Green Revolution

The **Green Revolution** is the increase in food production stemming from the improved strains of wheat, rice, maize and other cereals in the 1960s developed by Dr Norman Borlaug in Mexico and others under the sponsorship of the Rockefeller Foundation. This increased the crop yield in India, Pakistan, Philippines, Mexico, Sri Lanka and other underdeveloped countries.

More recently, the Green Revolution has faced criticism by environmentalists promoting integrated farming or organic farming techniques.

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History

The revolution began in 1945 when the Rockefeller Foundation and the Mexican government established the Cooperative Wheat Research and Production Program to improve the agricultural output of the country's farms. Norman Borlaug was instrumental in this program. This produced astounding results, so that Mexico went from having to import half its wheat to self-sufficiency by 1956 and, by 1964, to exporting half a million tons of wheat. This program was continued in India and Pakistan where it is credited with saving over one billion people from starvation. Norman Borlaug won the 1970 Nobel Peace Prize for his efforts.

From there, the technologies were exported abroad, finding use in regions all over the world. The success in increasing yields was undisputable. The growth of crop yields was such that agriculture was now able to outstrip population growth — per capita production increased every year following 1950.

The use of genetic engineering in agriculture to create genetically modified foods is viewed by some as the natural continuation of the Green Revolution.

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Technologies

The Green Revolution technologies broadly fall into two major categories. The first is the breeding of new plant varieties; the second is the application of modern agricultural techniques in new areas.

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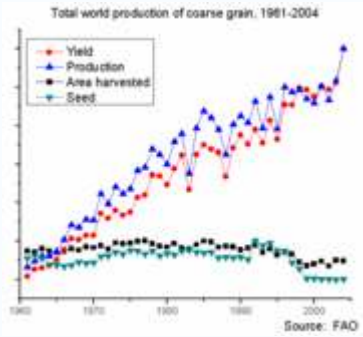
Hybrid strains



World production of coarse grain, 1961-2004, compared with area harvested over the same period.

Most crops consumed by the public-at-large in industrialized nations are Green Revolution crops. The design of high yielding varieties or hybrid strains (so called because they were created by cross-breeding a broad range of varieties to produce the desired combination of characteristics in a single variety, although very random mutagenesis was also used) was motivated by a desire to, first, increase crop yield, and also to increase durability transport and longevity for storage. Norin 10 wheat is an example of such a strain that helped developing countries, such as India and Pakistan to increase the productivity of their crops. Since then, strains have been bred for better appearance (e.g. plumper tomatoes, or straighter, more evenly-coloured rows of maize (corn)).

Since improved crop yield was produced mostly through the use of heavy fossil fuel inputs (discussed below), the increased efficiency of Green Revolution strains is geared towards these inputs; that is, the strains are more efficient at exploiting the chemical fertilizers used, and also are designed to be easier to harvest mechanically.

The artificial monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water which were earlier being wasted. Simple irrigation techniques were also adopted.

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Agricultural techniques

The techniques introduced to the developing world by the Green Revolution are, roughly:

- Extensive use of chemical fertilizers — Every plant basically relies on several basic compounds in order to grow. Primary is nitrogen need. Only in the nitrate form can plants absorb the nitrogen they require, with the exception of rice, which can absorb ammonium nitrogen as well. Certain microorganisms found in the soil are able to convert atmospheric nitrogen into the nitrate form plants can use. Also, some biological nitrogen fixation can take place by microorganisms living in small nodules on the roots of certain plants, such as legumes. Phosphates are also important, as well as numerous trace elements. Soil pH (acidity or alkalinity) must also be adjusted to the optimal conditions for the crop in question. Previously proper soil conditions had relied only on techniques such as crop rotation, mixing of crops, or organic fertilizers like horse manure. The major development of the Green Revolution in this field was the use of chemical fertilizers to adjust the soil pH balance and achieve the right levels of all the important chemical compounds needed for the plant to grow.

