AGRICULTURE ACTIVITIES

Know Your Crops

It is estimated that there are between 300,000 and 500,000 species of higher plants, out of which only about 250,000 have been identified. Out of these, about 30,000 are edible and about 7,000 have been cultivated or collected by humans for food at one time or another. Thus, several thousand species contribute to food security.

Objective

To encourage students to observe and collect information about farms and crops of their region.

Activity

Take the students to nearby different farms (preferably in different seasons). Let the students observe each farm and what is growing on it. They should try and collect as much information as possible by talking to the farmer/owner of the farm. The questions to be asked would include:

1. What is the crop that is planted?
2. Why is this particular crop planted?
3. What else could have been planted?
4. When is the crop planted (season, months, etc.)?
5. What preparations are necessary before planting the crop?
6. What is the crop used as (cereal, fodder, oilseed, etc.)?
7. Where are the seeds obtained from?
8. How do farmers preserve the seeds?
9. What part of the crop is useful?
10. What do the farmers do with the remaining parts of the plants?
11. Where does the water needed for the crop come from?
12. What fertilizers are used (natural or chemical), how often?
13. What are the crop's major pests?
14. What pesticides are used? Is any other method of pest control used?

Subject
Science, Social Science

Place
Outdoor (farms and fields)

Duration
Half a day (preferably when farming activities take place)

Group size
5–6 students

Materials
Notebook, pencil, map of India

15. When is the crop harvested?

16. How much yield is expected per hectare or part thereof?

Extension/Variation

Students could indicate the crops grown in their state/region in appropriate places on the state map. Ask them to compare the crops grown in other states/region of the country.

Is More Better?

Activity

The fertility of soil depends upon the quantities of nutrients the soil contains. If all the nutrients that crops need are present in the soil in well-balanced quantities, then the crops will grow well. However, though the key to soil fertility are nutrients, excessive amounts of chemical fertilizers harm soil, rather than making it more fertile.

Objective

To help students observe the effect of different amounts of fertilizer on plant growth.

Activity

Divide the students into groups of 5-6 and assign their groups names like Group A, Group B… Ask the first group to take two pots and label their pots as Pot 1 and Pot 2. Second group will label as Pot 3 and Pot 4 and so on. Ask them to fill the pots with soil mixed with chemical fertilizer in the quantities as suggested in the box 'How Much Fertilizer?'.

Ask the students to plant the same number of seedlings in each pot.

Keep the pots in a well-lighted and warm place. Water them when necessary. Observe the growth of plants for 4 weeks. Each week record the average height of the plants in each pot. Also record the relative leaf colour, and the size of the leaves. Leaf size may be outlined on graph paper as shown on page 140. Ask the students to note down the measurements on a chart (*See page 141*).

Evaluation

How do different amounts of fertilizer affect plant growth? Did the plants grow as they expected?

Ask the students whether based on their findings, they agree or disagree with the statement: 'the larger the amount of fertilizer added to soil, the better your plants will grow.' Ask them to give reasons.

Discussion

Crops do not grow properly if nutrients are not present in sufficient quantities. Too much nutrient can also cause problems. They can 'burn'

Subject
Science

Place
Classroom and outdoor

Duration
30 minutes on day 1 and regular observation for 4 weeks

Group size
4 groups of 5-6 students

Materials
8 plant pots with drainage hole, chemical fertilizer that has a balanced amount of nitrogen, phosphorus and potassium, sticks for stirring, soil, corn seedlings

How Much Fertilizer?

Group A: Pot 1 and Pot 2 will have only soil and no fertilizer.

Group B: Pot 3 and Pot 4 will have soil mixed with recommended dose of fertilizer.

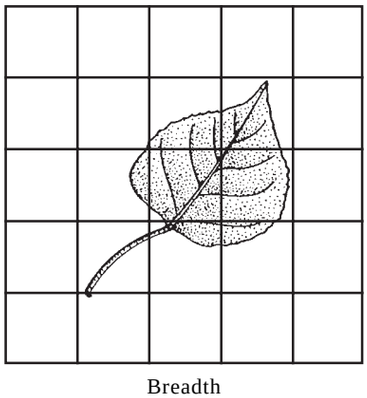
Group C: Pot 5 and Pot 6 will have soil mixed with twice the recommended dose of fertilizer.

Group D: Pot 7 and Pot 8 will have soil mixed with ten times the recommended dose of fertilizer.

the plants. Also, too much of one nutrient might lock up or interfere with the availability of another nutrient.

Too much nutrient not only harms crops, but excess fertilizer can also cause other problems. Chemical fertilizer may be washed off from farmland into rivers and lakes, and promote growth of algae in water. This give unnatural nourishment to algae (microscopic plants), causing them to flourish in huge amounts on waterbodies. As the algal growth explodes, it forms a cover on the water surface. This could starve the submerged life in the waterbody of oxygen and sunlight which are vital for life and photosynthetic activity. If uncontrolled, they choke the oxygen supply normally shared with other organisms like fish, etc., living in water. When these algae die, their decomposition uses up even more oxygen. As a result, the water becomes deficient in oxygen, fish die of suffocation and bacterial activity decreases. These conditions encourage organisms that can survive in the absence of oxygen (anaerobic organisms) to increase in number and attack the organic wastes. When anaerobic organisms break down organic substances, they release foul-smelling gases such as methane and hydrogen sulphide, which are harmful to the oxygen-requiring (aerobic) forms of life. Such disturbances slowly lead to the death of all forms of life in the waterbodies. This phenomenon is known as eutrophication.

Leaf Graph



Measurement in cm

Which Nutrients Are Missing?

Can you tell what happens to plants when certain nutrients are missing from the soil? Check out your plants!

Does the plant have…	**Then, the missing nutrient might be**
Unsatisfactory growth, small leaves, older leaves yellow?	Nitrogen
Small stem growth, scorching of older leaves?	Potassium
Thin stem, purple tints?	Phosphorus
Yellowing of new growth, but stems may be green?	Iron
Older leaves becoming orange/red with dead patches?	Magnesium
Pale green, red/purple tints in younger leaves?	Sulphur
Leaf edges folded, yellow?	Calcium

Measurement Chart

		Week 1	Week 2	Week 3	Week 4
Seedlings in Pots 1 & 2	Average height Average size of leaves Average number of leaves Leaf colour				
Seedlings in Pots 3 & 4	Average height Average size of leaves Average number of leaves Leaf colour				
Seedlings in Pots 5 & 6	Average height Average size of leaves Average number of leaves Leaf colour				
Seedlings in Pots 7 & 8	Average height Average size of leaves Average number of leaves Leaf colour				

Activity

Make Your Fertilizer Advertisement

Subject
Science

Place
Classroom

Duration
30 minutes

Group size
3 groups of 8–10 students

Materials
Fertilizers features sheet, colour pencils and markers, large chart papers, old newspapers, magazines

Some soils are very poor in nutrients or have specific nutrient deficits which constrain crop growth. Nutrients also are removed with the harvested parts of the plants. If these plants or crops are fed to the farm animals and the animal manure is returned to the soil, then some of the nutrients return to the soil. However, most crops are taken to the markets of towns and cities many miles away from where they are grown. Thus few nutrients return to the soils that grew them. To replace these lost nutrients, farmers add fertilizers to the soil, to enrich it and increase crop productivity.

