Economic Botany

Potato, Sugarcane and Vegetable oils

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Contents

POTATO

Solanum tuberosum ; Family: Solanaceae

HISTORY AND ORIGIN

The potato probably originated in the highlands of Peru and Bolivia. Potatoes were grown by the Incas and, together with maize, provided their staple food. Ever since, this tuber had dominated and still continues to dominate life in the Andean region of South America. Amongst every importance character of potato cultivation is represented on the pottery of Incas, now housed in the museums of Europe.

Potato was introduced to the Old World in the sixteenth century and at the time of discovery of America by Columbus, it was equally unknown in North and Central America. Spanish conquerors brought potato to Europe. It was introduced independently to England in 1586. Sir Walter Raleigh is accredited with its introduction into Ireland from England. From Europe, it spread to other parts of the world. Portuguese brought it to India in the seventeenth century, but its cultivation spread slowly. It was finally reintroduced into the United States from Europe in 1621, presumably by way of Bermuda rather than directly from South America.

The Irish recognized the potential of potato as a staple food and started its cultivation as a crop in the middle of the seventeenth century. However, in the later half of the eighteenth century, it had achieved recognition as a crop of great commercial importance. Having recognized its food potentials, royal edicts were issued in Germany in 1744 and in Sweden in 1764 to compel its planting. Antonie Parmentier was mainly responsible for the introduction of potatoes into France.

In Ireland, the potato remained main food crop until 1845-1846, when the potato blight (a fungal disease caused by *Phytophthora infestans* swept across Europe, and damaged potato crop. This resulted in one of the worst famines in the history of the Western World followed by an unparalleled migration. Death and emigration reduced the population of Ireland from nine to six and a half million within six years.

A majority of the cultivars of Solanum tubersoum grown in the Andes are tetraploid (2n=48), but diploid and triploid forms are also grown. There have been two views regarding the origin of cultivated potatoes: (i) It might have arisen directly form an ancestral from of S. stenotomum by simple chromosome duplication, (ii) It arose as a spontaneous amphidiploid hybrid between the ancient diploid cultivar S. stenotomum and the diploid weed S. sparsipilum

PRODUCTION

Europe with countries like Russia, Poland, Italy, Ukraine, Germany, Belarus, the Netherlands, UK, and France is major producer of potato. The potato homeland South America is distant seventh producing only about 11.8 million tones. In

Asia the major producers are China, India, Turkey, Japan and Korea. In India the major potato producing states are Uttar Pradesh, West Bengal, Bihar, Assam, Madhya Pradesh, Punjab, Gujarat and Karnataka. In the hilly tracts, the potato is grown as a summer crop while in the plains it is a winter crop.

BOTANICAL CHARACTERISTICS

Solanum tuberosum is a tuber bearing herbaceous perennial but its treated as an annual under cultivation. The aerial part of the stem is erect in the early stages of growth but later it becomes more spreading. The underground portion of the stem produces horizontal branches known as stolons arising from the axillary buds. Adventitious roots are produced in groups of three or four at the nodes of the main underground stolon as well as the stolons.

The leaves are irregularly imparipinnate, each consisting of one terminal leaflet, two to four pairs of large lateral primary oval leaflets with entire or serrate margins and small secondary leaflets . The leaflets are more or less opposite and are densely hairy when young but at maturity the hairs are confined to the midribs and lateral veins. The leaves are spirally arranged on the main stem with two small basal leaf like stipules clasping the main stem.

The tuber is the short, greatly enlarged apical portion of the stolon, full of the stored food. Morphologically, potato tuber is a shortened thickened stem bearing a group of buds or eyes. Each eye consists of a rudimentary leaf scar and a cluster of at least three buds lying in a slight depression, representing lateral branch with underdeveloped internodes. There is a considerable variation in the size, shape and colour of the tubers. The most common colours being white, red or purplish and yellow. The skin may be smooth or rough.

Anatomically, the potato tuber is a typical stem consisting of the following principal regions: the periderm, the cortex, the vascular cylinder, the outer medulla representing the internal phloem and the inner medulla or pith with only a narrow parenchyma zone in the interior and without phloem elements . The internal phloem is the principal storage tissue of the tuber. The inner medulla forms the central axis of the tuber and is not as rich in starch. The starch is normally more dense in the tissues surrounding the vascular ring. The periderm and xylem bundles contain little storage parenchyma. The thin corky periderm form the outer protective layer (the skin) and is pitted with lenticels. Deep peeling of potatoes should always be avoided as it removes the valuable nutritional ingredients proteins, minerals, tannins, crystals and pigments present in the outer layer of the cortex.

CULTURAL PRACTICES

Potato crop prefers cool moist regions and grows best in a climate where cool nights alternate with warm days during the period of tuber formation. This type of climate is available in large part of Europe, which accounts for roughly 70 per cent of the world's production. A mean growing temperature between 15° C and 21°C and a well distributed rainfall over a period of three and a half to four months are essential. Irrigation just before initiation of tuber formation will greatly enhance the number of tubers set. Potatoes are relatively sensitive to frost. Tuberisation is

greatest when the soil temperature is 17°C but above this tuber formation is totally inhibited. The potato is responsive to day length. Short days, cool temperature or deficiency of nitrogen favours early tuberisation. The crop can be grown on wide varieties of soils, but a friable, porous, well-drained soil is essential for good growth as it offers least resistance to the expanding tubers. Potatoes grow well under acidic conditions.

Large disease free 'seed potatoes' are cut into several section, each having at least one bud or 'eye'. They should be cut at right angle to the main axis to eliminate apical dominance. These pieces with eyes are planted generally on ridges 0.9 m apart. Spacing of the seeds within the rows varies from 20-30 cm. Harvesting is done after three and half to four months after planting. Hand digging is still practiced but in agriculturally advanced countries the crop is harvested mechanically. Defoliants like maleic hydrazides are sprayed about two weeks before digging of the tuber to prevent premature sprouting. Harvested washed potatoes are stored in cool environment at about 4°C .

VARIETIES

Some of the important varieties of potato are:

Kufri Sindhuri

It is cultivated in Maharashtra, Bihar, Gujarat, Karnataka, Bihar, Punjab, Uttar Pradesh, Jammu &Kashmir. Tubers are medium, round red deep eyes; moderately resistant to early blight and tolerant to Potato Leaf Roll Virus (PLRV); slow rate of degeneration. It can tolerate temperature and water stress to some extent. Crop matures in 110-120 days. Average yield is 40 t/ha. Tolerant to late blight disease, suitable for processing.

Kufri Chandramukhi

It is grown in Maharashtra, Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Orissa, Punjab, Uttar Pradesh and West Bengal. Tubers are large, oval, white, slightly flattened, fleet eyes and dull white flesh. Average yield is 25 t/ha. Crop matures in 80-90 days. Suitable for instant flakes and chips.

Kufri Jyoti

It is grown in Maharashtra, Bihar, Gujarat, Haryana, Uttar Pradesh, Punjab, Karnataka & WestBengal. Tubers are large, oval, white, fleet eyes and white flesh. Crop matures early in hills, Average yield in hills 20 t/ha. Moderately resistant to early and late blight. Slow rate of degeneration. It is suitable for processing purpose.

Kufri Lauvkar

It is cultivated in Maharashtra, Madhya Pradesh and Karnataka . Tubers are large, round, white, fleet eyes and white flesh. Able to build up yields rapidly under warmer climate. Crop matures in 75-80 days. Average yield is 30 t/ha. Suitable for chip making.

Kufri Badshah

It is cultivated in Gujarat, Haryana, Madhya Pradesh, Punjab, Uttar Pradesh, Jammu & Kashmir. Tubers are large, oval, white, fleet eyes, dull white flesh, and tubers turn purple on exposure to light. Moderately resistant to early and late blight and resistant to Potato Virus X (PVX). Crop matures in 100-110 days. Average yield is 50 t/ha. Suitable for table purpose.

Kufri Bahar

It is grown in Haryana, Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir. Tubers are large, round-oval, white, medium deep eyes. Slow rate of degeneration. Crop matures in 100-110 days. Average yield is 45 t/ha. Suitable for table purpose.

Kufri Lalima

Bihar and Uttar Pradesh are main producers. Tubers are large to medium, red, round, medium deep eyes and white flesh. Crop matures in 100-110 days. Average yield 40t/ha. Moderately resistant to early blight. Resistant to Potato Virus Y (PVY). Not suitable for processing

Kufri Jawahar

It is grown in Gujarat, Haryana, Madhya Pradesh, Punjab, Karnataka. Tubers are medium, round-oval, creamy white, fleet eyes and pale yellow flesh. Crop matures in 80-90 days. Average yield is 40 t/ha. Moderately resistant to late blight. Suitable in intensive-cropping systems. Suitable for table purpose.

Kufri Sutlej

It is grown in Bihar, Haryana, Punjab, Uttar Pradesh and Madhya Pradesh. Tubers are large, oval, white, fleet eyes and white flesh. Crop matures in 90-100 days. Average yield is 40 t/ha. Moderately resistant to late blight. Suitable for table purpose.

Kufri Ashoka

It is cultivated in Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal. Tubers are large, oval-long, white, fleet eyes and white flesh. Susceptible to late light. Crop matures in 70-80 days, Average yield is 40 t/ha. Suitable for table purpose.

Kufri Pukhraj

It is mainly cultivated in Maharashtra, Orissa, Uttar Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Punjab, Madhya Pradesh and West Bengal .Tubers are large, oval, slightly tapered, white, and yellow flesh. Crop matures in 70-90 days. Average yield is 40t/ha. Resistant to early blight and moderately resistant to late blight. Suitable for table purpose.

Kufri Chipsona-1

Bihar and Uttar Pradesh are main producers. Tubers are medium to large, oval, white, and dull white flesh. Crop matures in 90-110 days. Average yield is 40 t/ha. Resistant to late blight and tolerant to frost. Suitable for making chips and French fries.

Kufri Chipsona-2

This variety is cultivated in Bihar and Uttar Pradesh. Tubers are medium, Round-oval, white, and yellow flesh. Crop matures in 90-110 days. Average yield is 35 t/ha. Resistant to late blight and tolerant to frost. Suitable for making chips and French fries.

Kufri Anand

It is grown in plains of Uttar Pradesh and Bihar. Tubers are medium oval-long, white, flattened, fleet eyes, smooth skin and white flesh. Resistant to late blight and tolerant to frost. Average yield is 35-40 t/ha. Crop matures in 100-110 days. Suitable for preparing French fries.

Exotic Varieties:

Processing Purpose : White potato, Burbank Russet, Katahdin.

Table & Processing Purpose : Russet, Round White, Long White, Round Red, Yellow Flesh, Blue and Purple.

COMPOSITION OF POTATO TUBER

In general, the raw tubers contains 70-80 per cent water , 10 to 30 per cent carbohydrates (mainly starch but also a little sugar), 1-3 per cent proteins, 2 to 3 per cent fibers and 0.1 per cent fats. Potatoes are an excellent source of vitamin C and minerals, especially potassium, phosphorus, iron and magnesium. Green potatoes and potato sprouts contain a poisonous glycoside, solanin, which in high concentrations may cause sickness and even death in both humans and livestock.

USES

In the world's food economy, potato occupies a prominent position. As a fresh vegetable, potatoes are consumed in a great variety of ways-boiled, steamed, fried, baked or roasted. They are also used in the manufacturing of many products such as potato chips or crisps, dehydrated mashed potatoes, potato flour, frozen French-fries and canned potatoes. Chuno- a dehydrated potato product has long been valued as a food by the Andean people.

Potato is used in the preparation of nutrient medium for the growth of microorganisms. Large quantities of surplus potatoes (cull potatoes) in Europe are fed to livestock or processed into commercial products such as starch, alcohols, glucose, lactic acid, etc. Potato starch is used chiefly for sizing cloth and paper, in the laundry industry and in various food preparations. Vodka, a Russian alcoholic beverage, is prepared by the fermentation of cooked potatoes.

SUGARCANE (Saccharum officinarum)

Family: Poaceae

Sugarcane belongs to the genus *Saccharum* of the family Poaceae. The cultivated sugarcane is *Saccharum officinarum*. These are thick and juicy canes good for chewing purpose also. This species includes the tropical canes indigenous to the New Guinea. These canes contain high sugar content, low fibre and produce high tonnage. These are generally resistant to smut but are susceptible to red rot and mosaic diseases. The cultivation of this species is limited to tropical areas. But in recent years these canes have been succeeded by hybridisation among officinarum, spontaneum and other species in subtropical regions. Sugarcane is believed to have originated in the South Pacific and spread throughout most of southeast Asia at an early date.

AREA AND DISTRIBUTION

Sugarcane is grown over the land surface of the earth between latitudes 35°N and 35°S.The important sugarcane producing countries in the world are India, Brazil, Cuba, Mexico, Pakistan, China, Philippines and Thailand. It is one of the important crops of the world cultivated over an area of 19.4 million hectares with a total production of 1274.7 million tonnes of cane .

In India, area and production of sugarcane has been fluctuating from year to year depending upon pricing policy and climatic conditions. It occupies about 4.2 million hectares. Uttar Pradesh has the largest acreage under sugarcane, and accounts for about 48 per cent of the area under this crop in whole of India and also accounts for 38.6 per cent of the total annual production, But the production per hectare is the highest in Tamil Nadu followed by Maharashtra and Karnataka.

MORPHOLOGY

The sugarcane plant is a perennial rhizomatous giant grass with a thick solid jointed aerial stem 3 to 8 m tall and usually 3.8 to 6.0 cm in diameter (Figure 4.3). It grows in clumps (stands). The colour of the cane ranges from almost white through yellow to deep green, purple red or violet. Each cane joint has five conspicuous parts: 1. a node – the area where the leaf sheath is attached to the stem; 2. the root band composed of several rows of minute translucent dots- the root initials; 3. the intercalary meristem, a narrow meristematic zone just above the root bend which is responsible for the growth of the internode 4. the internode- a barrel shaped structure covered with a fairly thick waxy bloom and 5. the laterals buds placed alternately on opposite sides of the stem and protected from damages by the leaf sheath that forms a tight covering around the internode.

Anatomically, the outer most covering of the stem is composed of several layers of thick-walled lignified cells. Below this is present soft light coloured tissues (pith) in which are embedded numerous fibro-vascular bundles. The parenchyma cells surrounding them contain a high percentage of juice, which constitute about 85-88 per cent of the total weight of the fresh cane juice. The sucrose content of the juice varies from 12 to 17 percent.

