Chapter 13
Legumes

LEGUMES

Members of this family are in the dicots group of plants. The fruits are in pods; each pod contains one row of seeds. Each seed contains two cotyledons. Most leaves are simple; a few can be compound (pinnate or palmate). Legumes are rich in oil and proteins. Proteins in legumes are high quality proteins. All legume plants have root nodules that contain nitrogen-fixing bacteria. These organisms fix nitrates from atmospheric nitrogen; from these nitrates many plant proteins are formed. This information is significant in agriculture, in that crops that deplete the soil of nitrogen is often rotated in planting locations with legumes.

Legumes include beans of different forms (kidney beans, pinto beans, green beans, wax beans and butter beans), and peas. Beans contain about **25% of protein**. They are cultivated worldwide. They require **a moderate rainfall and a warm temperature**. Pea has a lower % of proteins and requires lower temperatures; the common pea is the garden pea (Pisum sativum).

Peanuts (also called groundnuts) came originally from South America, however they are also cultivated worldwide (Africa, North America). Peanuts grow best in **light sandy soils.** The plant produces **a flower stalk, which grows downwards, after pollination**. The developing **fruit is pushed back into the soil in order to mature**. The mature pod contains two seeds. Peanuts have a high % of **oil (45-50%)** and a relatively high % of **protein (25-30%).**

Soybeans were cultivated in Northern China. They were important staple food for Chinese and other Oriental countries. Soybeans are now currently being produced in large quantities in United States. It requires **warm temperature and moderate amount of rainfall.**

Soybeans contain **oil (13-25%)** and protein **(30-50%).** Soybean is never consumed raw because of **a trypsin inhibitor that will prevent the protein from being digested, however when cooked the inhibitor is inactivated therefore the soybean can then be digested** if eaten.

Soybean is important in the production of **soy sauce and Soy milk**. Fermentation of the soybean in brine (salt solution) produces the soy sauce. Soybean when soaked in water and pureed, produces a juice which when heated gives the product Soy milk, used as baby formula. Another important product is the **Tofu** which is used by many Oriental people. Tofu is obtained from Soymilk. **Tofu is used in Soy cheese, cream cheese, cheddar cheese, Swiss cheese, yogurt, sour cream and other dairy products**. Soy products are known to contain **isoflavin which is a phytoestrogen which can lower cholesterol and blood pressure. Isoflavin can lower the risk of osteoporosis and inhibit tumor growth.** Other products of Soybean include the **Tempeh and Miso** consumed by the Orientals. Both are fermented soybean products, Miso is a fermented food prepared from a mixture of soybeans and Rice, while Tempeh is a fermented soybean that forms a soybean cake. The oils from the soybeans can be extracted; also the soy meal can be used for soy flour. **Soy oils can be used for cooking, salad oil,**

margarine and shortenings. Soy oils can be used for industrial purposes (paints, inks, soaps, insecticides, and cosmetics). Lecithin is extracted from soybeans and is used as a food preservative.

Forage Legumes (alfalfa and cloves)

Legumes can be grown as forage crops for consumption by animals, among them include alfalfa that are dehydrated for livestock (cattle and horses). **Alfalfa** can also be consumed by humans in salad and in sandwiches; **they are high in proteins, vitamins and minerals**.

Alfalfa is also used in **biomedical research because it is easily grown in cell cultures** and can incorporate genes easily. **Extracts from alfalfa are being sold as pills in nutrition stores.** Other forage legumes include cloves.

Study Questions

1.Briefly describe a legume plant.

2.Name 3 examples of legume crops.

3.In nutrient contents (Fats and proteins) how will peanuts, kidney beans, and soybeans compare.

4.State 10 uses of soybeans.

5.Soybeans contain a chemical substance that can lower cholesterol, blood pressure, and the risk of osteoporosis. What is this substance?

6. List ten examples of legumes and state two important uses of each.

7. Mention five products of soybeans and their uses.

Chapter 14
Starchy Staples

Introduction

Starchy staples are modified roots or stems that store starch in plants. Most plants that are starchy **staples are tropical,** they can be best cultivated **asexually** and are highly productive. Among these are **potatoes, yam, and cassava**. These starchy staples are **high in carbohydrates** but **low in proteins and fats**.

