UNIT 12 GREEN REVOLUTION: NATURE AND EXTENT

Structure

12.0 OBJECTIVES

After going through this unit, you would be in a position to:

- appreciate the context in which HYV technology was introduced in India;
- identify the technical features of HYV;
- explain the impact of green revolution on output growth; and
- explain the extent to which the new technology has been adopted in India.

12.1 INTRODUCTION

As we learnt in Block 1 agricultural development during the pre-independence period was negligible and agricultural output was stagnant. In the post-independence period, however, substantial growth in agricultural output has taken place. This period in general can be considered as consisting of a low growth phase, till the middle of 1960s and a high growth phase after mid-sixties. Often the mid-sixties is taken as a turning point in the Indian agricultural scenario. Incidentally the mid-sixties marked the introduction of new technology in India. This technology is often referred to as high yielding varieties (HYV) technology and some termed it as green revolution. The terminology as well as the parameters of this technology, the benefits and consequences of it are often controversial. The points of view of agricultural economists range from admiration to scepticism. Admirers concentrated on the growth aspects while sceptics questioned the nature of growth as well as redistributive aspects.

The questions raised were: Did the Indian policy makers make a mistake in encouraging the adoption of this technology at the time they did? What were the options available at that time? Would it have been possible to mitigate the adverse effects of this technology?

To answer these questions we should understand the context in which the new technology was introduced.

12.2 THE CONTEXT OF GREENT REVOLUTION

Stagnancy in agricultural growth was attributed to the colonial policy of (i) plundering and neglecting agriculture, (ii) non-maintenance of local irrigation systems, and (iii) killing of local initiatives. During the British period many changes took place on the agricultural scene, viz., (i) monetisation of the country side, (ii) introduction of agricultural taxes, (iii) commercialization of agriculture (through promotion of cotton, tobacco, sugarcane and plantation crops), (iv) exports of raw material especially cotton and tobacco, and (v) imports of mass produced goods. All these threw the rural artisans and craftsmen out of work and forced them to be dependent on agriculture as agricultural labourers.

12.2.1 Pre-Independence Period

All these changes rendered the countryside much worse than it was before the colonial era. The production and yields stagnated for more than half a century before 1947. The agricultural production technology remained more or less the same throughout several centuries, except for minor changes now and then. The shortsightedness and neglect of agricultural development by colonial regime resulted in several famines. The Bengal famine of 1943 was the worst, which wiped off several millions of population. The relief efforts confined only to organising few gruel camps, which were much less than desired by the circumstance. Several observers termed such disasters as 'man made' and unnatural calamities.

Between 1891 and 1947, aggregate grain output in British India increased at an average rate of 0.11 per cent per year (see Table 12.1). In the latter half of the period the growth rate was only 0.03 per cent. Rice output actually declined over the 56-year period at an average annual rate of 0.09 per cent. Wheat production increased at an average annual rate of 0.84 per cent. The performance of non-foodgrain crops was no better. Population increased at a mercifully low rate of 0.67 per cent per annum in British India. For undivided India, the estimated production in 1947-48 was 66 million tonnes. This was slightly less than that in 1900-01 (67 million tonnes). Let us consider the period 1936-37 to 1965-66 (thirty years). In the first 15 years (1936-51) foodgrains production declined at a rate of 0.68 per cent per annum, while in the next 15 years (1951-66) it increased at a rate of 2.75 per cent per annum. If we consider per capita foodgrains production, during the first 15 years it declined sharply and index number of agricultural output dropped to 84.2. Thus for nearly 50 years since the turn of the century, foodgrains production was almost stagnant.

Table 12.1 : Growth performance of Major Crop Groups in Pre-Independence Period

(Percent per annum)

Sl. No.	Major Crop Groups	Period (1891-1946)		
		Area	Yield	Output
1	Foodgrains	0.31	-0.18	0.11
2	Non-foodgrains	0.42	0.86	1.31
3	All Crops	1.40	0.01	0.37

Source: Blyn, G. (1983)

In the developed world also stagnation was observed during this period. In UK from 1884 to the Second World War, the average rate of increase in yields of foodgrains was only 0.2 per cent per year. In USA the annual compound rate of increase in yields of foodgrains was 0.3 per cent between 1866-67 and 1901-05; no growth between 1901-05 and 1.5 per cent growth between 1936-40 to 1951-53. However, a breakthrough of 4.8 per cent was observed only in the post World War period of 1951-53 to 1961-63. Only in Japan the growth rate was above 1 per cent per annum during the corresponding two periods.