The leaves are attached alternately in two rows on either side of the stem at the nodes. The leaf blade is a long, thin, flat structure with a finely serrate margin, usually 2.5-10 cm wide and 0.9 –1.5 m or more in length, often clothed with hairs.

The inflorescence is an open feathery or woolly light silvery-tan coloured panicle, and is produced only in the left over or experimental plants. The flowers are produced in paired spikelet . Both spikelets are surrounded at the base by a ring of long silky hairs which impart a characteristic silky appearance to the inflorescence. The leaf sheath immediately surrounding the inflorescence is quite long, while the blade is quite short and known as the 'flag'. The structural plan of both the spikelets is similar, each having a pair of glumes that enclosed both the florets, the lower flower being represented by only a sterile lemma. The lemma is , however, missing in the upper flower of *S. officinarun* (but is present in *S. spontaneum* and its hybrids) whereas the palea as a small, thin, narrow structure. The lemma of the lower flower , nevertheless, strongly enfolds the palea of the upper fertile flower. Two lodicules, three stamens and a centrally placed gynoecium with two styles ending in feathery stigmas are present. The fruit is a caryopsis. The seed retain their viability for a very short time.

CLIMATIC REQUIREMENTS

Sugarcane grows most successfully in those regions where the climate is more or less tropical but it can grow in subtropics too as in north India. An average mean temperature of 26 to 32°C is best suited for the growth of sugarcane. Temperatures above 50°C arrest its growth; those below 20°C slow it down. Low temperature reduces tillering. The crop does best in the tropical regions receiving a rainfall of 75 to 120 centimetre per annum. Sugarcane requires a long growing season, from ten to twelve months, because certain number of heat units is required to bring the plant to maturity. The ideal climate for sugarcane is in the southern parts of the country, such as Maharashtra, parts of Karnataka, and the Telengana area of Andhra Pradesh,

In addition to temperature and rainfall, light also affects growth and development of cane. Under bright sunlight conditions the stems are thicker but shorter, and leaves are broader and greener, while under low sunshine, the stems are slender and long with narrower and yellowish leaves. Short day length decreases number of tillers per plant and ultimately the tonnage. Plants grown under long day conditions produce more dry matter. Day length also determines

flowering in cane. Thus climate plays a very .important role in yield of cane. The average yield of cane in north India is low as compared to that in the southern parts mainly due to climatic reasons.

SOIL

Sugarcane thrives best on well drained loamy soils. It can also be raised successfully on lighter soils provided there is adequate irrigation facilities and on heavy clays with proper drainage and addition of organic matter. Saline, alkaline and acidic, soils are not at all suitable for this crop. In northern India, it is cultivated largely on the loams and clay loams of the Gangetic alluviums, whereas in Peninsular India, it is grown on brown or reddish loams, laterites, and black cotton soils.

VARIETIES

In our country, sugarcane is being cultivated over a wide range of contrasting agro-climatic conditions and accordingly the varietal requirements also vary from location to location. A list of such high yielding, high sugar varieties is given in Table.

Table: Important varieties recommended for different states are as below:

STATE	EARLY RIPENING VARIETIES	MID-LATE RIPENING VARIETIES
Andhra Pradesh	CoC671, Co 6907, Co 7704, Co 8013, Co 8014, CoA 88088 CoA 89032; CoA 89085, CoA 89088, CoA 89098	Co 7219, Co 7805, Co 7706, Co 8021, COT8201, CoV 92101, CoV 92102
Bihar	BO 90, BO 99, BO 102, BO 120	Co 1148, CoS 767, BO 91, BO 104 BO 108, BO 109,BO 110, BO 116, BO 128
Haryana	CoH 56, CoJ 64, CoH 99, Co 7717	CoH 35, CoS 767, Co 1148, Co 1158
Karnataka	Co 419, KHS-3296, Co 6415, Co 7219, Co 7704	Co-449, Co 740, B 37172, Co 62175, Co 678, Co 740, Co 62175,
Maharashtra	Co 419, Co 7219	Co 678, Co 740, Co 62175, CoM 7125, Co 7527
Punjab	CoJ 64, CoJ 83, CoJ 86, CoP211	CoJ 79, CoJ 84, CoJ 83, CoS 767, Co 1148, CoS 8436
Tamil Nadu	CoC 671, CoC 771, CoC 8001, CoC 85061	CoC 772, CoC 773, CoC 774, CoC 775, CoC 777, CoC 778, CoC 779, CoC 62174,CoC 6304
Uttar Pradesh	CoJ 64, CoS 687, CoS 8436, CoS 88230, CoS 90265, CoS 92254, CoS 95255, CoS 96258 CoS 96268. CoS 98231, CoS 98247 ,UP0097	CoS 8432, CoP 84212, CoS 88216, CoS 92423, CoS 93278, CoS 94257, CoS 94270, CoS 95222, CoS 97264, UP01235
Water logged area of Uttar Pradesh	-	UP 9529, UP 9530, CoS 94636

CROPPING SYSTEMS

In North India, sugarcane is generally grown after harvest of cotton, paddy, maize, sorghum, toria, potato, pea, and wheat, etc. The common cropping systems followed in north India are given below

Maize-potato-sugarcane	2 years
Maize-sugarcane-wheat	2 years
Rice-sugarcane-wheat	3 years
Cotton-sugarcane-ratoon	3 years
Sorghum (fodder)-potato-sugarcane-wheat	3 years
Rice-chick pea-sugarcane-ratoon-wheat	3 years
Rice-toria-sugarcane-ratoon-wheat	3 years
Maize-wheat-sugarcane-ratoon	3 years
In southern India, sugarcane is usually rotated with paddy. The common cropping systems of southern India are.	
Rice-sugarcane-ratoon-wheat	3 years
Cotton-sugarcane-ratoon-wheat	3 years
Cotton-sugarcane-flax/ sorghum	3 years
Cotton-sugarcane-chick pea	3 years
Sugarcane-ratoon-Kharif paddy-winter rice	3 years
Rice-groundnut-sorghum-ragi-sugarcane	3 years
In north India where crop is sown under irrigated conditions, many short duration crops are intercropped with sugarcane in both autumn as well as spring planting canes.	

Field Preparation

Sugarcane requires a very thorough and clean preparation of land. Sugarcane needs deep tillage. Shallow ploughing with local plough limits the development of root system resulting in lodging of cane plants. Deep ploughing specially in heavy soils helps in the root system penetrating deep into the soil.

In peninsular India, where sugarcane soils are mostly clays and clay loams require more ploughings. In such soils one or two deep ploughings and one cross ploughing with a mould board plough is essential. It should be followed by two to three harrowings to bring the seedbed into fine tilth. There must be enough moisture at the time of planting.

SEED AND SOWING

Seed Selection

Sugarcane is propagated vegetatively by stem cuttings. Healthy seed material, free from pests and diseases like red rot, wilt, smut, ratoon stunting etc., is selected for seed purpose. The top one-third to half portion of a cane has buds of high viability and is best for sowing. Seed cane should be taken from erect and healthy crop of not more than 10-12 months age. Ratoon crop is not suitable for seed purpose as these canes may carry the disease of the previous crop. For best results separate crop nurseries should be raised specially for producing seed-canes under good crop management.

Seed Preparation and Treatment

Before planting, the dry leaves of the cane stalks are removed by hand in order to avoid any possible damage to buds. Thereafter cane is cut into three budded setts usually 30 to 45 centimetre long. To prevent the seed setts being attacked by fungal diseases and also to improve germination, the seed setts are dipped into 0.5 per cent solution of Agallol (3%) or 0.25 per cent solution of Aretan (6%) or Tafasan (6%) before planting. Aretan along with gamma BHC is also recommended in northern India. Aretan improves germination and keeps off fungal attack while gamma BHC keeps away the termites and shoot borers.

Time of Planting

In India, sugarcane is planted thrice a year in October (autumn), February-March (spring) and July (adsali). Adsali planting is quite common in Maharashtra while autumn and spring plantings are more common in northern India. In North India, sugarcane, by and large, is planted in spring.

Sugarcane requires about 25-32°C for good germination. March is the best time for cane planting in Punjab and Haryana, February-March in Uttar Pradesh and January-February in Bihar.The planting time is advanced as we move towards east. InTamil Nadu, Andhra Pradesh, Maharashtra and Karnataka cane planting is done in December-February.

Manures and Fertilisers

Sugarcane is a heavy feeder and make soil deficient in nitrogen, phosphoric acid, potash and calcium. Adequate manuring, therefore, is most essential for high yields. The fertiliser requirement of sugarcane depends upon the soil and climatic conditions. The nitrogen requirement of sugarcane ranges from about 120 to 150 kg per hectare in northern India and 250-350 kg per hectare in southern parts of the country.

Water Management

Water is one of the main factors which governs the cane yields and sugar recovery. The life cycle of sugarcane plant is divided into four distinct phases namely germination phase (from planting to 60th day); formative phase (from 60th day of planting to 130th day); grand phase (from 130th to 250th day) and maturity phase (250th to 365th day). The water requirement of the crop varies greatly with growth phase and environmental conditions, particularly climate and soil type. The water requirement during formative phase and grand growth phase is maximum.

Drainage is also equally important to prevent flooding of field which may cause deterioration of cane quality. Drainage greatly helps not only in increasing the yield of cane but also sucrose content of the cane

Weed Control

To achieve high cane yield, weeds must be controlled at a proper stage. If weeds are not controlled at a proper stage they directly reduce cane and sugar yields and indirectly add to the loss of the crop by providing favourable atmosphere for the development of insects and diseases. The loss in cane yield may go up to 60-80 per cent, depending upon the type of weed flora present and their intensity in an area.

Weed control in sugarcane is accomplished by adopting mechanical or chemical methods. Several herbicides have been tested for weed control in sugarcane. Some of them are very effective. 2,4-D is very effective against broadleaf weeds, which generally grow in autumn cane, it should be applied 25-30 days after planting or before the weeds attain three to four leaf stage. To control weeds in spring cane, Atrazine is sprayed just after planting.

Diseases

Sugarcane crop in India suffers from a large number of diseases. Generally two types of diseases attack sugarcane: those that are not carried by seed pieces and those that are mainly transmitted by seed pieces. The second group which include diseases like red rot, wilt, smut, albino (grassy shoot) and ratoon stunting are most destructive. These diseases not only reduce yield of cane but also adversely affect the quality of recovery of juice.

Diseases	*Causal Organism*	*Control Method*
Red Rot	Collectotrichum falcatum	Application of mercurial compounds like Agallol or Aretan
Smut	Ustilago scitaminae	Using disease resistant varieties
Wilt	Cephalosporium sacchari	Application of Agallol or Aretan
Albino (Grassy shoot)	Phytoplasma	Hot air treatment of seed canes
Ratoon stunting	Ratoon stunting bacterium	Hot air treatment of seed canes
Red Stripe	Xanthomonas rubrilineans	Burn affected tops

Insect Pests

Sugarcane crop is subject to attack by a large number of insect pests. Following is the list of major pests and methods of their control:

Pest	Control Measures
Early Shoot Borer	Spray BHC, Endosulfan or Nuvacron
Root Borer	Spray BHC, Endosulfan or Nuvacron
Gurdaspur Borer	Endosulfan or Nuvacron
Top Borer	Carbofuran, Nuvacron
Pyrilla	Malathion, endosulfan
Black Bug(Lygaeid)	Endosulfan, Nuvacron
Sugarcane Whitefly	Endosulfan, Nuvacron

Harvesting

The maturity of sugarcane is generally recognised by the lower leaves gradually withering up and leaving fewer green leaves at the top. Stalks are cut at the ground level, preferably after digging down the earthed up ridges. The dried leaves are stripped off from the cane and green top is cut from the topmost part of the cane and clean canes are tied up in bundles.

MANUFACTURE OF SUGAR

Harvested cane is quite perishable (the sugar being liable to undergo inversion into glucose and fructose) and, therefore, should always be sent to a nearby sugar mill without any loss of time. The process of manufacturing white crystalline sugar from cane involves the following steps.

Extraction of juice

This is done with the help of crushers and then passing through heavy, grooved steel rollers to squeeze out the juice. Several successive expression are required to ensure complete extraction of the juice. After each expression, the cane is moistened by sprays of water to facilitate a complete recovery. The material left behind is called 'bagasse'. The extracted juice is a turbid, dark-grayish sweet fluid full of impurities such as organic acids, minerals, gums, pieces of cane and other extraneous material.

Purification of juice

The juice is first filtered to remove the insoluble sand suspended particles. After this, the juice is heated with measured amount of lime to remove free organic acids and phosphates as insoluble calcium salts. The proteins and colloidal colouring matter are removed from the solution as a thick scum appearing on the surface. The precipitated calcium salts and the scum are removed by filtration through canvas. This process is known as defacation. During next step the filtered juice is allowed to come in contact with carbon dioxide (carbonation), a process which removes excess lime as calcium carbonate and also brings about decomposition of calcium sucrate into soluble black sugar. During sulphitation, the filtered carbonated juice is treated with sulphur dioxide to complete the neutralization of lime and the decomposition of calcium sucrate. The purified juice is now led to evaporators where it is boiled under reduced pressure until it becomes a thick syrup.

The concentrated raw syrup is finally boiled in a vacuum pan till the crystallization occurs. The resulting dark brown mixture of sucrose crystals and mother liquor (molasses) is next stirred in open tanks, or crystallizers, until it crystallizes. Finally the massecuite is led into centrifugal machines to remove crude sugar. The molasses still contain some crystallisable sugar and is mixed with the raw syrup and boiled. This is repeated three to four times to remove as

much sugar as possible. The centrifugal raw sugar is reddish brown somewhat grayish in colour and contains about 96 per cent sucrose. It is usually exported in this from, further refining being done in the importing country.

Refining and drying of crystal

The raw sugar is dissolved in hot water and treated with diatomaceous earth to remove the suspended impurities. This is followed by decolorization to a colourless sparkling liquid by treating with carbon black. The clear syrup, after vacuum concentration, is centrifuged so that pure sparkling white crystals of sugar separate out. The crystals are then dried in large rotary driers in the presence of a strong current of hot air. The dried granulated sugar crystals are now passed across inclined vibrating screens for grading.