Modified Stems can be underground or horizontal.

Among them include **stolons** or **runners**. These stems are horizontal, and above the ground, they produce buds and roots at internodes that grow into smaller plants (plantlets), examples include the strawberries, lawn weeds, and crabgrass.

Underground horizontal stems are rhizomes. On the surface of these rhizomes are buds that open into small scale-like leaves, while on the underside are the adventitious roots. Examples of **rhizomes are ginger, and iris**. Among the rhizomes that form storage organs are the tubers, which include the potatoes, and the yams.

Modified stems are **bulbs** (onion bulbs) and **corms. The bulbs are modified underground erect storage stems; examples include onions, tulips, daffodils and lilies.** Each bulb easily gives rise to a new plant by a vegetative reproduction. The **corms** are just like the bulbs, but do not have fleshy leaves of the bulbs

Modified root

An example is the **taro or cocoyam**. Other modified roots include the **tuberous roots** and **taproots**. These roots can reproduce asexually and also act as storage organs. Examples of **tuberous roots include sweet potatoes, and begonias; examples of taproots are carrots, and turnips**. The taproots are not considered starchy staples since the stored food is not mainly starch.

Solanium tuberosum

Potatoes are widely cultivated in the North America; among the wide use of potatoes are the French fries, potato chips and potato starch. The potato plant is an annual plant, it is herbaceous and it is a dicot plant. White potato *Solanium tuberosum* originated from **South America**. Although potato was introduced in the 16th century, people started eating it in the 18th century. Potato was highly cultivated in Ireland. Potatoes are usually infected by fungus (*Phytopthora infestans*) that causes the late blight of potato. The leaves and stems of potato become black with the infesting of this fungus. The leaves and stems of the potato are destroyed, also the potato tubers rot in the ground or in storage when attacked by this fungus. This attack caused famine in Ireland that largely depended on it for food. Many Irish people migrated from Ireland to United States. United States set up kitchens to feed these destitute. Potato was widely cultivated in United States because it was regarded as a cheap source of food for the peasants. Today Europe and the Soviet Union are the World leaders in the production of Potatoes followed by China,

Poland and United States the fourth in rank. The top potato producing State is Idaho, followed by Washington and Maine. Potato is consumed in the form of steamed, boiled, baked, French fries, chips, dehydrated flakes and potato starch.

The Solanum tuberosum grows well at low temperatures (15-18 ^{o}C). Cultivation of potato requires propagation of the tuber pieces with at least one eye. This type of cultivation is asexual / vegetative reproduction. Potato plants obtained by this means are genetically identical to parent plants. Potatoes are rich in **carbohydrates (25%)** and some **proteins (2.5%),** has some important **essential amino acids**. Potatoes are important source for **potassium, iron, Vitamin B and C**. Most of the nutrients are in the fibers, so it is recommended that the potatoes are eaten with skin.

Sweet Potato (*Ipomoea batatas*)

The plant and the flowers resemble those of the morning glory. They are very easy to grow at home. They can be propagated vegetatively. They require warm temperature for growth. It is believed to be native to South America. China leads the World in the production of sweet potato, followed by Asian countries. In Asia sweet potatoes are fermented and used for alcohol beverages. Most African Countries also use them for food. There are two varieties: a yellow type and a deep orange color type well known as yam. It is rich in **carbohydrate (sugar) and some vitamins (Vitamin A and C).** They have **more calories than the white potato and contain less protein.**

Cassava (*Manihot esculenta*)

