CHAPTER 1

Oilseed crops: Present scenario and future prospects

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1.1 Introduction

Oilseed crops belong to numerous plant families and their seeds are used not only as a source of oil but also as raw materials for various oleo-chemical industries. The raw materials act as a renewable source of energy and are associated with power generation (Jankowski & Budzynski, 2003). Among various oilseed crops, the preferred ones are soybean, sesame, safflower, sunflower, groundnut, and castor (Weiss, 2000). The crops of sunflower, soybean, and canola offer good management options for irrigation reduction, thus enhancing the benefits of reduced input costs of these oilseed crops (Aiken & Lamm, 2006). There exists a positive correlation between soil water extraction and rooting depth in oilseed crops. The tap root, along with the well-formed root growth system of safflower, allows this oilseed crop to extract moisture at greater depths from the soil. When safflower water requirements are satisfied with 68.6% and 78.4% water content, the crop provides the yield of 392 $kgha^{-1}$ after only one turn of irrigation. Safflower yields 762 $kgha^{-1}$ with two irrigations (Kar *et al.*, 2007). Oilseed crops like soybean, sunflower, and canola are susceptible to *Sclerotinia sclerotiorum*, a fungal pathogen that is responsible for a reduction in the yield of these crops. The application of sulfur as fertilizer on the oilseed crops results in increased concentration of oil as well as protein content of the *Brassica* seeds (Malhi *et al.*, 2006). For the production of a ton of oilseed, approximately 12 Kg sulfur is required (Ghosh *et al.*, 2000). Some 23.5% of protein content has been observed in canola after the application of 80 $kgha^{-1}$ of nitrogen but this did not play a significant role in increasing the oil content (Ahmad *et al.*, 2007). There has been an increased risk of blackleg in canola fields when crops are planted adjacent to canola stubble that is six months mature. To avoid serious damage by blackleg in canola fields, it is recommended that the crops should be sown in such a way that there is a distance of at least 500 m from last season's canola stubble (Marcroft *et al.*, 2004). Among the various oilseed crops, there are some anti-nutritive compounds such as condensed tannins, inositol phosphates, and glucosinolates, etc. All such anti-nutritive compounds are responsible for lowering the nutritive value of oilseed crops. In most situations these compounds do not harm the crop plants (Matthaus & Angelini, 2005). Advances in plant technology and the advent of metabolic engineering have enabled the modification of oilseed crops, thus establishing transgenic crop plants. Such transgenic oilseed crops have novel biosynthetic genes taken from noncommercial plants that provide the oilseed plants with good fatty acids (Thelen & Ohlrogge, 2002). To modify the fatty acid content

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of oilseed crops, the technique of mutagenesis is very important (Velasco & Fernández-Martínez, 2000). In this way, these modified crops are responsible for the provision of great benefits to human health (Thelen & Ohlrogge, 2002). Various catabolic as well as biosynthetic enzymes have also been shown to play a significant role in the regulation of the fatty acid component of the oilseed crops. Among such biosynthetic and catabolic enzymes, the best characterized ones include KAS (β-ketoacyl-ACP synthases), TE (thioesterases), and acyltransferases (Dehesh, 2001). In soils that are tainted with a high cadmium content, that has accumulated due to the application of phosphatic fertilizers, specifically in Australia, the linseed crops accumulated much greater concentrations of cadmium compared to other crop species, such as wheat, canola, lupins, and Indian mustard (Hocking & McLaughlin, 2000). Linseed crops follow a model of simulation termed STICS that ensures the calibrations of linseed are in harmony with water consumption, with the crop yield as well as the nitrogen content of the crop (Flenet *et al*., 2004). Of GM crops, one of the first to be modified was oilseed rape (*Brassica napus*), and various concerns were raised regarding pollution of the environment due to oilseed rape pollen contamination of non-GM crops from GM crops (Rieger *et al*., 2002).

1.2 Cultivation of oilseed crops

Aimed at the production of high quality seed crops via conventional breeding as well as through genetic engineering, it is worthwhile typifying the overall genetic variety of the crop plants (Iman *et al*., 2011). In the rankings of oilseed crops across the world, canola (*Brassica napus*) is the second leading oilseed crop in the world (Maheshwari *et al*., 2011). However, the oilseed crop, *Brassica napus*, when cultivated on large acreages of land, causes problems for the ecosystem as its large-scale cultivation results in a slanted relationship between the pollinator and the crop. The distorted relationship is the consequence of a decline in the bumblebee population along with an increase in nectar robbers (Diekotter *et al*., 2010). In vitro generation of canola through tissue culture using an MS medium showed that, in contrast to the root and hypocotyl, cotyledons of the seed are very able to regenerate (Kamal *et al*., 2007). As it is rich in protein content, canola is cultivated as food for shrimps and fish in the aquatic environment. The limiting factors why canola is not used for animal feed are the anti-nutritive compounds that include phytates and the phenolic compounds (Enami, 2011). Genetically modified canola crops for herbicide resistance were nurtured in Canada but stayed impotent in order to have good weed control (Gusta *et al*., 2011). Various rhizobacteria played significant roles in increasing the growth of the canola plant, along with the application of chemical fertilizers. *Azospirillum brasilense* (a rhizobacteria) triggered the canola seed to increase in size as well as in protein content. *Azotobactervinelandii* was responsible for the noteworthy rise of the oleic acid content in canola seeds (Nosheen *et al*., 2011).