There are two kinds of fertilizers: organic and inorganic (chemical) fertilizers. Organic fertilizer comes from natural sources, such as plant and animal remains and wastes, as well as crop residues. Inorganic fertilizers are manufactured industrially from chemicals—e.g., nitrogen fertilizers are mainly made from ammonia.

Objective

To help students understand the advantages and disadvantages of organic fertilizers and chemical fertilizers, and thereby encourage the proper and wise use of these.

Activity

Discuss with students about fertilizers, types of fertilizers, their advantages and disadvantages, their impact on soil and crops, etc. Ask them to list down advantages and disadvantages.

Divide the students into three groups of 8–10 each and name the groups as Group A, Group B, etc. Tell each group that they manufacture and deal with a particular a type of fertilizer. Their business involves manufacturing fertilizers and then selling them to the farmers. For example Group A manufactures organic fertilizer, Group B manufactures inorganic and Group C is a dealer of both the types of fertilizers.

Ask each group to make an advertisement to promote their fertilizers.

To make the advertisement, ask the groups to think back on their discussion on advantages and disadvantages of different types of fertilizers. Also give each group a ‘Fertilizers Reference Sheet’. Tell them that this list shows good and bad features of fertilizers. Some of these features apply only to organic fertilizer; some describe only inorganic fertilizers, and some apply to both. They should first decide which is which.

The groups could take the help of the Reference sheet for preparing their advertisements. The features of this sheet could be used to give captions. Ask the students to give a catchy title. Give them some old newspapers and magazine. They could use drawings, images or photos from these to make their advertisement attractive.

After the advertisement is prepared, ask each group to present their advertisement before other groups.

Ask them to give reasons why they want to promote this fertilizer. The other groups could debate/discuss if they do not agree to the points that are made.

Discuss how sometimes catchy and attractive advertisements gives false impressions/wrong information.

Discussion

Inorganic fertilizers in low to moderate amounts and in balanced combination with organic fertilizers can enhance the soil nutrients, soil balance and hence the crop health and crop production. Concentrated and continuous use of inorganic fertilizers should be avoided as they disturb soil life and lead to micronutrient depletion, soil degradation, poor crop health and lower crop yields.

Fertilizer Reference Sheet

1. Increase soil fertility
2. Supply nitrogen, phosphorus, potassium and other nutrients
3. Supply only the nutrients that are needed
4. Nutrients are in a form readily available to plants.
5. Nutrients are released slowly and steadily.
6. Are easily washed off from the soil.
7. Increase the water-holding capacity of soil. (This helps sandy or loamy soil in drier areas)
8. Kills the natural taste of food.
9. Increase the population and activity of soil micro-organisms. (this helps make more nutrients available to plants, and improves soil tilth)
10. Prevents compaction.
11. Reduces soil erosion.
12. Supplies more oxygen to plant roots.
13. Poisons the food with highly toxic pesticides residues.
14. Improves the physical condition of the soil, making it easier to cultivate.
15. Are inexpensive.
16. Are expensive.
17. Are locally available.
18. Are not harmful or toxic to soil, even if used in large quantities.
19. May increase the toxicity of soil.
20. Reduces natural fertility of soil.

Activity

Reaping What You Sow

Subject
Science, Social Science

Place
Outdoor

Duration
30 minutes

Group size
About 25

Materials
One farmer's card (as given) for each of the groups, papers and pencils, data sheet (as given) for each group or data displayed in a way that all groups can see it easily from where they sit.

What crop to grow in a particular region depends primarily on the physical environment such as climate and soil. Within these physical limits, the types and methods of farming are determined by socio-economic considerations. Some of the factors which influence the agriculture produce are: size of farm, ownership of land, availability of capital and labour, cost of production, market demand, government support policies and subsidies.

Objective

To help students understand the factors influencing choices made by farmers, which have a bearing on the sustainability of agriculture.

Preparation

For this activity, prepare the following materials:

Farmer's cards: Cut a piece of chart paper into cards. The dimensions of each card should be approximately 10 cms x 15 cms. Write the following paragraphs, one on each card:

Farmer 1: *You are a poor farmer with one hectare of land. Agriculture on this land is your only source of income. You do not own any livestock. You live in a dry area and are totally dependent on the rains for agriculture. There are six members in your family.*

Farmer 2: *You are a poor farmer with one hectare of land. You also own two cows and four goats. Produce from the land and the livestock is you only source of income. You live on the plains close to a perennial river, which is the main source of water for irrigation. There are two members in your family.*

Farmer 3: *You are a middle class farmer with two hectares of land. You also own three cows. The produce from the land and from the livestock are the main sources of your income. You live in an arid area where the availability of water for irrigation and fodder for cattle is a perennial problem. There are eight members in your family.*

Farmer 4: *You are a middle class farmer with three hectares of land and four goats. You also have a small business. Both agriculture and business contribute to your income. You live in a fertile, well irrigated area. There are six members in your family.*

Farmer 5: *You are a rich farmer with six hectares of land. You do not own any livestock. You have a profitable business in a nearby town. The business is the major source of your income, while agriculture is a secondary source. your fields are irrigated by water from a canal close by. There are five members in your family.*

Data sheet: Write the following data on the blank side of each farmer card or on a large sheet of paper and display it at a place where all participants can see it from where they sit.

Data Sheet

	Seed Varieties	
	Alpha	**Beta**
Yield (kg/hectare)	3300	4700
Water demand	12 units	36 units
Fertilizer requirement	50 units	90 units
Pesticide requirement	30 units	20 units
Grain:Straw ratio*	1:6	1:1

(***** Grain:Straw ratio is the ratio of the amount of grain produced to the amount of straw produced. The ratio 1:6 means that for every one unit of grain that is produced, 6 units of straw is produced. The ratio 1:1 means that for every one unit of grain that is produced, one unit of straw is produced. Straw is used for feeding livestock.)

Procedure

Divide the students into five groups of about 5-7 students each. Give each of the five groups a different farmer's card.

