Trust in the Seed

Bhagirath Choudhary
Kadambini Gaur

ISAAA

International Service for the Acquisition of Agri-biotech Applications, popularly known as ISAAA, is a not-for-profit international public charity and is supported by both public and private sector institutions.

ISAAA's mission is to contribute to poverty alleviation by sharing knowledge freely, and utilizing biotechnology to increase crop productivity and income generation, particularly for small and resource-poor farmers in developing countries, and to bring about a safer and more sustainable crop production system .

ISAAA's objectives are: to share knowledge freely on crop biotechnology; facilitate the transfer and delivery of appropriate biotechnology applications to small and resource-poor farmers in developing countries; build partnerships between institutions in the South and the private and public sector in the North; strengthen South-South collaboration.

For more information about ISAAA visit: www.isaaa.org

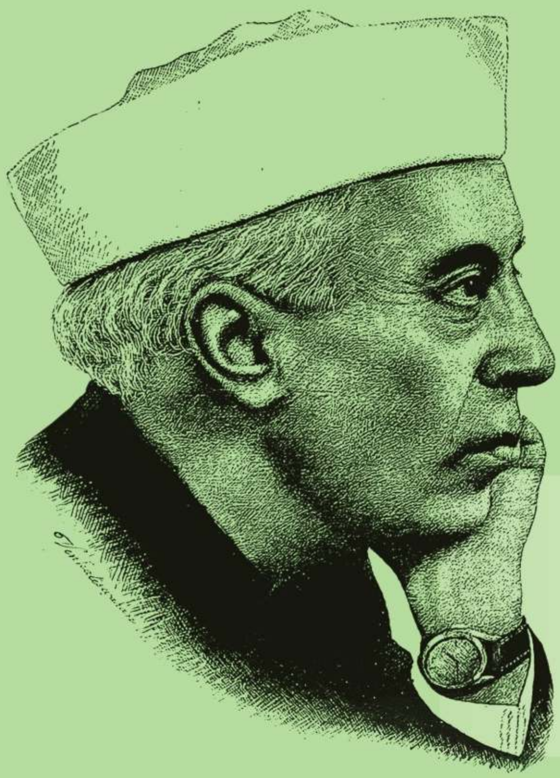
Citation: Choudhary, B. and Gaur, K. 2008. Trust in the Seed, ISAAA publication, ISAAA: New Delhi, India

ISBN: 978-1-892456-45-1

Contents

The Power of the Seed

Agriculture continues to be the backbone of the people and economy of India. Agriculture provides a livelihood for the majority of 600 million rural people who live in half a million villages spanning the length and breadth of India. For villagers and farmers, agriculture is a life style, agriculture is a festival, agriculture is a tradition and is by far, the largest industry in India. In a true sense, agriculture not only provides a livelihood to millions of small resource-poor farmers but is literally a life-line for 1.1 billion rural and urban Indians who depend directly or indirectly on agriculture for their sustenance. India's economic growth and prosperity as a nation depends on an annual rich harvest of crops, the principal source of food, feed and fiber. If agriculture grows, India grows!



"Everything else can wait, but not agriculture".

– Pandit Jawaharlal Nehru

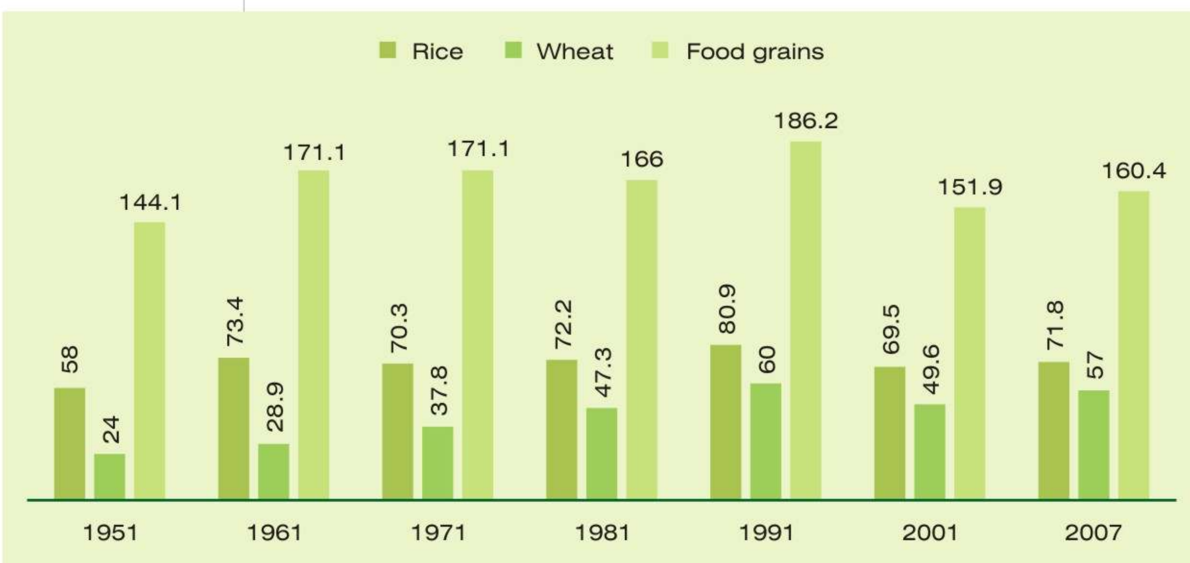
Pandit Jawaharlal Nehru, the first Prime Minister of Independent India, in his address to the nation 'India's tryst with destiny' on the eve of India's independence underscored the importance of agriculture by stating "Everything else can wait, but not agriculture."