Mustard, one of the best-known oilseed crops, is cultivated because of its wholesome strengths. *Sinapis alba*, ordinarily known as white mustard, when grown on contaminated soils tainted with Thallium, introduced that element into the oilseed crop, hence, providing an unwelcome element within the food chain (Vaněk *et al*., 2010). The cultivation of rapeseed-mustard requires special management strategies. Such management stratagems first of all include soil testing to check the nutrient content of the soil at the specific site. Apposite use of natural resources along with appropriate irrigation and defense against pests and diseases works as one of the best approaches to increase the yield of rapeseed-mustard (Shekhawat *et al*., 2012). In the rhizosphere, Indian mustard has exhibited pronounced growth in acidic loams whereas little growth has been observed in basic soils (Kim *et al*., 2010). In combination with sucrose, mustard is also responsible for the provision of a positive upshot towards ergo sterol, carbon, nitrogen, and phosphorus. However, the consequences are not as pronounced as they are in the case of sucrose. Sucrose application to mustard instigated a reduction in the root and shoot growth of the mustard crop (Khan *et al.*, 2010).

There is a huge genetic diversity within the genome of soybean crops. Evidence has been provided by the comparison between the wild and the cultivated soybean crop plants. In the soybean genome there are degrees of linkage disequilibrium (Lam *et al.*, 2010). There is a conflict between the soybean crops that have been genetically modified and those that have not been genetically modified. The differences between these two varieties can be examined through the use of a spectroscopic procedure called NIRS (Near-Infrared Reflectance Spectroscopy) (Lee & Choung, 2011). The anti-oxidative potential of soybean can be boosted naturally through the process of solid state fermentation. A fungal species called *Trichoderma harzianum* had been used as an entrant for the fermentation procedure. The fermented soybeans showed resistance to oxidative stresses and are also involved in the manufacture of various flavonoids in high amounts (Singh *et al.*, 2010).

Pronounced interruptions in growth arise during the cultivation of sesame. The problems are associated with the pathogens that are soil-borne and hence are responsible for seedling rot. The issue can be overcome through a bio-formulation that uses the strain *Pseudomonas fluorescens* (Choi *et al.*, 2014). Sesame crops demand very low operational costs and less irrigation for their cultivation (Sarkar & Roy, 2013).

In the category of non-edible oilseed crops, castor crops play a significant role. Castor farming can be enhanced through its production in highly rain-fed expanses (Cheema *et al.*, 2013). Weeds are one of the chief problems in the inadequacy of castor cultivation (Sofiatti *et al.*, 2012).

Several heavy metals like copper, zinc, cadmium, and nickel have had a deleterious influence on safflower seedling growth when the crop is cultivated in soils containing such toxic metals (Houshmandfar & Moraghebi, 2011). Farming of safflower in a briny environment encourages the assembly of secondary metabolites by the oilseed crop under consideration.

1.3 Uses of major oilseed crops

The most important product produced by oilseed plants, for food as well as feedstock, is the oil (Harwood *et al.*, 2013). Oilseed crops are characterized as one of the major sources of biodiesel manufacture. Biodiesel is an alternative fuel in the petroleum industry and this can be viewed both positively and negatively. Positively is the production of low price biofuels, on the one hand, but on the other, the disadvantage is the prevalence of fuel over food, as edible oilseed crops are used to produce biodiesel fuel. In the past few years, non-edible oilseed crops have been explored as producers of biofuel (Balat, 2011). Oilseed crops are a good alternative to vegetable oil. Through biotechnology and metabolic engineering, oilseed crops can be transformed in a way to deliver the advantageous properties of the oil content (Lu *et al.*, 2011). The most important oilseed crops are linseed, sesame, safflower, etc. but there are also other certain minor oilseed crops, which have important implications. In the class of minor oilseed crops, Niger is of great significance. The crop contains major fatty acids, including oleic acid, palmitic acid, stearic acid, and linoleic acid. The fatty acid content of the oilseed crops is the reason for the long-term eminence of the crop plants (Yadav *et al.*, 2012). The survival of *Jatrophacurcas*, an oilseed crop, in harmful climatic circumstances, further heightens the standing of oilseed crops. This crop plant is an important source of feedstock and biofuel. The decline in the noxiousness of the crop through metabolic engineering can permit it to become feed for animals (Francis *et al.*, 2013). Uses of major oilseed crops are presented in Table 1.1.

Table 1.1 Major oilseed crops and their uses.