In India and other parts of Asia, Africa and Latin America, a considerable amount of juice is evaporated over an open fire in large shallow iron pans with flaring sides. At 118-120^{o} C, syrup forms a thick semi-solid mass which solidifies on cooling .It is known as ‘gur’ in India, jaggery in Africa and ‘panela’ in Columbia. Technically it is usually refereed to as ‘non-centrifugal sugars”.

USES

The sugarcane is used as food (sugar), fibre (cellulose), fuel (bagasse) and fodder (green tops, trash, molasses etc.) crop. There are many by-products prepared from sugarcane:

1. **Sugar**: The sugar is used by everyone in the world. Large quantities of sugar is used in soft drinks, confectionery, ice-creams and chocolates etc.

2. **Bagasse:** Bagasse is the fibrous residue left over after sugarcane is crushed. It is used as a raw material for producing any kind of cellulose based products. However, the pentosan content present in bagasse is used in the manufacture of chemicals such as furanics and furfural. Therefore, bagasse is used in paper industry, manufacture of boards, panel or insulating boards, particle board, bagasse cement board. Electric power can be generated by using bagasse and it is possible to generate about 450kwh electricity from one metric tonne of bagasse.Bagasse can be used for the production of sludge or biogas. It can be used to drive both the petrol and diesel engines.Bagasse can be used in the manufacture of plastic. It can also be used as cheap and light filter in building material. Dehydrated fresh bagasse can be used as agriculture mulch. Bagasse can be used as soil conditioner and as compost. Bagasse can serve as emergency cattle feed. Bagasse can be used as substrate for growing mushrooms.

3. **Molasses.** It is a by-product in the manufacture of sugar. It is heavy, viscous liquid separated from the final low-grade massecuite from which no further sugar can be crystallized out by the usual methods. Molasses is used for the production of ethyl alcohol, citric acid, itaconic acid, acetone, butyl alcohol etc. Molasses can also be used as animal feed. It contains carbohydrate, mainly as sugars. There are several advantages of using molasses as animal feed. Molasses stimulates the microflora of the rumen and allows cattle and sheep to deal effectively with low grade roughage such as straw. Molasses is rich in potash and nitrogen and is widely used as fertilizer for sugarcane. Molasses is used for the preparation of edible syrups, dextran, potassium salts, activated carbon, road surfacing materials with coal tar, solubilizing the phosphate of bone and rock phosphates, and production of combustible gases.

4. **Press-mud Cake**: The precipitated impurities present in the cane juice after removal by filtration form a cake. It is also known as press mud. Disposal of filter cake in the cane field is most ideal, as it has resulted in appreciable yield responses. The micro flora, dominated by Bacilli and Actinomycetes increases the stability of soil aggregates, while the nutritional value of filter cake gives high cane yield. Dried filter cakes can be used in combination with molasses tops, as an animal feed. The wax content in filter cake is being recovered for commercial use and it is used as a substitute for imported Carnauba wax. It is an excellent electric insulator.

5. **Sugarcane Green top and Trash**: Green tops of sugarcane are mainly used as cattle feed in India. The trash or mass of thick dried leaves that is left on the field furnishes valuable organic matter for incorporation into the soil and used as manure.

6. **Fermentation Waste or Vinasse**: The liquid waste after alcohol fermentation is a valuable by-product. Because of high potassium content, it can be used as fertilizer. It can also be used for production of biogas and activated carbon, glycerol, etc.

OIL YIELDING CROPS

Oils, fats and waxes have been in use since prehistoric times. Probably the fats initially used by man were of animal origin such as tallow, obtained from cattle and sheep and grease from pigs, and were separated from the other tissues by 'rendering', a process involving heating either in the presence (wet rendering) or absence of water (dry rendering). Ancient Chinese and Hindus developed the art of recovering vegetable oils from the oil-bearing materials with the help of primitive mills much earlier than in any other parts of the world. The old Chinese oil presses were driven by man, in contrast the primitive Indian extractor (known as the ghani, kolhu*)* were driven by bullocks. Even today, the *ghani* is still being used in remote rural areas of India and operates on the principle of a pestle rotating in a mortar, generally made of wood.

Vegetable oils were used for food and for anointing by the ancient Egyptians and Phoenicians. As early as 1400 B.C., Egyptian lubricated chariot wheels with greases consisting of fats and lime. From the Egyptians and Phoenicians, the knowledge of the use of fats and oils spread to the Hebrews and to the Greeks. Pliny wrote about the use of vegetable fats inn soap making. Today oils and fats are used in a variety of ways.

Vegetable oils and fats are triglycerides of complex organic fatty acids. Naturally occurring fats are usually mixtures of triglycerides of various fatty acids with general formula:

CH_2—COOR1
CH— COOR2
CH_2—COOR3

R1, R2 and R3 represent the carbon chains of the different fatty acids. Most commonly, each fatty acid radical is different. Fats in which all the fatty acid molecules are identical are common. The fatty acids are of two principal kinds- saturated and unsaturated. The common saturated fatty acids in fats are palmitic and stearic, the former being the most abundant in vegetable fats. The common unsaturated fatty acids are oleic (one double bond), linoleic (two double bonds) and linolenic acids (three double bonds).

The most important fatty acids are given in Table 6.1 along with their empirical formulae.

Table.1: Important fatty acids with empirical formulae

Saturated acids		Unsaturated acids	
Acids	Empirical formula	Acid	Empirical formula
Capric	$C_{10}H_{20}O_2$	Oleic	$C_{18}H_{34}O_2$
Laturic	$C_{12}H_{24}O_2$	Linoleic	$C_{18}H_{32}O$
Myristic	$C_{14}H_{28}O_2$	Linolenic	$C_{18}H_{30}O_2$
Palmitic	$C_{16}H_{32}O_2$	Ricinoleic	$C_{18}H_{54}O_5$
Stearic	$C_{16}H_{36}O_2$	Erucic	$C_{22}H_{42}O_2$

Oils, fats and waxes are very similar in their composition, Oils are liquid at ordinary room temperature whereas fats are solid or nearly solid. In general, at ordinary temperatures the triglycerides of unsaturated fatty acids are liquid whereas glycerides of saturated fatty acids with 12 or more carbons atoms are solid. Coconut oils, palm oil, palm kernel oils, cocoa butter and shear butter are examples of fats.

Vegetable oils differ from volatile or essential oils in a number of important respects. (1). They do not volatilize at ordinary room temperatures, (2). They cannot be distilled without being decomposed; (3). They leave a permanent greasy stain on paper; (4). Being glycerides, they form soaps with alkali; (5). They lack strong taste and odour of essential oils and may become rancid on long exposure to air.

CLASSIFICATION OF VEGETABLE OILS

Non-drying oils According to their ability to absorb oxygen from the atmosphere, vegetable oils are generally classified into three main groups, namely; non-drying oils, semi-drying, and drying oils.

These oils remain liquid at normal temperatures and never undergo oxidation to form a film. They are largely glycerides of saturated acids and oleic acid, with little or no linoleic and linolenic acids. The iodine number is less than 100. These oils are of no use in the paint, varnish or lacquer industry but are very useful in the manufacture of soaps, as lubricants and as food. These oils are found notably in plants of tropical regions. Groundnut, palm, olive, castor, rape and almond oils are a few important examples.

Semi-drying oils

These are intermediate between the drying and non-drying oils, and are characteristics in having large amounts of linoleic and saturated acids but no linolenic acid. The semi-drying oils absorb atmospheric oxygen slowly, producing only a soft film after prolonged exposures to air (they never form a tough elastic film as is the case in drying oils). The iodine number is between 100 and 130. Examples of semi-drying oils are cottonseed, sesame, sunflower, corn and croton.

Drying oils

Such oils readily absorb oxygen on exposure to air and form a tough, elastic and resistant film. These oils are fatty rich in glycerides of the unsaturated fatty acids, particularly linoeic and linolenic with few oleic compounds. They are very important as solvents for pigments in the paint and varnish industries. Drying oils have a high iodine number, more than 130. Examples of this category are linseed, soybean, safflower and hempseed.

Vegetable oils and fats are generally located in the form of small insoluble droplets within the cells of endosperms and cotyledons. However, In most of the cereals, the fat occurs almost exclusively in the embryo. Olive and palm oils are two important examples that are obtained from the fleshly pericarp of the fruits, less frequently, oils and fats are extracted from the roots, stems, and foliage.

METHODS OF OBTAINING OILS

Crude vegetable oils and fats are extracted from the oil bearing cells by either of the following methods: mechanical pressure or solvent, extraction. The former being by far the most common method.

For extraction of oil the seed coats (hulls) are removed with the help of specially decorticating machines (decorticators) and thereafter the kernels are reduced to thin flakes.

Mechanical expression

In this method pressure is applied to the oil-bearing tissues to squeeze out the fat. Hot expression is more common and involves the preheating of kernels with steam to allow the lipids to escape from the cells. In cold expression the kernels are merely pressed without resorting to steaming. As a result of pre-cooking, yield is higher but the quality is relatively poor.

Solvent extraction

In this process a solvent is employed to leach out the oil, and is the only practical method for recovering oils from tissues having relatively low proportion of oil. This method is quite effective but expensive. A number of solvents can be used, including gasoline, benzene, carbon disulphide, petroleum ether and chlorinated hydrocarbons. The fatty oils are freed from the extracting solvents by distillation. The cake mass obtained durring solvent extraction contains only one per cent or less of oil, compared to four to seven per cent in mechanical pressing.

As crude oils often contain impurities (such as water, dirt, cellular material, free fatty acids and phosphatides, pigments, odiferous compounds), the oils are subjected to a refining process to rid them of all impurities. The albuminoid fraction of the crude vegetable oil is removed through coagulation by heating, whereas free fatty acids are removed by agitation with sodium hydroxide. In some cases bleaching or deodorisation is also practiced.

KEEPING QUALITY OF OILSEEDS AND VEGETABLE OILS AND FATS

ome seeds, if they are not bruised, can be stored for years without any change in the fat due to the presence in them of antioxidants such as vitamin E (tocopherol). Vegetable fats usually contain appreciable amounts of tocopherol, while animal fats are relatively poor. In addition to antioxidants, other compounds known as synergists are present which increase the activity of a true antioxidant. Phosphatides function as antioxidants and may also enhance the activity of other antioxidants. Sesamol is an antioxidant contained only in sesame oil whereas gossypol is present in crude cotton seed oil. Removal of antioxidants during refining process from fat and oils is responsible for deterioration of quality and development of unpleasant odour and taste. This change is known as rancidity.

Hydrogenation of oils results in the production of plastic fats. Hydrogenated fats are generally many times more stable than the oils from which they are produced. i.e., they are less likely to become rancid.

In India a large variety of oilseed crops is grown. With the exception of palm, palm kernel, olive and tung oils, India produces all the other principal seeds which form the basis of the crushing industry. Oilseeds, with a current production of about 20.1 million tonnes, are the second largest agricultural crops in quantity and value.

Five major oilseeds producing states of India are: Gujarat (3 173 900 t), Andrha Pradesh (2 173 000 t), Tamil Nadu (1 727 500 t), Karnataka (1 169 700 t), Uttar Pradesh (1 111 000t), Madhya Pradesh (1 099 700 t), and Maharashtra (886 300 t).

UTILISATION OF VEGETABLE OILS AND FATS

Vegetable oils and fats have wide ranges of uses.

As a Food

The contribution of fats and other lipids to our daily diet is great as they are highly concentrated reserve of energy and have a high caloric value. Fats and other lipids have a role in the satiety value of a food i.e., they give a feeling of satisfaction and delays the onset of hunger as fats retard the rate at which food leaves the stomach. They add flavour and variety to foods and make meals palatable. Fats act as solvents for the fat soluble vitamins such as vitamins, A, D, E, K, and provitamin A. Many of these oils, for example, olive, groundnut, soybean, corn and cottonseed are used as cooking oils.

The residue left after the extraction of oil, known as oil-cake, is often rich in protein and, therefore, can be incorporated into livestock feed and occasionally human food. Some oil cakes, e.g., castor, linseed and tung, however, contain toxic constituents that make them unsuitable for feeding purposes but may be used as nitrogenous fertilizers.

Industrial Uses

Oils and fats are used in the manufacture of paints, varnishes, and lacquers, soaps, detergents, candles, plastics, synthetic fibres, printer's ink, artificial leather, polishes, cosmetics and lubricants and as components in linoleum and oilcloth.

Fixed oils and fats such as castor and croton oils are used pharmaceutically for their soothing properties.

OIL SEED CROPS

Oil seed crops have been the backbone of agricultural economy of India from time immemorial. Today these crops are cultivated on approximately one-tenth of the total cultivated area in India. On the oilseed map of the world, India occupies a prominent position, both in regard to acreage and production. The important oilseed crops grown in this country in order of importance are groundnut, rapeseed, mustard, sesame, linseed, safflower, castor, sunflower, coconut and niger.

1. *Groundnut* (*Arachis hypogaea* L.)

Synonym: Peanut, monkey-nut;

Family: Fabaceae

Usually, the application of only N and P is resorted to, since most of the Indian soils are rich in K. The application of N in two equal split doses, one before sowing and the other 30 days after sowing, is found to increase the yield. In virgin lands, when groundnut is newly introduced, the application of a culture of *Rhizobium* as seed treatment is beneficial in increasing nodulation and nitrogen fixation. The application of gypsum at 500 kg per ha at the pegging stage will enhance pod formation.

Groundnut is a native of Brazil and it became widely distributed throughout South America at an early date. It was brought to West Africa by Portuguese, whereas Spaniards took groundnuts across the pacific to the Philippines from where these were introduced to China, japan, Malaysia, India and Malagasy Republic. At present it is extensively cultivated in tropical and subtropical regions all over the world, and also in warm temperate regions. Major producers are India, China, USA, Sudan, Senegal, Nigeria, South Africa, Indonesia and Brazil.

Groundnut is a low-growing annual herb with compound leaves, each having two pairs of opposite leaflets. Leaves are moderately hairy. Flowers are yellow, sessile and develop singly or in clusters of 2 to 4, papilionaceous. Self pollination is common. After fertilization the ovaries are pushed downward to the soil due to the formation of positively geotropic gynophore. After reaching to a depth of 2-5 cm., gynophore starts growing horizontally and the ovary develops into a fruit.