Agriculture has been the top priority in the national planning agenda in the last 60 years since India's independence. Prior to the Green Revolution of wheat and rice, in the mid 1960s, the Agriculture Gross Domestic Product (GDP) registered only a modest annual growth of 2.5 per cent, compared with an overall 3.7 per cent growth in the national GDP. The lean years of 1950 to 1965 were a period of severe shortages, famines and food crises. In contrast, during the post Green Revolution decades of the 1980s and 1990s, India achieved self-reliance in food production with agricultural GDP growing at 3.5 per cent and 3.7 per cent respectively; the latter period marked the beginning of national economic reforms (Economic Survey, 2008).

1. Nehru in wheat field with farmer

The agriculture sector was the main beneficiary of the Green Revolution technologies of the 1960s that enabled India to transform itself into a country self-sufficient in food. Food grains production increased at an average annual rate of 2.5 per cent compared with a population growth rate of 2.1 per cent during the period of 1950-51 to 2006-07. The surplus food production substantially increased per capita consumption of rice, wheat and total food grains. The per capita availability of wheat increased by 150 per cent, from 24 kg per annum in 1951 to 60 kg per annum in 1991. At the same time, total food grains availability increased by 30 per cent from 144.1 kg per capita per annum in 1951 to 186.2 kg per capita per annum in 1991 (Figure 1). The considerable increase in food grains production improved farm income, increased farm based activities, reduced poverty and ensured food security.

Figure 1. Per Capita Availability of Food Grains in India, 1951 to 2007 (in kg per capita per annum)



2. Farmer with IR-8 rice harvest

Opportunities and Challenges

Food Security

In the last decade, the trend in growth of staples such as rice, wheat and total food grains has been stagnant, with per unit productivity plateauing and annual per capita availability of food grains declining, from a high of 182.6 kg in 1991 to 160.4 kg per annum in 2007. The per capita net food grains availability has fallen sharply by 12 per cent or by 22.2 kg from 1991 to 2007. The annual per capita availability of wheat and rice, the most important staple food in India has also declined since 1991 (Figure 1). The decelerating trend in availability of food grains, particularly in staples, is threatening food security as there is an increased demand for food grains for an ever growing population. In 2007 the National

3. Farmer in lush green rice field, Haryana

Commission on Population estimated that India's population will be 1.2 billion in 2011, and 1.4 billion in 2026 (Census of India, 2001). Population growth coupled with rapidly improving living standards for several hundreds of millions of people will increase demand for food, feed, fibre and fuel many fold. Coincidentally, land, water and other resources that are vital for improving productivity are diminishing (National Policy for Farmers, 2007).

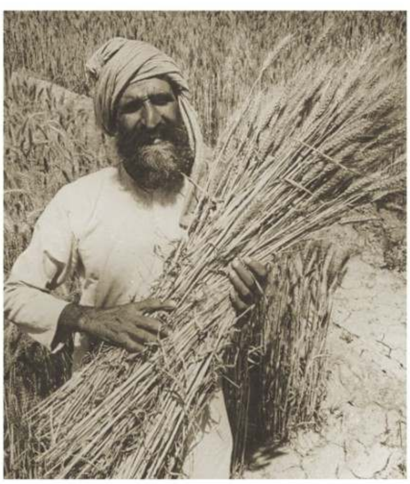
Another daunting challenge is to bridge the widening disparity in per capita income between agriculture and other sectors. Agriculture's share of GDP has declined steadily from 36.4 per cent in 1982-83 to 18.5 per cent in 2006-07. This is a big cause of concern for a country of 1.1 billion people where agriculture continues to provide a livelihood to over 600 million people and is the major source of employment for 52 per cent of the workforce. Therefore, it is vital to deploy new technologies and substantially increase investment in R&D to achieve the desired growth in agriculture which is essential for India's stability and prosperity. Crops are the principal source of food, feed and fiber and increasing per unit area of crop productivity is the primary means to achieve the desired national goal of food security. The resurgence of a well planned and resourced national initiative is essential for achieving robust growth of the national economy and ensuring food, feed, fibre and fuel security.

In the past, the introduction of technologies to improve seeds has been the key contributing factor to quantum increases in wheat and rice productivity and total food grains production in India. Notably, three significant developments in improved seeds and crop technologies have changed the face of Indian agriculture and contributed to increased food production and the alleviation of poverty and hunger.