12.2.2 Post-independence Period

Independence brought several changes in India. The government took several steps towards (i) fulfilling the aspirations and expectations of the population in feeding them, (ii) developing agriculture in the direction of achieving self sufficiency in food, (iii) providing raw material to industry, and (iv) keeping the prices under control so that urban consumers (the purchaser of foodgrains) can be taken care of. Several initiatives were launched such as:

a) Introduction of Five Year Plans: This helped in (i) setting sectoral targets, (ii) mapping the available and required resources to meet the targets, and (iii) realizing the objective of higher growth along with equitable distribution of the benefits of growth.

b) Launching land reforms: This helped in (i) abolition of intermediaries such as Zamindars, Watandars, Zagirdars, Taluqdars, etc., (ii) conferring ownership rights to the tenants, (iii) consolidation of holdings, (iv) introduction of tenancy reforms (fixation of rents, protection of rights of tenants), and (v) fixation of land ceilings through legislation.

c) Creation of institutions: The Government created several institutions to make adjustments/corrections in demand supply situation such as maintenance of buffer stocks through FCI, setting up of agricultural prices commission; National water commission, and National Agricultural Commissions. These institutions were expected to suggest policy measures to tackle the problems of growth and distribution.

d) Introduction of rural development schemes: The Government introduced several programmes to tackle the problems of poverty. Several Schemes were launched to boost production such as IADP and Grow More Food Campaign. Some areas were targeted to boost agricultural production.

Some other areas were also given emphasis. These are: i) improvements in local varieties of seeds, ii) application of fertilisers and other changes in agricultural practices, iii) expansion of area under crops, and iv) expansion of irrigated area (by creating several minor and major irrigation projects).

All these efforts resulted in some improvement in agricultural production especially food products. Minor changes in agricultural technology continued off and on as had always. But because of public health policies (massive immunization, creating public hospitals in towns and public health centres in rural areas) the mortality rates came down considerably and the birth rates increased. As a result, the population increased by leaps and bounds which gave rise to imbalances between food availability and the population growth. All these efforts in increasing food production did not match the requirements of population.

12.2.3 Extent of Foodgrains Shortage

Between 1949-50 and 1964-65 the compound growth rate of agricultural production was 2.98 per cent per annum for foodgrains and 3.19 per cent per annum for all

crops. Productivity growth rates were 1.60 per cent per annum for both foodgrains and all crops. This is not stagnation, but in view of the annual growth of population at 2.2 per cent the balance between food availability and population became precarious.

During the middle of 1960s two successive disastrous droughts brought down foodgrains production from 89 million tonnes in 1964-65 to 72 million tonnes in 1965-66 and 74.2 million tonnes in 1966-67. Foodgrains had to be imported to the extent of 10 million tonnes in 1966. However, it was not sufficient to compensate the shortfall in domestic production. The Government looked into the options of increasing domestic production of foodgrains.

Several policies were experimented in this respect. During the 1950s the Grow More Food Campaign (GMFC) was tried to improve food production. First three years of Second Plan (1956-61) witnessed stagnation in production. 1957-58 was particularly a bad year. At this juncture the Ford Foundation Team recommended Indian government to concentrate development effort on crops and areas that had the greatest potentialities for increase in food production. This led to the adoption of Intensive Agriculture District programme (IADP), which had two salient features, viz., (a) development of a package of improved agriculture practices for each crop through research, and (b) assistance to cultivators to develop farm production through supply of required inputs and the amount of credit required to acquire these inputs. This package approach was extended in a slightly diluted form under IAAP – Intensive Agriculture Area Programme that covered nearly 10 per cent of cultivated area in 1966-67.

But the two consecutive disastrous droughts in 1965-66 and 1966-67 wiped off all the gains in production achieved through IADP and IAAP. As stated earlier, foodgrains production dropped by 17 million tonnes in 1965-66 from the peak of 89 million tonnes in 1964-65. In the next year, i.e., 1966-67, production increased by a meager two million tonnes. During this year foodgrains imports reached an all time high of 10.4 million tonnes, which created a desperate situation (see Table 12.2). We observe from the table that cereal imports went up to more than 10 million tonnes in 1966 from 0.6 million tonnes in 1955. Per capita availability of foodgrains was diminishing despite the imports. The index of foodgrain prices rose by 30 per cent in five years.