Tell them that they are farmers who have to make a decision on the kind of seeds that they will sow. Display the data for all the groups to see.

Tell them that as farmer they need to keep the following in mind while making their decisions:

Yield of the crop: Their choice will depend on: the number of members in their families, whether they would like to market their produce, if agriculture is the only source of their income, etc.

Water, fertilizer and pesticide demand: All of these will require investments to be made.

Straw production: Their choice will depend on the number of livestock they possess and their ability to buy animal feed if required.

Sustainability: Their choice will depend on their perception if they can continue farming in the same manner in the future. For example, if they choose a variety which needs more water than is naturally available in the area, irrigation may be required. Irrigating an arid area may cause the soil to become saline over a period of time and become unproductive.

They have 15 minutes to make the decision and to list down the reasons for taking the decision.

At the end of fifteen minutes, ask each group to present their decisions and the reasons behind the decisions. The reasons should not be just the data already given for the seed varieties, but they will need to expand on this. For example, a statement which says 'We choose the Alpha variety because it requires 50 units of fertilizer' is not valid. The groups have to say something like 'We choose the Alpha variety because it requires 50 units of fertilizer. We feel we cannot afford to buy the 90 units of fertilizer that the Beta variety requires.'

Discussion

What factors governed their decision regarding the kinds of seeds they will sow?

For each group of farmers, the factors which govern their decisions may vary. While the yield of the crop variety may be a common consideration, other factors which influence the decision will be the investments the crop demands, the amount of straw it produces for feeding livestock, the water it consumes, the amount of chemical fertilizers and pesticides it needs, etc.

What are the kinds of seeds available to farmers today?

Both traditional varieties of seeds and commercial varieties of seeds are available to farmers today. Commercial varieties are hybrids usually marketed by corporates, government bodies, etc. Traditional varieties are generally maintained by individual farmers.

What governs farmers' decision of which seed to sow?

Farmers consider a number of factors while taking decisions regarding which seeds to sow. Some of the factors may be the yield of the crop variety (both the seed and the straw), its resistance to pests and disease,

its ability to survive in harsh climate, soil and water conditions, the cost of the seed, the investment it requires in term of irrigation, fertilizer, etc. Another important factor is the information that farmers have about the crop variety.

Does the choice of seed influence agricultural practices?

The types of seeds have a significant influence on agricultural practices. Modern varieties focus largely on yield and disease resistance. They often compromise on other important features of the crop like ability to yield fodder, adaptation to harsh climatic conditions, etc. Traditional and natural varieties of crops usually place equal importance on the 'wholeness' of the crop. The emphasis is not just on crop yield. For instance, high yielding rice typically produces a one to one ration of grain to straw. Traditional varieties of rice produce four to five times as much straw as grain. Thus a shift to high yielding varieties from traditional varieties increases the grain available but decrease the straw. The scarcity of straw leads to a scarcity of fodder for cattle. Modern seed varieties also need much more water and fertilizer than indigenous varieties. High yielding varieties of wheat for example need three times as much irrigation as traditional varieties.

Does the choice of seed influence the sustainability of agriculture?

Seeds—both modern and traditional, have specific characteristics and requirements. Some varieties of seeds demand more inputs such as water, fertilizers, and pesticides. These demands may impact the sustainability of agriculture. For example, excessive irrigation to meet the demands of high-yielding varieties of seeds has led to salinization of soils in parts of India affecting their productivity. Fertilizers and pesticides may find their way into local water bodies through run-off, causing pollution.

More About Agriculture

Agriculture is the practice of cultivating the soil, harvesting crops, and raising livestock. It refers to the process of obtaining food from a given area of land by encouraging plant and animal species found useful, and discouraging others.

In the early stages of human development, people lived as hunter-gatherers. That is, they found food by hunting animals or by gathering fruits and roots that grew in the wild. Later, people started domesticating some animals. After this came the farming stage, where people started the first agriculture—they started growing plants which they found were good sources of food. And then came the stage known so well—the industrial stage.

Agriculture in Ancient India

India is primarily a rural society. Agriculture forms the backbone of the economy. This reliance on agriculture is not a recent phenomenon. Agriculture flourished in ancient India. It supported the development of ancient urban centres such as Harappa. Among the ruins at Harappa are huge granaries which indicate that there was surplus food produced by agriculture during that time.

Farming methods in ancient times did not use as many resources as are being used today. The ancient agricultural system used minimal skill, labour and equipment and the land was not ploughed, fertilized or irrigated. Flooding of low lying lands was a regular natural phenomenon. After the flood waters receded, people sowed cereals on this fertile land and grew crops.

With time came the practice of ploughing the soil. We know that the Aryans practiced ploughing. They also recognized that agricultural land should be left fallow (uncultivated) for a period of time. They fertilized their fields using cow dung manure. Irrigation was also practiced.

Many cropping methods of these times are still in practice today. Practices such as reaping, threshing, and winnowing have continued in much the same way since the Aryan times.

Agricultural Practices

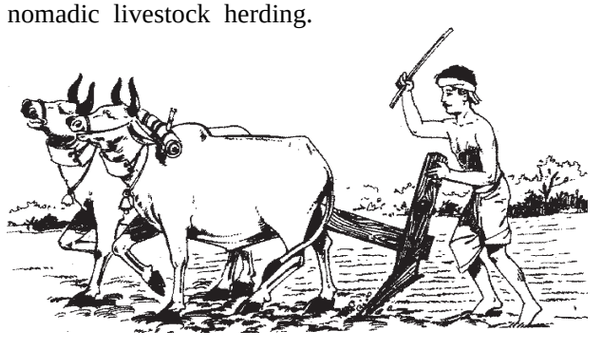
Farming is not simply a collection of crops and animals to which this or that input could be applied and immediate results expected. Rather, it is a complicated interwoven mesh of factors—soils, plants, animals, implements, workers, other inputs and environmental influences. Over time, a variety of farming systems have developed throughout the world.

Agricultural practices may be classified as **traditional or industrialized**.

Traditional Agriculture: Traditional farmers found various ways of improving soil structure, water-holding capacity, and nutrient and water availability without the use of artificial inputs.

There are two main types of traditional agriculture: ***traditional subsistence agriculture*** and ***traditional intensive agriculture***.

Traditional subsistence agriculture produces enough crops or livestock for a farm family's survival, and a surplus to sell or put aside for hard times. Subsistence farming involves human labour and animals. This includes shifting cultivation and nomadic livestock herding.