First Development

The Green Revolution

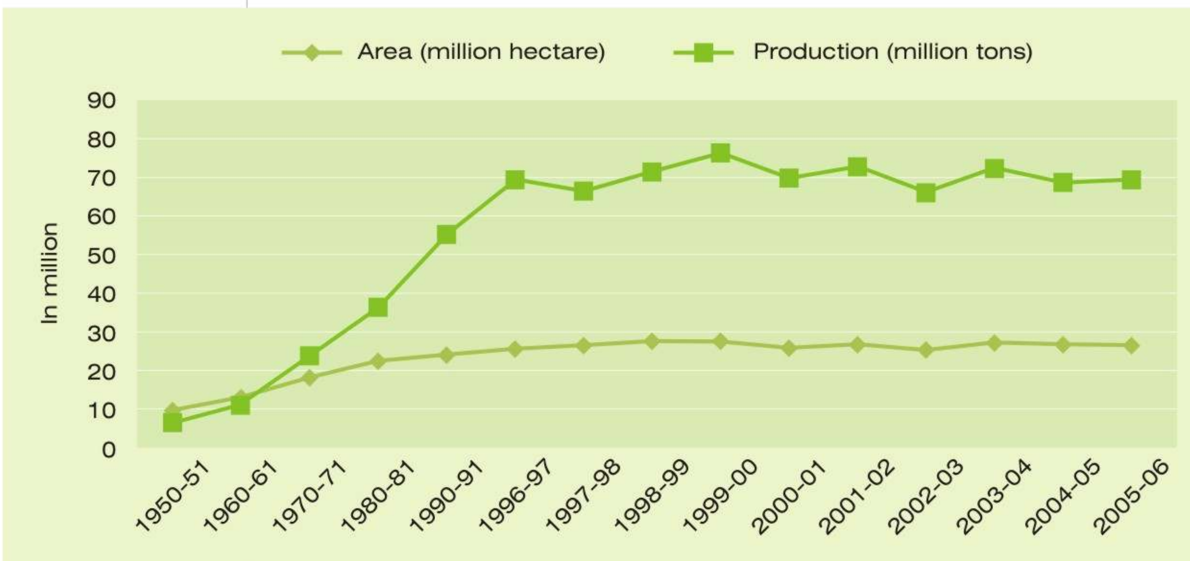
4. Farmer with wheat harvest, Punjab



The first major development was the Green Revolution in the 1960s and 1970s which resulted in unprecedented increases in food production. The introduction of high-yielding, semi-dwarf wheat and rice varieties doubled production in a short span of five years, 1965-66 to 1971-72. Wheat production increased from 10.4 million tons in 1965-66 to 26.4 million tons in 1971-72. The same period witnessed a doubling of wheat yield from 827 kg/ha to 1380 kg/ha. Growth in wheat production continued until 1996-97 when India achieved its highest wheat production of 69.3 million tons with a productivity of 2679 kg/ha (Figure 2). Similarly, in 1996-97 rice production increased to 82 million tons (Figure 3) with a productivity of 1900 kg/ha (Ministry of Agriculture, 2008).

5. Dr. Norman Borlaug and Prof. M. S. Swaminathan at IARI, 1965

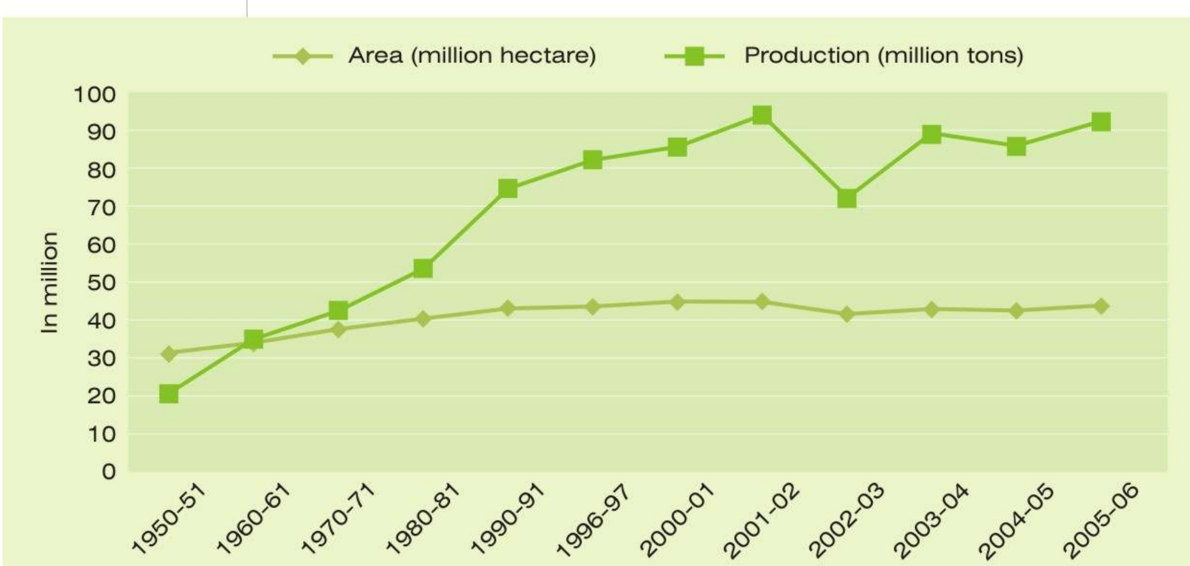
Figure 2. Trend in Wheat Production, 1950 to 2006



It is important to note that the Green Revolution technologies had an enormous impact only on wheat and rice which led to substantial increases in the main staples. Pulses and oilseeds which are important crops nutritionally for every household in India got inadequate attention during the Green Revolution period. Significant growth in production of pulses and oilseeds crop was not observed until the late 1980s. Since then, there have been some moderate increases in productivity growth of pulses but this has not been comparable to the high growth of wheat and rice during the Green Revolution (Figure 4).