The fruit is an elongated oblong, indehiscent pod, containing one to three seeds, constricted slightly between the seeds. The dry pericarp is fairly fibrous, characterized by reticulate markings. The seed coat is papery white to pink, purple, brown. The embryo consists of a large radicle, a plumule and two white cotyledons.

There are two main varieties of groundnut:

Branch or erect type: short duration, maturing in three to four months. Pods are comparatively smaller and borne in clusters near the base of the plant. Pericarp is thin and fruit contains one or two small seeds.

Runner or spreading type: produce medium sized pods with thick walls, borne all along the length of branches. It takes about four to six months to ripen.

Groundnut is crop of warm season and requires abundant sunshine for normal development. It is grown in regions with an annual rainfall of about 100 cm. For high yield and good quality, a frost free growing period of four to six months is essential with a brief period of dry weather during fruit ripening and harvesting. The crop is generally sown on loose, friable sandy soil of poor fertility, but well drained sandy loams are the most favourable for growing groundnuts.

Healthy and well-developed pods should be hand shelled or shelled with a suitable groundnut sheeer about fortnight before sowing. Well-defiled kernels should be selected and treated with 5 gm of thiram or 3 g of Captan per kg of kernels. The kharif crop is sown with a speed-drill or with a suitable planter at a depth of 8 to 10 cm. Spacing adopted differs from place to place. For the rain fed bunch groundnut the inter-row spacing between the adjacent rows varies from 20 and 30 and intra-row spacing between 10 and 20 cm. The quantity of well-developed seeds required per hectare with the above spacing will be about 110 kg for semi-spreading and spreading varieties and 120 kg for the bunch varieties.

Weeds cause considerable reduction in yield. For controlling weeds, and also to keep the soil in a friable condition, the crop should generally receive a hand-weeding and one or two hoeing, with bullock-drawn implements, the first about three weeks after sowing and the second and the third about a fortnight and a month later. No interculture would be done after the pegs have commenced going underground. Earthing up can be done in the case of bunch and semi-spreading types to facilitate the maximum penetration of the pegs into the soil. Weeding can also be done quickly and efficiently with a wheel hand-hoe, if the soil is light. It should be run before weeds make excessive growth. Weeds can also be controlled effectively with Lasso or Tok-E-25 weedicides at the rate of 5 litres in 500 litres of water per hectare as a pre-emergence soil spray within two days of sowing groundnut. If the Kharif crop is cought in a long spell of drought, especially at the pod formation stage, supplemental irrigation is given, if water is available. For the irrigated groundnut, the frequency of irrigation depends on soil texture and interval between

irrigation ranges from 8 to 12 days. Studies on the water requirement indicate that the period between the fifty first and fifty seventh day(i.e. at peg formation stage) the crop depends on timely irrigation during this period.

Shelled groundnuts contain about 26% protein and 45% oil. Seeds are also rich in phosphorus and vitamins (thiamine, riboflavin and niacin). Cold pressed groundnut oil is golden yellow, with a faint agreeable odour, whereas hot pressed oil develops a reddish orange colour. The prinicipal fatty acids are: oleic acid 956%), linolenic acid(25%), palmitic acid96-12%), and little quantities of steric, arachidic acid and higher saturated acid. Arachin and conarachin are two main proteins found in seeds.

Groundnut seeds have a very high calorific value. It is the second largest source of vegetable oils. About two third of the world production of groundnut is used for the production of oil. Groundnut oil is mainly used for cooking, as salad oil. In India, major part of groundnut oil produced is used for the manufacture of vegetable ghee by hydrogenation. Lower grade oil is utilized in the manufacture of soaps, lubricants and illuminant. The residue left after oil extraction, is a high protein livestock. Medicinally, oil is used as a laxative and emollient.

The prominent symptoms of maturity are the yellowing of leaves, the shedding of older leaves, the development of proper color of the testa and the dark tint inside the shell. The bunch and semi spreading varieties are usually harvested by hand pulling when there is adequate moisture in a soil. The spreading types, on the other hand, are harvested by digging with a mammity or by ploughing or working a blade harrow. The pulled out plants are stacked for a few days for drying and stripped afterwards.

The stripped pods are cleaned and dried to a safe moisture content of not more than 5%. Damp nuts, if stored, will ferment and allow the development of poisonous moulds, e.g. Aspergillus flavus in the Kernels, leading to contamination with aflatoxin--a health hazard both for human beings and livestock. The oil express from such produced will be rancid and the cake when fed to poultry results in a heavy mortality of the birds. It is desirable to store groundnut in gunny bags which are stacked in a store room in tires in such a way that the air keeps circulating to avoid damage from dampness, rats, etc. The store rooms should be periodically inspected to ensure that there is no storage pest or fungi.

*2. **Rape, mustard and relatives** (**Brassica spp**.)*

Family: Brassicaceae,

The genus *Brassica* includes over 150 species of annual, biennial or rarely perennial herbs, and many species are of considerable economic importance. These are mostly native to the north temperate parts of the Old World,

especially the Mediterranean region. There are perhaps three centers of genetic diversity; Europe, central and southern Asia and China. The different species have spread to the subtropics and tropics as cold season crops. The cultivated *Brassica* species may be divided into two distinct types; the vegetable types and the oilseed types, the former includes cabbage, cauliflower, brocolli, turnip and rutabaga. On the other hand oil seed types are extensively cultivated for the extraction of oil. This category includes *Brassica napus, Brassica juncea, B. praecox and B. campestris*. In India, the principal oilseed crops are *B. campestris* and *B. juncea. Eruca vesicaria* subsp. s*ativa*, (Taramira) is grown mainly in Punjab. Three distinct varieties have evolved from *B. campestris* in India; brown sarson, yellow sarson and toria, restricted to distinct eco-geographical regions. In western Europe, different varieties of *B. campestris* are grown as oilseed crops. In Europe and Canada, *Brassica alba* and *B. nigra* are much used for oil extraction.

Rape and mustard are temperate crops, preferring cool moist conditions and rich sandy loams. They are also grown both in subtropical and tropical countries as winter crops. In Asia it is chiefly grown in China, India and Pakistan, which together account for about 45 per cent of the world's production. Other leading producers are Canada, Germany, France, United Kingdom, Poland, Czech Republic, Denmark and Australia. However, the bulk of the mustard seed production comes from Russia, Canada, Nepal and Denmark.

India has the largest acreage and production of rape and mustard in the world. The chief rapeseed and mustard producing states are Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, Gujrat, West Bengal and Bihar. The Rajasthan alone accounting for nearly 60 per cent of the production.

Rape and mustard plants are slender, erect, branched annual herbs, about 0.6 to 1.5 m tall, generally covered with a waxy deposit termed 'bloom'. The leaves are auricled, generally lyrate (pinnatipartite) . The flowers are yellow and borne in a corymbose raceme. The fruit is a siliqua or silicula (a short and compressed pod). The seeds are small spherical, yellow brown to black in colour, and may be mucilaginous or non-mucilaginous. The seeds of *Brassica* are known to possess a glucoside sinigrin or potassium myronate. Both are virtually without physiological activity, but on hydrolysis with the enzyme myrosin, they yield dextrose and essential oil of mustard. The pungency of rape and mustard oil is due to the presence of essential oil of mustard.

The oil is extracted by expression using expeller or solvents. The oil content of the seeds of different oleiferous forms of *Brassica* and other related genera varies from 30 to 45 per cent depending upon the variety and the climatic conditions under which it is grown. In addition, the seeds contain about 20 % protein. All varieties are characteristic in having a high percentage of erucic acid (45-50 per cent of total fatty acids). Oleic and linoleic acids, on average,

are present about 47 per cent, the former varying from 20 to 30 per cent. The other saturated acids such as palmitic ,stearic and lignoceric are present in very small quantities.

Mustard seeds, particularly rai are used as a condiment in the preparation of pickles and for flavoring curries and vegetables. Mustard oil is used almost entirely for edible purposes. It is also used for manufacturing of general-purpose greases, lubricants, soft soaps and synthetic rubber. Inferior grades of oil are used as an illuminant and also as cutting oil. The erucic acid fraction of the oil is used for lubricating jet engines and in the manufacture of plastics. Mustard oil is employed to impart a soft and pliable texture to skins and hides during the tanning process. In India the mustard oil is often used as hair oil and for body massage. The seeds and oil are used as condiments in the preparation of pickles. The oilcake is mostly used as livestock feed in India and as a fertilizer in Japan, India and Europe owing to its high content of nitrogen. The presence of isothiocyanate in the rape seed meal greatly limits its utilization as a protein supplement for all classes of livestock feed, but processes have been developed which destroy the enzyme (myrosinase) during milling. Efforts are also being made to breed strains with little or no thioglycoside. On the contrary, the value of mustard seeds as a table condiment lies in the production of isothiocyanate. Medicinally, the essential oil of mustard is an extremely powerful, irritant, causing severe blisters on the skin and, therefore, is used as a counter-irritant in highly dilute concentration. For increasing the productivity of rape and mustard crops, the improved varieties, which are capable of giving high yields, should be cultivated. Description of some of the important varieties of rapeseed and mustard is given below:

Rapeseed (A) Toria

Type-9: This variety matures in 90-95 days. Plants are about one meter tall and semi-spreading type. Seeds are of medium size, brownish black in colour and contain 40 per cent oil. The crop usually escapes aphids. Its yield potential is 12-14 quintals per hectare. It is specially suited for cultivation in Uttar Pradesh.

Bhawani: This variety matures in 80 days. Plants are dwarf in nature. Seeds are medium in size, brown in colour and contain 43 per cent oil. Crop usually escapes aphids. It is suitable for growing under irrigated conditions in Uttar Pradesh. Its yield potential is 12-13 quintals per hectare.

PT-30: This variety matures in 90-93 days and is suitable to grow in Tarai of Uttar Pradesh. It is tolerant to white rust, downy mildew and Alternaria blight. Seeds contain 43 per cent oil. Its yield potential is 12-15 quintals per hectare.

PT-303: This variety matures in 90-95 days. This variety is suitable for growing under irrigated conditions in Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Orissa, Bihar and Assam. Seeds contain 44 per cent oil. It is tolerant to white rust, downy mildew and white rust diseases. Yield potential is 15-18 quintals per hectare.

TH-68: This variety matures in 90 days. It is recommended for irrigated conditions in Haryana. Seeds are small in size (3.2 g/1000 seeds) and contain 44 per cent oil. Its yield potential is 12-15 quintals per hectare.

71-75: This variety matures in 85 days and in suitable for cultivation under rain fed as well as irrigated conditions in Haryana, Punjab and Himachal Pradesh. Seeds are bold, brown in colour and contain 44 per cent oil. Its yield potential is 12-15 quintals per hectare.

Sangam: This variety matures in 97-100 days. Plant height is about 1.5 metre. Plants are of semi-spreading type with profuse branching. Seeds are medium in size and brownish black, having 44 per cent oil. It is recommended for growing in Haryana. Its yield potential is 12-18 quintals per hectare.

TLC-1: This variety matures in 100 days and is recommended for cultivation under irrigated conditions of Punjab. Seeds contain 39.5% oil. Its yield potential is 12 quintals per hectare.

PT-507: This is latest variety released from Pant Nagar, which matures in 85-90 days. Seeds contain 44 per cent oil. Yield potential is 14-18 quintal per hectare. It is suitable to grow under irrigated conditions in Uttar Pradesh and Bihar.

M-27: This variety matures in 90-95 days. Plants are dwarf (85 cm tall) and spreading type with profuse branching. Seeds are bold and black having 44 per cent oil. It is suitable for growing in Assam. Its yield potential is 10-12 quintal under rain fed conditions.

TS-29: This variety matures in 85-90 days. It's recommended for cultivation under rain fed conditions in Assam and Orissa. Seeds contain 44% percent oil. Its yield potential is 10-12 quintals under rain fed conditions.

Agarni (B-54): This variety matures in 70-75 days. It is suitable for growing in rain fed conditions in West Bengal. Seeds contain 38 per cent oil. Its yield potential is 8-10 quintals per hectare.

BR-23: This variety matures is 100 days. It is suitable for growing under rain fed conditions in Bihar. Seeds contain 43 per cent oil. Its yields potential is 8-10 quintals per hectare.

Panchali: This variety matures in 80-82 days. It is suitable for growing under rain fed and irrigated conditions in Bihar, Orissa and West Bengal seeds contain 43 per cent oil. Its yield potential is 9-12 quintals per hectare.

PVT-37: This variety matures in 95-98 days. It is suitable for growing under irrigated conditions in Punjab, Haryana and Rajasthan. Seeds contain 42.5 per cent oil. Its yield potential is 13-15 quintals per hectare.

Rapeseed: (B) Brown Sarson

BSH-1: This variety matures in 135-140 days. Plants are medium in height with profused branching. Seeds are medium and brown with average oil content of 46 per cent. It is moderately resistant to Alternaria blight. Its yield potential is about 20 quintals per hectare. It is suitable for growing in Haryana and Punjab.

Pusa Kalyani: This variety matures in 125-135 days. Seeds are medium and brown in colour with an average oil content of 45 per cent. Its yield potential is 16-20 quintals per hectare. It is suitable for growing in Uttar Pradesh, Punjab and Rajasthan.

Rapeseed: (C) Yellow Sarson

VST-151: This variety matures in 135-140 days. It is suitable for growing mixed with wheat because of tall growth and compact branching. Seeds are bold and yellow in colour with average oil content of 45 per cent. Its yield potential is 11-15 quintals per hectare. It is suitable for growing in Uttar Pradesh.

Type-42: This variety matures in 125-130 days. Seeds are medium and yellow with average oil content of 46 per cent. This variety is rated for high quality oil. Its yield potential is about 12-15 quintals per hectare.

K-88: This variety matures in 130 days. Seeds are medium and yellow with average oil content of 47 per cent. Its yield potential is 14-16 quintals per hectare. It is suitable for growing in Uttar Pradesh.

YS-24: This variety matures in 150 days. Seeds are medium and yellow with average oil content of 46 per cent. It has a yields potential of 12-14 quintals per hectare. It is recommended for growing in all parts of Punjab under irrigated conditions.

Vinoy (B-9): This variety matures in 90-95 days. It is suitable for growing under rain fed conditions in Assam, West Bengal and Orissa. Seeds contain 46 per cent oil. Its yield potential is 12-14 quintals per hectare.

