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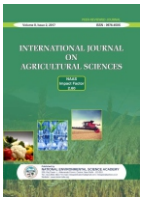

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LINSEED: A PREMIUM CROP PLANT

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Review Article

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ABSTRACT

This article examines the history, morphology, cultivation area, production and productivity, economic significance, and cultural practices of linseed/flax (*Linum usitatissimum* L.).

Keywords: Linseed, Linum.

INTRODUCTION

Linseed (*Linum usitatissimum* L.) (2n=30, X=15) is a self-pollinated crop belongs to the family Linaceae and the genus Linum (Sran *et al*. 2021). The origins of flax (Linum usitatissimum L.) are one of the oldest plants which are unknown. It is widely presumed that linseed is originated in the Fertile Crescent, an area east of the Mediterranean Sea toward India. Linseed oil's extensive use in the paint and varnish industries has recently been restricted due to the availability of other, less expensive petroleum compounds with comparable or occasionally greater drying qualities. Linseed oil is the primary ingredient in the medical, chemical, pharmaceutical, and cosmetic sectors, because they are non-allergic, renewable, biodegradable, and have elevated phytochemical content.

Linseed product diversification for medical and other industrial uses must be increased by focused research efforts in order to improve the linseed crop's value and stimulate the economy. Crop improvement through recombination breeding using elite germplasm for the production of double-purpose (oil and fibre) crops with high yield and stress resistance (both biotic and abiotic) attributes is one of the main study areas.

History and origin

According to depictions of flax plants in bloom found on tomb and temple walls at Thebes, the usage of flax for the creation of lilen dates back to 3000 B.C. In northern Europe, flax fibre has been used to make textiles since the Neolithic era (New Stone Age). One of the first domesticated plants, flax (Linum usitatissimum L.), has an unknown origin. Nevertheless, it is widely acknowledged that linseed originated in the "Fertile Crescent," a region that stretches from the Mediterranean Sea eastward toward India (Zeven & Zhukovsky, 1975; Anonymous, 2010). It was likely domesticated there originally. The species name, usitatissimum, was given by Carl Linnaeus and is from the Celtic word lin, which signifies thread. So it explicitly alludes to its many uses and historical significance.

The four centres of origin for linseed, namely the Central Asian Center, the Near Eastern Center, the Mediterranean Center, and the Abyssinian Center, are where it is thought to have first appeared. It migrated south to India and north to other regions of Asia and Europe. Linseed's botanical origin, however, has not yet been definitively established. But two hypotheses, including polyphyletic origin and origin from the wild Linum angustifolium Huds. (2n=30) species, have been put forth (Gill, 1987).

The hypothesis on the diverse derivation of the names (lin, llion, linu, linon, lien, lan, linseed, etc.), which existed in the Europian language and the antiquity of its cultivation in

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Egypt, Europe, and the north of India, forms the basis of the polyphyletic origin theory regarding the likely progenitor of *Linum usitatissimum* L. This theory states that the Peninsular varieties of farmed flax (shorter plants, bold seeded, and more oil content) were descended from *Linum usitatissimum* by natural crossing with *Linum perene* or *Linum mysorense*, and the Indo-Gangetic types (tall plants, small seeded, and low oil content) developed through natural crossing of Linum usitatissimum with Linum strictum. However, although this theory appears to have been based on experiment, there are currently no experimental data to support it instead of experimentation, relying on observation.

The idea that *Linum usitatissimum* L. originated from a single wild spice The Mediterranean region, possibly the primary source of flax, is where *Linum angustifolium* Huds is found. It is obvious that the species was Linum angustifolium Huds, which was maybe farmed by the people who lived near lakes in Switzerland and Italy. This notion is supported by a sufficient amount of experimental evidence as well as early civilization archaeological relics. Both species are annuals that grow in the winter and have long, slender stems with several branches. In addition to dehiscent capsules, they have tiny deep blue blooms. Both species share the same number of chromosomes (2x=30).