The impact of the semi-dwarf wheat varieties, a new wheat seed, was far reaching. Everyone realized the significance of the improved seeds. To commemorate the quantum jump in wheat production, the then Prime Minister

Figure 3. Trend in Rice Production, 1950 to 2006



6. Farmers threshing wheat crop

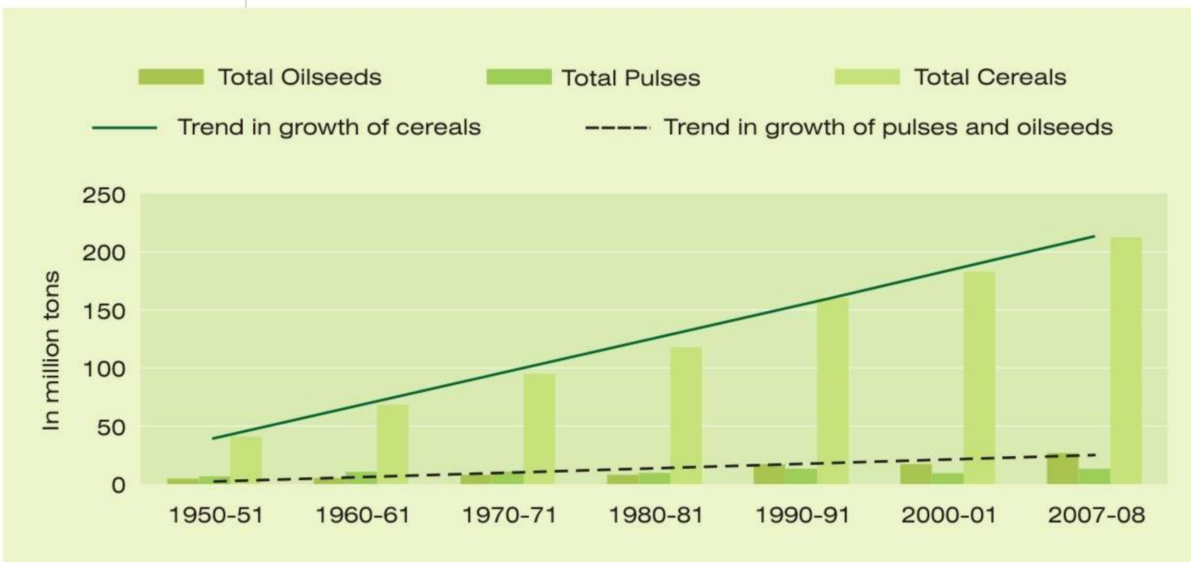
Development of semi-dwarf, high-yielding wheat varieties

The development of semi-dwarf Norin 10 wheat cultivars was a painstaking R&D work spanning three decades, which involved a group of scientists from Japan, USA, Mexico and India. Norin 10 wheat cultivars featured two very important genes, Rht1 and Rht2 that dwarfed wheat plants to a height of only two feet, compared with the usual four feet. This dwarfing produced wheat plants that were less prone to lodging (plant falling-over); with improved uptake of nutrients and more responsive to fertilizers.

Dr. Norman crossed Norin 10 wheat cultivars with Mexican traditional wheat varieties and obtained semi-dwarf, US winter adapted wheat cultivars called 'Gaines' at the International Wheat and Maize Improvement Center (CIMMYT) in Mexico. Four lines of semi-dwarf, high-yielding Gaines varieties of wheat, Sonora 63, Sonora 64, Mayo 64 and Lerma Roja 64A were imported and evaluated at different locations in 1963-64 and 1964-65 by the Indian Council of Agricultural Research (ICAR) under the leadership of Prof. M.S. Swaminathan. Notably, Sonora 64 and Lerma Roja 64A out-yielded the best national checks, NP 824 and C 306 by 17% and 22% respectively and were released for cultivation in irrigated areas by the Government of India.

Subsequently, these two semi-dwarf varieties were back-crossed with local strains resulting in the development and release of four new semi-dwarf, high-yielding, rust-resistant, fast-maturing and locally-adapted wheat varieties namely, Kalyansona, Safed Lerma, Sonalika and Chhoti Lerma, of which Kalyansona and Sonalika became highly popular in all the wheat growing regions of India. It is noteworthy that, farmers promptly adopted these semi-dwarf wheat varieties on millions of hectares. It transformed India from a begging-bowl to a wheat and rice surplus country (Ramanujam, 1980; Swaminathan, 2006; Singh and Kulshrestha, 1996; the Economist, 2005).