Plant	Common name	Family	Type of oil	Uses
Brassica napus	Rapeseed	Brassicaceae	Diesel fuel	• Biodiesel • Vegetable • Animal feed • Protein supplement
Glycine willd	Soybeans	Fabaceae	Vegetable oil	• Protein supplement • Cooking oil • Flour • Infant formula • Pharmaceutical industry
Helianthus annuus	Sunflower	Asteraceae	Seed oil	• Cooking oil
Cocos nucifera	Coconut	Arecaceae	Vegetable oil and biofuel	• Culinary uses • Decoration • Food industry • Chocolates • Vinegar • Cooking • Nectar
Arachis hypogea	Peanut	Fabaceae	Cooking oil	• Peanut butter • Cooking • Cosmetics • Plastics • Dyes • Textile material • Flour

1.3.1 Rapeseed

Rapeseed is one of the most innovative protein sources used as a replacement for proteins that are obtained from animals (Spiegel *et al.*, 2013). A member of the series of bio-energy crops, *Brassica napus*, commonly known as rapeseed, is a familiar bio-energy crop (Houben *et al.*, 2013). Glycerol is the spinoff of biodiesel formation from methanol and triglycerides. This has led to glycerol over-production and it is classified as waste. Rapeseed has solved the problem through changing rapeseed oil into biodiesel by means of carboxylate esters without producing glycerol (Goembira *et al.*, 2012). Rapeseed oil composition includes several vital fatty acids. The oil removed, through treatment by supercritical carbon dioxide fluid extraction, is made up of 2.60% palmitic acid, 47.09% erucic acid, 16.54% oleic acid, 11.20% eicosenoic acid, 9.62% linoleic acid, and 4.77% linolenic acid (Yu *et al.*, 2012). Rapeseed oil can help as a feedstock as it produces vegetable oil-centered bio-polyols that are considerably more economical compared to petroleum-based polyols. These bio-polyols are further used in the manufacture of PUR foams (Dworakowska *et al.*, 2012). A concoction of rapeseed cake together with sawdust is used to produce wood fuel pellets (Stahl & Berghel, 2011). Rapeseed scum possesses the important quality of being used as a green compost which provides the soil with an increase in soil organic matter (SOM). This feature further augments the growth of microbial flora within the soil. Rapeseed residues are also valuable in the reduction of metals such as cadmium and lead in rice fields. In this way rapeseed plays its part in the reduction of the metals that damage the rice plant (Ok *et al.*, 2011). By means of the hydrolytic feature of the enzyme *Alcalase* on rapeseed proteins, rapeseed protein hydrolysates (RPHs) are created. RPHs present inordinate antioxidant abilities by enabling the detoxification of free radicals, hydroxyl radicals, and superoxide. As well as the antioxidant ability, RPHs moreover have great nutritive value (Pan *et al.*, 2011).

1.3.2 Soybean

One of the most important plants for oil extraction as well as providing a dietary basis for protein is soybean, universally considered a significant crop plant (Hartman *et al.*, 2011). In various places around the world, soybean has become as essential a foodstuff as corn and hence it is now nurtured to produce large yields (Na *et al.*, 2014). The crop is nurtured on enormous tracts of arable land and aims to produce high yields, since it is an essential foodstuff, either directly or indirectly used in several other food products. A decline in soybean crop produce could threaten global food security. With the help of biotechnology, it has turned out to be possible to make soybean a crop *par excellence* for its exploitation either as a food product or its consumption as a vegetable crop (Hartman *et al.*, 2011). Oleic acid is considered the element that produces the oxidative permanence. Its occurrence in soybean is what gives that crop plant a pronounced industrial importance. Environmental changes ensured that soybean would have various concentrations and constancy of oleic acid combined with mutations within its genome (Lee *et al.*, 2012).

Through innumerable phases of growth from seed to mature crop, soybean has displayed variability in its silhouette regarding its chemical composition. The crop protein content declines during the first 3–5 weeks, nonetheless, then it starts to increase. Contrariwise, enriched oil content amasses in the course of early growth. Likewise increased starch content has been detected within the developing seeds that became less at maturity. Such categorizations contained by the soybean crop make it available in practice for several uses at different points of germination (Saldivar *et al.*, 2011). Soybean oil has been engineered to increase its oxidative steadiness, from the parallel creation of designed biotech variability, as well as non-biotech uses. The cross flanked by soybean MON 87705 appears through a variety that has a low capacity of linolenic acid. This ends up in a soybean crop that is stumpy in saturated fatty acids and has a huge amount of oleic acid. Linolenic and linoleic fatty acids are called saturated fatty acids. In this way, soybean has the capability to replace common cooking oils with raised levels of oleic acid containing vegetable oils, which have oxidative stability (Tran *et al.*, 2011). Within the category of bio-energy producing expertise. soybean biomass has paved the way for pronounced applications. By controlling soybean proteins, gene manifestation is tangled in lignin, polysaccharides, and fatty acid metabolism (Pestana-Calsa *et al.*, 2012). In unfriendly ecological settings, the hydroponic procedure favors the farming of soybean; hence, it provides proteins and oils. In the manufacture of dietary fibers and fats, a study has revealed that the hydroponic culture technique has assisted the soybean seeds to enhance their dietary factors (Palermo *et al.*, 2012). Soybean seeds are supplied with numerous kinds of sugars that comprise sucrose, stachyose, and raffinose. Such saccharides are the source of diverse groups, with the quantity related to the basis of dominance and recessive physiognomies. Such qualities are responsible in soybean food evaluation for breeding plug-ins aimed at the setting up of a desirable parent (Mozzoni *et al.*, 2013).