PS-66: This variety matures in 110days.lt is suitable for growing under irrigated conditions in Gujrat. Seeds contain 42 per cent oil. Its yield potential is 12-14 quintals per hectare.

PYS-842: This variety matures in 115-120 days. It is suitable for growing under irrigated conditions in Uttar Pradesh. Seeds contain 44.5 per cent. It is moderately resistant to Alternaria blight and white rust. Its yied potential is 16-18 quintals per hectare.

NDYS-842: This variety matures in 110 days. It is suitable for growing under irrigated conditions in Assam, Bihar, Orissa and West Bengal. Seeds contain 43 per cent oil. Its yield potential is 14-15 quintals per hectare.

Mustard (Rai or Raya)

Sita (B-B5): This variety matures in 100 days. It is suitable for growing under rainfed as well as irrigated conditions in Arunachal Pradesh and West Bengal. Seeds contain 38 per cent oil. Its yield potential is 10-12 quintals per hectare.

Bhagirathi (RW-351): This variety is suitable to growing rain fed and irrigated conditions in Assam, West Bengal, Bihar and Orissa. It matures in 100 days. Seeds contain 41 per cent oil. Its yield potential is 12-14 quintals per hectare.

Varuna (T-59)*:* This variety matures in 125-130 days. It is a bold seeded fertilizer responsive variety. Plants are tall semi-spreading type. Seeds are bold, brownish black having 42 per cent oil. Its yield potential is 18-25 quintal per hectare. It is suitable for commercial cultivation in Uttar Pradesh, Bihar, Gujrat and West Bengal.

Shekhar: It matures in 130-135 days. It is suitable for growing in rain fed and irrigated conditions in Uttar Pradesh. Seeds contain 40 per cent oil. Its yield potential is 18-20 quintals per hectare.

Kranti**:** This variety matures in 125-135 days. Seeds are bold and brownish black with an average oil content of 40 per cent. This variety is resistant to Alternaria blight, downy mildew and white rust. Its yield potential is 20-25 quintals per hectare. It is suitable to grow under irrigated conditions of Uttar Pradesh, Haryana, Punjab, Gujarat, Madhya Pradesh and Bihar.

Krishna: This variety matures in 128-132 days. Other characteristics are similar to Kranti. Its yield potential is more than Kranti (22-28 quintals/ hectare.). Seeds contain 40 per cent oil. It is recommended for cultivation in Uttar Pradesh, Assam, Punjab, Rajasthan, Madhya Pradesh and West Bengal.

Narendra Rai**:** This variety matures in 125 days. It is suitable for growing in Uttar Pradesh and Madhya Pradesh. Seeds contain 39.5 per cent oil. Its yield potential is 25-30 quintals per hectare.

Vaibhav: This variety matures in 120-125 days. It is suitable for growing in rain fed conditions in Uttar Pradesh and Madhya Pradesh. Seeds contain 38 per cent oil. Its yield potential is 15-20 quintals per hectare.

Vardan**:** It matures in 120-135 days. This variety is resistant to Alternaria blight and white rust. It is suitable for growing in irrigated conditions in Uttar Pradesh and Madhya Pradesh. This variety does well in late planting too. Seeds contain 40 per cent oil. Its yield potential is 22-28 quintals per hectare.

Rohini: This variety matures in 135-140 days. It has fairly well resistant against most of the diseases and pests. Seeds contain 40 per cent oil. The variety is suitable for growing under irrigated conditions in Uttar Pradesh and Madhya Pradesh. Its yield potential is 22-28 quintals per hectare.

Gujarat Mustard-1**:** This variety matures in 120 days. It is suitable to grow in irrigated areas of Gujarat State. Seeds contain 38% oil. Plants are dwarf in nature.Yield potential is 18 quintals per hectare.

Durgamani**:** This variety matures in 135-140 days. It is suitable for growing under rain fed as well as irrigated conditions in Rajasthan. Seeds contain 39 percent oil. Its yield potential is 10-12 quintals per hectare.

Prakash**:** This variety matures in 150-155 days. Plants are tall with profused branching. Seeds are medium in size and black brown in colour with average oil content of 39 per cent. It is moderately resistant to *Alternaria* blight. Its yield potential is 20-22 quintals per hectare. It is suitable for growing in Haryana.

Saurabh (RH-8113): This variety matures in 150 days. Plants are tall with profused branching. Seeds are medium in size and dark brown in colour with an average oil content of 40 per cent. It is moderately resistant to Alternaria blight, downy mildew and white rust diseases. This variety is recommended for general cultivation in Haryana, Punjab, Himachal Pradesh, Rajasthan and Gujarat. Yield potential is 20-25 quintals per hectare.

Laxmi (RH-8812)*:* This variety is recommended for commercial cultivation in irrigated areas of Haryana.It matures in 142-145 days. Seeds are bold, black in colour and contain 40 per cent oil. Yield potential is 20-25 quintals per hectare.

RH-781**:** This variety matures in 140 days. Seeds contain 40 percent oil. It is recommended for cultivation in irrigated areas of Haryana. This variety is tall (180 cm) with profused branching. It is tolerant to frost and *Alternaria* blight. Yield potential is 18-20 quintals per hectare.

***RH-819*:** This variety matures in 148 days and is suitable for growing in rain fed areas of Haryana. Seeds are medium in size and contain 40 per cent oil. It yield potential is 12-15 quintals per hectare.

***RLM-619*:** This variety matures in 140-145 days. Seeds contain 40 per cent oil. It is suitable for growing in rain fed areas of Haryana, Punjab, Rajasthan and Gujarat. It is good for late planting also. Yield potentials 15-16 quintals per hectare.

***Pusa Bahar*:** This variety matures in 110 days. It is recommended for rainfed cultivation in Bihar, Orissa, Delhi and West Bengal. Seeds contain 42 per cent oil. Yield potential is 12-15 quintals per hectare.

***Pusa Jai Kishan*:** This variety matures in 115 days. Seeds are medium in size and contain 40.5 per cent oil. It is suitable for growing Rajasthan, Gujarat and Delhi. Its yield potential is 18-20 quintals per hectare.

***Rajat*:** This variety matures in 115 days. Seeds contain 42 per cent oil. It is suitable for growing under irrigated conditions in Rajasthan and Gujarat. Its yield potential is 20-25 quintals per hectare.

***TM-2*:** This variety matures in 110-115 days. This variety is recommended for general cultivation in Assam. Seeds contain 39 per cent oil. Its yield potential is 14-16 quintals per hectare.

***PRB-91*:** It is a high yielding variety recommended for cultivation under both irrigated and rain fed conditions in Punjab. Its yield potential is 18-20 quintals per hectare.

Climatic Requirement

Rape seed and mustard crops require somewhat cool, dry weather and long day conditions for satisfactory growth. They require a fair supply of soil moisture during the growing period and a dry clear weather at the time of maturity. In India they are grown in Rabi season from September-October to February-March. Toria is sensitive to cold and is, therefore, usually sown earlier and harvested before the onset of frost. These crops are not drought tolerant and require an annual precipitation of 35-45 centimetre. The crop also does not tolerate water-logging.

Cultivation

Rape seed and mustard can grow under a wide range of soil conditions but they thrive best on light loam soils. Plants can tolerate moderate salinity reasonably well but a soil having neutral pH is ideal for their proper growth and development. Rape and mustard are grown in rotation with other crops like maize, cotton bajra, pulses, etc. Rape and

mustard should never be grown in fields, which were sown with the same crops in previous two years. Such a minimum period of rotation is required to break insect and disease cycle.

A clean and well-pulverized seedbed of good tilth is needed for better germination. Care should be taken to see that weeds and stubbles are well removed from the field and the soil contains adequate moisture to ensure good germination. Planting time is the single most important variable affecting the seed yield of rape seed and mustard to a great extent. Delay in planting reduces the yield on account of its depressing effect on the plant growth, flowering duration, seed formation and seed size. Spacing has no absolute value in the cultivation of rape and mustard as it fluctuates a great deal with the growth habit of variety, date of sowing, manuring and irrigation practices. Before sowing, seed should be treated with Thiram or Captan at the rate of 2.5 g per kg of seed.

Rape seed and mustard respond well both to organic and inorganic manures. If available, apply 15-20 tonnes of farmyard manure or compost at the time of field preparation. These crops show good response to chemical fertilizers. For good harvest, application of nitrogen, phosphate and potash is required. Split application of nitrogen has been found very useful for rape and mustard crop. Rapeseed and mustard have higher requirement for sulphur, therefore, nitrogen should preferably be applied through ammonium sulphate and phosphorus from single super phosphate.

Rape seed and mustard are usually raised as rain fed on the conserved moisture from monsoon rains. Two irrigations at pre-bloom and pod filling stages are beneficial. Weeds in rape and mustard crop cause approximately 20-30 per cent reduction in yield. The most common weeds, which grow in rape and mustard crop, are *Chenopodium album* (bathua), *Lathyrus* spp. (chatrinatri), *Melilotus indica* (senji), *Cirsium arvense* (keteli), *Fumaria parviflora* (gajri) and *Cyperus rotundus* (motha). Care should be taken to remove all weeds either manually or by spraying Nitrofen or Isoproturoi.

Diseases

A number of diseases have been recorded on these crops. Of these, *Alternaria* blight, downy mildew and white blister are the most important diseases, which take a heavy toll of the crop.

Altenaria Blight

This disease is caused by a fungus, *Alternaria brassicae*. The pathogen perpetuates through seed and affected plant portion (refuse) in the soil. The disease is characterized by the appearance of concentric black spots on leaves, stem and pods. Such pods contain shriveled, undersized seeds.

Control Measures: Use of healthy seeds for sowing or Spray Iprodione or Mancozeb 75 WP.

Downy Mildew

This disease is caused by a fungus, *Peronospora brassicae.* In the disease affected plants, yellow irregular spots appear on the upper surface of leaves and white growth is visible on the under surface. The affected inflorescence is malformed, twisted and covered with a white powder. No pods are produced on such inflorescence.

Control Measures: Treating seeds with Apron 35 SD before sowing and by spraying the crop with 0.2% Ridomil or 0.1% Karathane.

White Blister

This disease is caused by the fungus, *Albugo candida*. The white raised blisters on leaves, stem, petiole and floral parts characterize the disease. There is much deformity of the floral parts. Flowers get malformed and become sterile.

Control Measures: Treat the seed with Apron 35 SD before sowing or spray the crop with 0.2% Ridomil.

Insect Pests

These crops are subjected to the attack of insect pests right from the seedling stage to the pod formation stage. The major insect pests are as follows.

Mustard Sawfly

This is the most important seedling pest of rapeseed and mustard. This pest can be controlled by dusting with 2% Methyl Parathion or by spraying the crop with 0.05% Malatti EC.

Mustard Aphid

It is a very serious pest and is the main limiting factor in the production of rapeseed and mustard. This pest can be controlled by spraying of crop with 0.07% Endosulfan 35 EC or 0.05% Malathion 50 EC.

Painted Bug of Mustard

The insect sucks the sap of the pods with the result both quantity and quality of seed is adversely affected.This bug can be controlled with 2 per cent Methyl Parathion dust or by Spraying with Endosulfan 35 EC or Malathion 50 EC

Cabbage Butterfly

The larvae of this pest feed voraciously on the leaves, branches and pods of the crop. The plants are defoliated with the result the small plants die while the grown up plants suffer in growth and yield. This pest can be controlled by spraying with Malathion 50 EC or Monocrotophs (Nuvacron) 40 EC.

Harvesting And Threshing

Harvesting is done when the pods turn yellowish-brown. The harvested crop is stacked in threshing floor for five to six days before threshing. The pods easily shatter and give away seeds. Cleaned seeds are dried in the sun for four to five days.

3. *Coconut* (*Cocos nucifera L.*)

Family: Arecaceae

Coconut palm is one of nature's greatest gifts to mankind as all parts of the plant are useful in one way or the other. However, the dried kernel (copra) is of prime importance. Earlier it was believed to be a native of the Pacific coast of tropical America. But available evidence now indicates that the place of origin of coconut is somewhere in the India-Pacific region from where it scattered throughout the coastal regions of the world by sea currents.

The plant is now widely grown in coastal and deltaic regions of tropical and subtropical countries. Phillippines (1 780 000 t), Indonesia (1 365 00 t), India (455 000 t), Vietnam (230 000 t), Mexico (170 000 t), Papua New Guinea (100 000 t) are chief producers of coconut. The United States of America is the biggest importer of coconut. India ranks third in copra production.

In India, its cultivation is mainly confined to coastal areas of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh, the first alone contributing nearly 50 per cent of total Indian production. It is also grown on a limited scale in Goa, Daman and Diu, Andaman and the Nicobar Islands, Mahrashtra, Orissa, West Bengal, Lakshadweep, Pondicherry, Assam and Tripura.

Coconut palm is a tall, handsome tree attaining a height of 15-30 m and is characteristic in having an inclined trunk having prominent ring-like leaf scars. Dwarf varieties attaining a height of about 12 m are available. The main stem is normally unbranched with a thick swollen base surrounded by a mass of adventitious roots and is crowned by 20-30 large, paripinnate leaves, about 1-8-6.0 m long and each weighting 10 to 15 kg. The inflorescence (spadix) is produced in the axil of the leaf and consists of a central axis with tip to 40 lateral branches. The whole inflorescence is first enclosed by the spathe. Male flowers are numerous , borne in the upper part of the floral axis, while the female flowers are relatively few in number and are located, usually singly, at the base of the inflorescence. Each male flower consists of a perianth of six small unequal tepals arranged in two whorls. The six stamens are arranged in two whorls. The female flowers, on the other hand, consists of three-celled ovaries closely invested by two whorls of perianth of nearly equal size.

Trees start flowering at the age of four to five years old and continues for more than fifty years. One of the most remarkable features of the coconut palm is that it keeps on flowering all the year round and the fruit takes about 9-12 months to ripen fully. The number of fruits, which reach maturity, is generally between three to seven per inflorescence.