Table 12.2 : Gross Imports on Government Account 1951-1966

(in thousand tonnes)

Year	Total Cereal Imports	Year	Total Cereal Imports	Year	Total Cereal Imports
1951	4800	1957	3630	1963	4556
1952	3930	1958	3224	1964	6266
1953	2040	1959	3868	1965	7450
1954	830	1960	5137	1966	10340
1955	600	1961	3495		
1956	1400	1962	3640		

Source: Dantwala (1996)

Low foreign exchange reserve and adverse balance of payment conditions compelled the government to import food with political strings attached from the US. This led the country into further crisis. Several international organisations and scholars questioned the capability of India to survive the calamity of food shortages.

Government found itself at its wits end. It was groping for strategies to boost production on sustainable basis - to get out of the need to import and to feed its millions without

going for begging bowl. All the measures resorted to, given the obsolete techniques of production, could not improve the yields further; area and irrigation expansion were going on as usual at a slow pace. There was a need to do something urgent to boost production.

Around this time by coincidence, HYV seeds, particularly wheat, were developed in the developed countries. The HYV technology broke the barriers on yield improvement as these seeds were capable of absorbing a lot of chemical fertilisers in irrigated condition and gave very high yields. This technology was immediately adopted by the government in India. It was focused on all possible areas that had the necessary pre-requisites like assured irrigation and other infrastructure like roads, electricity and a dynamic peasantry. The necessary inputs like seeds and fertilisers were provided by the government liberally.

12.3 INNOVATION OF HYV IN DEVELOPED ECONOMIES

According to induced innovation hypothesis put forth by Yujiro Hayami and Kennon L. Ruttan (1931) the relative abundance of capital and scarcity of labour are two important factors which led to discovery and use of HYVs, in land scarce (Japan) and labour abundant economies. Steep decline in relative price of fertilisers was also an additional factor. In response to this research was focused on discovery of seeds which are highly fertiliser consuming.

The challenge of growing population pressure on land and food scarcity compelled the developing economies like India to borrow yield-increasing technologies from developed countries. The transfer of this technology was made possible by coordinated, adaptive research by international research centres like CIMMYT and IRRI. In India it was adopted initially in land abundant regions and much later in land scarce regions. The reason was mainly the environmental or agro-climatic suitability of new technology. The areas endowed with a favourable environment are also resourceful both in terms of investible capacity and institutional preparedness. The regions with low to medium rainfall but served with assured sources of irrigation happened to be the most appropriate site for application of the HYV technology. These areas are sufficiently exposed to sunshine and are relatively free from pests and diseases. Punjab and Haryana are such states with assured irrigation where farmers are resourceful and state governments were efficient with responsive administration. Governments in democracies have to be responsive to the needs of consumers and poor farmers who are in majority. Hence agri-research slowly expanded into new areas to respond to resource poor regions and farmers. The scientists attempted to evolve technologies suited to unfavourable agro-climatic environments and came out with packages and practices to suit resource-poor regions and farmers.

In this context biotechnology has an important role to play in raising yields. If technological progress could be scale-neutral (i.e., yield would increase irrespective of the size of the firm) then all sections of farmers can equally derive benefits. This is possible as biotechnology focuses on seeds, rather than on fertilisers and pesticides as seeds are expected to (i) be genetically modified to yield more, (ii) be pest resistant, and (iii) have stability in yields. Hence it can be beneficial to poor farmers and poor regions as well.

12.4 FEATURES OF HYV

The core of the green revolution was the development and propagation of High Yielding Varieties (HYV) of seeds, particularly rice and wheat, adaptable to local ecologies. The new HYVs are designed to be high yielding in response to high levels of inputs. These sturdy, short-stemmed plant types are capable of carrying the heavy growth of grains.

HYV technology comes in a package of HYV seeds – water – fertilisers. All these are needed together, in correct proportions and at various stages of growth and yields can be increased by 50 to 200 percent. You may note that HYV seeds are land-saving and labour-using innovations. They are also neutral to scale of operations and therefore usable by all farmers regardless of farm size.

12.4.1 Sensitivity to Water

Performance of HYV seeds would depend upon adequate control of weeds and pests. However, water control is the most critical factor. Even in irrigated areas minor laterals are often insufficient and drainages are rarely built. Thus the exact water control required for HYVs can hardly be expected. As mentioned earlier, the HYVs were developed according to the prototypes in the temperate zone. The prototype had been developed within the favourable environmental conditions with irrigation systems that allowed precise water control. Both inadequacy and excessive water are harmful to the HYVs. Not only water should be available in desired quantity, its use has to be tailored to the needs of the plant at different stages of its growth.