This is a starch staple for tropical people. It can be called tapioca, yucca or mandioca. Brazil is the leading producer of tapioca in South America. The Portuguese introduced cassava to the West and East Africa and currently Nigeria is the World leader in the production of cassava followed by Zaire. Asia also produces cassava, and is considered the next leader in the production of this crop. The plant is a tall shrub with palmate leaves and tuberous roots. They can easily be cultivated by propagation of the cut stems. These plants grow very fast and yield enormous cassava roots for consumption. Seeds can also be used for cultivation for genetic variability, however this is not a fast way to cultivate cassava. These plants can grow in hot tropical countries. They require heavy rainfall but not flooded soils. Some varieties can tolerate cold temperatures. It can grow in nutrient - poor soils. It is tolerant to acid soils. It is tolerant to many insects (example, locust) and fungal pathogens. The plants can be harvested after every 8 to 12 months and even up to 2 years. **Cassava contains hydrocyanic acid**; during processing, this cyanide is easily removed before consumption. Cassava can be eaten by frying, by boiling or by grating; or it can be dried into cassava flour, or it can be fermented and be used for food. It is also processed to form a meal called Farihna in South America. In Africa it is grated and allowed to ferment, the juice is all squeezed out; the final product is used to make fufu. Another way, cassava can be used is to make garri. In this case, the cassava is grated, and fried dry without fermenting; the product is stirred in a small amount of boiling water to make the garri.

The main nutrient in cassava is starch, it is poor in protein. The root contains some vitamin B and C, however during processing some of the vitamins are destroyed, especially vitamin C. The leaves are very rich in proteins and are edible in many African countries. **Cassava is also used for the production of starch that can be used for textile, paper and pharmaceutical industries**.

Yams (*Discorea).*
Cultivated mainly in tropical West Africa. They are eaten just like potatoes. They grow best in sub-humid weather conditions. They grow best in the tropical rain forest. The yam tubers are used for cultivation by propagation. These tubers are usually very deeply buried with heaps of soil over them. The plants are monocots with twining stems that need sticks to support them. They grow for 8-12 months before harvest. The tubers can vary from small potato size to very large size of about 2 to 3 meters in height depending on the soil.

Taro (Colocasia esculenta)
The plant has large leaves and it is also herbaceous. They are grown and eaten just like the potatoes. Meals are prepared from their roots; the leaves are also edible. The main nutrient is starch and only **2% protein**. It is eaten mainly by Hawaiians. It originated from South Asia and spread to Japan, Pacific Islands, and Hawaii. It is cultivated in the tropical rainforest.

Cocoyam (Xanthosoma spp.)
Cocoyam is a related member of the taro family. It is cultivated in the same way, and is also prepared for meal in the same way. It has **50% of carbohydrates, 12 % protein and 30% fat.**

Banana (*Musaceae)*
Banana plants are of two kinds: the sweet ones that are eaten raw as fruits, generally known as banana, and the other that is eaten cooked, known as the plantain. Unlike the cassava, yams, and potatoes, bananas are fruits, most have seeds; a few are seedless. Africa is the world leader in the cultivation of plantains and bananas, however bananas originated from the Central America. The plants require tropical climate with moisture. The plant is usually large and is herbaceous. The plant can grow as tall as 20 feet. At the end of one year, it produces monoecious inflorescent flowers. Ones the fruits are produced, the plants die, but new shoots quickly replace the old ones and growth continues.

Key Points

1. Starchy staple plants store starch. Most are tropical plant. They can easily be cultivated by asexual (or by vegetative) reproduction. Examples of starchy staple plants are potatoes, yams, and cassava.

2. Some starchy staple plants have modified roots or stems for storing the starch. Among the modified stems are stolons or runners that grow horizontally underground, producing roots at their internodes.
3. Rhizomes are good examples of underground horizontal stems, examples are ginger, potatoes and yams.
4. Other modified stems are bulbs and corms. An example of a bulb is the onion, tulips, dafodils, and lilies. They reproduce vegetatively. An example of a corm is the Taro.
5. Other modified roots are tuberous and taproots. An example of tuberous root is sweet potatoes and begonias. An example of taproots are carrots and turnips these are not typical starch staples.
6. White Potatoes: French fries, potato chips, potato starch, baked potatoes. The potato plants are annual, herbaceous dicot, cultivation of white potato (solanium tuberosum) requires propagation of tuber pieces with at least one eye. This is asexual (or vegetative), the offsprings will be genetically identical. They grow best at low temperature (15 – 18C)
7. Sweet Potato (lpomea batatas): easily cultivated by vegetative propagation. The plants require warm temperature for growth. They are used for alcohol beverages. Contains high sugar and carries high calories as compared to white potatoes.
8. Cassava (Manichote sculenta) or tapioca, or yucca or mandioca. The plant has palmate leaves with tuberous roots. They are easily cultivated by propagation of the cut stems. They grow best in hot climate with heavy rainfall. It can grow anywhere with very limited nutrient. It is resistant to fungus & insect. The plants can be harvested 8 – 12 months.
9. Cassava contains hydrocyanic acid that can be removed during processing before consumption.