1.3.3 Sunflower

Considering its use in the fabrication of innumerable goods, from edible oils to pharmaceuticals, in petroleum industries to biofuels as well as bio-lubricants, sunflower (*Helianthus annuus*) is the most important product (Fernandez *et al.*, 2012). In the category of vegetable oils regulated in USDA reports, sunflower stands in fourth position behind the three most important oilseed crops: palm, soybean, and canola. The oil haul from the flower is accessible in three groupings: one high in linoleic acid and the other two in oleic acid. Oleic acid is available in great to moderate concentrations in the other two categories. These three fatty acid conformations are completely free from genetic manipulations. In contrast, through canola and soybean oil, sunflower seed oil is free of linolenic acid. This distinguishing feature gives oxidative stability to the seed oil. Being developed from enriched tocopherol, sunflower oils are not in need of hydrogenation reactions that mostly become contaminated and are due to catalytic poisoning. Along these lines, they have functioned as an unadulterated replacement for trans fats, and hereafter are a prerequisite in a variability of foodstuffs (List, 2014). Sunflower seeds are full of innumerable nutrients, most notably minerals and vitamins. They are a source of protein, vitamins A and B, nitrogen, iron, calcium, and phosphorus. Sunflower is an extremely rich source of vitamin E, which is a vital vitamin (Arshad & Amjad, 2012). Sunflower oil, by means of the hybridization domino effect, offers a way to the chemical industries to aid in the assembly of biofuels (Cvejic *et al*., 2014). Diesel manufactured by means of sunflower oil, when cast off in running the engine, generates less carbon monoxide as well as additional hydrocarbons in comparison to diesel produced from cotton oil (Arapatsakos *et al*., 2011). In the manufacture of novel bioactive agents, lecithins taken from sunflower and altered through oil in water suspensions, worked as a pronounced substitute (Cabezas *et al*., 2011). Lumbrokinase that worked, for example, as an imperative anti-fibrinolytic protein, had been endorsed as expressed in sunflower seeds. Elevated anti-thrombotic effects have been detected in mice who have consumed such transgenic seeds. In this fashion, transgenic sunflower seeds provide a route for therapeutic properties designed for humans (Guan *et al*., 2014). In contemporary studies, the exploitation of sunflower, together with rapeseed, has achieved prominence in various biotechnological applications. These include their practice in the fermentation industry in the making of different enzymes, in pharmaceuticals, in the assembly of antibiotics and correspondingly designed to produce antioxidants (Lomascolo *et al*., 2012).

1.3.4 *Brassica*

Brassica, a genus made up of a number of species, is very important for health and nutrition. Due to the occurrence of phenolics over and above glucosinolate, the crop vegetables are employed as anti-cancers, accompanied by their use in the treatment of degenerative disorders (Velasco *et al*., 2011). Nonetheless there is still a debate about the low glucosinolate breeding lines. This was the prerequisite for seed meal enhancement as certain elevated levels of glucosinolate found in the seeds are responsible for the reduction in the taste of the meal in conjunction with unpleasant consequences (Augustine *et al*., 2013). Wild types of *Brassica* correspondingly are used as biocidal crops in conjunction with nutraceuticals fabrication (Branca & Cartea, 2011).

The genomic portrayal of one of the species of *Brassica*, the so-called *Brassica rapa*, was very useful in polyploidy genome studies. In addition to this, the aforementioned contributed to the enhancement in the oils removed from *Brassica* in additional vegetable crops production (Wang *et al*., 2011).

Brassica oleracea, known as cauliflower, is one of the most essential vegetables used in the kitchen besides its use in the fresh form (Thanki *et al*., 2012). It is one of the polymorphic specie that includes other vegetables such as broccoli, brussels sprouts, and cabbage. The specie further has the capacity to provide innumerable health benefits owing to the presence of numerous flavonoids and carotenoids. In cabbage and kale glucosinolate, hydroxycinnamic acids and flavonoids have been recognized; these complexes are of significance to health (Velasco *et al*., 2011). Vegetable classes inside *Brassica oleracea* have antibacterial factors with the bacterial diversity of a gram positive and gram negative nature that are responsible for the putrefaction of foodstuff (Jaiswal *et al*., 2012). To suspend the senescence after broccoli buds are harvested, the vegetable florets are treated by way of low intensity light while kept in storage settings. Hereafter the yellowing of broccoli flowerets can be delayed (Buchert *et al*., 2011).

Selenium is distinguished as the chief micronutrient essential in the human diet, for instance, it has a part in enzyme glutathione peroxidase – an antioxidant enzyme. The abovementioned insufficiency turns out to be the root of different ailments, such as heart diseases, asthma, arthritis and hypothyroidism, accompanied by a low immune system. Oilseed rape, scientifically defined as *Brassica napus*, in contrast to wheat, contains a vast amount of selenium; however, it is unable to produce it in the seeds. Henceforth, selenium is hoarded within the seed capsules and the stems of the oilseed rape crop (Ebrahimi *et al*., 2014). *Brassica napus* is regarded as an important medicinal element in the cure of livestock diseases (Kumar & Bharati, 2013).