After fertilization, two of the three carpels degenerate and the third develops into a fruit. The mature fruit is a fibrous drupe, usually ovoid, and is differentiated into 'exocarp'-the outer covering which is tough, smooth and hard, green in the younger stages but becoming yellow, orange, or reddish brown later on; the middle thick fibrous 'mesocarp', constituting the coir of commerce; and the inner hard, dark brown 'endocarp' with three ridges on the outside and three eyes or depressions at basal end. One of the eyes is larger and softer and under this a small embryo is located, the other two being harder and smaller, and represent the aborted carpels. The endocarp (shell) encloses within it a single hollow seed with a thin brown testa or 'spermoderm' closely appressed to the endocarp externally and adhering firmly to the solid endosperm or 'meat'—the copra of commerce. The cavity of the nut is partially filled with liquid 'coconut milk' representing the liquid endosperm.

Coconuts are propagated by seeds. Germination is slow and it takes about four months for the shoot to emerge. The cotyledon of the embryo begins to swell and elongate and extend backwards into the cavity of the endosperm where it enlarges into a haustorial organ, known as the 'apple'. Initially, it absorbs nutrients from the coconut water and then from the solid endosperm. The young shoot and root then grow through eye of the nut. Nutrients are also absorbed by the root from the fibrous mesocarp.

The palm requires plenty of sunlight, an average temperature between 27-32^{o}C, and a well-distributed rainfall of 1270-2550 mm of per annum. It can be grown on a wide variety of soils provided they have good drainage and adequate soil aeration. Thus, porous soil behind beaches is best suited for the growth of coconut.

For copra production, fully ripe fruits should be harvested as copra and the oil content is high at this stage. On the other hand,' nuts for coir production are picked when ten months old. Drinking nuts are harvested earlier, usually at about seven months.

The fruits are dehusked with the help of an upright steel bayonet fixed on a wooden post. An experienced worker can husk about 2000 fruits per day. The husked nuts are split across the middle, usually with a sharp blow from a cutlass. The endosperm is removed and dried either in the sun or in kiln. Good quality copra contains as little as three to four per cent moisture and has an oil content of 60 to 65 per cent. The oil content of copra is also affected by the method of extraction, varying from 55 to 65 per cent.

Coconut oil contains lauric acid (44-51%); myristic acid (13.1-18.5%); palmitic acid (7.5-10.5%); caprioic acid (0.2-0.5%); caprylic acid (5.4-9.5%); capric acid (4.5-9.7%); stearic acid (1.0-3.2%); arachidie acid (0-1.5%); oleic

acid (5.0-8.2%) and linoleic acid (1.0-2.6%). Coconut oil is a white to yellowish solid fat at temperature below 24°C. At higher temperatures, however, it melts to give coluorless or pale brownish-yellow oil.

Due to its many and varied uses, coconut palm has attained a unique position among the tropical plants, providing all the necessities of life. On account of these useful features, coconut has been called 'The tree of heaven'—*Kalpavriksha.*

The fresh kernels are eaten raw or in the preparation of puddings, sweets, curries and chutneys. Coconut milk is a very refreshing and delicious drink and is highly prized as a source of food. The coconut water is laxative and diuretic. Coconut milk contains plant growth substances and is, therefore, used in the experimental culture of plant tissues. An exudation, 'toddy', is obtained by tapping the unopened spadices of coconut. It may be drunk fresh or may be boiled down to produce palm sugar or 'jaggery'. The fermented toddy makes a highly intoxicating beverage containing about six per cent alcohol. After 24 hours of fermentation, the toddy is unpalatable as a beverage and can be used for the production of vinegar.

Coconut oil is used as an edible as well as industrial oil. The oil has a very high saponification value due to its higher content of lauric and myristic acids. The soap obtained from coconut oil lathers freely in hard and salt water. The oil is still being employed in the manufacture of margarine. It is also utilized in the manufacture of lubricants, detergents, cosmetics such as face creams, shampoos, rubber, synthetic resins and hydraulic brake fluids for aeroplanes. The coco-sterarin fraction from coconut oil is used in the manufacture of candles. Coconut oil is also commonly used as hair oil and for anointing the body all over India.

Coconut occupies a very important place in Hindu rituals and fully mature coconut (ball copra or cup copra) is used as religious or sacrificial offerings. Coconut shells are used for making drinking vessels, buttons, combs, bangles and musical instruments. The shells are also used for fuel, particularly in copra kilns. Finely powdered shells are used as filler in plastics. On distillation, shells yield wood tar and furfural. The tree trunk is used as timber for house construction and the leaves can be plaited and used for thatching mats, screens, baskets and other articles used in daily life.

4. *Elaeis guineensis Jacq.* (Oil palm, African oil palm)

Family: Arecaceae

The African oil palm produces two distinct vegetable oils, palm oil derived from the fleshly mesocarp of the fruits and palm-kernel oil from the seeds (kernels). It gives the highest yield of oil per acre than any other oilseed crop.

The oil palm is native to West Africa where it grows wild in the coastal areas. The palm oil is extracted in country of origin but oil from the seeds is seldom extracted in the producing country.

Earlier cultivation of oil palms was restricted to West Africa but now it is extensively grown in Africa, Southeast Asia, the American tropics and the West Indies. The leading producers are Malaysia (7 220 410 t), Indonesia (3 890 000 t), Nigeria (950 000 t), Colombia (2328 904 t), Zaire (181 000 t) and Ecuador (165 000 t). Other nations in the order of importance are China, Cameroon, Ghana, Costa Rica, Honduras, Sierra Leone, Angola, Liberia, Guinea and Peru. Nigeria is the largest exporter of palm oil, much of which reaches the United Kingdom, Germany, the Netherlands, France and the Middle East countries, In India, oil palm is cultivated principally in the states of Andhra Pradesh, Karnataka and Tamil Nadu.

The African oil palm is a long erect tree, about 20 m high at maturity. The trunk is characterised by persistent, spirally arranged leaf base. Tree bears a crown of massive leaves (about 3-5 m in length) with 100-160 pairs of leaflets. Spadices bearing male and female flowers arise in the axils of leaves. Female flowers in the axils of the lower leaves where as the males in the axils of the upper leaves.

The male inflorescence has a short, stout peduncle (rarely more than 10 cm long and 5 cm broad) that bears a cylindrical mass of finger-like, spineless, brown spikes, each with a large number of closely packed minute male flowers. Each male flower has a small triangular bract, six small free perianth segments, six stamens with sagittate anthers on short filaments that are united at the base and a rudimentary ovary.

The female spadix is stouter and peduncle of the female spadix is shorter bearing as many as 140 spikelets each with 20 to 30 widely separated flowers which are much larger than the male flowers. The female flower consists of a single whitish yellow or green bract terminated by a spine, a pair of small bracteoles, six broad perianth segments and a three celled ovary Normally one ovule is functional and develops into the fruit.

The fruits are borne in large bunches each containing a variable number of fruits (200-2000). The average weight of each bunch is approximately 23 kg but sometimes it may weigh up to 82 kg. The fruit is a sessile, ovoid drupe, 4 cm long and 2 cm broad, with a pointed apex and varying in colour from yellow to orange or nearly black. Four varieties of the palm can be distinguished on the basis of the fruit structure, especially the thickness of the endocarp: var. *macrocarpa*, 40-60 per cent shell; var *dura*, 20-40 per cent shell, var. *tenera*, 5-20 per cent shell and var. *pisifera*, a shell-less from .

For oil extraction, the ripe fruits are boiled in water and pounded to disintegrate the pulp, thus freeing the nut. In parts of the West Africa the fleshy pulp is boiled again with a large volume of water (soft oil process). The oil floats on the surface and can be skimmed off. The oil so obtained is of good quality and is characterized by a low free fatty acid content. In another method known as the 'hard oil process', the disintegration of the pulp is accomplished through fermentation rather than boiling and pounding and then cooking the decayed mass with water. The oil obtained by this method contains a large amount of free fatty acids. In more progressive countries the fruits are steam sterilized to inactivate the fat hydrolyzing enzyme, lipase.

Palm Oil

It is yellow to orange-red in colour due to the presence of large quantities of carotene, particularly ß-carotene-the precursor of vitamin A. It is more or less solid at ordinary temperatures. The fatty acid composition of palm oil is: myristic acid; 1.0- 2.5 per cent; palmitic acid, 32-43 per cent; stearic acid, 1-9 per cent; oleic acid, 40-53 per cent and linoleic acid, 2-11 per cent.

Palm oil has long been used as edible oil especially in West Africa. Palm oil is also consumed in the manufacture of soaps, candles, lubricants and in tin plating industry. Sometimes it is used as fuel for internal combustion engines. The oil can also be used in the place of cod-liver oil for as a source of vitamin A.

Palm Kernel oil is obtained from the kernel or endosperm, which contains about 50 per cent oil. The nuts, left after the removal of the pulp, are dried to loosen the kernels. The shells are removedr by wooden hammers or with help of nut-shelling machine. Broken shells are separated from the kernels either by hand picking or by floating off the kernels in brine. The milling of palm kernel is mainly carried out in USA and Europe. The kernels are milled either by hydraulic press, screw press or by solvent extraction method.

The oil is colourless or light yellow in colour liquid at room temperatures. The fatty acid composition of palm kernel oil is; caprylic acid, 3-4 per cent; capric acid, 3-7 per cent; lauric acid, 46-52 per cent; myristic acid, 14-17 per cent; palmitic acid, 6.5-9 per cent; stearic acid, 1.0-2.5 per cent; oleic acid, 13-19 per cent and linoleic acid 0.5-2.0 per cent.

Palm kernel oil is used in hard water soaps and in the manufacture of glycerine, shampoos and candles. The better grades are used in the manufacture of margarine. The stearine fraction of palm kernel oil is used in confectionery, especially as a substitute for cocoa butter, whereas the olein fraction may be used in biscuits and cakes. The press cake is used as cattlefeed.

5. *Olea europaea L.* (Common Olive)

Family: Oleaceae

Olive oil is obtained from the fruits of common olive, tree, *Olea europaea.* Olive trees have been under cultivation since Biblical times. The tree is native of western Asia and is now grown extensively in countries bordering the Mediterranean sea, altogether accounting for 98 per cent of the total world production. There are now hundreds of cultivars, some developed exclusively for oil extraction. The major producers are Italy (2 779 000 t), Spain (2 624 000 t), Tunisia (665 000 t), and Morocco (560 000 t). Other olive producing countries are: Syria, Portugal, Algeria, Egypt, the United States (California), Argentina, Jordon, Lebanon, Libya and Israel. More recently, olive cultivation has been undertaken in South Africa, Mexico and Australia. Several European countries and the United States of America are the leading importers of live oil. Unsuccessful attempts have been made to grow olives in different parts of India but have not been successful as the trees fail to bear fruits.

O. europaea is a narrow-leaved xerophytic tree attaining a height of 15.0-18.5 m under natural conditions but in plantation the height is kept low, i.e., 4.5 m. The fruit is one-seeded drupe globular, oblong or crescent-shaped. The colour of the fruit is green at first and then passes through blue, purple and red to black. The mesocarp or pulp is oily and encloses an elongated brown seed, often, referred to as a 'stone' .

The olive tree grows only in regions with a warm and dry summer and an average temperature of at least 18^{o}C and a mild winter during which the temperature does not drop below - 5^{o}C. For good flowering and fruiting a mean temperature of 10^{o}C or lower (chilling) is considered necessary for nearly two months. The tree will grow but not fruit in the tropics. Typically, olives are grown in semi-arid regions, where rainfall is low (60-75 cm per annum). They are grown successfully on many type of soils, but prefer light, deep soils, thriving best on calcareous sandy loams. Regions adjacent to the Mediterranean Sea are ideal for the olive cultivation.

The olive tree is propagated by means of cuttings or grafting. The trees begins to bear fruits after six years and productivity declines after fifty years. Like mangoes and other fruit trees, olives are prone to alternate bearing-a heavy fruit set one year followed by a light crop the next year.

The oil content of the fruit varies from 25 and 60 per cent depending upon variety, climatic conditions and maturity. The fruit pulp (mesocarp) contains at least 75 per cent oil. The kernels, on the other hand, have 12-28 per cent oil. Fully ripe olives have high oil content. As the chemical compositions of both types of oils is identical the kernels are not separated from the pulp. Several expression are made, the first pressing yielding the more valuble 'virgin oil' suitable for use without refining.

The fatty acid components of olive oil are; oleic acid, 65-86 per cent; palmitic acid, 7-20 per cent; linolenic acid, 5-15 per cent; myristic acid 0-1 per cent and stearic acid 0.3 per cent.

Over 90 per cent of the world production of olives is used for oil production, the remainder being pickled or canned either in the green (immature) or black (ripe) stage. Green olives contain a bitter glycoside (oleuropein), which is removed by neutralizing it with sodium hydroxide and thereafter they are pickled in the brine. Green olives are greater demand and a small proportion, after removal of the stone, is stuffed with red pepper.

Olive oil is largely used in cooking, salad oils and food preservation. It is also used in the manufacture of high-class toilet preparations, cosmetics and in pharmaceuticals. In the textile industry, it is used in wool combing. The oil is still being used for anointing the body and to improve the complexion.

The residue left after milling is known as Oil pomace. It is employed as a livestock feed or as manure. The stones are an important sources of furfural and are used in the manufacture of moulded products and plastics.

6. *Ricinus communis L.* (Castor)

Family: Euphorbiaceae

Caster is probably indigenous to North Africa and is now extensively grown in tropical and subtropical regions, usually as an annual crop. India (700 000 t) and China (280 000 t) are leading producers of castor. Others castor producing countries are Brazil, Thailand, Ethiopia, Paraguay, Russian Federation, Sudan and Tanzania. The United States of America is the largest importer, followed by France and the United Kingdom. In India, Gujarat is the major castor producing state (500 000 t), followed by Andhra Pradesh (75 000 t), Orissa and Karnataka (13 200 t each) and Tamil Nadu (10 300 t).

It is a tall glabrous perennial plant, having well-marked nodes and prominent leaf scars. The leaves are large, palmately lobed and arranged alternately. The castor plant is monoecious; the female flowers are produced in the upper part of the panicle, while the male flowers develop in the lower part. The capsular fruits (regma) may be spiny or smooth, arising from a tricarpellary, syncarpous ovary. It splits at maturity into three one-seeded cocci. In recent years, however, annual dwarf strains have been developed that grow to a height of about only 1 to 2m and complete their growth cycle in 150-180 days. Only these varieties are becoming of much significance in modern farming as they are of non-shattering types.