12.4.2 Sensitivity to Fertiliser and Pesticides

The HYV seeds have the technical capacity of turning soil nutrients into larger amounts of grains than leaf growth. Hence any increase over and above that is possible with the existing natural nutrients of the soil can be brought about by application of chemical fertilisers. Higher the amount of such inorganic fertilisers, larger is the output of grains.

Use of fertilisers gives rise to the growth of weeds on a large scale. These seeds being new to the soil and non-acclimatized to the region these are prone to local pests and diseases, which is not the case with indigenous traditional varieties. Hence there is a greater need for application of germicides and pesticides.

12.4.3 Short-duration Maturity

These seeds mature into plants in a shorter period of time and these are non-photosensitive, i..e., their period of maturity is independent of the length of exposure to the sunlight. Moreover, these plants are dwarf in size, i.e., the plants are of much shorter stature as compared to the indigenous variety. But HYVs are laden with abundant grains. For these reasons it becomes necessary that harvesting is done over a short period.

Two consequences follow from the above.

a) Because of short-duration and photo-insensitivity there is a possibility of multiple cropping in a year. In this respect, new technology is land-saving. Since each crop requires lesser time to mature, land is available for more than one crop.

b) The quick maturing requires the protection of harvested crops. As a result, drying and storage are also important.

The initial results of HYV in terms of production yields were dramatic in the ideal conditions causing observers to call this development nothing short of revolution though green variety. Since such prerequisites for introduction of HYVs was present in only North West region of the country (consisting of Punjab, Haryana and Western UP) and the South Eastern regions, (consisting of coastal Andhra, Tanjore district in Tamil Nadu) these were introduced first in those regions. Since the results in terms of improved yields and profits were good, the existing regional inequalities between these regions and other regions increased further. Adoption of this technology helped in realisation of the immediate objectives such as: i) boosting production, ii) doing away with imports, and iii) feeding millions of people.

As we discussed in Unit 11 India has much variations in terms of climatic condition across regions. These regions differ in terms of climate, soils, irrigation systems, farming systems and historical developments. Keeping this in view the country is divided into agro-climatic zones. Basically we have the following major types:

1) Alluvial Plains (North Western) consisting of Punjab, Haryana and Western UP.

2) South East Deltas (Krishna, Godavari and Kaveri deltas consisting of coastal Andhra, Tanjore in Tamil Nadu).

3) Poor but potentially rich areas (Middle and lower Gangetic basin consisting of Eastern Uttar Pradesh, Bihar, Bengal, Assam and Orissa).

4) Peninsular India / semi aid areas: consisting of Maharashtra, parts of Gujarat, Andhra Pradesh and Karnataka)

5) Arid Areas (Rajasthan and parts of Gujarat)

In terms of economic development, these agro-climatic zones can be divided into three groups: (a) advanced area, consisting of (1) and (2); (b) potentially rich but still very poor zones consisting of (3); and (c) Peninsular India consisting of (4) and (5) which face severe natural constraints.

All the ingredients for introducing HYVs were present in alluvial plains and South Eastern deltas, viz., rich irrigation sources (tube wells in North West and canal irrigation in South East); (ii) developed infrastructure (with roads and electrified villages); (iii) resourceful and dynamic farming communities eager to welcome new innovations with a view to get richer; and (iv) political stability and more responsive government machinery. Government provided inputs such as seeds, fertilisers and pesticides. In addition, institutional credit to facilitate easier purchase of these inputs was also emphasised. This led to immediate spurt in growth, providing cushion to the government.

Check Your Progress 1

1) What are the initiatives taken by the government in the post-independence period to boost agricultural development?

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2) What are the technical features of HYV seeds?

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12.5 IMPACT OF GREEN REVOLUTION ON OUTPUT GROWTH

Introduction of new technology resulted in substantial increase in agricultural output. However, the rate of growth has not been uniform throughout. According to Michael Lipton (1989) the green revolution period can be divided into four phases as follows:

- Phase I characterised by Euphoria. This comprises the late-Sixties.
- Phase II (early 1970s) characterized by growing fears of accentuating inequalities, pauperisation.
- Phase III (late 1970s) characterised by recognition of poor gaining absolutely but losing relatively.
- Phase IV (1980s) characterised by extreme optimism.

Thus the initial euphoria yielded to pessimism, slowly being replaced by optimism and finally realistic assessments of the efficiency, relevance and significance of technological changes.