Figure 4:
Trend in Production of Cereals, Pulses and Oilseeds, 1950 to 2008



of India Mrs. Indira Gandhi released a postage stamp entitled 'Wheat Revolution' at the Indian Agricultural Research Institute (IARI), New Delhi on 17 July, 1968 (Picture 8).

The timely deployment of semi-dwarf, high-yielding wheat and rice varieties in mid 1960s literally saved millions from hunger in India. Dr. Norman Borlaug was awarded the Nobel Peace Prize in 1970 for developing the semi-dwarf wheat varieties, which were credited with saving 1 billion lives in Asia, the majority in India. The Government of India honored him with the 'Padma Vibhushan' award in 2006. In the same year, he was awarded the Congressional Gold Medal, the USA's highest and most distinguished civilian award. Dr. Borlaug's counterpart in India was Dr. M.S. Swaminathan, the recipient of the first World Food Prize in 1987.

7. Prof. M. S. Swaminathan receiving the World Food Prize

"Poverty and not ignorance is often responsible for resource -poor farmers not taking to new technologies"

Prof. M.S. Swaminathan, National Academy of Agricultural Sciences, February 16-28, 2005, Pune , India

8. Release of Postage Stamp on Wheat Revolution

Second Development

Hybrid Seeds

The second development was more modest and associated with the introduction of hybrid seeds which replaced open pollinated varieties (OPVs) primarily in selected vegetable crops such as brinjal, bottlegourd, cabbage, capsicum, chilli, okra, onion and tomato and in field crops such as castor, cotton, maize, pearl millet, sorghum and sunflower in the 1980s and 1990s. Whereas hybrid seeds need to be replaced by farmers every year, they offer an attractive incentive to both large and small farmers because of the significant yield gains from hybrid vigor, and moreover they provide an important technology platform for enhancing productivity in a sustainable manner in the longer term.

Development of hybrid seeds

In India, the first hybrid seeds of field crops were developed and released for cultivation as early as 1962 for pearl millet, sorghum in 1964, maize in the 1960s, cotton in 1968, sunflower in 1974, rice in 1994. For hybrid vegetables, bottlegourd was released in 1971 and tomato in 1973. Hybrids are bred to exploit vigor by improving seeds. The first generation hybrids were developed for open pollinated crops as it was relatively easy to exploit hybrid vigor in those crops. The second generation hybrids were developed in self-pollinating and naturally inbred crops like rice which present more difficulties. Some of the hybrids are based on the heterosis system and others on the cytoplasmic male sterile (CMS) line system, where three lines are required to exploit hybrid vigor.

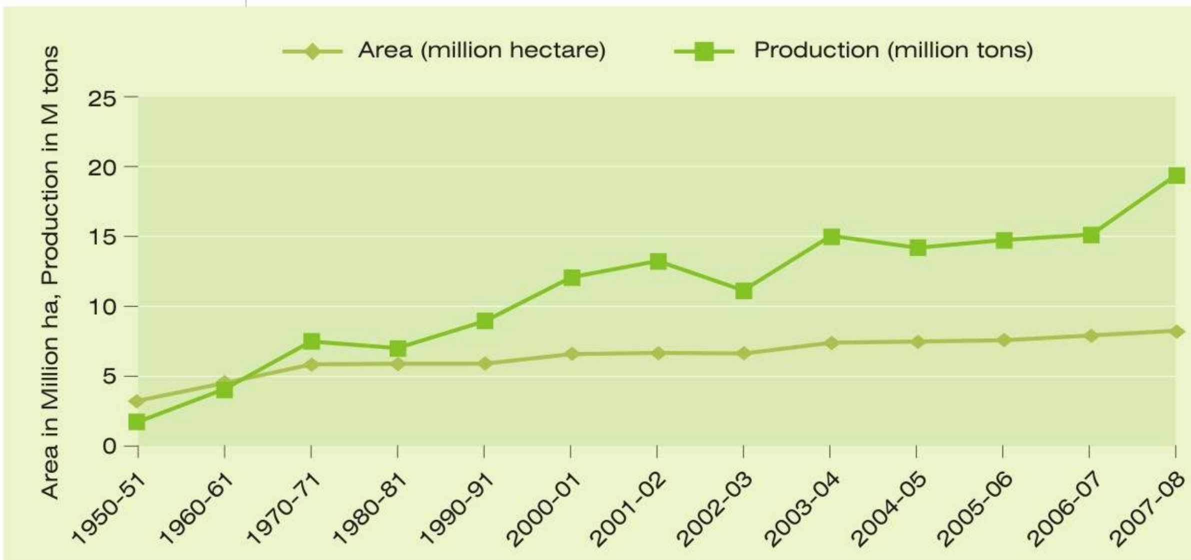
9. Hybrid Pearl Millet Pusa-23 crop standing in field

The coarse cereals, pulses, oilseeds and vegetables emulated the success of Green Revolution with the introduction of hybrid seeds. Later, the development of disease resistant hybrid seeds helped achieve remarkable increases in productivity particularly in pearl millet, sorghum and cotton - crops of rainfed and desert areas where hybrid seeds were adopted by millions of farmers. Pearl millet production which had been constant at between 3 to 5 million tons over many years, increased rapidly to 9.79 million tons in 2007-08, doubling in yield from 452 kg/ha in 1971-72 to 1,030 kg/ha in 2007-08. Similarly, the impact of sorghum hybrids was equally impressive with yield almost tripling from 353 kg/ha in 1950-51 to 981 kg/ha in 2007-08. As a result of higher productivity, the area under sorghum declined sharply over the last six decades whilst production increased to 7.78 million tons in 2007-08 (Figure 5).

