Crop rotation is one technique for avoiding soil depletion which avoids the problems associated with fallowing and use of animal manure or chemical fertilizers.

9.2 Rotation

9.2.1 Concept and Importance of crop rotation

Crop rotation is the strategy of raising crops from a piece of land in such an order or succession that the fertility of the land suffers minimally and the farmer's profits are not reduced. This system is in contrast with the practice of growing the same crop year after year. Crop rotation systems have been practiced in Pakistan from time immemorial and every farmer is quite familiar with it. The main benefits of a scientific rotation are:

1. By rotating crops of different seasons, it is easy to *control weeds*. Some weeds (Johnsongrass, nut grass) are much more troublesome in summer than in winter, and can be suppressed by growing rabi crops after summer fallowing. Similarly, some crops like potato and fodders (berseem, alfalfa) when included in rotation exert a useful weed smothering influence.
2. By planned, regular, and careful succession of crops, it is easy to *keep plant diseases and insect pests under control*. Some fungi and insect pests attack only particular genera or orders of plants, and become especially troublesome when such crops are grown on the same land every year. Rotation, therefore, offers an easy way to keep such pests in check.
3. By growing crops in a suitable order it is possible to *maintain the fertility of the land*. The reasons are:
   a. As different crops remove different plant nutrients in different quantities from the soil, a proper balance of nutrients cannot be maintained if the same crop is grown year after year on the same land. Those nutrients which are removed in large quantities by that particular crop will be exhausted and the land will not be able to produce a decent crop, even though there may be plenty of other nutrients in the soil to grow other crops.
   b. Differences in the root systems of various crops affect the quantities of nutrients removed from the soil. Shallow-rooted crops remove more plant food from the surface, while deep-rooted crops open up the subsoil and take food from the lower layers as well.
   c. Leguminous crops have the property of fixing atmospheric nitrogen with the help of bacteria present in the nodules of their roots. Their inclusion in the rotation is therefore very helpful in maintaining fertility.

   d. Soil fertility is closely linked with its humus content. This is very important in hot climates and also with extreme types of soils like sands and clays. By including green manuring crops in the rotation at regular intervals, the humus content of the soil can be kept up.
4. Growing a variety of crops with different sowing and harvesting periods enables the farmer to *distribute his labour force more evenly*. It also ensures some return on capital at different times of the year for domestic requirements and farm needs. Proper marketing of the commodity and availability to the consumers is assured.

9.2.2 Principles of crop rotation

In view of the advantages of rotation, the following basic principles should be kept in mind while planning a scientific rotation programme.

1. Crops of the same natural order (family) should not follow each other.
2. Crops of the same type of root system (shallow or deep) should not follow each other.
3. Leguminous crops should be included in the rotation at least every three to four years.
4. Green manuring and forage crops should be given a place in the rotation at regular intervals.
5. Crops like potato, sugarcane, and seasonal vegetables which require more thorough cultivation than others should be included in the rotation, as their cultivation makes a very good preparation for the following crop.
6. Alternating crops susceptible to certain diseases with those that are resistant helps control pests and diseases.

9.2.3 Limitations of crop rotation

Rotation cannot be considered a complete replacement for manures and fertilizers needed for the production of various crops. In the vicinity of large cities, where fruits, vegetables, and fodder crops are more remunerative than other crops, it is difficult to follow desirable rotation principles completely. In rainfed areas also, because of scarcity of water, rotation cannot be followed in some seasons of the year. Farming has become so commercially oriented that in the vicinity of sugar and ginning mills sugarcane and cotton are grown in close succession using high inputs.

9.2.4 Choice of rotation

The choice of a crop rotation pattern is determined by the following factors.

1. Physical condition of the soil
2. Prevalence of weeds
3. Supply of plant food
4. Availability of desired quantity of good quality water
5. Economic and political conditions
6. Financial condition of the farmer

9.2.5 Definition and computation of cropping intensity

In the days when population pressure was not so great, farmers were not very concerned about cropping intensity, but now, because of growing population pressure, farm lands need to be thoroughly prepared and proper rotations followed so as to maximize crop yield for each year. The term **cropping intensity** refers to the ratio of actual cultivated area to total farm area over a year. For example, if a farmer has 12.5 hectares of land, out of which 3 hectares are cropped in kharif and 7 are sown in rabi season, the cropping intensity is 80%. It is calculated as follows.

$$\text{Cropping intensity} = \frac{\text{Actual cropped area}}{\text{Whole farm area}} \times 100$$

$$= \frac{10}{12.5} \times 100 = 80\%$$

If the area under crops is 15 acres over the whole year, the intensity of cropping would be 120%.

Cropping intensity is mainly dependent on availability of sufficient irrigation water and level of soil management. Because of the ready availability of artificial fertilizers, the maintenance of soil fertility is no longer a serious problem, and thus water supply becomes the critical factor in increasing the intensity of cropping.

Sometimes a whole farm block is divided into sub-blocks of fixed area, depending upon the period or number of years, to follow a specific rotation. If only one crop, for example rice, is to be cultivated in a one-year rotation pattern, the intensity would be 100%, but if two crops, rice and wheat, are grown in a year, the intensity would be 200%.