There is another view (V.M. Rao), which divides the green revolution period into two sub-periods. The first round of green revolution: 1965-66 to 1980-81 (15 years) and the second round of green revolution: 1980-81 to 2000-01 (20 years).

12.5.1 Growth in Output

The growth rates after mid-sixties and before mid sixties (post and pre-green revolution periods) is a matter of controversy, especially the rates during the initial phase. There is a view that growth rates in post-green revolution period are dramatically high and the period was termed as a turn around in agriculture by some (Dantwala, Mellor, for example). There is another view that the growth in fifties was higher than the first round of green revolution period (C.H.H.Rao, C.T. Kurien, etc.).

According to J.M. Rao and S. Storm (see Table 12.3) the trend growth rate of overall crop output fell sharply from 3.1 per cent per annum in pre-green revolution period during 1949-65 to 2.3 per cent per annum in the first round of green revolution (1967-82) However, it made a strong recovery to 3.4 per cent per annum during 1981-92 (the second round of green revolution period).

The controversy regarding pre-and post-green revolution growth rates is due to the method of calculation and due to selection of base and terminal years. For example, if one takes 1960-61 to 1970-71 (as done by CHH Rao) agricultural productivity increased by 2.1 per cent per annum for all crops and 2.5 per cent per annum for foodgrains. If we make adjustment for drought years 1965-66 and 1966-67, the respective growth rates shifts up to 2.3 per cent per annum (all crops) and 2.8 per cent per annum (foodgrains). However, these growth rates are far less than those observed during the earlier decade of 1949-50 to 1959-60.

On the other hand, if one takes 1962-63 to 1970-73 period the growth rates are: 2.25 per cent per annum(all crops) and 2.74 per cent per annum (food grains). For the period 1954-57 to 1967-65, these are 2.60 and 2.54. Thus, in the case of foodgrains, the growth rates are clearly higher (2.74% p.a.) in 1960s than (2.54% p.a.) in 1950s. (JNU, PPD study).

Researches have analysed the growth performance of Indian agriculture in another way — by comparable weather years. CHH Rao has compared the growth rates in foodgrains output between peak years during 1950s and 1960s. According to him, there are reasons to believe that even without the green revolution, the growth rate

(of foodgrains output) would have been maintained at about 2 to 2.5 per cent per annum.

On the other hand, Mellor (1974) using similar methodology reaches a different conclusion. According to him both 1964-65 and 1970-71 witnessed favourable weather throughout most of India and excellent crop production. During this period foodgrains production increased by 19.1 million tonnes, a compound annual growth rate of 3.3 per cent. As a comparison it is 1.8 per cent per annum higher than the growth rate shown by the same measure between similar crop years 1949-50 to 1960-61.

The impact of HYV on agricultural output growth is considered to be exaggerated by CT Kurien. After analysing Tamil Nadu agriculture he felt that often the impact of HYV programme was evaluated against the background of poor performance of mid - 1960s. The 13.01 per cent increase in the production of paddy between 1968-69 and 1969-70 and even the more striking 24.80 per cent increase between 1969-70 and 1970-71 are cited as the contribution of 'green revolution'. By looking into these figures alone it gives a 'revolutionary' appearance. But in longer perspective the achievements of green revolution are much more modest. The post-green revolution growth rates are much lower than what was achieved in 1950s. The growth performance between 1968-71, and the even more spectacular one between 1974-76, must be regarded as " recovery growths."

According to Kurien, if we do not take into account 'recovery rates', the post HYV performance has been of the order of less than 6 per cent increase from year to year compared to the 7 to 8 per cent which were frequent in the 1950s.

12.5.2 Sources of Growth

There is near unanimity on the sources of growth in the post-green revolution period vis-à-vis the pre-green revolution period. In the pre-green revolution period (Period II in Table 12.3), the growth in foodgrain output was almost equally accounted for by area expansion and yield increases. On the other hand, agricultural growth in the first round of the green revolution (Period III in Table 12.3) output growth was marked by sharp reduction in area expansion and a perceptible upward shift in yields. Expansion in area contributed 0.37 per cent to output while yields contributed to 1.85 percent per annum. However, during this period the yield, improvement across all the crops was too modest to compensate for the decrease in the rate of area expansion. As a result, growth rate of production came down from 3.13 per cent per annum during Period II (1949-65) to 2.29 per cent per annum during Period III (1967-81).