Shifting Agriculture

Shifting agriculture is a system of agriculture in which the land cultivated is rotated. Land on which the crop is grown for one or a few seasons is vacated and allowed to lie fallow, while the cultivator shifts to cultivate another plot of land for the next season's planting. This pattern of farming is continued till the farmer returns to the original piece of land when its fertility has been restored. This type of cultivation has also been called 'slash and burn' because it involves chopping down trees or bush cover, and setting fire to the fallen vegetation. The burning of vegetation releases nutrients that can be used by crops for one or two years before the soil is exhausted. The return of the natural vegetation prevents erosion and repairs the damage done by temporary agricultural use.

This traditional method was practicable when the population was small and people had small land holdings. With the increase in population and other associated problems, and the pressure on land, this is not practical any more.

Traditional intensive agriculture involves increased inputs of human labour, fertilizer, and water to get a higher yield per area of cultivated land to produce enough to feed their families and a surplus for sale.

Industrialized (modern) agriculture uses large amounts of fossil-fuel energy, water, chemical fertilizers and pesticides to produce huge quantities of crop or livestock. The emphasis here is on high yields. Industrialized agriculture involves continuous cropping (rotations of crops one after the other on the same land), tillage of the soil, and extensive use of machines to cultivate large tracts of land, as well as use of pesticides and weedicides to kill plant and animal species harmful to crops.

The industrial revolution brought about major changes in the way food is grown. Fertilizers have brought about massive increases in the amount of grain that could be produced per unit area of cultivated land. Pesticides and weedicides ensure that plant and animal species harmful to crops are killed. The use of machines makes it easy for large tracts of land to be brought under cultivation. Building dams, constructing canals and diverting river waters brought more areas under irrigation and made them suitable for cropping.

Post-Independence Agriculture in India

Modernizing agriculture in the country has successfully made the country self-sufficient in food grains. This was made possible by improving the productivity with high yielding varieties. In 1996, Indian farmers harvested over 60 million tonnes of wheat, as compared to 6 million tonnes at the time of Independence.

Agricultural practices have probably changed faster in the past 200 years or so, than ever before. The way food is raised today is an important factor that determines the availability of food in the future. A glance at the Indian agricultural scenario provides indications about our ability to raise food in the future. The Green Revolution spanning the period from 1967-68 to 1977-78 changed India from a nation deficient in food to one of the world's leading agricultural nations.

What is Green Revolution?

The term "Green Revolution" is a general one that is applied to successful agricultural experiments in many countries. It is not specific to India but it was most successful in India. It was coined by Dr. William Gadd of the U.S, in 1968 when India brought about a great jump in wheat production by taking up the cultivation of high yielding varieties of seeds.

The History

In 1942, Mexico was importing more than half of the wheat needed to feed its people. Their national average yield was only about 750 kilograms per hectare. In response to the Mexican Government's

request for assistance in increasing the production of maize and beans, a cooperative agricultural research and training programme was launched in 1943. The scientist chosen for this programme was Norman E. Borlaug.

Borlaug produced high-yielding wheat varieties by adopting some new concepts in plant breeding. The most important concept adopted by him was that of an efficient plant type capable of responding to very high dosages of fertilizers and irrigation. He incorporated dwarfing genes into various Mexican and Colombian wheats. The newly developed dwarf varieties were released in 1961. By 1965, Mexican wheat production showed a per-acre yield as much as 400 per cent as compared with that in 1950.

Green Revolution in India

The world's worst recorded food disaster happened in 1943 in British-ruled India. Known as the Bengal Famine, an estimated four million people died of hunger that year alone in eastern India (that included today's Bangladesh).

Achieving food security was a paramount item on free India's agenda. This awareness led to the Green Revolution in India. Efforts until 1967 largely concentrated on expanding the farming areas. But deaths due to starvation, and a population increasing at a much faster rate than food production, were some of the factors which called for drastic action to increase yield. The action came in the form of the Green Revolution.

Dr. M.S. Swaminathan often referred to as the 'Father of the Green Revolution', made a significant contribution to the introduction of the dwarf Mexican varieties of wheat into India.

There were three basic elements of the Green Revolution:

1) Continued expansion of farming areas

   Expansion of farming areas was continued but this was not enough to meet with rising demand for food. While this was not the most striking feature of the Green Revolution, the expansion of cultivable land continued.

2) Double-cropping existing farmland

   Double-cropping was a primary feature of the Green Revolution. Instead of one crop season per year, the decision was made to have two crop seasons per year. The one-crop season per year practice depended on the monsoon. Two crops seasons per year required two monsoons. This artificial/second monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water which were earlier not tapped in a large way. Simple irrigation techniques were also adopted.

3) Using genetically improved seeds

   The Indian Council for Agricultural Research developed new strains of high yield variety (HYV) seeds, mainly wheat and rice but also millet and corn. The most noteworthy HYV seed was the K68 variety of wheat. The credit for developing this strain goes to Dr. M.P. Singh who is also regarded as the hero of India's Green Revolution.

Impact of Modern Agriculture on the Environment

Like any other production activity, agriculture too, has three basic components: The inputs, the processes or the technology used, and the outputs and consequences.

The 'inputs' include all things that are 'put in' to make production possible. In agriculture the inputs usually are seeds, water, fertilizers, pesticides, human labour, and energy (for running tractors, pumpsets, etc.).

The 'processes' refer to the pattern of agriculture. For example, does the farmer raise three crops each year or does she/he leave the land uncultivated for a certain period of time to allow it to regenerate? Does the farmer cultivate only one kind of crop or does he/she grow a mixture of different crops?

The 'outputs' and 'consequences' are the things that result from the production process. These will include:

a) the desired outputs, which in the case of agriculture are food grains, fruits, vegetables, etc., and

b) the undesired consequences, which include wastes. Certain wastes are unavoidable in the production process. For example, when crops are grown for oil seeds, only the seeds may be the desirable part of the plant. Some parts of the plant such as leaves may be used as fodder. But some other parts of the plant—the stem, the roots, etc., do not have direct utility and may have to be disposed of as waste. Certain other wastes are created because of the production process. For example, if the farmer applies excessive quantities of fertilizer, some of it may not be absorbed by the plant, and may remain in the soil. This may find its way, through run-off, to nearby water bodies and affect their well being.

Agriculture and Environment

The inputs, processes and outputs associated with modern agriculture have influenced our environment in many ways. Some of the factors that impact the environment are discussed here.

Fertilizers

Fertilizers are used to increase the fertility of the soil by adding nutrients that help in plant growth. Fertilizers are of many different kinds, depending on the kind of nutrients they give the soil. They are broadly divided into two groups—organic fertilizers and chemical fertilizers.

Organic fertilizers are natural fertilizers, e.g. cow dung and compost. They are made up of natural components which are biodegradable. Organic fertilizers are used in traditional agriculture.

