

The Green Revolution refers to a set of research and development of technology transfer initiatives occurring between the 1930s and the late 1960s (with prequels in the work of the agrarian geneticist Nazareno Strampelli in the 1920s and 1930s), that increased agricultural production worldwide, particularly in the developing world, beginning most markedly in the late 1960s. The initiatives, led by Norman Borlaug (often called the Father of the Green Revolution), who received the Nobel Peace Prize in 1970, involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, and distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers. They are credited with saving over a billion people from starvation.

## Green Revolution in India

Before the mid-1960s, India relied on imports and food aid to meet domestic requirements. However, two years of severe drought in 1965 and 1966 convinced the government to reform the agricultural policy. India adopted significant policy reforms focused on the goal of food grain self-sufficiency. This ushered in India's Green Revolution. It began with the decision to adopt superior-yielding, disease-resistant wheat varieties in combination with better farming knowledge to improve productivity. The state of Punjab led India's green revolution and earned the distinction of being the country's bread basket.

The initial increase in production was centered on the irrigated areas of the states of Punjab, Haryana, and western Uttar Pradesh. With the farmers and the government officials focusing on farm productivity and knowledge transfer, India's total grain production soared. A hectare of Indian wheat farm that produced an average of 0.8 tonnes in 1948, produced 4.7 tonnes of wheat in 1975 from the same land. Such rapid growth in farm productivity enabled India to become self-sufficient by the 1970s. It also empowered the smallholder farmers to seek further means to increase food staples produced per hectare. By 2000, Indian farms were adopting wheat varieties capable of yielding 6 tonnes of wheat per hectare.

With agricultural policy success in wheat, India's Green Revolution technology spread to rice. However, since irrigation infrastructure was very poor, Indian farmers innovated tube-wells to harvest ground water. When gains from the new technology reached their limits in the states of initial adoption, the technology spread in the 1970s and 1980s to the states of eastern India — Bihar, Odisha and West Bengal. The lasting benefits of the improved seeds and new technology extended principally to the irrigated areas, which account for about one-third of the harvested crop area. India also adopted IR8, a semi-dwarf rice variety developed by the International Rice Research Institute (IRRI), that could produce more grains of rice per plant when grown with certain fertilizers and irrigation. In 1968, Indian agronomist S.K. De Datta published his findings

that IR8 rice yielded about 5 tons per hectare with no fertilizer and almost 10 tons per hectare under optimal conditions. This was 10 times the yield of traditional rice. IR8 was a success throughout Asia and dubbed the "miracle rice." In the 1960s, rice yields in India were about two tons per hectare. By the mid-1990s, they had risen to six tons per hectare. In the 1970s, rice cost about \$550 a ton. In 2001, it cost under \$200 a ton.

In the 1980s, Indian agriculture policy shifted to emphasize other agricultural commodities like oil seeds, fruit, and vegetables. Farmers began adopting improved methods and technologies in dairying, fisheries, and livestock to meet the diversified food needs of a growing population.

## Criticism

A main criticism of the effects of the Green Revolution is the cost for small farmers using high-yielding varieties, with their associated demands of increased irrigation systems and pesticides. A case study has demonstrated that the Indian farmers who buy Monsanto BT cotton seeds, sold on the idea that these seeds produced "natural insecticides," still must pay for expensive pesticides and irrigation systems. This might lead to increased borrowing to finance the change from traditional seed varieties. Many farmers have difficulty paying for the expensive technologies and the gains of the Green Revolution are

hardly available to all Indian farmers, particularly those cultivating smaller land plots.

The increased usage of fertilizers and pesticides for high-yielding varieties has also led to decreased soil fertility while the use of electric tube wells decreased groundwater table below the previous level. The negative environmental impacts of the Green Revolution are barely beginning to show their full effects. The widespread chemical pollution in communities that utilize pesticides and herbicides is creating a public health problem that has disproportionately impacted women. In the state of Punjab, touted as a success of Green Revolution, cancer rates have skyrocketed. In a 2008 study by Punjabi University, a high rate of genetic damage among farmers was attributed to pesticide use. Ignorance on the appropriate use of pesticides resulted in heavy use, improper disposal, the use of pesticides as kitchen containers, and contamination of drinking water with heavy metals.