10. Hybrid Sorghum MRS 4649 in research field of Mahyco

Figure 5.
Area, Production and
Yield of Sorghum
in India, 1950 to 2007

Figure 6.
Trend in Maize
Production in India,
1950 to 2008



A significant impact in production was also observed in maize which is a key food and feed crop. Maize yields in India was 547 kg/ha in 1950-51, the lowest yield in the world. Between 1950-51 to 2007-08, maize production increased from 1.73 million tons to 19.3 million tons, a 12-fold increase. Maize yield increased from 547 kg/ha to 2,337 kg/ha in 2007-08, a 330% jump in yield. It was mainly due to a substantial increase in the proportion of maize hectarage planted with hybrid seeds, which was approximately 60% of the total maize area (Figure 6) in 2007-08 (Ministry of Agriculture, 2008).

11. Dr. B. R. Barwale receiving the World Food Prize


12. Hybrid Chilli


13. Hybrid Tomato

A similar trend of adopting hybrids was noticed in other field crops such as castor, sunflower and cotton and it is projected that high adoption of hybrid rice and eventually wheat will improve food grains production substantially in India.

A major change in the cropping system was witnessed with the introduction of early maturing, short duration hybrid seeds. Hybrid seed technology allowed farmers to plant a second crop after harvesting the principal crops, such as pearl millet, sorghum and cotton. This has enabled farmers to increase farm income ensuring a better livelihood for their families.

Figure 7.
Vegetable Production in India, 1991 to 2006

From the 1980s onwards, hybrid varieties of bottlegourd, tomato, brinjal, okra, chilli, onion, muskmelon, cucumber, capsicum and cabbage were introduced for commercial cultivation (Rai and Mauria, 1996). Farmers across India rapidly adopted hybrid vegetables. Most of these hybrids are marketed by private vegetable seed companies in India. Hybrid seeds occupied as much as 90% of the total area of cabbage and tomato by 2005-06. Cabbage production doubled from 2.77 million tons in 1991 to 5.92 million tons in 2006 and yield increased by 42% (Indian Horticulture Database, 2006).

Tomato production registered a growth of 120% over the period 1991 to 2006, an increase from 4.24 million tons to 9.36 million tons. There was a similar trend in increased production and productivity of other hybrid vegetables. As a result, vegetable production almost doubled in the last 15 years, from 58.5 million tons in 1991 to 93.8 million tons in 2000 to 109 million tons in 2006 (Figure 7). The contribution of private seed companies in improving seeds was recognized when the World Food Prize Foundation awarded Dr. B.R. Barwale with the prestigious World Food Prize in 1998.

Third Development
Biotech Crops

The third major development was in 2002, which featured the application of biotechnology to crops which led to the approval and commercialization of Bt cotton, the first biotech crop in India. Bt cotton hybrids are incorporated with a new insecticidal gene(s) sourced from the common soil bacterium *Bacillus thuringiensis* that confers resistance to the critically important lepidopteron insect-pests, cotton bollworms. The Bt cotton experience in India is a remarkable story, which has clearly demonstrated the enormous impact that can be achieved by adopting genetically modified hybrid seeds. In the short span of six years, 2002 to 2007, cotton yield and production doubled as indicated in Figure 8 (Cotton Advisory Board, 2007). The profitability almost doubled and insecticides application was almost halved. The introduction of Bt cotton hybrids transformed India from an importer to an exporter of cotton. Bt cotton has achieved unparalleled success in India simply due to the multiple and significant benefits it consistently delivers to farmers and it is reflected in the unprecedented 125 fold increase in Bt cotton hectarage between 2002 and 2007 (James, 2007).

Development of biotech crops

Biotech crops or genetically modified crops are developed by introducing new gene(s) isolated from organisms (such as bacteria) unrelated to plants with the help of genetic engineering tools which otherwise would not have been possible by conventional breeding. Biotech crops carry desirable traits such as insect resistance, herbicide tolerance and abiotic stress tolerance etc. Due to its precision, predictability and versatility, genetic engineering technology has the potential to accelerate crop improvement and has already yielded encouraging results. Biotech crops allow farmers to cut cost of production by substantially decreasing pesticides applications and also increasing yield significantly. The insect-resistant Bt crops are the first generation of genetically modified crops that are developed to confer resistance to specific insect-pests. Bt crops carry an additional gene or a combination of genes derived from the soil bacterium *Bacillus thuringiensis* that provides in-built protection against targeted insect-pests.