Castor seed, often referred to as castor bean, exhibits a great range of variations in size and colour. The hilum is almost concealed under the caruncle–an integumentary proliferation at the micropylar end. The raphe is very

prominent. A tiny embryo with a distinct radicle, an undifferentiated plumule and two thin, flat, distinctly nerved, papery cotyledons is embedded in the endosperm.

The crop thrives best in conditions of high temperature (20-25^0 C) throughout the growing season. Castor can withstand dry arid climates. It is generally grown on sandy or clayey loams but it cannot tolerate heavy rainfall and waterlogging.

Castor beans are harvested before the seeds reach full maturity. The seeds are decorticated with the help of specially designed hullers, the seed coats contributing up to 25 per cent of the weight of the seed. A fixed oil is obtained from kernels. The remaining cake contains at least three toxic substance, ricin, an extremely poisonous substance present in large amounts, ricinine–a slightly toxic alkaloid and an allergen–a protein polysaccharide. Ricin is also used are as blood coagulant.

Castor oil is a nearly coloureless or very pale greenish yellow viscous liquid. The typical fatty acid composition of castor oil is ricinoleic acid (91-95%); linoleic acid (4.5%); palmitic and stearic acids (1.2%) and a negligible amount of oleic acid. The oil and its derivatives, are used for various industrial purposes. Dehydrated castor oil is a good drying oil and is used for paints and varnishing. It is an important raw material in the manufacture of various chemicals, e.g., sebacic acid and undecylenic acid, used for the production of plasticisers and nylon fibre. Chemicals (Heptaldehyde and undecylenic acid), obtained by the decomposition of castor oil at higher temperatures are used in perfumery. Undecylenic acid is also employed as a bactericide and fungicide. Castor oil and its derivatives are used as lubricants for locomotives, marine engines and aeroplane engines. A large proportion of castor oil is used in Hydraulic brake fluid. It is also employed in the manufacture of transparent soaps, printing ink, linoleum and oil cloth. Due to their strong bactericidal action, sodium ricinoleate and sulpho-ricinoleate are important ingredients of toothpaste formulations. Sulphonated castor oil (Turkey oil) is used in cotton dyeing and printing and also in the leather industry.

After hydrogenation castor oil is used in the manufacture of ointment bases, waxes, polishes, carbon paper and candles. Ricinoleic acid is used in the manufacture of chemical contraceptives. The oil is very commonly used in pharmacy as strong laxative. Castor oil is used as illuminating oil in rural areas. Castor stemp is suitable for the production of wrapping papers and strawboard.

The residue left after the extraction of the oil, is quite rich in protein, carbohydrates and minerals like phosphorus, calcium, potassium, magnesium and iron, but the presence of ricine (a blood coagulant) makes it unsuitable as a livestock feed. It is used chiefly as fertilizer. A method has now been found, however, to detoxicate the meal.

7. *Gossypium spp.* (Cotton seed Oil)

Family: Malvaceae

Cottonseed oil is extracted from the seeds of various species of *Gossypium* that are grown primilary for their fibres. Prior to the invention of the cotton gin at the close of the eighteenth century, the seed was considered to be of little value and was generally discarded. Today, cottonseed forms the basis of an important subsidiary oil and stock feed industry. Various species of Gossypium are cultivated in many tropical and subtropical countries. Major cottonseed producers are: China (8 500 000 t), the United States (6 957 000 t), India (5 900 000 t), Pakistan (2700 000 t), Uzebekistan (2 380 000 t), Turkey (9 44 000 t), Brazil (900 000 t), Turkmenistan (830 000 t), Greece (495 000 t), Egypt (490 000 t), Italy (480 000 t), Austrial (466 000 t), Tajikistan (401 000 t), and Mexico (154 000 t). The leading cottonseed producing states in India are Gujarat, Punjab, Maharashtra, Karnataka, Haryana, Andhra, Pradesh, Tamil Nadu, Rajasthan and Madhya Pradesh, altogether accounting for nearly 95 per cent of Indian production.

Cottonseed, as it comes out of the gin, are covered densely with short fibres which give the seeds a whitish or greyish colour. The testa is tough constituting nearly 35-40 per cent of the whole seed and encloses an embryo with a long radicle and convoluted cotyledons, invested by at thin papery membrane (perisperm).

The seeds after the removal of the fuzz, are dark brown or nearly black in colour and pointed ovoid in shape. The hilum and micropyle are at the pointed end of the seed. The raphe is indicated by a slight ridge along the seed. The speckled appearance of the kernel is due to numerous tiny dark coloured pigment glands containing gossypol (1-2 per cent)–a polyphenolic substance that is toxic to pigs and chickens but not to cattle. The gossypol content of *G. barbadense* is the highest of all the species (1.9-3.4 per cent), followed by that of *G. hirsutum* (1.4-2.1 per cent). The seeds of *G. herbaceum*, however, have a relatively low gossypol content. In addition, the glands also contain gossypurpurin, gossyfulvin and gossycaerulin.

The oil and protein contents of the seeds vary with the variety and agroclimatic conditions. The American upland and Sea Island types contain higher percentage of oil than Indian cultivars. Generally long-staple varieties yield a higher amount of oil on expression. The fatty acid composition of cotton seed oil is: linoleic (40-55%); palmitic (20-25%); oleic (18.3%); steaic (2-7%); and a small proportion of myristic and arachidic acids. Cotton-seed oil also

contains 0.9 per cent tocopherol (vitamin E), known for its antioxidant effect, which helps to maintain the quality of the oil.

Refined cotton seed oil is used mainly for edible purposes such as salad and cooking oils, margarine and a lesser extent in the packing of the fish and cured meat. In USA, about three quarters of the cotton seed oil is used in the manufacture of lard substitute. Cottonseed flour is a valuable supplement for cereal flour. Low grade cotton oil is used in the manufacture of soaps, lubricants, sulphonated oils and protective coatings.

The press meal, obtained at a by-product during the refining of cottonseed oil, is used in soaps, washing powder, oil cloth, artificial leather, insulating materials, roofing, tar, putty, glycerine and nitroglycerine.

In India, the whole seeds are fed to dairy cattle as well as cake and meal are used as a livestock feed. Cotton seed hulls are used as fertilizer, fuel and also to make paper and furfural. Pharmaceutically, cotton seed oil is used as an emollient. The refined cottonseed oil is used as a solvent for the preparation of steroid hormone injections.

8. ***Sesamum indicum L.*** **(Sesame, gingelly or beniseed)**

Syn. S. *orientale* L. (Family: Pedaliaceae)

Sesame as an oilseed crop has been cultivated since ancient times in the hotter and drier parts of the Mediterranean region, Africa, India and the Far East. Africa is considered as primary centre of origin of sesame and India as a secondary centre. At present, sesame is cultivated in all tropical and subtropical countries. Major producers of sesame are India, China, Sudan, Myanmar, Uganda, Nigeria, Mexico, Ethiopia, and Tanzania. The major exporting countries are Sudan, Mexico, and Nigeria, the supplies chiefly going to the Mediterranean countries, Japan and the United States. India is the leading producing country and contributes about 33 per cent of the world's production. Major sesame growing states are West Bengal (95 000 t), Maharashtra (83 300 t), Madhya Pradesh (68 400 t), Tamil Nadu (59 100 t), Rajashtan (53 900 t), Andhra Pradesh (39 600 t), Karnataka (37 700 t), and Gujarat (35 400 t).

The plant is an erect, bushy annual, up to 2.0 m in height. Stem is longitudinally furrowed and densely hairy. The lower leaves are broad and generally lobed, whereas the upper leaves are more or less lanceolate. The bell-shaped white, pink or mauve flowers are borne in leaf axils. Capsules are hairy, oblong or ovoid, upright, deeply grooved with short triangular beaks. The fruits, dehisce by splitting along the dorsal suture of each carpel. Two types of fruits have been recognized, one developing from a bicarpellate (four-loculed) and the other arising from a quadricarpellate (eight-loculed) gynoecium. In the latter case the fruits are usually developed singly. The seeds are numerous small compressed, somewhat pear-shaped, ranging form pure white to brown or black in colour with a

smooth or rough surface, enclosing an embryo with prominent cotyledons. The endosperm is found as a thin layer around the embryo. Sesame is a crop of the hot dry tropics, and requires an annual rainfall of 50 to 110 cm. Heavy rainfall and high humidity damage the plant but it is drought resistant and gives a good yield even when grown on residual soil-moisture alone. The seeds germinate at soil temperature above 21^{o}C.

In India, sesame is usually raised as rainfed *kharif* crop and matures within 100-140 days. The crop is harvested when the lowermost capsules begin to turn yellow, but before they open. The stems are tied in bundles and stacked upside down over mats or threshing floors to ripen the seed. The seeds fall as they ripen and also when the heads are shaken. Threshing can also be carried out by beating with sticks.

The seeds contain about 50 per cent oil and 20-25 per cent protein. There is variation in the oil content of different varieties. The finest quality of oil is obtained from white or yellowish seeds, whereas the dark coloured seeds of red, brown or black types yield a high percentage of fixed oils. Sesame oil contains about 85 per cent unsaturated acids. The fatty acid composition of the oil is : oleic (37-50%); linoleic (37-47%); palmitic (7-9 %) and stearic (4-5%). The oil contains two minor constituents that are not found in other fixed oils, namely sesamin (0.5-1.0 %) and sesamolin (0.3-0.5%). On hydrolysis, the latter yields sesamol–a powerful antioxidant.

In India, sesame seeds are important as ingredients in a variety of sweetmeats and confections such as '*rewri'* and '*gazak'*. The seeds may be eaten fried or mixed with sugar. In USA and European countries, seeds are used as garnish for bread rolls and bakery products, cakes, pastry and bread. The sesame seeds are also often recommended as a protein supplement for the wheat or corn flour. The Hindus in their religious rituals use them. Normally, seasame oil is used for edible purposes and can also be used as a substitute for olive oil. It is also utilised in the manufacture of cooking fats, margarine and salad oils. Lower grades are employed in the soap and point industries and also as a lubricant and illuminate. In India, the oil is extensively used in manufacturing of perfumes. Apart from its emollient properties, in medicine sesame oil is highly prized as a carrier or suspending agent for antibiotics, vitamins and steroid hormones, and also in insecticidal preparations. Sesame oil and sesamin concentrates are also used for their synergistic effect in pyrethrum insecticide.

The oil-cake is an excellent protein rich supplement for dairy cattle, seed cattle, poultry and pigs. The cake is also quite rich in calcium, phosphorus and niacin.

9. *Glycine max (L.) Merr.* (Soybean)

Syn. *G. soja* ,*G. hispida* ,*Soja max* ,Family: Fabaceae

Soybean was an important food plant in the Orient (China, Manchuria, Korea and Japan) since the earliest times. Soybean has been cultivated in China from prehistoric times, as is evident from Chinese writings dating back to 2800 B.C., in which it is mentioned as one of the five principal and sacred crops. It was carried to Europe by French missionaries in 1740 and to the Royal Botanic Gardens, Kew, in 1790. Although soybeans were introduced to the United States in 1804 but its potential has been recognized only relatively recently and has, therefore, now become widespread. At present, it ranks high among the leguminous crops in its nutritional value owing to a high protein as high as 43% and oil content about 20%. Soybean is an excellent protein supplement for enriching our cereal diet and has earned a special place in the nutrition programme. Due to varied uses of the soybean that is called the 'wonder bean'.

United States of America, China and Brazil are major producers of soybean. Other important producers are China and Argentina, India, Canada, Indonesia, Ecuador, Italy, Thailand, Russian Federation, Korea and Colombia.

Soybean was introduced to India in about 1880 and is now being cultivated in Madhya Pradesh (3 600 000 t), Maharasthra (670 000 t), Rajasthan (370 000 t), and to some extent in Uttar Pradesh, Karnataka, Himachal Pradesh, Assam and Manipur.

Soybean is a subtropical erect, much branched, pubescent annual. The leaves are trifoliate, large, alternate, stipulate and generally have a long petiole. leaflets are ovate to lanceolate, each being subtended by a short pointed stipule. The flowers are small, nearly white to deep purple and are borne on short axillary racemes, each bearing three to fifteen flowers. Self-fertilization is normal. The seeds are small, globose with a small hilum, ranging in colour from creamy white through various shades of grey and brown to nearly black, and are contained in short, narrow hairy. The pods are slightly constricted between the seeds, each having two or three seeds (occasionally four).

G. max is cultivated in tropical and temperate regions up to latitude 52^{o}N. It is concentrated mainly in regions with hot, damp summer weather. An evenly distributed rainfall during the g rowing period and more or less dry weather during the period of ripening are necessary. Excessively high temperatures or extreme winters are harmful to the crop. Soybean grows on the nearly all types of soil, but thrives best on deep fertile soils with high calcium content. It is essentially a short-day plant.

The crop is propogated from seeds. Early varieties of soybean mature in 75-110 days, while the late ones take 100-200 days. The crop is harvested when the leaves being to turn yellow and drop.

Black-seeded varieties are richest in protein and have a low percentage of oil. In contrast, yellow-seeded forms have a higher oil content but are low in proteins. The fatty acid constituents of soyabean oil are: oleic acid (23-34%); linoleic acid (52-60%); palmitic acid (7-14%); stearic acid (2-6%); linolenic acid, (3.0%). Soybean contains the gylcosides genistin and diadzin and four saponins. It has a higher percentage of proteins especially glycinine. Besides this, phaseolin and legumelin are also present. The seeds are also a rich source of calcium, iron and vitamins, especially of the B complex type.

Soybeans are grown mainly as a food crop in China, Japan and other East Asian countries. The seeds are consumed as vegetable. Roasted and salted seeds are used in cakes and candies. Soybean milk, obtained by grinding boiled seeds with water, is extensively used for infant feeding throughout China. It is highly nutritious is made into curd, butter milk, cheese and other milk products. Soy sauce—a brown sauce is prepared by fermenting soybean and rice flour by *Aspergilus oryzae*. The fermented beans are then immersed in brine for many months in the sun to extract the flavour. The soya sauce is used with meat and fish and also to flavour rice.

Soybean flour is becoming increasingly important as an ingredient of foodstuffs and bakery products. The flour forms an ideal ingredient of food for diabetic patients all over the world as it contains less starch. Since the raw seeds contain a trypsin-inhibiting substance, soybean flour must be specially treated to destroy the inhibitor before it can be used in substantial amounts.