Study Questions

1. What do you understand by the term ‘starchy staples’?
2. List 5 crops considered starchy staples.
3. Briefly describe each of the following plants and the cultivation method: Potato, sweet potato, cassava, yams, taro, and cocoyam. Compare the nutrient content of each.
4. Taro and cocoyams are not common starchy staples when compared to *Solanum tuberosum* in United States, can you state the probable reasons?
5. State the climatic conditions for the growth of *Discorea* (yams)
6. . State 5 uses of *Manihot esculenta*.
7. State the difference in the nutrient content of *Manihot escu*lenta as compared to *Solanum tuberosum*
8. What is the difference between *Ipomoea batatas* and *Solanum tuberosum* in their nutrient content.

Chapter 15
Breeding for Agricultural Improvement

Gregor Mendel was the first to start the breeding of plants to produce varieties, which included seed size /shape, flower colors and plant type. The best example is the hybrid corn. A very good example of artificial selection in plant breeding is in the development **of cabbage, kale, broccoli, cauliflower and Brussels all come from a single specie *Brassica oleracea*.** **Genetic engineering** and **tissue culture** are the techniques employed now for plant breeding. Increase in crop yield has led to the use of fertilizers, pesticides, irrigation and mechanization to provide excellent growing conditions. This is known as Revolution. High yield varieties of crops have been produced; among them include the high yielding dwarf strains of wheat and that of rice. Breeding programs at Agricultural research centers continue to produce new improved pest resistant and high yield crops. The most well known pathogens of crops include fungus; an example the potato pathogen that caused famine is *Phytophthora infectans*.

Sustainable Agriculture

Monoculture, that is growing the same plant in an area year after year is very common. Polyculture of perennial plants, for example planting of grasses and legumes in close proximity may tend to facilitate harvesting of both crops at the same time prevent the two crops from competing for the same mineral resources. A suitable agricultural design will require planting of perennial crops to be harvested for several years without replanting. The advantage of this polyculture is the prevention of soil erosion which could be caused from yearly plowing.

Genetic Erosion

In effort to produce high yield and pest resistant crops, some crops have become extinct; this is known as genetic erosion. To offset this genetic erosion, seed banks are established. Seeds of plants are collected and preserved at sub-zero temperatures.

Biotechnology and Agriculture

The use of genetic engineering to create plants with new and useful characteristics is now the common practice in agriculture. In this process, a significant trait is identified; this trait is then injected into the DNA of an already existing crop plant. Through genetic engineering, several traits can easily be introduced into an already existing crop plants to yield new improved ones. Genetic engineering permits the transfer of genes from unrelated species into each other to produce new crops. Through genetic engineering, herbicide resistant and insect resistant crop plants have been produced.

Cell Culture or Tissue Culture

Cell or tissue culture is another way that crop plants with new traits can be produced. In this technique small pieces of plants tissue are grown on a nutrient medium supplemented with plant hormones. After a few days, the cells divide and produce an undifferentiated mass of tissue called callus. From this callus, tiny plantlets emerge. These plantlets are removed and replanted and allowed to grow to maturity.

Protoplast Fusion

Another technique to produce plantlets is the use of protoplast fusion. In this process, plant cell wall can be removed by enzymatic action, the protoplast is then placed in a medium with the protoplast of another plant that has the needed traits and allowed to grow into plantlets.

Study Questions

1.What do you understand by the "Green Revolution"?

2. Briefly discuss Phytophthora infectans

3. What do you understand by "Sustained Agriculture"?

4. Explain the term "Genetic Erosion" in agriculture

5. State two ways in which biotechnology can be incorporated into agriculture to improve yield.

6. State three ways by which new genetically different crop plants can be produced.