One-year rotation:
rice = 100%
rice – wheat = 200%

Two-year rotation:
wheat – fallow – wheat – cotton = 150%

Three-year rotation:
wheat – fallow – toria – cotton = 100%

Four-year rotation:
sugarcane – fallow – cotton – berseem – fallow – wheat – maize = 125%

Cropping intensity in the above examples is calculated as follows:

$$\text{Cropping intensity} = \frac{\text{no. of crops taken}}{\text{no. of years taken for cropping}} \times 100$$

In this modern and competitive age, cropping intensity must be increased as much as possible—mainly because of limited available land—to meet all types of human wants. This is now possible to a large degree because fertilizers are available, and farming can be mechanized. However, higher cropping intensity without an assured supply of water is not possible. Potential shortfall of water will be most critical in those areas of Pakistan where rainfall is not dependable.

Intercropping is another way to increase the intensity of crop cultivation. In the vicinity of Peshawar, it is not uncommon to see farmers raising three intercrops in a year; for example, wheat + sugarcane (dormant) + tomato or onion (in spring). The intensity in this particular case would be 300%. Much more increase is possible with relay patterns of cropping.

Crop rotation patterns in Pakistan are classified as irrigated, well-irrigated, and rainfed (barani) area rotations.

9.2.6 Common crop rotation patterns

The following are some of the crop rotation patterns followed in irrigated, well-irrigated, and barani areas.

Table 9.1 Crop rotation patterns (GM = green manure)

Area/rotation	Cropping intensity
A. CANAL-IRRIGATED AREAS	
Two-year rotations	
a. wheat–cotton–fallow–wheat	150%
b. maize–senji–cotton	150%
c. rice–maize	100%
Three-year rotations	
a. wheat–toria–cotton	100%
b. guara buried (GM)–wheat–toria–cotton	133%
c. wheat–fallow–cotton	66%
d. wheat–fallow–cotton–wheat	166%

Area/rotation	Cropping intensity
e. wheat–maize–senji–sugarcane	166%
f. wheat–maize–sugarcane	100%
g. wheat–sugarcane–sugarcane (ratoon)	150%
h. sugar beet–sugarcane–sugarcane–tobacco + maize	166%
Four-year rotations	
a. wheat–wheat–toria–cotton	100%
b. guara (GM)–wheat–toria–cotton–wheat	125%
c. wheat–maize + senji–sugarcane–cotton	125%
d. wheat–wheat–gram–cotton	100%
Five-year rotations	
a. wheat–fallow–wheat–toria–cotton	80%
b. wheat–wheat or gram–maize + senji–sugarcane–cotton	120%
c. kharif fodder–oat or gram–wheat guara (GM)–wheat–mash + cotton	140%
d. wheat–fallow–wheat–kharif fodder–gram–cotton	100%
B. WELL-IRRIGATED AREAS	
One-year rotations	
a. potato–maize–potato	300%
b. tobacco–maize–potato or cauliflower	300%
c. cauliflower–gourd	200%
d. cabbage–cauliflower–onion–maize	400%
e. wheat–cotton	200%
f. cauliflower–cabbage–onion–cucurbits–maize fodder	500%
Two-year rotations	
a. kharif fodder–wheat–maize–wheat	200%
b. wheat–cotton–fallow–wheat	150%
c. maize–wheat–bajra–turnip	200%
Three-year rotations	
a. maize–wheat–bajra–melon–oat or wheat	200%
b. tobacco–maize + senji–sugarcane	138%
Four-year rotations	
a. wheat–maize + senji–sugarcane–cotton	125%
b. wheat–mash or turnip–cotton + senji–sugarcane or tobacco	125%
C. BARANI AREAS	
Two-year rotations	
a. wheat or gram–chari + guara or bajra	100%
b. wheat–gram or sarson	100%
c. wheat–mash + sesame–fallow	150%
d. wheat–fallow–wheat	66%

In conclusion, a well-planned crop rotation pattern has important functions in soil improvement and fertility, weed control, regulation of labour and water use, and stability and security of income, so that in many cases it can confer economic advantages over monoculture.

9.3 Farming systems

9.3.1 Concept of type and system of farming

The term '**farming system**' consists of two words; let us define each of these words separately, and then the term 'farming system'. A farm is a piece of land on which crops, livestock, or both are raised. Farming is the business of operating a farm, which includes all the operations farmers do to raise crops or livestock. A system is an established way of doing things. Thus a farming system is an established way of operating a piece of land for raising crops, livestock, or both; it involves everything done on the farm or outside of the farm which is related to farm operations.

When a farmer operates a farm, he is trying to achieve certain objectives. Farmers use resources like land, water, manure, labour, and capital to accomplish the jobs necessary to reach their goals. They also operate under constraints like limited resources, non-availability of machinery, labour, or markets, restrictions, and public opinion. The interaction of objectives, resources, and constraints leads to a specific way of operating a given piece of land to raise crops and/or livestock, which we call a farming system—the totality of things done on a farm.

Each farm has a unique system which has evolved in relation to the environment and soil of the farm, social and economic conditions, technology and capital availability, communication and marketing facilities, plant and animal genetic resources, and implements and labour available. Though each individual farm has its own particular system, relatively similar systems can be grouped, based on different criteria, into various classifications.

There are two broad types of farming systems, with a third resulting from a combination of the two.

1. Arable production
2. Livestock rearing
3. Mixed farming

Other classification criteria are: (a) extensive and intensive farming systems, (b) subsistence and commercial farming systems, (c) dry and irrigated farming systems, (d) sole and multiple cropping systems. There are also other ways to group farming and cropping systems, like grassland farming, fruit farming, truck farming, vegetable farming, dairy farming, poultry farming, monocropping, and organic farming systems.