
UNIT 1 CROP ROTATION

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1.0 OBJECTIVES

The present Unit aims at familiarizing you with the :

- Concept and objectives of crop rotation;
- Principles of crop rotation;
- Impact of crop rotations;
- Advantages and disadvantage of crop rotation; and
- Agronomic approaches to maintain the crops in a rotation.

1.1 INTRODUCTION

As we know, in organic farming crops are raised without any chemical supplement. The soil nutrient deficiencies and pest problems are alleviated by adopting nature pro techniques. In this line, the **Crop Rotation** is an important tool.

Now, let us define Crop Rotation. The Crop rotation is stated as growing one crop after another on the same piece of land in different timings (seasons) without impairing the soil fertility. It is a planned order of planting specific crops on the same field. Crop rotation also means that succeeding crops are of a different genus, species, subspecies or variety than previous crop. Examples would be legume after wheat, row crops after small grains, cereals after legumes, etc. The planned rotation sequence may be for a two- or three-year or longer period. The crop rotations have been found to be beneficial for the soil and farmers in different ways. There are significant impact of rotating the crops on crop yield, soil fertility and socio-economic condition of the farmer. We shall see an elaboration on these aspects later in this Unit. One immediate economic benefit of crop rotations is improved yields.

Some soils are so rich in fertility that they can sustain continuous mono cropping with reasonably higher yields. But the researches have shown that after some time, the yield of the crop start declining. The mono cropping leads to a number of problems related to the soil, pest and resource utilization and pest management. A well developed plan that can be altered when necessary should always be followed. Otherwise, the desired crop sequence may be interrupted and the maximum benefits of the rotational effect will not be obtained.

Let us discuss the different aspects of crop rotation in detail.

1.2 PRINCIPLES OF CROP ROTATION

Soil is the base for crop plant growth and development. Successful crop husbandry depends on the choice of right crop on the right soil.

In deciding sequence of crops in a rotation, soil types, fertility and its health, crop rooting habit, inputs availability and their prices, agro-climatic and socio-economic conditions of the farmer, farmers' skill and knowledge should be taken into consideration.

With this background, let us examine the principles of crop rotation. The crop rotation aims at helping the farmers in different ways. The basic principles of crop rotation are as follows:

- Deep rooted crops should be succeeded by shallow rooted crops such as cotton, castor, pigeon pea-potato, lentil, green gram etc.
- Dicot crops should be rotated by monocot crops such as, mustard, potato-rice, wheat- sugarcane.
- Leguminous crops should be succeeded by non-leguminous crops and *vice versa* (green gram- wheat).

- Exhaustive crops should be succeeded with restorative crops such as potato, sorghum, sugarcane, castor -sun hemp, black gram, cowpea.
- Foliage drop crop should be succeeded with non foliage drop crops such as pulses, cotton-rice.
- Grain crops should be followed by foliage crops such as, wheat- *dhaincha*, black gram.
- Long duration crops should be succeeded by short duration crops such as sugarcane, napier, lucerne-cowpea, black gram, groundnut.
- Field crops should be succeeded with fodder crops such as wheat, potato maize + cowpea- berseem.
- Seed crop should be succeeded with multi-cut or multi-harvest crops such as black gram, wheat, barley-lucerne, berseem and oat.
- Minimum tillage crops should be followed by deep tillage crops such as green gram, black gram-sugarcane, potato.
- Dry crops should be followed by wet crops such as rice and sugarcane.
- Crops susceptible to soil borne pathogens and parasitic weeds should be followed by tolerant trap crops such as sugarcane-marigold (for nematodes) mustard, tobacco-rice, pulses (for orobanche), pearl millet-castor (for *striga*), Lucerne, *berseem* – oats (for *cuscuta*).
- Crops with problematic weeds should be followed by clean crops/multi cut crops and other dissimilar crops such as wheat – puddle rice for *Phalaris minor*, *berseem* – potato for *Chicorium intybus*, rice – vegetables for *Echinochloa crusgalli*.
- Pasture crops should be followed by fodder or seed crops such as Napier grass – maize + cowpea or oat.
- Heavy irrigation and intensive labour requiring crops should be followed by less water and labour requiring crops such as sugarcane, paddy- mungbean and sesame.