Chemical fertilizers are essentially chemicals, which are produced in factories and packaged. Chemical fertilizers are beneficial in increasing crop yields, but their prolonged usage can have detrimental effects on soil health. Excess fertilizer from agricultural fields finds its way into ponds, lakes and rivers through run-off water from the fields. These run-off fertilizers speed up the growth of algae in the pond, lake and river waters. The toxic substances can kill the fish in the water and cause illness to humans. Chemical fertilizers also create nitrate pollution in groundwater when they dissolve in water and seep into the soil.

Some Facts

About 60 per cent of India's cultivated land area suffers from soil erosion, water-logging and salinity problems.

It is estimated that from 4.7 to 12 billion metric tons of top soil is lost each year as a result of soil erosion.

About 30 million hectares of fragile land now under cultivation is progressively degrading.

Our livestock requires 932 million metric tons of green and 750 million metric tons of dry fodder annually. But only 250 and 414 million metric tons respectively are available. Inadequate fodder affects livestock productivity and health.

Biofertilizers

Intensive use of chemical fertilizer is not only costly but has detrimental effect on the natural resources like rivers and soil. Agricultural runoff pollutes the water as well as soil. Hence, due to economic and environmental considerations, there is need to find alternative to this.

Biofertilizers is one such alternative. Biofertilizers are efficient nitrogen-fixing, phosphate solubilizing, cellulose-decomposing microorganisms which when applied to seed or soil, enhance availability of nutrients to plants and offer an ecofriendly, economically viable and socially acceptable means of reducing external input of chemical fertilizers.

Some of these are *Rhizobium, Azotobacter.*

Rhizobium are the most important biofertilizers which fix atmospheric nitrogen by forming nodules on legume plants which converts nitrogen into ammonia.

Azotobacter are non-symbiotic micro-organisms, produce growth promoting substances and chemicals which are inhibitory to certain root pathogens. The response of Azotobacter depends upon the amount of organic matter in the soil.

Source: Indian Farmers' Digest, May 2001

Pesticides

Pesticides are used with the intention to kill certain species or control population of unwanted fungi, animals, or plants because they harm the crops. For example insects that feed on crops are pests (other insects, like bees, are beneficial for pollinating plants). Unwanted plants are generally referred as weeds. But pesticides are not selective in their killing. Also exposure to pesticides over long periods can harm the health of humans and animals that come into contact with them. Pesticides also adversely affect other species such as frogs, snakes and birds which are natural pest control mechanisms. They also destroy earthworms which are highly beneficial to agriculture.

Less than one out of 1000 kinds of insects is pest but insecticides kill indiscriminately.

Types of pesticides: Pesticides can be divided into several categories based on the kinds of organisms they are used to control.

Insecticides are used to control insect populations by killing them. Unwanted fungal pests that can weaken plants or destroy fruits are controlled by **fungicides**. Mice and rats are killed by **rodenticides**. Plants pests are controlled by **herbicides**.

A perfect pesticide kills or inhibits the growth of only the specific pest organism (target organism) that causes problem. However, most pesticides are not very specific and kill many non-target organisms as well. For example, most insecticides kill both beneficial and pest species, rodenticides kill other animals as well as rodents, and most herbicides kill a variety of plants, both pests and non-pests. Thus pesticides do not just kill pests but can kill a large variety of living things, including humans.

The effectiveness of a pesticide is found to reduce when it is used over a period of time. There has been an alarming increase in the number of cases of resistance to pesticides in insects, plants, pathogens, vertebrates and to some extent in weeds also. For example, resistance in insects has risen from seven species resistant to DDT in 1938 to 447 species which are now resistant to almost all the principal classes of pesticides. 133 pesticides have been registered for regular use in India which includes 34 that are either banned or restricted in some other countries, but are still used here.

Effect of pesticides: Pesticides from agricultural lands run down with rain water and enter the local stream or lake. People who use the lake water for bathing, washing, etc. are obviously affected. Pesticides affect the health of farmers who use them. They can enter the body, in small quantities, through the skin and eyes, or through the nose and the mouth.

Bioaccumulation and Biomagnification

Pesticides can accumulate in food chains. If an animal receives small quantities of pesticides in its food and is unable to eliminate them, then the concentration of this increases within the animal's body. This process of accumulating higher and higher amounts of material within the body of animal is called **bioaccumulation**. When such an affected animal is eaten by other animal at a higher trophic level (say a carnivore) these toxins are further concentrated in the body of the carnivore. This phenomenon of acquiring increasing levels of a substance in the bodies of higher trophic level organisms is known as **biological amplification** (biomagnification).

(See chapter 'Ecology' for Food chains and Trophic level)

Plant Genetic Diversity

Agricultural practices affect and are affected by the genetic diversity of the crop plant and of livestock. This diversity refers to the number, variety, and variability of crop plants and livestock. These include traditional and modern varieties of crops and livestock, their wild relatives and other wild species that can be used now and in the future for food and agriculture. Genetic diversity is vital for maintenance and improvement of agriculture.

Values of crop genetic diversity

Only about 30 crops 'feed the world'. These are the crops which provide 95 per cent of dietary energy (calories) or protein. Wheat, rice and maize alone provide more than half of the global plant-derived energy intake. A further six crops—sorghum, millet, potatoes, sweet potatoes, soybean, and sugar (cane/beet) bring the total to 75 per cent of the energy intake.

While the number of plant species which supply most of the world's energy and protein is relatively small, the diversity within such species is often immense.

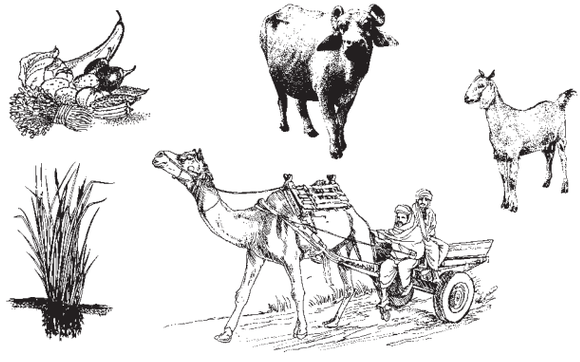
Biopesticides

Biological Pest Control is a method of pest control in which pests are suppressed by their natural enemies, such as birds, spiders, mites, fungi, bacteria, viruses or plants.

Some examples are as follows:
Farmers plant bamboo stalks in paddy fields so that predatory birds can use these as supports while they pick and eat insect pests from rice plants. Farmers in Telangana, Andhra Pradesh, light bonfires in fields during *Deepawali* and *Sankranti* to attract and destroy flying insect pests.