1.3.5 Coconut

Cocosnucifera (coconut) has an opulent magnitude of saturated fats, and its secret lies in its inability to increase the lipid content in the human body. The fruit is henceforth responsible for endowing noble quality fats called high-density lipoproteins to the body (Ganguly, 2013). The most essential one lies in *Cocos nucifera*'s use as liquid refreshment. Coconut water provides abundant minerals, sugars, furthermore, it is used in pharmaceutical practice, together with developmental activities (Prades *et al*., 2012). The oil haul from the parched fruit is augmented with saturated triglycerides. This is an indispensable element in cosmetics, colognes, hair and skin acclimatizing mediators (Burnett *et al*., 2011). Toddy is removed from the latex of the coconut palm. Toddy has several applications; its normal use is to replace foodstuffs together as feedstock for biofuel production (Hemstock, 2013). A blend of titanium oxide through coconut shell powder is used in the photo-catalytic reduction of contaminants in pharmaceuticals or by personal care products. The domino effect displayed 99% success in contrast to titanium oxideon its own, which provides only 30% contaminant exclusion (Khraisheh *et al*., 2014). The naturally produced protein removed from the seed of fresh coconut is called CMP, the coconut milk protein, which has wholesome significance. As well as in sonication-alleviated emulsifications of CMP, it can be adapted since it has been found to be a poor emulsifier (Lad *et al*., 2012). The fiber acquired from coconut milk is used to reduce cholesterol (Sriamornsak *et al*., 2014). The micronutrient investigation of coconut milk by means of inductively coupled plasma optical emission spectrometry (ICP OES) has revealed that coconut milk encompasses an array of essential micronutrient elements. These include calcium, zinc, copper, phosphorus, iron, sodium, potassium, manganese, and magnesium in vast amounts (Santos *et al*., 2014). Virgin coconut oil has an antimicrobial action owing to the occurrence of numerous fatty acids, that include caprylic acid, capric acid, and lauric acid. Caprylic acid accompanied by capric acid is valuable in the reticence of growth. Contrariwise, lauric acid helps in the antibacterial process by the disturbance of bacterial cell membrane and the cellular cytoplasm. In an ecologically welcoming style, virgin coconut oil plays its role in the synthesis of silver nanoparticles (Zamiri *et al*., 2011). One of the most pronounced influences of virgin coconut oil consumption lies in the reduction of liver impairment owing to paracetamol intake; hence, this product has hepatoprotective properties (Zakaria *et al*., 2011).

1.3.6 Peanut

Among the various food crops around the world *Arachis hypogea* (peanut) stands in thirteenth position, however, in the category of oilseed crops, peanut in in fourth position. It works as an essential cash crop grown in numerous states from north to south in both tropical and temperate regions. The seeds are the source of oil and proteins to the percentages of 50% and 25% respectively. The seeds are comprised of high oleic acid content which offer countless health benefits, that include reduced cardiovascular possibilities, reduced insulin confrontation together with anti-tumor effects (Wang *et al*., 2012). Peanut skins, after being spray-dried, have displayed pronounced antioxidant properties. Peanut residues attained after the spray-drying process with the removal of phenolic compounds, as they are rich in protein content, work as animal feedstuff (Constanza *et al.*, 2012). In the assessment of peanut protein with peptides, it has been perceived that the peptide of the peanut has larger foam stability, accompanied by improved emulsifying proficiency with low water holding and fat adsorption capacities. Peanut peptides further have antioxidant properties designed for the detoxification of hydroxyl radicals (Tang *et al.*, 2012). Peanut skins are further used in food fortification designed to augment the poly-phenol content of cookies as an antioxidant (Camargo *et al.*, 2014). Georgia University has set up a high yield peanut cultivar that can fight viruses in stem rot in conjunction with tomato spotted wilt virus. The cultivar is called "Georgia-12Y" (Branch, 2013). Peanuts, on one hand, have great nutritional value, nonetheless, on the other, they are vulnerable to fungal toxicities instigated by *Aspergillus spp* that produce aflatoxins. Aflatoxins are concomitant with widespread hazards such as teratogenicity, carcinogenicity, and mutagenesis. Ozonation is the preeminent process to scavenge aflatoxins without impairing the nutritive value (Chen *et al.*, 2014). Peanut oil is used extensively; nevertheless, there is an alternative sort of peanut oil that distinguishes it from other vegetable oils, called roasted peanut oil, for instance, ARPO, i.e. Aromatic Roasted Peanut Oil. The process of roasting is imperative to set up the characteristic aroma of roasted peanut oil and consequently it forms the significant basis of the food industry (Liu *et al.*, 2011). Regrettably, peanut is the cause of anaphylaxis due to allergic reactions to peanut proteins and henceforward is designated as IgE arbitrated immune hypersensitive responses (Husain & Schwart, 2012). However, in future it is to be hoped that by reducing the allergen levels with enzymatic treatment, this problem can be solved. Roasted peanuts, when treated through the enzymes trypsin and chymotrypsin under ideal conditions, solubilize the protein content of the peanut, thence making it allergen-free (Yu *et al.*, 2011).