Table 12.3 : Agricultural Growth. 1891-1991 (Percent Per Annum)

	Pre-Independence period (1891-1946)			**Pre-Green Revolution period (1949-50 to 1964-65)**			**Early Green Revolution period (1967-68 to 1981-82)**			**Late Green Revolution period (1981-82 to 1991-92)**			**During the last decade (1990-91 to 1998-99)**		
	I			II			III			IV			V		
	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output*
A. Foodgrains	0.31	-0.18	0.11	1.41	1.43	2.93	0.37	1.85	2.21	-0.26	3.19	2.92	-0.1	1.4	1.8
i) Rice				1.33	2.13	3.49	0.69	1.45	2.16	0.62	3.25	3.87	0.5	1.3	1.9
ii) Wheat				2.68	1.27	3.99	2.60	2.55	5.21	0.28	3.06	3.33	1.7	1.6	3.1
iii) Jowar				0.99	1.50	2.50	-0.84	3.50	2.61	-1.96	1.83	-0.10			
iv) Bajra				1.08	1.24	2.34	-1.03	0.33	-0.78	-0.90	2.33	1.49	-1.8	2.0	0.2
v) Maize				2.66	1.18	3.87	0.10	0.49	0.58	0.11	2.46	2.62			
vi) Pulses				1.90	-0.22	1.39	0.47	-0.65	-0.17	0.10	1.13	1.26	-0.2	1.7	1.0
B. Non-food grains	0.42	0.86	1.31	2.52	0.93	3.54	1.06	1.34	2.41	1.71	2.55	4.30	1.5	1.4	3.3
All Crops (A+B)	0.40	0.01	0.37	1.61	1.30	3.13	0.54	1.74	2.29	0.49	2.93	3.43	0.4	1.4	2.2

Note: * Output growth rate presented in column V is for the period 1990-91 to 1999-2000.
Sources: Mohan Rao (1998) and V. M. Rao (2000)

The second round of green revolution (1980-92), i.e., period IV in Table 12.3, had a more creditable record with almost the entire growth rate of 3.43 per cent per annum coming from improvement in yields. The creditable performance of Indian agriculture during the post-independence period is incontrovertible when compared with the pre-independence period (see Table 12.3).

Table 12.4 : Growth Performance of Major Crop Groups in Pre and Post Independence Periods

(per cent per annum)

Sl. no.	Major Crop Groups	Pre-Independence Period (1891 to 1946)			Post-independence Period (1949-50 to 1985-86)		
		Area	Yield	Output	Area	Yield	Output
1)	Foodgrains	0.31	-0.18	0.11	0.69	1.73	2.64
2)	Non-foodgrains	0.42	0.86	1.31	1.12	1.11	2.62
3)	All Crops	1.40	0.01	0.37	0.78	1.54	2.64

Source: V.M. Rao (1991)

12.6 SPREAD OF HYV TECHNOLOGY

The spread of HYV seeds in terms of area and use of fertilisers (second most important component of this package) is often described as swift and dramatic. The spread of area under HYV technology is usually explained in terms of a generalized model of adoption process. This would explain the spread of an innovation across different sections of farmers as well as different states.

Adoption of an innovation by farmers increases at a slow pace in the beginning. However, over time the rate of adoption catches on and it increases at an accelerated rate till about half of the potential adopters come to adopt it. Thereafter, the adoption increases but at a diminishing rate. Thus, we notice three phases: Percentage of adopting farmers rises very slowly in the initial stage, rises rapidly in the second stage and tapers off in the third stage. This is the familiar growth path, which implies that adoption of an innovation follows a *normal distribution*. In this approach adopters of an innovation are generally classified into three groups: early adopters, majority and late adopters.

Distinctive characteristics of early adopters are that they are younger, more educated, venturesome and willing to take risks. They operate large farms and have high income and social status. Late adopters, in contrast are older, less educated, security minded (conservative) operators of small farms with low income. Given these characteristics, early adopters of an innovation would reap large income benefits and *abnormal profits*. By the time the majority adopt the innovation, income gains realized by early adopters would disappear, unit costs of production would rise and product prices would fall. The average adopter therefore does not gain much from an innovation while the later adopters gain nothing.

Along with yield and net returns costs of production (paid out in cash) for HYVs also turned out to be several times greater than the cash costs of production for local varieties.

12.6.1 Spread in Area

From a modest beginning in 1965, use of HYVs spread to 9 million hectares in 1968-69. By the end of the first round (1967-81), it covered nearly half of the cropped area. Over the years it has spread to other parts and presently covers more than three fourths of cropped area (see Table 12.5). However, you have to keep in mind that area under HYV varies from crop to crop. Its spread has been the highest in the case of wheat. By late 1980s nearly 90% of wheat area came under HYV. In the case of rice it is moderate at about 60% of the area. Only about one third of area is under HYV in the case of Maize, Jawar and Bajra crops are under HYV presently.