In the United States, a large production of the soybean oil is used for edible purposes particularly as a salad oil and for the manufacture of margarine and shortening. It is also employed for packing sardines, tuna and other kinds of fish. Soybean oil is used in the manufacture of soaps, glycerine, printing inks, greases, lubricants, waterproofing material, oil-cloth, linoleum, putty, resins, insecticides, disinfectant and leather dressings. The oil is now utilized in the paint, varnish and enamel industries. Soylecithen, an important by-product of the oil industry, is used in the food industry as an emulsifier and in the cosmetics as well as pharmaceuticals. Soya meal is a very rich protein feed (40-48%) for cattle, pigs and poultry. The meal is also used in the manufacture of adhesives, sizing, water proofing, plastics, synthetic textile fibre, foaming solutions and as a fertilizer.

10. Linum usitatissimum L. (Linseed)

Family: Linaceae

Linseed is a source of both oil and fibre. It is one of the earliest plants to have been domesticated for the extraction of fibres in the Mediterranean region and southern Asia. Presently, it is grown widely in many parts of the world,

both in tropical and temperate zones. Generally speaking, the crop is grown in hot dry regions mainly for oil production and for high grade fibre in temperate regions. The varieties grown for fibre are usually different from those for oilseed production. The major producers of linseed are: Canada (964 000 t), China (420 000 t), India (340 000 t), the United Kingdom (200 000 t), and Aregentina (127 000 t). Other producers are the United States, Russian Federation, Ethiopia, Bangladesh, and Nepal .

In India leading linseed producing states are Madhya Pradesh (40 700 t), Bihar (31 200 t), Orissa (14 500 t), Rajasthan (12 200 t) and Karnataka (7 100 t). The fruit is a small, indehiscent, globular, multi-chambered capsule with a persistant calyx. It contains up to ten seeds,which are oval, 4-6 mm long by 2 to 3 m wide and have a distinct obliquely pointed end. The hilum and micropyle are located in a slight depression. The seeds are characteristically smooth and flattened with a shining yellow to reddish brown testa and possess a distinct raphe. The testa produces a large amount of mucilage when wetted. The endosperm is scanty and surrounds the thick cotyledons.

Linseed varieties grown for seeds are comparatively shorter and profusedly branching and spaced farther apart to encourage added branching and increased seed production. The linseed crop matures in about six to seven months. After harvesting, the crop is dried in the field for a few days and then threshed to separate the seeds.

The oil is present in the form of yellowish globules intermixed with aleurone grains in the cells of the two large cotyledons. Both cold and hot expression methods are used for the extraction of oil. In general, before crushing, the seed is rolled into a meal and cooked in a steam jacketed trough. The oil content of the seed is between 33 and 45 per cent. On exposure to air, this oil is converted into an elastic solid known as linoxyn. Linseed oil is a yellowish brown liquid, characterised by the presence of a high percentage of linolenic acid (50-60%). Other fatty acids are stearic and palmitic, (6-16%); oleic (13-36%); linoleic (10-25%) and traces of myristic and arachidic acids.

Being a drying oil, linseed is principally used in the paint and varnish industry and also in the manufacture of linoleum, oil cloth, printing and lithographic inks and soft soaps. Lubricants, greases and polishes are also prepared from this oil.

Raw linseed oil is used in pharmaceuticals as an emollient, demulcent, expectorant and diuretic. Because of the hydrophilic property of the mucilaginous substances present in the seed coat (spermoderm), the whole seed is used as a laxative as it draws fluid from body tissues with which it is in contact. It is also used for the preparation of water paints.

Seeds contain a cyanogenetic phycoside, 'phaseolunatin' (linamarin) which has poisonous effect on living organisms. Cattle poisoning is caused by the hydrocyanic acid or prussic acid which is released by the activity of the enzyme linase on linamarin. Hot pressed linseed cake is harmless as the linamarin fraction is not hydrolysed to HCN owing to the denaturation of the enzyme linase during cooking. Oil cake is a palatable, protein-rich (30%) livestock feed.

When the raw linseed oil is heated to 90-150^{o}C in the presence of driers such as the salts of certain metals (lead, manganese, cobalt and zinc) oil forms a smooth and lustrous film and are preferred for most industrial uses, e.g., in the paint, lacquer and varnish industries.

Oil cake, either alone or with other inorganic manures, can be used for increasing soil fertility.

11. *Safflower* (*Carthamus tinctorius* L.)

Family: Asteraceae

Safflower crop is now cultivated, primarily for its seeds which yield oil, earlier it used to be grown mainly for the extraction of an orange dye. The seeds are edible and are eaten after roasting. Their oil content varies from 24 to 36 per cent, depending on the variety, soil, climate and other conditions. The cold-pressed oil is golden yellow and is used for culinary purposes, or for making soap. The oil obtained by dry hot distillation is black and sticky and is used only for greasing well ropes and leather goods exposed to water. Safflower oil has good drying properties and is, therefore, used in the manufacture of paints, varnishes and linoleum. It can be mixed with white paint without any after-yellowing effects. The cake, particularly from decorticated seed, is used as a concentrated cattle feed, and that from undecorticated seed is sometimes used as a manure.

Safflower is believed to have originated in Southern Asia and has been cultivated in the Middle East and East Africa for centuries. The safflower plant is highly branched, herbaceous, erect annual, varying in height from 30 to 160 cm. It has many branches each terminating in a flower. The leaves are spinosely serrate. The inflorescence is broad, flat or slightly curved and densely bristled owing to the presence of numerous floral bracts. The flowers are yellow to red, containing 20 individual florets, each of which produces a seed.

Distribution area and production

The important safflower producing countries are: India, USA, Mexico, Ethiopia, Spain, the USSR. and Australia. In India, it is cultivated in the states of Maharashtra (04.4%), Karnataka (26.0%) and Andhra Pradesh (8.0%).

Climate and soil

Safflower is raised from seeds and it is grown during rabi primarily as a rain fed crop. It can not tolerate high rainfall or humidity. Water-logging due to poor drainage or prolonged rains even for relatively short periods can cause substantial fall in seed-yield. Being drought-resistant, it is cultivated on all types of soil including sandy soil but it thrives best on water-retentive black soil and alluvial loams. The crop is fairly resistant to saline condition.

Safflower is grown mostly as a mixture with wheat, barley, gram and rabi jowar, three rows of safflower being planted after every nine, 12 or more rows of the main crop. Sometimes, it is sown as border rows surrounding the crops of wheat, rabi, jowar, etc., because being spiny, it protects the main crop against cattle trespass. As a pure crop, it is rotated with wheat, gram and rabi jowar.

The number of ploughings should be as few as possible and be aimed at preserving the maximum amount of soil moisture. Sowing is generally done in September and October. In general, the pure crop is given one or two weeding and application of nitrogen fertilizer results in a substantial increase in yield. The mixed crop shares the preparatory tillage, manuring and cultivation given to the main crop. When the plants have developed the central flowering head, they are topped to promote branching, flowering and seed production.

The crop matures in 4 or 5 months after sowing. The ripe plants are either cut or pulled out, stacked for a few days to dry, threshed by sticks, and the resulting material is winnowed to obtain clean seeds.

The safflower aphid (*Dactynotus carthami*), thrips (*Franklinie sulphurea*) and the flower bud fly (*Acanihiphilus helianthi* Rossi) are the serious pests of the crop. Spraying the crop with O.1% Fenithion, 0.03% Dimethoate and 0.07% Endosulfan is recommended for controlling aphids, thrips and budfly, respectively. Rust (*Puccinia carthami*), Alternaria leaf-spot (*Alternaria carthami*) and root-rot (*Phytophthora drechskri*) are the important diseases of safflower. The growing of resistant varieties is recommended to avoid damage from these diseases.

12. *Sunflower* (Helianthus annus L.)

Family: Asteraceae

The cultivated sunflower (*Helianthus annus* L.) is a native of southern United States and Mexico, from where it was taken to Spain before the middle of the sixteenth century. In the nineteenth century, the cultivation of sunflower as an oilseed crop began in the Soviet Union and the majority of the present day varieties grown all-over the world trace back their origin to the USSR. The major sunflower-producing countries of the world are the Soviet Union,

Argentina, Bulgaria, Roumania, Turkey and South America. Sunflower, as an oilseed crop, was introduced into India in 1969.

Sunflower is mainly grown for its oil. The oil is used for culinary purposes, in preparation of vanaspati and in the manufacture of soaps and cosmetics. It is especially recommended for heart patients. Its cake is rich in protein and is used as a cattle and poultry feed.

Sunflower belongs to the family Asteraceae and the genus *Helianthus*. The cultivated genotypes are characterized by a fall single stem with heavy head. Sunflower is protandrous, in which the male and female elements mature at different times. There appears to be a time-lag of 18-24 hours in the maturity of the male and female elements. So it is essentially a cross-pollinated plant, besides showing varying degrees of self-incompatibility.

Sunflower is a day neutral plant can be grown successfully in different seasons under varying conditions of day length, provided the temperature is favourable. Sunflower, is a crop of temperate region but can be grown commercially in tropical or sub-tropical conditions. It grows best with clear sky and occasionally rain shower during early stages. This crops requires a cool climate during germination and seedling growth and warm non-cloudy weather and high temperature during flowering to maturity. Sunflower can tolerate temperature range of 8 to 30^0C but the temperature below 16^0C and above 40^0C reduces yield and oil content. High temperature affects pollination and fertilization, thus care should be taken to adjust the sowing date in such a way that flowering does not coincide with high temperature. The optimum temperature for best performance under controlled conditions is 27-28 ^{0}C. Sunflower can be planted successfully when soil temperature exceeds10^0C, though germination begins at 3-5^0C. Young plants(1 or 2 pairs of leaves)can withstand frost to -6^0C. However, plants are frost sensitive from 6-8 leaf stage until flowering finishes. Late frost does not destroy the whole plant but destroys the fruiting head, leading to increased branching, resulting in small heads with many empty fruits. Average minimum temperature below 17^0C between flowering and maturity is necessary to ensure best oil quality.

Sunflower can thrive on a wide range of soils such as sandy loam, black soil and alluvial soil, but it thrives best on sandy loam soil. However, good drainage is more important than soil type. Thus, fertile, well drained, medium textured soils having heavy water holding capacity are best suited for the cultivation of sunflower. Sunflower is highly susceptible to water logging. Sunflower requires a fine seedbed, and adequate soil moisture is essential for getting good germination.

Many hybrid varieties have been developed. These are: MSFH8, PSFH-67,GKSFH-2002, Jwalamukhi, Mega-363 and NSFH-592. These hybrids are medium tall with dark green leaves. their seeds are black in colour and mature in about 110-125 days Mega-363 is a long duration hybrid and hence should not be selected for cotton areas. These hybrids have an average yield about 20 quintals per hectare with an oil content of 40.5 to 43.0 percent. In hybrids fresh seed is to be sown every time which adds to its cost of cultivation.

For sowing, spring season is the best for getting higher and stable seed yield sunflower. Sunflower is a cross pollinated crop and depends on honey bees for pollination and seed setting. Honey bees are abundant during spring season and help in pollination. Planting during spring should be made after the soil temperature exceeds 10^0C at 10cm depth. Earlier, planting at lower temperature increases time of flowering without much earliness. Best results are obtained when crop is sown in the first fortnight of January which produces higher seed yield than later planting. Sowing of short duration hybrids like GKSFH-2002,PSFH-67 and NSFH-592, however, can be extended upto second fortnight of January. Besides low yields, the late sowing may also face early mansoon rain at harvesting and threshing causing difficulty in its management. Seed should be treated with Brassicol or Thiram to control seed and soil borne fungal diseases. Hybrid sunflower responds well to nitrogen and phosphatic fertilizer application.

It responds to K application only on soils deficient in available potassium.

Sunflower can withstand moderate drought because of its deep root system. However, it responds favourably to irrigation and its seed yield can be increased substantially by sustaining adequate moisture in soil by timely irrigations besides improvements in oil content.

The crop is ready for harvesting when the back of flower heads turn lemon yellow or yellowish brown near the stalk and the discs start drying. At this stage the seeds give a blackish look and are fully ripe. The shading of disc-flower residues from undamaged heads also indicate physiological maturity. Promptly harvesting seed after physiological maturity has many advantages : seed is least exposed to bird and rodent attack; the crop cycle is shorter resulting in more time to prepare for the next crop ; reduces harvest seed losses ; provides high quality seed and reduces exposures to bad weather. The harvested heads are mildly dried and threshed by beating or trampling with tractors or sunflower threshers.The sunflower thershers are more efficient and economical. After threshing the produce should be throughly dried before storing otherwise in storage it gets affected by fungus and decomposes.

Sunflower has been found to depresse the growth and productivity of succeeding crops. The reason postulated are the allelochemicals being secreted by sunflower crop and decomposing residues of sunflower. Phytotoxic

compounds released into the soil rhizosphere have been observed to cause varying degree of allelopathy/autotoxicity in crop. Chromatograhic and physico-chemical analysis of allelochemicals in sunflower parts showed the presence of chlorogenic and isochlorogenic acids in both stems and leaves besides these some unidentified phytotoxins were also observed.

Many pests attack sunflower crop. Some of them are:

Pest	**Control Measures**
Cut worm (Agrotis spp.)	**Spray of Dursban/radar 20 EC**
Tobacco caterpillar (Spodoptera litura)	
***Cabbage Semi-looper (Plusia orichalcea*)**	
Bihar hairy caterpillar (Spilosoma obliqua)	**Spray, Thiodan (Endosulfan), Nuvan**
Head borer (Helicoverpa armigera)	**spray of Endosulfan**

Sunflower is also attacked by many plant pathogens. Some of these are: Stem rot or cotton rot or charcoal rot and head rot.

Uses:

- Edible oil of sunflower is of superior quality because of anticholestrol and non-cholestrol contents and is thus preferred over other oils for cooking food. Its oil is used for making vanaspati, soap and margarine.
- Sunflower meal in the form of cake is used for animal feed or manuring field. Salted and fried kernels of sunflower are eaten as such and its meal is used for confectionery. The concentrates and isolates of defatted meals are used for protein additives, meat analogues, meat extenders, emulsifying agents, bakery products, beverages, snack products, etc.
- Sunflower husk finds use in the preparation of ethyl alcohol and yeast.