1.3.7 Rice

Over and above maize and wheat, rice (*Oryza sativa*) is the third crop plant used as a diet source round the world. Besides being a source of earnings and nourishment, these three crop plants are the staple food of more than four billion people. In Asia, rice is the staple food, supplementary in lieu of the provision of 35–80% calories. Therefore, a universal water crisis is a matter of Asian food security since rice requires large amounts of water for its cultivation (Bouman, 2001). In India, embers produced from rice husk are used in the decontamination of water through the establishment of a filtration bed by means of the ash cast in a pebble and cement milieu. The method has been able to separate 95% of bacteria accompanied by turbidity found in drinking water used in rural areas of India. Ash of rice husk permeated with iron hydroxide, in addition to aluminum hydroxide, has been further exploited for the removal of arsenic and fluoride respectively from underground water, providing health assistance to those who became ill from drinking arsenic-tainted ground water (Malhotra *et al.*, 2013). In assessing countless varieties of rice, brown rice was pronounced more advantageous than white rice. Brown rice assists in the reduction of glucose levels for almost 24 hours (Mohan *et al.*, 2014). Rice meanwhile is the essential food of half of the world's population but is lacking in vital micronutrients; once those necessities become bio-available, there will be an end to the prevalence of malnutrition suffered by developing nations. Biotechnology has provided a beautiful way out of this problem through the enhancement of the nutritive content of rice endosperm using the phenomenon of bio-fortification (Bhullar & Gruissem, 2013). Among diabetic patients, it has been witnessed that white rice intake has provided the patients through abridged serum LDL with a cholesterol level not found with brown rice. On the other hand, a great decline in diastolic blood pressure has been perceived in diabetic patients who have consumed brown rice (Zhang *et al.*, 2011). In the meantime white rice is one way or another accompanied by metabolic disease syndrome. In Costa Rican adults whose diet was a mixture of white rice and beans, if they reduced the amount of white rice in a ratio so that the smaller quantity of rice was replaced by the addition of beans, the cardiometabolic dangers can be reduced (Mattei *et al.*, 2011). Germinated brown rice has known anti-diabetic effects owing to the manifestation of various bioactive compounds that consist of gamma-oryzanol, phenolics, gamma-aminobutyric acid, acylatedsteryl beta-glucoside, dietary fibers and vitamins, together with a variety of minerals (Imam *et al.*, 2012).

1.3.8 Cotton

Due to its importance as a textile and in the food industries, the cotton crop (*Gossypium hirsutum*) has played a pronounced role in the fabrication of cottonseed oil, which henceforth is being exploited for the production of biodiesel (Fernandes *et al.*, 2012). Cottonseed kernels function as an opulent source of oil over and above protein (Horn *et al.*, 2011). Once cottonseed oil-generated biodiesel had been used to power an engine without any further alteration to the engine configuration, it was found that fewer hydrocarbons, carbon monoxide and nitrogen oxide expend discharges were produced in comparison with diesel fuel blends (Altun *et al.*, 2011). As well as the reduction of the compound $[Ag\ (NH_3)_2]^+$ with glucose, silver nano-particles have been spawned on cotton fibers. In addition, the advance amendment through hexadecyltrimethoxysilane has helped to establish superhydrophobic cotton textiles. The manufactured articles thus fashioned have displayed antibacterial activity against *E.coli* and have many functions in electronic devices of biomedical origin (Xue *et al.*, 2012). Furthermore, cotton contained in textile assembly has many uses. The fabrication of wicking cotton in actual fact is hydrophilically fashioned through the management of cotton with cold plasma under atmospheric pressure (Samanta *et al.*, 2014). Cottonseeds are so rich in protein content that they are able to fulfill the protein requisite of enormous masses every year. This feature of cottonseed is not fully exploited due to the presence of poisonous gossypol in the cotton crop. Gossypol is a defense mechanism in the cotton crop against several insect pests. Molecular biologists have solved the problem of gossypol toxicity by means of the phenomenon of RNA silencing of the gene dCS (delta-cadinene synthase), which is responsible for gossypol fabrication. The silencing occurs only at the level of the seed and therefore the rest of the crop that comprises the foliage; roots, etc. preserves the phenolic compound gossypol. Along these lines, by using the practice of protection and perseverance, cottonseed has been empowered to solve the food security issue of billions of people (Rathore *et al.*, 2012).