You will have an idea of the spread of HYV seeds from the fact that in Tamil Nadu the area under HYV expanded from a modest beginning of 4% in 1969 to more than 25% of the area within five years, i.e., by 1974.

Table 12.5 : Progress of HYV Programme in India: 1966-98

(Area under HYV, in million hectares)

Crop	1966-67	1971-72	1976-77	1981-82	1986-87	1987-88	1988-89	1990-91	1991-95	1997-98
Paddy	0.88 (2.00)	7.41 (19.62)	13.34 (34.64)	19.69 (48.37)	24.02 (58.90)	20.75 (54.78)	29.00	27.4	31.0	32.2
Wheat	0.54 (4.10)	7.86 (41.07)	14.52 (69.40)	16.75 (75.64)	19.14 (83.90)	19.61 (86.50)	22.00	21.0	23.2	23.0
Maize	0.21 (4.10)	0.44 (7.76)	1.05 (17.67)	1.60 (26.96)	2.19 (37.30)	1.94 (35.19)	2.50	2.6	3.4	3.6
Jowar	0.19 (4.11)	0.69 (15.03)	2.37 (23.37)	3.88 (35.20)	5.50 (34.74)	5.44	6.00	7.1	7.1	9.0
Bajra	0.06 (0.50)	1.77 (19.20)	2.27 (21.11)	4.57 (38.78)	5.27 (47.00)	3.49 (36.09)	5.50	5.7	5.4	7.0
Total HYVs	1.88	18.17	33.56	46.49	56.12	51.23	65.00	65.0	71.3	76.0

(Figures in parentheses indicate percentages to the total area under the crop).

Source: Dantwala (ed.) 1991 and Economic Survey 2000.

12.6.2 Spread of Inputs

The spread in use of almost all inputs is another indicator of spread of HYV technology at a rapid pace. We will consider fertilisers and machineries in this section.

Table 12.6 shows that, consumption of nitrogenous fertilisers have grown by more than 100 fold and that of phosphatic fertilisers by 329 folds during the period 1951-52 to 1995-96. Consumption of potassic fertilisers has risen from almost nil to 120 million tonnes during the same period. Total consumption of fertilisers has increased by 230 times. The growth rate for total fertilisers was 14.65 per cent per annum during 1951-88.

Table 12.6 : Consumption of Chemical Fertilisers in India: 1951-52 to 1995-96

('000 tonnes of nutrients)

Year	Nitrogeneous	Phosphatic	Potassic	Total
1951-52	58.7	6.9	-	65.6
1960-61	211.7	53.1	29.0	293.4
1970-71	1487.1	462.0	228.2	2117.3
1980-81	3678.1	1213.6	623.9	5515.6
1995-96	9800.0	2900.0	1200.0	13900.0
Growth Rates (per cent per annum)				
1951-88	13.62	17.47	17.45	14.65
1951-66	17.29	23.48	27.50	19.09
1966-88	9.66	11.10	10.37	10.06
1966-77	11.34	12.02	10.68	10.98
1977-88	7.17	10.11	6.16	7.71

Source: Dantwala (ed.) 1991 and Economic Survey 2000

Table 12.7 : Input Use in Indian Agriculture 1950-51 to 1990-91

Item	Unit	1950-51	1960-61	1970-71	1980-81	1990-91
Bullocks	No./1000 ha GCA	0.5	0.5	0.5	0.5	
Tractors	No./1000 ha GCA	0.1	0.2	0.9	2.7	5.8
Electrical	No./1000 ha GCA	1.0	16.8	52.0	59.8	
Diesel Pumps	No./1000 ha GCA	2.7	19.1	50.1	56.0	
Chemical Fertiliser	Kg./hectare	Negligible	1.9	13.1	31.8	69.7
Electricity	Million KWH	203	833	4470	14489	50321
Net irrigated area	(Million hectares)	20.9	24.7	31.1	38.7	47.4
Gross Irrigated area	(Million hectares)	22.6	28.0	38.2	49.8	61.8
Share of modern inputs in						
a) Total Inputs (% share)		1.1	2.9	13.5	21.5	36.2
b) Output (% share)		0.3	0.7	3.3	7.1	11.8

Source: J. Mohan Rao (1998)

Table 12.7 on input use shows that absolute increments of 'modern' inputs including tractors, pumpsets, fertilisers were large in the post HYV period reflecting a marked shift to mechanization. The cost of cultivation, per hectare, thus increased over time.