Soil fertility status also has a role in selecting crops for rotation. Growing of fertility restorative crops in rotation has immense importance. Low fertile soils are not found suitable for crops like maize, potato, cauliflower. Similarly, if sesame is grown in high fertile soil, the flowering will remain at the apex or terminal point, and then there will not be synchronous pod/capsule maturity. The lower most capsules may ripen early and dehisce before harvested. Lodging prone crops should not be grown in high fertile soils.

The objectives of the crop rotation are to:

- Achieve better soil fertility and its physical, chemical and biological properties through addition of organic matters.
- Keep the soil free from disease, pest and weed through various crop and agronomical/cultural manipulations.

- Regulate continuous supply of food, feed, fodder, fibre and fuel as well as funds for various family commitments.
- Make best use of residual soil moisture and nutrients by selective crops.
- Achieve greater insurance against natural calamities and instability in market prices.
- Make best use of labour power and capital through out the year.
- Achieve higher yield without incurring extra expenditure.

1.3 EFFECTS OF CROP ROTATION

After having learnt the principles and objectives of crop rotation, now let us examine the impact of rotation on various aspects in detail.

1.3.1 Balanced and Economic Nutrient Absorption

In a crop rotation, essential plant nutrients are absorbed by the crop plants in a balanced manner, as the nutrient requirement of crops are different, some taking up more of one kind of nutrient than another. A process of single sided depletion may therefore take place, unless a change of crops or rotation is practiced. The difference in the crop uptake of nutrient is shown in the following Table.

Table 1.1: Nutrient Removal by Different Crops

Crops	Nutrient Removal (kg/ha)		
	<i>N</i>	<i>P₂O₅</i>	<i>K₂O</i>
Sugarcane	56	68	190
Wheat	48	21	29
Tobacco	100	16	150
Potato	67	24	77

Further, the higher productive crops generally remove higher amount of nutrients. Therefore, to achieve the targeted higher yield, application of higher amount of manure is required. Considerable quantities of unused manure remain as residue in the soil. If a crop performs poor or fails due to any reason, it is unable to utilize the applied nutrients. Such unutilized nutrients persist in soil as residue and can be taken up by the succeeding crop. Hence, the succeeding crop should be selected in the manner so that it can utilize considerable amounts of residual and instant resources fully.

1.3.2 Soil Fertility and Health Build Up

We know, that different crop plants are having different rooting systems. Some crop plant's roots spread both in depth and in lateral areas, other's root may be straight deep or shallow, spreading in all directions, and others with roots crowding in certain zones in the soil. These differences in rooting system lead to the absorption of essential nutrients from different depths in the soil. Thus, growing of the same crop year after year on the same field will lead to the

impoverishment of particular depths, where as growing crops with different root system in alternate years will lead to effective utilization of the plant nutrients in the soil. Alternating shallow with a deep rooted crop may be regarded as a method of soil restoration, because the soil nutrients are lifted from lower layer to upper layer by the action of roots.

Soil digging is a method of harvesting of crops like Groundnut, Potato, Garlic, Onion etc. The digging benefits the succeeding crop, as it kills many weeds, insect pests and diseases. It also helps pulverize the soil, improve soil aeration and hasten the decomposition process. Soil seed bank is also disturbed. It also helps in improving the soil tilth or soil friability.

Now let us examine the other aspect of crop rotation benefiting the soil.

1.3.3 Legume Effect

Some crops are directly beneficial to the succeeding crops in more than one ways. The legume crops are in this category. The legumes assimilating nitrogen from the atmosphere and enriching the soil with their root system, forms an important component in the rotation. The crop residues of such crops are also available for the succeeding non-leguminous and other crops grown in the rotation. The protein content of the legume residues are high, hence preferred by the microbes which decomposes the residues readily.

