone would not help accelerate production, unless coupled with other essential inputs, particularly remunerative prices for the produce and assured marketing opportunities.

I captured the keenness of farmers in the following words:

> Brimming with enthusiasm, hardworking, 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.

On the occasion of his receiving the Nobel Peace Prize in 1970, Dr Borlaug was gracious enough to write:

> The Green Revolution has been a team effort and much of the credit for its spectacular development must go to Indian officials, organisations, scientists and farmers. However, to you, Dr Swaminathan, a great deal of the credit must go for first recognising the potential value of the Mexican dwarfs. Had this not occurred, it is quite possible that there would not have been a Green Revolution in Asia.

These developments emphasize that there is no miracle in agricultural progress – it involves hard and integrated work with concurrent attention to all links in the production, marketing and consumption chain. There would have been no wheat revolution without public procurement from farmers and without the work done by India's wheat scientists in breeding very speedily high-yielding varieties with amber grains and good *chapati*-making quality.

I would also like to make a brief reference to the transition from Green to Ever-Green Revolution in agriculture. In January 1968, I made the following statement in my Presidential address to the Agricultural Sciences Section of the Indian Science Congress held at Varanasi:

> Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally-adapted varieties with one or two high-yielding

> strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened during the Irish Potato Famine of 1845. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us into an era of agricultural disaster in the long run, rather than to an era of agricultural prosperity.

This statement was made early in 1968 before Dr William Gaud coined the term ‘Green Revolution’. To achieve an evergreen revolution, India needs technologies, which can help farmers improve productivity in perpetuity without associated ecological harm. By mainstreaming ecological principles in technology development and dissemination, India can achieve sustained and sustainable advances in productivity.

The scientific and public policy initiatives described above led to the Green Revolution of the 1960s. Among them, sharply focused inter-disciplinary research and international collaboration are important. Eternal vigilance is the price of stable agriculture and this will call for concerted and continuous attention to soil and plant health and to the scientific checkmating of the adverse impact of climate change. At the public policy level, assured and remunerative marketing opportunities hold the key to stimulating and sustaining farmers’ interest in achieving higher productivity and production. This is what made it possible for India to confer a legal right to food with home-grown food to about 70 per cent of India’s population through the National Food Security Act. Higher consumption creates the market essential for farmers to produce more. This is the pathway to shape India’s agricultural future.