12.6.3 Constraints on the Spread of HYVs

The spread of HYV seeds is limited by the quality of irrigation and other pre-requisites. In the case of rice, water logging and overhanging cloud cover during maturity period reduce the yield. It becomes susceptible to pests under these conditions. Strong sunshine alone in the Rabi season adds about 20-25 percent to yields. In the case of wheat, timing and spacing of irrigation can raise yield by as much as 40 per cent. To meet such requirements there must be controlled sources of water. Thus irrigation is a pre-requisite to determine the success of HYV technology.

The major obstacles to the spread of new technology in rice are variously narrated as the following: (i) poor farm management, (ii) lack of farmer's knowledge, (iii) inadequate extension, (iv) low prices, (v) unsatisfactory land tenure system, and (vi) inadequate institutional credit. These factors, however, have not affected the area under HYV for wheat crop. How do the same technology affected one cereal (rice) adversely and not the others (wheat)? Probably the factors noted above would not have an adverse affect in favourable physical environmental conditions like adequate water supply and quality of irrigation. Wheat meets these conditions in India and Pakistan while rice meets these only in Pakistan.

It may be noted that the yields of new varieties are considerably greater than those of local varieties even without fertiliser application. The operator of an irrigated holding can always harvest a larger crop even if he has no cash to purchase fertilisers. The operator of an un-irrigated holding is not that fortunate. The absence of irrigation entirely rules out the possibility of growing HYV— without irrigation other inputs are of no use.

You know from Unit 10 that irrigation development in India has a long history. In the North Western India and Punjab (including the part now in Pakistan) the new wheat varieties have got the greatest impact. During the pre-independence period large investments in the development of water resources were made in this region. In fact, about 50 per cent of gross investment in irrigation was in Punjab alone in the period 1898 - 1914. In addition, since 1947, considerable investment has been made in irrigation development and in the expansion of irrigated area. You may recall that the HYVs were introduced in this part of the country first because of availability of irrigation fertilisers.

12.7 LET US SUM UP

During the 1960s there was an acute shortage of foodgrains in India. In order to overcome the problem the government put emphasis on introduction of new technology. There was limited scope for bringing in additional area under cultivation and increase in yield through new technology was a viable option. Around that time a scientific break through was made in the field of high yielding varieties of seeds. Through concerted efforts by the government the HYV technology was introduced on a massive scale in India.

The HYV technology increased agricultural output manifold, mainly through increase in yield of crops. This technology was also adopted very fast among cultivators. However, it was adopted more in the case of wheat than in the case of rice and other cereals. Assured irrigation facilities is often cited as an important reason for such discrepancy. Along with adoption of HYV technology, the use of chemical fertiliser and modern equipment has increased.

Check Your Progress 2

1) Discuss the impact of green revolution on output growth in India

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2) What are the constraints on the spread of HYV in India?

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12.8 KEY WORDS

Commercialisation of agriculture : Commercialisation usually implies cultivation for the market, not self-consumption. Thus cultivation of cash crops such as cotton, tobacco, sugarcane, etc., leads to commercialisation of agriculture. The British are blamed for forcing Indian farmers to cultivate cash crops rather than foodgrains. This is largely because at that point of time India needed foodgrains while cash crops were promoted or forced upon so that these can be exported to Britain.

Land-saving technology : Any improvement in technology that reduces the use of land in agricultural production. Short-duration maturity and multiple cropping implies that the same plot of land can be utilized more that once in a year (in the presence irrigation facility).

Yield : Productivity of land measured through production per hectare.

12.9 SOME USEFUL BOOKS

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12.10 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) The initiatives taken were introduction of Five Year Plans, land reform measures and rural development schemes. See Sub-section 12.2.2 for details.

2) The HYV seeds are sensitive to inputs like water fertilisers. They have short-duration maturity and short stem. Thus they convert soil nutrients into grains rather than leaves.

Check Your Progress 2

1) Point out the growth rates in agricultural output in different phases of Post-green revolution period. See Table 12.3 also. Look into the growth rates of foodgrains, wheat and rice and bring out the contrast between wheat and rice during different phases.

2) Read Sub-section 12.6.3 and point out the major obstacles to spread of HYV. These obstacles would provide an idea on why HYV could not be successful in the case of rice, particularly in Eastern India.