1.3.4 Reduction in Insect Pest Build Up

Insects can be controlled entirely or partially by rotations. The insect populations go up within a cropping system where only one or two crops are continuously grown over the time. The insects are able to develop a kind of parasitic relationship with the crop plants and perpetuate till the system is changed by alteration with crops. The feeding habit and habitat of the insects are destroyed by rotations. Insects such as maize borer and stem weevil readily migrate to nearby or distant fields in absence of maize. In such cases, only partial control can be obtained by rotation. Increasing field isolation from fields seeded with the same crop, help controlling of insects. Some of the examples of insect control through crop rotation are as follows:

Table 1.2: Insects Controlled Partially or Entirely by Rotation

Insect	Susceptible Crop
Wheat stem sawfly	Wheat, rye
Wheat stem maggot	Wheat
Hessian fly	Wheat
Alfalfa weevil	Alfalfa
Sweet clover weevil	Sweet clover
Sunflower insects: moth, banded moth, stem weevil, midge and beetle	Sunflower, cultivated and wild
Maize root worm	Maize
Sugarbeet, maggot and root aphid	Sugarbeet

Michael D. Peel (1998)

Reduction in pest incidence in crops under any rotation may be the result of :

- Enhanced predator and parasitoid population.
- Availability of alternate food for natural enemies.
- Reduced colonization and reproduction of pests.
- Masking and feeding inhibition from non host plants.
- Prevention of pest movement.
- Development of optimum synchrony between pests and natural enemies are some of the ways which effectively control the incidence of insects and pests.

Intercropping systems are also found very effective for pest reduction. Inclusion of aromatic plants such as garlic, onion and tomato can disturb pest orientation to the crop plants. For example: Garlic as an intercrop with sugarcane effectively controls sugarcane top borer. Cowpea intercropped with sorghum reduces sorghum stem borer infestation. Coriander with sugarcane reduces top borer in sugarcane. Change in planting date also affects pest population. For example: maize planted 20 to 30 days earlier reduced leaf hopper population.

1.3.5 Weed Management

Rotating crops helps in weed management. There are certain weed species that are associated with a particular crop. The micro-climate of the crop is favourable to weeds. Such weeds are called **crop bound weeds**. In the long term, these weeds cause severe damage to the crop yield. If the particular crop is unavailable, the weeds also disappear. These weeds can be eradicated by adopting crop rotation.

Crops sown under rotation have to be selected in such a way that they are able to suppress the weeds. For example: Johnson grass (*Sorghum helipense*) becomes a problematic weed in continuous sorghum cultivation, which can be controlled by putting a pulse crops in the rotation. 'Sugarcane-wheat' system in place of 'rice-wheat' brings down Little Canary Grass (*Phalaris minor*) infestation. Nutsedge (*Cyperus spp.*) can be managed by adopting 'sesame-wheat' rotation. *Orobanche* can be controlled by replacing mustard and tobacco by some cereal crops. The differential rooting pattern of the crop in a rotation also helps in depleting the weed seed bank.

1.3.6 Crop Disease Management

Crop rotations are suitable agronomic system to reduce disease infestations in different crops. Crop rotation can reduce the inoculum of many pathogens. There are many examples where crop rotations are an important tool for disease management in different crops. Maize-Cowpea intercropping can reduce *Ascochyta phaseolorum*. Pigeon pea wilt caused by *Fusarium oxysporum* f. sp. *udum* can be minimized when it is intercropped with *sorghum*. Some examples of crop rotation as an important tool to manage different plant diseases are given below:

Table 1.3: Common Disease Controlled Entirely or Partially by Rotation

Disease	Major Crops Attacked	Best Control Methods
Common root rot	wheat, barley, grasses	Rotation , seed treatment
Ergot	rye, wheat, grasses	Rotation , tillage
Bacterial blights	wheat, barley, grasses, rye	Rotation
Scab	wheat, barley, maize, rye	Rotation
Tan spot	wheat, durum	Rotation , fungicide
Net blotch	barley	Rotation , fungicide
Septoria (different species)		wheat, barley, Rotation , fungicide
Septoria (different species)		wheat, Rotation , fungicide
Septoria (different species)		barley, Rotation , fungicide
Pasmo	flax	Rotation , variety
Wilt (flax)	flax	Rotation , variety
Rust (flax)	flax	Resistant Variety, Rotation
Seedling blight	wheat, barley, maize, oats, rye	Seed treatment
Smut (maize)	maize	Rotation
Bacterial wilt	alfalfa	Variety resistance
Crown rot	alfalfa	Variety resistance
<i>Verticillium</i> wilt	potato, sunflower, safflower	Rotation , variety
Rust (sunflower)	sunflower	Variety, rotation
<i>Sclerotinia</i> (white mold)	sunflower, dry beans safflower, soybean, potato, canola	Rotation for 4 to 5 years

From Michael D. Peel (1998)

1.3.7 Efficient Resource Utilization

As you know, crops in a rotation differ in their nature, resource requirement and resource utilization. The natural resources such as water, space, land, family labour and sunlight are efficiently utilized through proper crop planning.