- Irrigation — Although it has been in use in agriculture for thousands of years, the Green Revolution further developed irrigation methods to allow for more efficient irrigation. It was possible to have more than one harvest per year with reduced dependence on monsoon seasons.

- Use of heavy machinery — Mechanized harvesters and other machinery were not new to agriculture — the McCormick reaper was developed in the nineteenth century — but the Green Revolution allowed a drastic reduction in the input of human labor to agriculture by extending the use of machinery to automate every possible agricultural process.

- Pesticides and herbicides — The development of chemical pesticides and herbicides (including organochlorine and organophosphate compounds) allowed further improvements in crop yields by allowing for efficient weed control (by use of herbicide early in the growing season) and eradication of insect pests.

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Achievements of the Green Revolution

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Increased yields

Green Revolution techniques have increased the production per unit area of wheat and other food crops in some major development countries like India. Because of this,

food security of large areas, such as the developed world, South America, South Asia, East Asia, South East Asia and large portions of Africa has been achieved.

The Green Revolution resulted in a record grain output of 131 million tons in 1978-79. This established India as one of the world's biggest agricultural producers. No other country in the world which attempted the Green Revolution recorded such level of success. India also became an exporter of food grains around that time.

The Green Revolution in agriculture helped food production to keep pace with population growth. Many people believe a second Green Revolution is likely to take place, and should focus on the food crops grown by the 2 billion people in the world who lack food security.

Without the Green Revolution, agriculture would not be able to meet the basic food requirements of the world's current population. According to some estimates[1], the Green Revolution has saved almost a billion human lives.

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Labour saving

The high level of mechanisation associated with Green Revolution techniques led to a reduced dependance on low-skilled human labour. As a result, farmer and agricultural worker incomes rose substantially and production costs plummeted. The efflux of labour, however, brought problems at its own, like the increased migration to the cities and creation of massive slums.

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Criticisms of the Green Revolution

Prominent critics of the Green Revolution include Indian writer and activist Vandana Shiva.

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Agricultural quality

Critics here focus on whether the Green Revolution's focus on hybrid, genetically modified and high-yield crops have had a deleterious effect on the quality of agricultural production.

- Loss of biodiversity — The spread of Green Revolution hybrids and the associated techniques have resulted in the cultivation of many fewer varieties of crops. Some crops have seen upwards of a 90% reduction in crop varieties. Dependence on one or a few cultivars of a crop means a greater exposure to famine due to a new crop pest (see Irish Potato Famine), external dependence of the population for other foodstuffs, and an impaired ability to improve crops in the future through breeding. External dependence is a problem with

modern agriculture that has been solved in rich countries through extensive systems of crop insurance and farm subsidies, but remains a great problem in poorer countries where agricultural output is taxed not subsidised. The lack of crop insurance means that farmers who depend on paying for their basic needs can easily fall victim to predatory lenders when they have the inevitable lean year.

- Health value and food quality — The replacement of multiple staple crops by a single HYV staple crop can mean a less varied diet. In addition, critics argue, many Green Revolution crops are bred for high caloric efficiency, storage longevity, and appearance; but not for health value. As such, many hybrid crops are claimed to be inferior in nutritional value to their ancestors, potentially leading to malnutrition. One reason is an often-overlooked side-effect of Green Revolution crops: due to the increased level of weed control in the crop, wild plants which are occasionally eaten as a vegetable, such as Colocasia ssp. in rice, disappear.

  On the other hand, the replacement of various nutrition sources with a single Green Revolution alternative has led to higher gross nutrition levels and increased caloric intake. According to Green Revolution advocates, these nutritional concerns are being tackled through mechanisms as diverse as the encouragement of vegetable gardens, the development of high-yield varieties with enhanced nutrient content, such as the so-called golden rice with enhanced carotene, and new attention to developing HYV versions of less common agricultural crops such as oca.
  A side-effect of the pesticides used is that the chemicals have killed not only the pests, but also fish in the paddy fields that they used to eat or sell. Water buffaloes used to plow the land have contracted unknown mouth diseases, lost hooves, and suddenly died. Several villages that have always had enough to eat suddenly experienced severe famine and have not recovered since.