14. Maize hybrid

Bt cotton hybrid seeds allowed farmers in India to benefit from a 39% reduction in insecticides, a 31% increase in yield and a 88% increase in profitability which is equivalent to a $250 gain per hectare, or more. These gains in crop production are unprecedented (Mayee, 2008). In 2007 alone, 3.8 million small farmers in India elected to plant 6.2 million hectares of Bt cotton hybrid seeds - the fastest adopted seed technology in the recent history of agriculture, outperforming the adoption rate of semi-dwarf high-yielding varieties of the Green Revolution period. The vote of confidence of farmers in Bt cotton is also reflected in the "litmus-test" trust which confirms that more than 9 out of 10 farmers who planted Bt cotton in 2005 also elected to plant Bt cotton in 2006, and the figure was even higher in 2006-2007. This is a very high level of repeat adoption for any crop technology by industry standards and reflects the level of trust in the technology by small resource-poor farmers who have elected to make the additional investment in Bt cotton because of the superior returns and benefits it offers over conventional hybrid cotton and even more over open- pollinated varieties.

Figure 8. Area, Production and Yield of Cotton in India, 2002 to 2007

15. Bt Cotton hybrid

In addition, genetically modified hybrid seeds, Bt cotton in this case, offer significant environmental and socio-economic benefits including lower insecticide residues in the soil and aquifers, and significantly less farmer exposure to insecticides. With the substantial increased farm income from Bt cotton welfare benefits such as better health care for women with more prenatal visits, and more vaccinations for children are emerging in the Bt cotton growing zones in India, and generally a better quality of life for small resource-poor farmers and their families. Thus, Bt cotton is already contributing to the alleviation of poverty of small resource-poor farmers, who represent the majority of the acutely poor in India, and who play a critical role to produce cotton and other commodities for India's burgeoning population.

16. Farmer in Bt Cotton field

India experienced a remarkable success with Bt cotton. Apart from safety and benefits to human beings and environment, Bt cotton also contributed to a more sustainable agriculture. Bt technology offers unprecedented benefits and there has not been any credible evidence to the contrary in relation to safety of animals and human health.

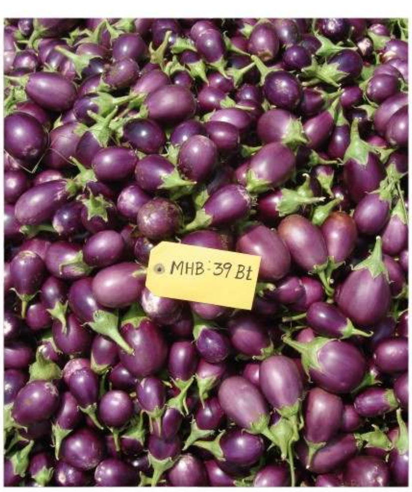
Bt Brinjal

In the context of this publication, the development of Bt brinjal is an appropriate and timely step because it will extend the proven significant benefits of Bt from a fibre crop, cotton, to a food crop, brinjal, which is important for small resource-poor farmers, consumers and Indian society at large. The adoption of Bt brinjal by farmers and consumers in India will be a very important experience from which India and the world can benefit enormously by: better facilitating the harnessing of the immense power that crop biotechnology offers global society; ensuring an adequate supply of safe, more nutritious and affordable food; contributing to a more sustainable crop production system less dependent on external inputs, particularly insecticides; and contributing to the alleviation of abject poverty and hunger in India and other developing countries throughout the world (Choudhary and Gaur, 2009).

"I now say that the world has the technology - either available or well advanced in the research pipeline – to feed on a sustainable basis a population of 10 billion people. The more pertinent question today is whether farmers and ranchers will be permitted to use this new technology", Dr. Norman Borlaug, 1970 Nobel Peace Prize Laureate, The Norwegian Nobel Institute, Oslo, September 8, 2000.

The Farmer: The Practitioner
The Judge

17. Bt Brinjal hybrid



Importantly, one common element in all of the three above major developments in improved seeds was the willingness, indeed the eagerness, of small resource-poor Indian 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. Thus Indian farmers have not only been receptive but proactive in the adoption of all the new technologies, as and when they were made available to them - they are the practitioners and the best judge of any crop technology and they are also the masters of risk aversion. The pace of introduction of new technologies has been slow in agriculture compared to any other sector because of onerous regulation requirements. These regulatory constraints have been exacerbated by procedural delays precipitated by activists who are well resourced and mobilized in national campaigns to unnecessarily delay the adoption of new generation seeds and biotech crops which are subject to a very rigorous science-based regulation system.

Pictures: Caption and Source

1. Pandit Jawaharlal Nehru, the first Prime Minister of India in wheat field with farmer. Source: Indian Council of Agricultural Research (ICAR), New Delhi, www.icar.org.in

2. An Indian farmer with a bumper IR-8 rice harvest, 1967. Source: International Rice Research Institute (IRRI), the Philippines, www.irri.org

3. Farmer in field of improved pusa basmati rice (Pusa-1460) with resistance to bacterial blight, Urlana Village, Haryana. Source: Dr. A.K. Singh, Indian Agricultural Research Institute (IARI), New Delhi, www.iari.res.in

4. Farmer with wheat harvest in Punjab. Source: Indian Council of Agricultural Research (ICAR), New Delhi, www.icar.org.in