1.3.8 Soil Moisture Utilization

The soil moisture is properly utilized by rotating the crops. The deep rooted crops such as sunflower may utilize soil moisture from deeper soil layers. In contrast, the shallow rooted crops utilize the soil moisture from shallow layers. In another way, the varied root structure and spread allows more water percolation and conservation at different soil depths.

1.3.9 Reduction in Soil Erosion

Crop rotation with recommended packages of practices reduces wind and water soil erosion. Direct seeded (broadcast) crops such as small grain crops provide

better protection against water erosion than row crops. Different crops make available their residues throughout the year and hence, protect the soil by the action of mulching.

1.3.10 Income Stability

Growing different crops in different seasons provides contingency income. If something goes wrong with any crop, the next crop would help mitigate the loss.

1.3.11 Time Management

The crops in a rotation have different input requirements, application schedules and expense demand. Their maturity time also differs. This helps the farmer to manage his time to look after different crops efficiently. The occupancy of family members in different farm and domestic works is ensured efficiently.

1.3.12 Machinery Efficiency

Different crops in different seasons keep the machine with the farmers active in operation. Their full engagement and availability in the operation get ensured.

Check Your Progress Exercise 1

Note: a) Space is given below for the answer.

b) Compare your answer with that given at the end of the unit.

1) What do you mean by crop rotation?

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2) What are the objectives of any crop rotation?

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3) How rotation help in balanced nutrient absorption?

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1.4 FARMERS SKILL

In adopting suitable crop rotations in organic farming, farmers should have a sound understanding of the different aspects of crop and crop rotation. A farmer is the ultimate user of any technology at the farm. He/she is also the decision maker at the field level. The skill and knowledge of farmers are of prime importance in acquiring, adopting and inventing new ideas suitable to his farming eco-system.

Majority of Indian farmers get the major share of income from crop production. Therefore, it is very much important to select the right crop, in the right season so that maximum profit may be achieved. In selecting a crop for a season, both post and pre season crops should also to be examined.

1.5 CROP ROTATIONS AFTER GREEN REVOLUTION

With the advent of high yielding and photo and thermo insensitive varieties, almost all crops can be grown in all seasons. This leads to perpetuation of insect pest and diseases and other formidable enemies of crop plants. For example: continuous cultivation of groundnut, cotton, and chickpea has given rise to serious pests and diseases like white grubs, pink bollworm, wilt or premature drying and also pod borer which is a serious pests for many crops. The crop plants possess their defense mechanism but it gets broken because of faulty agronomic practices and repeated sowing of same crop year after year on the same piece of land. Such practice is the root cause of many problems like weeds, insect pests disease build up and soil sickness. This is well documented as **Phagocytic Theory** of soil fertility that some of the crops secrete certain substances which can attract or repel one or other bioagents in the soil and can be useful or harmful to the crops.

After the Green Revolution, 'rice-wheat' rotation expanded in the larger areas of the country. The practice of growing rice and wheat continuously for longer period of time resulted in decline in yields of both the crops. Before the Green Revolution, farmers were growing some legume crops or sometimes the field is left as fallow in the rotation which kept soil healthy.

Post Green Revolution witnessed more spread of 'rice-wheat' rotation in the country, particularly in Indo-Gangetic plain zone. Due to continuous adoption of the same rotation, several problems have propped up. The weed and pest problems got aggravated. This led to the decline in the yields of both the crops. Canary grass (*Phalaris minor*) in wheat and Jungle rice (*Echinochloa colona*) in rice become the problematic weeds if rice-wheat rotation continues for many years and causes significant yield reductions in both the crops.

1.6 AGRONOMICAL PRACTICES FOR CROPPING SYSTEM

Agronomical practices include all management practices required for raising crops either in isolation or in rotations. Agronomic practices involve : land preparation, application of manures, scheduling and application of irrigation, and methods of plant protection including weed management, plant population management and crop geometry. These practices are affected by the soil types, climate and socio-economic status. Requirement and resource available influence the selection of crops. Let us discuss the agronomic practices in detail.