1.4 Applications of oilseed crops

1.4.1 The biofuel industry

Faced with ecological contamination and economic constraints, at this moment it is now necessary to replace the currently used petrochemicals with renewable assets. Such renewable resources are straightforwardly accessible worldwide in the form of agronomic biomass over and above agricultural wastes. These can be used in place of feedstock in the assembly of liquefied biofuels (Nigam & Singh, 2011). In the contemporary world where environmental toxic waste is responsible for severe atmospheric destruction due to the greenhouse gas emanations, biodiesel has been successfully delivered, as well as helping in the reducion in carbon monoxide emissions accompanied by other volatile and non-volatile hydrocarbons (Drenth *et al.*, 2014). Fossil fuels, in their relentless use, are running down and their supplies are limited in the forthcoming years, consequently, biofuel is the only solution. In point of fact, the fuels fashioned from biomass are biofuel spawned in any of the solid, liquescent or gaseous forms. Such biofuels consist of bio-hydrogen, bio-ethanol, biodiesel over and above bio-methanol. Biodiesel is the most eco-friendly fuel, shaped via esterification reactions of animal fats in addition to vegetable oils. It can further be straightforwardly produced from either non-edible or edible oils (Yusuf *et al.*, 2011). Oilseed crops are ready to be replacements as the pronounced home for biodiesel production. Soybean is grown in Brazil as a source of feedstock designed for biodiesel. Brazil is the fourth leading manufacturer of biodiesel around the world and the second biggest cultivar of soybean. The situation that demand for biodiesel exceeded supply, in conjunction with the low oil yield capacity of soybean, has led Brazil to ponder on additional oilseed crops as a resource in lieu of biodiesel (Bergmann *et al.*, 2013). In contrast to non-GM oilseed rape, GM oilseed rape has revealed additional points on the way to producing a high yield accompanied by high quality feedstock meant for biofuel fabrication in Austria. In this fashion, ways to produce genetically modified oilseed crops were laid in a similar or even possibly less than previously utilized arable land to provide amounts of feedstuff, food and biofuel in amounts greater than before (Moser *et al.*, 2013). There is some oilseed crops, which are not engaged in the production of food sources and henceforth can function as the preferred feedstock for biofuel manufacture. These oilseed crops are *Thlaspi arvense* (pennycress), *Camelina sativa* (camelina), and *Brassica carinata* (carinata). These crops have revealed definite agricultural characteristics. In association with traditional feedstock, these oilseed crops have provided analogous domino effects in respect of emissions, fuel consumption, along with thermal efficiency with the advantage of not being used as a source of foodstuff (Drenth *et al.*, 2014). Due to the reduced nitrogen fertilizer requirement, it is possible in future that soybean feedstock will be more competent energetically in the same way as canola. On the other hand, owing to the higher oil content of canola, the aforementioned can correspondingly be used as a prolific biofuel feedstock. On the basis of prime yields, reduced fertilizer involvement and the elements exploited for biofuel, it has been discovered that canola has considerable greater competence in place of feedstock than soybean (Fore *et al.*, 2011). Applications of oilseed crops are shown in Figure 1.1.

1.4.2 The food industry

For nourishment and health, oilseed crops play the foremost role in the food industries due to the existence of enriched nutritional content in the oilseeds. An oilseed crop baptized Guizotiaa by ssinica, frequently labeled Niger, has known pronounced importance. At present it is being extensively investigated due to its enriched nutritional singularity and antioxidative properties (Ramadan, 2012). Oilseed crops rich in protein content are a food source for humans as well as animals. An oilseed crop genus called *Jatropha* has raised content of all indispensable amino acids with the exception of lysine. Along these lines it is endorsed for 2–5-year-old children. Unlike soybean and rapeseed, Jatropha spoil vintages are considerably higher and therefore this had unlocked ways for use in the food industries (Sosa-Segura *et al.*, 2014). The oilseed crops are particularly used in the provision of cooking and vegetable oil (Friedt *et al.*, 1988).

1.4.3 The pharmaceutical industry

After fuel as well as food, oilseed crops correspondingly have a prominent role in the pharmaceutical industries. An oilseed crop called Niger has extreme medicinal worth due to the occurrence of antioxidants (Ramadan, 2011). *Jatropha spp.* is rich in oil content and has prodigious applications in drug preparations (Sosa-Segura *et al.*, 2014).

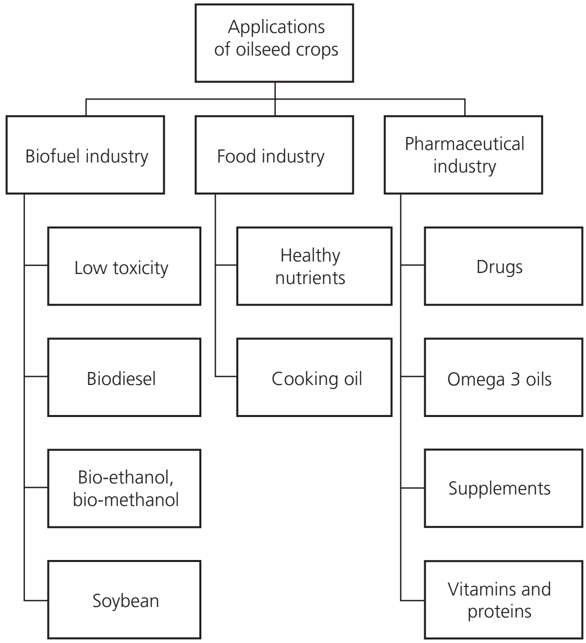

Figure 1.1 Applications of oilseed crops in different industries.

1.4.4 Sustainability of the environment

Environmental sustainability can be achieved if using fuel produced from oilseed crops. This reduces the pollution in the environment and does not increase carbon emissions. *Jatropha curcas* is an oilseed crop, which has been used for the production of biofuel. The fuel which is produced from this crop contributes to sustainability because it does not increase the prices of food items as it is nonfood crop, also it does not produce pollution and hence does not increase the carbon emission number. This crop has been significantly used to provide fuel and ethanol (Mofijur *et al*., 2012). Biodiesel which is produced from oilseed crops is renewable as well as eco-friendly (Jain & Sharma, 2010).

1.5 Conclusion and future prospects

Oilseed crops are considered bio-energy crops. The future is really secure in terms of energy production by growing these crops. In future, it is expected that the diesel and energy which is produced from fossil fuels and electricity will be replaced by bio-energy produced by oilseed crops. One common example is the research going on to use corn seeds in the production of biofuel and bio-ethanol. Corn-based bio-ethanol production is expected to increase more than two-thirds in ten years. Corn-based bio-ethanol will reduce the consumption of common fuels (Elobeid *et al*., 2007). These oilseed crops have a bright future in biodiesel energy. Production of biodiesel can be increased in an environmentally sustainable fashion by producing it from soybean. This crop will provide immense benefits for the production of biodiesel as large amounts of diesel can be prepared with just a low concentration of crop. Moreover the left-over part of this crop can be used as feedstock for animals (Padula *et al*., 2012).