- Health effects. The chemicals- insecticides and pesticides- needed to protect the HYV crops are not only toxic to insects or pests, but also to humans. People in First World countries may use protection when spraying these chemicals on the plants, but protection is generally not used in Third World countries. Firstly, the people are too poor to buy protective suits. Secondly, they do not trouble to put on protection. They work in the burning sun all day and cannot be expected to wear such protection at risk of getting heat stroke. As a result, their bodies absorb the pesticides and herbicides. They are slowly but surely being poisoned. 80% of deaths from pesticides occur in the Third World.

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Globalization and social change

Critics here focus on how the Green Revolution changes the structure of rural agricultural societies.

- Corporate dependence — many hybrid strains are sterile, or are sold on the condition that farmers cannot save their seed. F1 hybrids have a much higher yield due to their very high level of heterozygote alleles than their descendants, which makes the propagation of F1-hybrids by farmers less practical. Critics argue that this helps seed companies maximize their profit at the expense of farmers, who are forced to buy new seed each year. Critics have also pointed out that farmers are compelled for competitive reasons to buy hybrid seed, since non-hybrid seeds are so much less productive.

- Social change — The Green Revolution introduced major changes into a world where the majority of the people still depend on farming for their livelihood. The result of many of these techniques was the encouragement of large-scale industrial agriculture at the expense of small farmers, who were unable to compete with the high-efficiency Green Revolution crops. The result has been massive displacement and increasing urbanization and poverty amongst these farmers, and the loss of their land to large agricultural companies, who are more able to manage the considerable enterprise involved in effectively exploiting Green Revolution techniques.

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Sustainability

A final set of criticisms focuses on whether the agricultural practices of the Green Revolution are sustainable.

- Fossil fuel dependence — While agricultural output increased as a result of the Green Revolution, the energy input into the processes (that is, the energy that must be expended to produce a crop) has also increased at a greater rate, so that the ratio of crops produced to energy input has decreased over time. Green Revolution techniques also heavily rely on chemical fertilizers, pesticides, and herbicides, some of which must be developed from fossil fuels, making agriculture increasingly reliant on petroleum products. This has raised concerns that a significant decrease in world oil and gas production, and the corresponding price increases, could plunge billions into hunger.

- Fertilizer dependence — Nearly all fertilizers, such as potassium, phosphorus and magnesium, come from limited mineral deposits. (An exception is nitrogen fertilizers, which are produced from inexhaustible atmospheric nitrogen, but which requires methane for production in the Haber process.) High-yielding varieties require an increased nutrient input. The Pacific island of Nauru has been mined for its phosphate deposits, which caused significant ecological destruction.

- Pollution — Fertilizer, pesticide, and herbicide runoff continue to be a significant source of pollution, and a major source of water pollution. Although the dangerous, toxic and sometimes cancer-causing pesticides of the early half of the century (like 2,4,5-T and DDT) have mostly been phased out of agricultural usage (although DDT continues to be used in Third-world

nations for control of the *mosquito* which is the transmission vector for malaria), their effects have often not been erased.

- Land degradation — Critics charge that the Green Revolution destroys soil quality over the long term. This is a result of a variety of factors, including increased soil salinity that results from heavy irrigation; erosion of the soil, a decreased flux of organic material to the soil because of lesser allocation of photosynthetical production to stems and roots, and the loss of valuable trace elements. These factors can lead to increased reliance on chemical inputs to compensate for deteriorating soil quality, a process which may ultimately fail.

On the other hand, agricutural techniques may evolve as resource constraints or environmental damages emerge. The emergence of no-till farming, for instance, has reduced erosion. Alternative energy sources, closed nutrient cycles, the development of disease- and pest-resistant crops may help address some of the sustainability issues.