Neem contains several chemicals, including azadirachtin, which affects the reproductive and digestive process of a number of important pests. Neem also acts as a repellent and anti-feedant, and its oil is effective against leaf folders, helliothis, and aphids and bollworms. In addition to being environmentally safe, neem is effective against a wide range of pests. About 200 species of insects are known to be controlled by neem.

Biological control is sensitive to external factors like climate, type of crop, size of the plot, etc. Biological control is not new to agriculture. Even the earliest farmers practiced biological control by rotating their crops and fertilizing with organic manures. These and many other traditional practices give effective disease control by allowing the time and opportunity for biological destruction of disease organisms.



Domestic Breeds Diversity in India	
Groups	**No. of Species**
Cattle	30
Sheep	40
Goats	20
Camels	8
Horses	6
Donkeys	2
Poultry	18

Agricultural Diversity in India	
Groups	**No. of Species**
Cereals and millets	51
Fruits	104
Spices	27
Vegetables and Pulses	55
Fibre crops	24
Oil seeds	12

For instance, within the rice species (*Oryza sativa*), there are an estimated 100,000 distinct varieties. Rice originated in India and then spread throughout Asia. Rice grows in many places where other food crops are difficult to grow. This is possible because the rice plant has a very flexible genetic make-up and the ability to adapt to the local environment. According to Dr. Richharia, the well known rice scientist, 400,000 varieties of rice existed in India during the Vedic period. Even today 200,000 varieties of rice exist in India. This means that even if a person were to eat a new rice variety every day of the year, he could go on for over five hundred years without reusing a variety! That is the genetic diversity within one species.

With this astounding diversity of crops, it helps to classify them on some basis. Generally, crop varieties can be classified into 'modern varieties' and 'farmer's varieties'. Modern varieties are the products of plant breeding by professional plant breeders in private companies or publicly-funded research institutes. These varieties are sometimes called 'high-yielding varieties' (HYVs). They typically have a high degree of genetic uniformity. Farmer's varieties, on the other hand, are products of breeding or selection carried out by farmers over many generations. Farmer's varieties tend not to be genetically uniform and contain high levels of genetic diversity. Because of this genetic diversity, farmer's varieties are the focus of conservation efforts.

Genetic diversity provides stability for farming systems. It enables farmers to adapt crops suited to their own ecological needs, culture and traditions. It also provides self-sufficiency and security during difficult times. Losses due to the failure of a particular crop or variety are compensated for by the yield of other crops or varieties.

Genetic diversity is an insurance against future adverse conditions. While we may not be aware of the potential use of genetic resources today, they may in future provide useful characteristics, such as resistance to new diseases or adaptability to changed climatic conditions.

Genetic diversity represents a 'treasure chest' of potentially valuable but as yet unknown resources. This is the reason for maintaining both wild ecosystems and traditional farming systems, as plants in these habitats are likely to contain and develop new and valuable genetic characteristics. For example, in India cassava yields have been increased up to 18 times with the disease resistance provided by genes from wild Brazilian cassava.

Some Environmental and Social Consequences of Green Revolution

Use of chemical fertilizers and soil fertility

The Green Revolution was essentially a 'seed and fertilizer' package, since the new seeds were bred to be high 'consumers' of fertilizers. Since the inception of the Green Revolution, fertilizer consumption in Punjab has increased thirty-fold.

After some years of bumper harvests in Punjab, crop failures at a large number of sites were reported, in spite of liberal applications of NPK (Nitrogen-Phosphorus-Potassium) fertilizers. The fact is that plants need more than just NPK. They need micronutrients such as zinc, iron, copper, manganese, magnesium, molybdenum, boron, etc. Zinc deficiency is the most widespread of all micronutrients deficiencies in Punjab.

As a result of soil diseases and deficiencies, the increase in NPK application has not shown a corresponding increase in output in rice and wheat. The productivity of wheat and rice has been fluctuating and even declining in most districts in Punjab, in spite of increasing levels of fertilizer application.

The Green Revolution has also resulted in soil toxicity by excess quantity of trace elements in ecosystems. For example, fluoride toxicity has been an unintended consequence of irrigation in various parts of India. Water used for irrigation may sometimes contain excessive fluorine. When this water evaporates, it leaves behind excess fluorine in the soil, and this causes fluorine toxicity.

Most examples in this section are from Punjab, since this was the 'seat' of Green Revolution in India.

Change in land use patterns

In Punjab, a very rapid change in the pattern of land-use took place. Since the start of the Green Revolution, the area under wheat has nearly doubled and the area under rice has gone up by five times. During the same period, the area under pulses (legumes) has been reduced by one-half. Wheat and rice are considered 'soil depleting' crops, while pulses are considered 'soil building' crops. Reducing leguminous crops means depriving the soil of a natural fertilizing agent. Repeated cropping of wheat and rice means draining the soil of nutrients.

Loss of genetic diversity

Traditional agriculture encourages diversity in crop breeds. The Green Revolution displaced genetic diversity in two ways. Firstly, the Green Revolution brought in monocultures of wheat and rice which replaced the existing mixtures and rotation of diverse crops like wheat, maize, millets, pulses, and oil seeds. Secondly, even in rice and wheat, the Green Revolution encourages the growing of single varieties derived from exotic dwarf varieties, to maximize grain production. This is at the cost of the diverse native varieties of rice and wheat which are suited to the different soil, water and climatic conditions. It is dangerous to depend only on a couple of crop varieties to meet the food supply of thousands of people. All the wheat and rice varieties grown in Punjab since the Green Revolution are derived from the genetically narrow base of the Borloug wheats and IRRI rice. This makes the crop more vulnerable to outbreaks of disease and other adverse natural conditions.

The cropping pattern in Punjab has witnessed a major shift towards wheat in the *rabi* season and paddy in the *kharif* season. Wheat has spread at the cost of gram, barley, rape seed and mustard which were usually sown as mixed crops with traditional wheat varieties. Similarly, the area under paddy has increased at the cost of maize, *kharif* pulses like moong, and masoor, groundnut, green fodder and cotton. While this practice loses out on the nitrogen-fixing capacities of the displaced leguminous crops, it demands artificial fertilizer inputs for the cultivated paddy.

Irrigation

Intensive irrigation is a major component of the Green Revolution. The Green Revolution increased the need for irrigation water at two levels. First, it

prompted a shift away from crops which require less use of water such as millets and oilseeds to mono-cultures and multicropping of wheat and rice which require water inputs throughout the year. Secondly, the crop varieties promoted by the Green Revolution need much more water than indigenous varieties. High yielding varieties of wheat, for example, need three times as much irrigation as traditional varieties.