The world is moving into the era in which production of nonfood industrial crops will increase due to the immense benefits of these crops. With the advent of new technology and biotechnological tools such as new breeding methods for crops, these crops are expected to be grown largely in future to meet the increasing energy demands. Presently most of these crops are used as pharmaceutical materials and cooking oils but with the introduction of high technology methods, in the near future, these crops will be leading the bio-fuel industry of the world. *Brassica napus*, sunflower, and rapeseed are some of the many examples of crops which can be used in the production of bio-diesel and bio-ethanol by growing them efficiently (Li *et al.*, 2010). Until now a total of 64 crops have been identified, only in China, which have the potential to be used to produce bio-fuel; of these, 38 are oilseed crops. Manipulation of these crops is necessary to use them as a potent agent for the production of bio-ethanol in future (Li *et al.*, 2010).

Biodiesel production started in the early 1990s. This industry is considered to be one of the fastest-growing industries in the world. It is due to this fact that the production of crops that are used to produce biodiesel has also increased. The largest market for biodiesel is in Germany. Production of biodiesel can be further enhanced by applying modern breeding methods to oilseed crops (Balat, 2009). Environmental concerns are increasing daily, so biofuel production is also increasing. Many countries in the world have increased their use of biofuels, therefore, biofuel-producing organisms need to be manipulated to generate the highest yields. For this purpose, oilseed crops can be used in the production of second-generation fuels. In addition to seeds, by-products which are produced from these crops can also be used in the production of biofuel, after controlling the inner processes of plants and manipulating the breeding processes of these crops. Oilseed crops are seen as playing an important role in the reduction of the demand for fossil fuels. Research has also been conducted to produce second-generation biofuels from oilseed crops (Puri *et al.*, 2012).

It is clear that the major part of world trade will turn to oilseed crops and their products in the near future. These crops can be used for food as well as nonfood elements. The fatty acid composition of seeds differentiates the oil produced from different seeds. Techniques such as mutagenesis, breeding, and selection can be used to increase the production of oil from seeds of these crops. Research is being conducted on improving the quality of oil which is produced by these crops (Velasco & Fernández-Martínez, 2002). Time to conduct further research on these crops and to save them from climate changes that are supposedly affecting yield of these crops (Barbetti *et al.*, 2012) is necessary. Scientists' search for an alternative source of energy ended with the advent of fuel production from oilseed crops. Oilseed crops can be used to produce renewable biodiesel. In practice, biodiesel which can be produced from oilseed crops is the cheapest form of fuel when compared to others. Production of biodiesel from *Jatropha curcas* has been considered an innovation in the biofuel industry because the use of *Jatropha curcas*, which is a nonfood crop, does not increase the price of any food item and also produces fuel in an environmentally friendly manner (Mofijur *et al.*, 2012). Oilseed crops are also paving the way in the pharmaceutical industry. The oil produced from these crops can be used as an alternative to fish oil. This oil is produced sustainably and hence also reduces the carbon emissions. Metabolic engineering of oilseed crops can be performed to enhance the production of fish omega 3-like oil from these crops (Sayanova & Napier, 2011). Industrially useful lipids are also prepared by modifications of oilseed crops. Metabolic engineering followed by subsequent field production will result in the production of fatty acids and lipids that can be prepared on a large scale and can be customized. Camelina is known to be a potent plant which can be used for the production of oil (Liu *et al.*, 2015). Camelina is a promising oilseed plant which will help us to contribute to the growing demands for vegetable oil (Fuessner, 2015).

With the increase in industrialization and the modernization of the world, the methods and techniques used in research are also modifying. The increased demand for petroleum products forced scientists to turn away from fossil fuels and consider oilseed crops. These crops can provide oil security in the world. High concentrations of bio-energy and bio-fuel can be produced from these crops after a few alterations. Scientists are now working on these crops to produce sustainable and renewable bio-fuel in large amounts from a small concentration of crops. In future, oilseed crops will be produced which will use only a small amount of land and fertilizers and provide a high yield of fuel (Jain & Sharma, 2010). Genetically modified oilseed crops have been grown worldwide to increase the production of oilseed and to get maximum benefit from this industry. The majority of these GMO crops include soybean, canola and cotton (Blair & Regenstein, 2015). Food crops which were used as first-generation oil crops can now be used for the production of second-generation fuels (Heaton *et al*., 2008). The future belongs to high value products from oilseed crops and their by-products. These products can be considered the first step towards sustainability (Sims *et al*., 2006). In future, scientists are needed to devise ways for the production of the maximum amount of oil from oilseed crops. It is noted that altering the growing conditions of seeds and the placement of seeds can result in changes in seed oil yield. These approaches can be used to produce the maximum amount of oil (Aiken *et al*., 2015). With these developing approaches, many products with enhanced economic values can be produced from oilseed crops in the near future (Del Gatto *et al*., 2015; Jankowski *et al*., 2015).

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