1.6.1 Land Preparation

We all may agree that appropriate tillage is needed to establish an ideal zone (tilth) for the crops. The ideal zone minimizes the stress and provide a favorable condition for the seed germination and subsequent plant growth. Potential stresses include moisture stress (excess or inadequate), unfavourable temperature, soil crusting/impedance, pests, pathogens, weeds infestation etc. The seedbed should be prepared in accordance with the crop requirements.

Examples of suitable seedbed may be : puddled field for rice, ridges and furrows for maize, cotton and vegetables and flat seedbed for many other crops.

Now days, Zero Tillage is being advocated where wheat is sown after rice crop without field preparation. As we know, after harvest of rice, the time is short and if the field is prepared properly, the wheat sowing gets delayed. Delay sowing of wheat reduces its yield significantly.

The field preparation also includes proper crop residue management. You may recall that after harvest of any crop, some residues of it are left in the field. It takes time to get fully decomposed and prior to that it lie over the surface create physical hindrance in further operations.

In multiple cropping, minimum tillage is preferred due to shortage of time between two crops. To store and conserve soil moisture, deep tillage is practiced during monsoon season and shallow tillage is recommended during *rabi* season. Deep ploughing is recommended at certain interval also to break the hard pan which buildup after rigorous machine use.

1.6.2 Manuring

In order to have a better crop yield, the soil should be fertilized properly. In organic farming, crop nutrient requirement are met through the organic sources

only. Crops differ in their nutrient requirement. So, in a rotation, nitrogen and phosphorus rich organic manures should be applied to cereals, phosphorus rich manures to short duration legumes, potash rich manures to sugarcane and tuber crops, sulphur rich to the oilseed crops and calcium rich (like poultry manure) to groundnut crop.

When rice is grown in the rotations, green manure crops such as sunnhemp or *Dhaincha* may be used. The green manure crop is incorporated before their flower initiation and 10 to 15 days are allowed to decompose it before planting rice. Biogas slurry and fresh cattle urine can be useful to the crop suffering nitrogen deficiency. Judicious use of biofertilizers such as *Azolla*-Blue green algae, *Azotobacter*, *Azospirillum*, *Rhizobium*, Phosphorus solubilizing microorganisms and VAM also recommended.

1.6.3 Water Management

Water management in crop rotation is very important. The general principles applicable to sole crops will also apply for the crops in rotation. Most of the *Kharif* crops are dependent upon monsoon rains. The important aspects of water management are harvesting of rain water, supplemental irrigation and reduction in evapotranspiration through various agronomic practices. Scheduling of irrigation at appropriate time with adequate amount of water without water logging, salinity and alkalinity are some of the irrigation management measures to be followed for efficient use of water.

1.6.4 Weed, Pest and Disease Management

In a rotation, weeds, pests and diseases should be managed through intercultural operations. The infested plants should be removed physically and burnt or buried. Weed biomass after cutting should be spread on the ground to act as mulch. If rotation is followed properly, these problems remain under control.

1.7 SELECTION OF CROPS IN ROTATIONS

In any rotation, while selecting any crop, the farmer should select the crop or crop varieties on the basis of following criteria:

- 1) Adaptable to the local climatic conditions.
- 2) Have demand in the market.
- 3) Short duration.
- 4) Timing of input requirements should differ.
- 5) Maturity of crop should match with the market demand.
- 6) Crop demand should match with the available resources.
- 7) Resistant to pest and diseases.

1.8 ADVANTAGES OF CROP ROTATIONS

These are the following advantages of a crop rotation:

- Higher yield with out incurring extra investment.

- Enhanced soil fertility and microbial activities.
- Avoid accumulation of toxic substances.
- Better utilization of nutrients and soil moisture.
- Insurance against natural devastation.
- Maintain soil health by avoiding insect pest, diseases and weed problems.
- Provide proper labour, power and capital distribution through out the year.
- Higher chances to provide diversified commodities.
- Slow but steady income, which is beneficial to marginal and small farmers.
- Deep rooted crops work the soil below plough layer.