The demand for water has put a lot of pressure on Punjab's groundwater resources. Ninety per cent of Punjab's groundwater resources are used for agriculture. This is 20 per cent more that the national average. Research studies show that for every three litres of groundwater used for agricultural purposes, only one litre is replenished.

Irrigation without proper consideration for drainage of excess water can be dangerous.

Land gets waterlogged when the water table is within 1.5 to 2.1 metres below the ground surface. The water table rises if water is added at a rate greater than the rate at which it can drain out. Waterlogging is associated with another problem—salinization. In regions of scarce rainfall, the soil contains a large amount of unleached salts. Excessive irrigation brings those salts to the surface and leaves behind a residue when the water evaporates. It can also cause unleached salts to accumulate in the upper layers of the soil. This excessive salt built up in the soil is called salinization.

Salt-pollution diminishes the productivity of the soil, and in extreme cases, ruins it forever.

Both these conditions—waterlogging and salinization—can lead to desertification. The rich alluvial plains of Punjab suffer seriously from desertification caused by the introduction of excessive irrigation water to make Green Revolution farming possible.

Equity

The Green Revolution type of agriculture requires intensive inputs and technologies—for example new seeds, more fertilizers and pesticides, tractors and other agricultural machinery and irrigation. Traditionally, access to many agricultural inputs was either free, or was locally traded in non-monetary ways, or was available at prices affordable by most farmers. But when such inputs had to be necessarily bought from the market, poorer farmers could not afford them. So the existing inequities grew.

The Green Revolution technology also demanded land holdings of a substantial size, for making the use of these inputs and technologies viable. For instance, employing a tractor is not economically viable on small land holdings. These factors contributed to farmers with smaller land holdings and less capital being sidelined. For example, small farmers, with land upto 5 acres, constitute 48.5 per cent of the cultivating households in Punjab. In 1974, each small farmer in Punjab was annually running a loss of Rs. 125 whereas farmers with land between 5 and 10 acres had a profit of Rs.50. Farmers with land more than 20 acres were producing a per capita profit of Rs. 1200. Unable to maintain their land holding, many small farmers gave them up. Between 1970 and 1980, the number of small holdings reduced in Punjab by about 25 per cent due to economic non-viability.

This makes clear that the gains from the Green Revolution have not been spread evenly across the society. Only particular crops, regions and farmers have actually benefitted from the Green Revolution because it requires large land holdings, irrigation facilities, high inputs of fertilizers and pesticides, and intensive irrigation. Only the rich farmers seem to have reaped the benefits.

Recent studies and research at International Rice Research Institute (IRRI) show that growth in rice yield has slackened, and is failing to outpace population growth in many countries. Cereal productivity increases—rises in yield per hectare—have been declining, from 2.2 per cent per year in 1967-82 to 1.5 per cent per year during the 1980s and early 1990s. These trends, combined with rapid population growth and environmental degradation has already affected 40 per cent of

cropland and cleared 20 to 30 per cent of forests. It is clear that agriculture must be made more productive and its adverse impact must be reduced.

In the words of Dr. M.S. Swaminathan, an 'Evergreen Revolution' is needed, one that achieves sustainable productivity advances, rooted in the principles of ecology, economics, social and gender equity, and employment generation.

What is Sustainable Agriculture?

Agriculture is sustainable when it is ecologically sound, economically viable, socially just, culturally appropriate and based on a holistic scientific approach. Sustainable agriculture integrates three main goals—environmental health, economic profitability, and social and economic equity.

Sustainable agriculture implies:

- An incorporation of natural processes such as nutrient cycling, nitrogen fixation, and pest-predator relationships;
- A minimization of the use of external and non-renewable inputs that damage the environment or harm the health of farmers and consumers;
- The participation of farmers and rural people in all the processes of problem analysis, technology development, adaptation and extension, and monitoring and evaluation;
- A more equitable access to productive resources and opportunities;
- A greater productive use of local knowledge, practices and resources;
- The incorporation of a diversity of natural resources and enterprises within farms;
- An increase in self-reliance amongst farmers and rural communities; and
- Economic viability of farm operations.

Some Elements of Sustainable Agriculture

Proper selection of site, species and variety

Preventive strategies adopted early can reduce inputs and help establish a sustainable production system. Some examples of this are:

In a dry region, where rainfall is scarce and uncertain, crops like bajra and jowar which can grow with less rainfall, are suitable. Bringing in extensive irrigation in such areas may make it possible to grow water-intensive crops like paddy. But this may lead to other problems such as waterlogging and salinization.

Similarly, choosing pest-resistant crop varieties reduces the need for applying external pesticides.

Diversity

Farms with more diversity are more economically and ecologically resilient. Monoculture cropping does have advantages in terms of short-term efficiency and ease of management. But the loss of the crop in any one year could put a farmer out of business and/or seriously disrupt the stability of a community dependent on that crop. When a variety of crops are grown at the same time, even if one or two fail, the impact is not as much. Also, practicing diversity over a period of time can protect the farm in other ways. Rotating the crops grown on a particular field over a period of time can suppress weeds, pathogens and insect pests that depend on and affect specific crops.

Soil management

Healthy soil is a key component of sustainability. Healthy soils will produce healthy crop plants that have vigour and are less susceptible to pests. Crop

management systems that impair soil quality often also need greater inputs of water, nutrients, pesticides, and/or energy for tillage to maintain yields. In sustainable systems, soil is viewed as a fragile and living medium that must be protected and nurtured to ensure its long-term productivity and stability. Methods to protect and enhance the productivity of soil include using cover crops, compost and/or manures, reducing tillage, avoiding traffic on wet soils, and maintaining soil cover with plants and/or mulches. Regular additions of organic matter or the use of cover crops can increase soil aggregate stability, soil tilth, and diversity of soil microbial life.

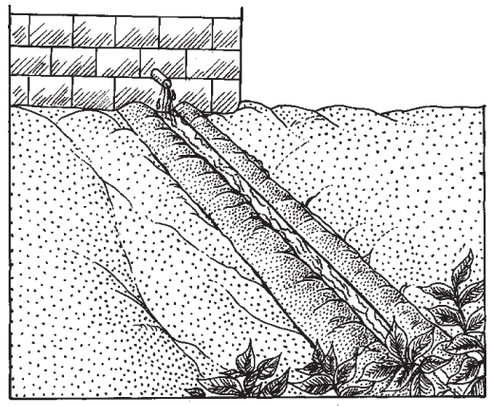
Efficient use of inputs

Sustainable agriculture relies heavily on natural, renewable and on-farm inputs. It also places equal importance on environmental, social, and economic impacts of a particular farming practice. But this does not mean that the use of inorganic inputs is completely forbidden in sustainable agriculture. A judicious combination of organic and inorganic inputs may be used, to ensure that this strategy is the least toxic and least energy intensive, and yet maintains productivity and profitability.