5. Dr. Norman Borlaug and Prof. M.S. Swaminathan along with other scientists in semi-dwarf high-yielding wheat field at the Indian Agricultural Research Institute (IARI), New Delhi, 1965. Source: Indian Council of Agricultural Research (ICAR), New Delhi, www.icar.org.in

6. Farmers threshing rich wheat harvest, Punjab. Source: Indian Council of Agricultural Research (ICAR), New Delhi, www.icar.org.in

7. Prof. M.S. Swaminathan receiving the first World Food Prize in 1987 from James Ferguson, the CEO and Chairman of General Foods Corporation. Source: The World Food Prize Foundation, Des Moines, USA, www.worldfoodprize.org

8. Release of a postage stamp titled "Wheat Revolution" by the then Prime Minister of India, Smt. Indira Gandhi at the Indian Agricultural Research Institute (IARI), New Delhi on 17th July, 1968. Source: Indian Council of Agricultural Research (ICAR), New Delhi, www.icar.org.in

9. Pearl Millet hybrid Pusa-23 crop in the field, Rajasthan. Source: Dr. O.P. Govila, former pearl millet and cotton breeder, Indian Agricultural Research Institute (IARI), New Delhi.

10. Sorghum hybrid MRS-4649 in the research field of Mahyco, Jalna, Maharashtra. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

11. Dr. B.R. Barwale receiving the World Food Prize in 1998 from John Ruan III, Chairman of the World Food Prize Foundation, John Ruan, Sr., Chairman Emeritus of the World Food Prize Foundation and Dr. Norman Borlaug, Founder of the World Food Prize. Source: The World Food Prize Foundation, Des Moines, USA, www.worldfoodprize.org

12. Chilli hybrid MHCP-317 (Sierra) in the research field of Mahyco, Jalna, Maharashtra. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

13. Tomato hybrid in the green house facility of Bejo Sheetal Seeds, Jalna, Maharashtra. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

14. Maize hybrid 900M harvest. Source: Monsanto India, www.monsantoindia.com

15. Bt cotton hybrid at harvest stage in Fatehabad, Haryana. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

16. Farmer in Bt cotton hybrid field in Bhatinda, Punjab. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

17. Bt brinjal hybrid MHB-39Bt in research trials at the Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu. Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA), www.isaaa.org

References

Census of India 2001. The Office of Registrar General and Census Commissioner of India. Retrieved from http://www.censusindia.gov.in/

Choudhary, B. and Gaur, K. 2009. The Development and Regulation of Bt Brinjal in India *(Eggplant/Aubergine)*. ISAAA Brief No.38. ISAAA: Ithaca, NY.

Cotton Advisory Board (CAB), 2007. Minutes of the Meetings for the Cotton year 2006-07 and Cotton Projections for 2007-08, Ministry of Textile, Government of India.

Economic Survey (2007-08). The Ministry of Finance, Government of India. Retrieved from http://www.finmin.nic.in/the_ministry/dept_eco_affairs/dea.html

Indian Horticulture Database, 2006. National Horticulture Board, Ministry of Agriculture, 2007.

James, C. 2007. Global Status of Commercialized Biotech/GM Crops 2007, ISAAA Brief No. 37, ISAAA, Ithaca, NY.

Mayee, C.D. 2008. Chairman, Agricultural Scientists Recruitment Board (ASRB), Ministry of Agriculture, Personal Communication.

Ministry of Agriculture, 2008. Agricultural Statistics at a Glance 2008, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

National Policy for Farmers 2007. Ministry of Agriculture, Government of India. Retrieved from http://agricoop.nic.in/NPF/npff2007.pdf

Rai, M., and Mauria, S. 1996. Hybrid Research, 50 Years of Crops Research in India, Indian Council of Agricultural Research (ICAR), New Delhi, November 1996.

Ramanujam, S., *et al*. 1980. Science and Agriculture: M. S. Swaminathan and the Movement for Self-reliance, Indian Society of Genetics and Plant Breeding, Indian Agricultural Research Institute (IARI), New Delhi, India.

Singh, R. B. and Kulshrestha, V. P. 1996. Wheat, 50 Years of Crops Research in India, Indian Council of Agricultural Research (ICAR), New Delhi, November 1996.

Swaminathan, M.S. 2006. Looking back at the Green Revolution, the World Food Prize 2006 International Symposium, Des Moines, USA, 19 October 2006.

The Economist, 2005. The Story of Wheat, 20 December 2005. Retrieved from http://www.economist.com/displaystory.cfm?story_id=E1_VPNPPGN

ISAAA's Global Knowledge Center on Crop Biotechnology (KC) is the information sharing initiative that delivers the benefits of new agricultural biotechnologies to farmers in developing countries and builds on the strength of its global network of Biotechnology Information Centers (BICs) to ensure that the voice of developing countries is recognized in the field of agricultural biotechnology.

For more information about ISAAA Knowledge Centre
visit **http://www.isaaa.org/kc**




ISAAA

ISAAA South Asia Office
c/o ICRISAT, NASC Complex,
Dev Prakash Shastri Marg,
Opp. Todapur Village,
New Delhi-110012, India
Tel: +91-11-32472302
Fax: +91-11-25841294
Mobile: +91-9999851051
Email: b.choudhary@cgiar.org