1.9 DISADVANTAGES OF CROP ROTATIONS

Adopting a crop rotation is always advantageous. However, there are certain ill-effects of a rotation if it has not properly followed, as listed below:

- Repetition of same crops in rotations for many years may nullify long term benefits and may develop associated weeds and insect pest and diseases.
- Difficult to shift to crops of high demand or ethnic requirements.

Check Your Progress Exercise 2

Note: a) Space is given below for the answer.

b) Compare your answer with that given at the end of the unit.

- 1) What changes took place in crop rotation after Green Revolution in the country?

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- 2) Elaborate the features of a crop rotation in terms of advantages and disadvantages citing a suitable example of rotation, preferable from your area.

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1.10 LET US SUM UP

In this Unit, we studied the concept, principles, objectives and implications of crop rotations. Component crops are selected in a way to up keep soil health and fertility. Besides, rotation is an important tool to tackle the problems of diseases, insect pest infestation and weeds. Through rotation, a farmer can utilize his resources efficiently by managing family labour and putting the farm implements in optimum use.

Paddy- pulses, bajra-pulses, sorghum – pulses, maize – pulses or clovers, groundnut – wheat, soybean – mustard are some of the important crop rotations prevalent in India. There are several small variations of these which are followed in conjunctions with other crops such as tobacco, potato, cotton, sweet potato, chilies, vegetables etc.

1.11 KEY WORDS

Solid Planting/Sole Cropping	: One crop variety grown alone in pure stand at normal density.
Monoculture	: The repetitive growing of the same sole crop on the same land over the years.
Rotation	: The repetitive cultivation of an ordered succession of crops (or crop and fallow) on the same land (one cycle may take several years to complete).
Cropping Pattern	: The yearly sequence and spatial arrangements of crops or of the crops and fallow on a given area.
Cropping System	: The cropping pattern used on a farm and its interaction with farm resources, other farm enterprises, and available technology which determine their make up.
Multiple Cropping	: Intensification of cropping in time and space dimensions. Growing two or more crops in the same field in a year.
Sequential Cropping	: Growing two or more crops in sequence on the same field per year. The succeeding crop is planted after the preceding crop has been harvested.
Double Cropping	: Growing two crops a year in sequence.
Triple Cropping	: Growing three crops a year in sequence.
Intercropping	: Growing two or more crops with fixed crop geometry on the same field at the same time.
Diversified Cropping	: A cropping plan in which no single crop contributes 50% or more towards the total crop production or monetary income annually.
Fallow Land	: A land left unfarmed for one or more growing seasons to kill weeds, make the soil richer.
Mixed Cropping	: Growing two or more crops simultaneously without any set crop geometry.

- Residual Effect** : Effect of the previous crop in a sequential cropping pattern on the productivity of current crop.
- Relay Cropping** : Seeding or planting of succeeding crop after flowering and before the harvest of the standing crop. It is analogous to a relay race where one crop hands over the land to the next crop in quick succession *e.g.* Maize-potato-wheat-mung.

1.12 FURTHER REFERENCES

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1.13 MODEL ANSWERS

Check Your Progress Exercise 1

- 1) The crop rotation is growing different crops in different seasons on a piece of land with an aim to improve the soil fertility and crop yield. When crops are planted in sequence, the farmer enjoys the diversity of the products and time of operations in the field. Some of the examples of the rotations are as : rice-wheat, maize-wheat, sugarcane-wheat, rice-potato-wheat etc.
- 2) As we have read in this Unit, the benefits of any crop rotations are many. Some of the objectives are: meeting the diversified food requirement of farmer, efficient resource utilization and pest and disease management.

The rotations also act as assured source of income for the farmers because in the event of crop failure, the next crop would yield some income.

- 3) The crops in a rotation are having different features. Due to their varied root structure and spread, the crops are able to draw soil nutrient from different layers in the soil. The soil nutrients which are lying unused, would be utilized by the other crops of the rotaion.

Check Your Progress Exercise 2

- 1) After Green Revolution, the spread of photo and thermo-insensitive varieties of rice and wheat were very much in the country due to their adoption by the farmers. Previous to this event, the farmers were growing different crops having the traditional varieties, which were poor yielder. The 'rice-wheat' rotation spread largely in irrigated areas.
- 2) Take an example of a crop rotation of your area and visualize the significance of having many crops on a piece of land in different seasons. You may discuss with any farmer of your area about the advantages and disadvantages of adopting a crop rotation.