Better Agricultural Practices

The challenge is to meet the increasing demands for food, fibre, etc. without compromising on the long-term well being of the environment.

- Agricultural system should be designed so as to fit the environment (soil, water, climate and pest populations) of the region.
- Water-demanding crops should not be grown in arid and semi-arid areas. Limit livestock grazing on arid and semi-arid areas.
- Encourage water conservation by using irrigation systems that minimize water waste, salinization.
- Maintain vegetative cover on cropland.
- Encourage organic fertilizers, crop rotation and intercropping to increase the organic content of soils.
- Encourage diverse mix of crops and livestock, instead of monoculture production of a single crop or livestock type.
- Whenever possible, rely on locally available, renewable biological resources and know-how, and use them in ways that preserve their renewability. For example using organic fertilizers from animal and crop wastes (green manure and compost), building simple devices for capturing and storing rainwater for irrigating crops, and cultivating crops adapted to local growing conditions.
- Reduce the use of fossil fuels in agriculture by using locally available perpetual and renewable energy resources such as sun, wind, and flowing water, and by using more organic fertilizer instead of inorganic fertilizer.
- Emphasize biological pest control instead of chemical pesticides.
- Provide incentives for farmers using sustainable practices.
- Encourage local people to grow food for local people and let them plant what they want, instead of encouraging export of cash crops that reduces food available to local people.



Save Our Seeds

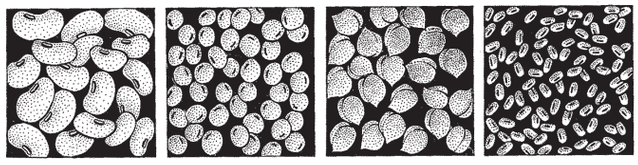
Jardhargaon is a typical Himalayan village in Tehri Garhwal district of Uttranchal state of North India. After the Green Revolution of 1960s in India, farmers in these hilly regions also started using high input-intensive techniques of farming to increase productivity. New 'improved' seeds of high yielding varieties were introduced here, along with a range of pesticides, fertilizers and other externals inputs. In the race for modernization, the farmers began to rapidly lose their traditional systems of sustainable agriculture. Ironically, despite increasing investments and inputs, the soil fertility, and hence land productivity, began to decline gradually. This realization initiated a movement away from the new methods and a return to the traditionally more sustainable ways of farming. The movement, known as Beej Bachao Andolan (Save the Seeds Movement) is not only about conserving traditional seeds but also about promoting agricultural biodiversity, sustainable agriculture and local traditions.

It has not been easy. Several indigenous practices and seeds had already been 'lost'. One of the key needs was to revive these. This was the basis of the Save the Seeds Movement. A group of villagers, led by farmer and social activist Vijay Jardhari from Jardhargaon, started visiting remote villages in search of varieties of traditional seeds. After intensive traveling, the group collected as many as 250 varieties of rice, 170 of kidney beans and many others, which had been presumed 'lost' in the region. In the course of this search, a wealth of information was documented for the first time. For instance, during their search, the Beej Bachao Andolan campaigners found that in the valley of Ramasirain, farmers grew a distinctive variety of red rice called *chardhan* (four grains). The rice was nutritious and did not require huge external inputs. The farmers also grew other indigenous varieties of rice, locally known as *thapchini*, *jhumkiya*, *rikhwa* and *lal basmati*. Agriculture was totally free from the use of chemical fertilizers and pesticides, yet good yields were obtained.

Another remarkable traditional system of cropping which came to light was *baranaja*, where twelve crops are simultaneously grown in the same field. This not only avoided monoculture, but also helped restore soil fertility and ensure food security.

In the *baranaja* (literally meaning twelve grains) system of traditional mixed farming, there is intercropping of twelve, or sometimes more, crops. A combination of cereals, lentils, vegetables, creepers, and root vegetables is grown. The twelve crops ae such that can grow in harmony with each other. The creepers of legumes use the stems of grain plants as a natural support, while the grain roots grip the soil firmly, preventing soil erosion. Due to their nitrogen-fixing abilities, legume crops return nutrients which are used by other crops. No external chemical inputs are given and pest control is achieved through use of leaves of the walnut and neem, and the application of ash and cow's urine. This system of biofarming helps maintain ecological balance, and enables the farmer to get benefit from certain varieties even in case of damage to some crops.

In hilly areas, most peasant families have very limited land holdings. Hence it is not possible to plant different staple food crops separately. In this context also, the concept of the twelve grain systems is scientific and sustainable. Different corps harvested at different time of the year provide security against food shortage, as well as against drought and crop failure in a small piece of land. Diversity in crops also helps in maintaining soil fertility and replenishing nitrogen. Moreover, due to the diversity of crops, it also provides for nutritional security. Millets are rich in calcium, iron, phosphorus, and vitamins, while legumes are a rich source of proteins.



Harvest Festival

From sowing of seeds till the crops mature, months of hard work goes into it before the crops are harvested. When the crops are ready to be harvested, it is time to relax and enjoy. Thus all over the world, men and women celebrate harvest festivals with great joy and enthusiasm.

Study of the Mohanjadaro civilisation reveals the prevalence of harvest festivals in ancient times in India.

The ancient Greeks worshipped the goddess of corn, *Demeter*, who was honoured at the festival of *Thesmosphoria* held every autumn.

In Rome, the goddess of corn is worshipped as *Ceres*, in a festival which helds on October 4, when the goddess is offered the first fruits of the harvest and pigs.

The Chinese celebrate the harvest festival *Chung Ch'ui* on the full moon that falls on the 15th day of the eighth month.

Jewish families celebrate the harvest festival of *Sukkotu*, during the Hebrew month of Tishri.

Egyptians celebrated the harvest festival in honour of *Min*, the god of fertility and vegetation, during spring time.

India is a land of festivals. Seventy per cent of India's population lives in villages, and a vast majority solely depends on agriculture. As a result, many festivals are related to the agricultural activities of the people. *Pongal* is one such festival celebrated in Tamil Nadu every year after the harvest season in mid January. Farmers get ready to thank God, earth and their cattle for the wonderful harvest and celebrate the occasion with joyous festivities and rituals.

Bhogali Bihu celebrated in Assam, *Lohri* in Punjab, *Bhogi* in Andhra Pradesh, *Makar Sankranti* in Karnataka, Maharashtra, Uttar Pradesh, Bihar and Bengal are also harvest related festivals. To mark the harvest season, *Baisakhi* an important festival in Punjab is celebrated in April.