However, evidence suggests that Linum Bienne Mill, a small-seeded flax, may have given some genetic material to the likely Linum usitatissimum L.'s ancestor. The species may have come from Iran and Kurdistan. However, research by Muravenko *et al*. (2003) demonstrated that three species, namely *Linum usitatissimum* L., Linum Bienne Mill., and *Linum angustifolium* Huds, were thought to have shared a common ancestor, with Linum angustifolium Huds being the one that was closest to it.

Morphology

Linseed is an erect perennial herb that grows to a height of 30-120 cm and has a slender, glabrous, grayish-green stem. Linseed varieties are cultivated so that the oil can be extracted from the seeds. The flax varieties are planted so that the stems can be harvested for fibre. The flax varieties have straight culms, fewer secondary branches near the top of the stem, and are comparatively taller (80–120 cm) (Gill, 1987). These plants often yield smaller seeds and fewer capsules. The old (linseed) variety grows 60–80 cm tall and has a short tap–tote branching structure. The shoot has several branches and a bushy appearance. Without stipules, the leaves are lanceolate, simple, narrow, alternating, and 20–40 mm long. A smooth upper surface, an acute or acuminate shape, with a greyish green coloration. The spectacular, different-shaped, regular, hermaphrodite, pentamerous, and hypogynous flowers are borne in a loose terminating raceme or open cyme and are coloured blue, white, or pink. Five ovate, acuminate persistent sepals make up the calyx. The corolla is made up of five free, clawed, fugacious, imbricate, bluish, or white, deciduous petals that fall before midday, the androecium has ten five stamens that have been transformed into staminodes make up the outer whorl, however. The base of the gynoecium is surrounded by a fused ring made up of the inner five fertile stamens that have been expanded. The petals fit within this ring and are narrow at the base. At the enlarged bases of the stamens are glands that secrete nectar. The anthers encircle and extend over the stigma in the majority of Linum usitatissimum L. flowers, but in some variants, the stigma protrudes slightly beyond the anthers. The two-celled, longitudinally dehiscing, introrse anthers. There are five connected carpels in the upper gynoecium. Because each carpel has a fake septum, the ovary is ovoid and ten celled, and it can produce up to two ovules in each carpel. The ovaries have an axile placentation, five filiform, free, or united styles that are twisted together to form a stigmatic surface with a small club-like shape, and the ovules are succulent and anatropous. Fruit is a 5- to 9-mm-diameter spherical, smooth globular capsule. The only species of the Linaceae family having non-dehiscent or semi-dehiscent capsules for modern cultivation is Linum usitatissimum L. (Getinet and Nigussie, 1997). It has up to 10 light brown, smooth, glossy, and apple pie-shaped seeds that range in length from 4 to 7 mm. The capsule is of the indehiscent form in the majority of types.

The majority of linseed is self-pollinated. Insects can cross-pollinate, but only at very low rates (less than 2%) (Tadesse *et al*., 2010). Due to the pollen's relative weight and stickiness, wind pollination is not observed (Anonymous, 2010).

Area of cultivation, production and productivity

Since ancient times, linseed has been grown in Egypt, Europe, and India. The major producers of linseed are India, Russia, Canada, Argentina, and the United States. The Asian region accounts for 8.79 lakh ha, or 41.62 percent, of the world's 21.12 lakh hectares, or 5.35 lakh tones, of the overall production (21.23lakh tones). This region's productivity (608 kg/ha) is almost 60% of the global productivity (1006 kg/ha) (Anonymous, 2011a). In terms of area under cultivation, India is second to Canada as the world's greatest producer of linseed (21.21 percent). India is fourth (8.20 percent) in the globe in terms of production, after Canada (40.51 percent), China (18.68 percent), and the United States (10.89 percent) (Srivastava, 2009). However, according to statistics from the Food and Agricultural Organization the area harvested for linseed 3540139 ha, yield was 9512 hg/ha and production value was 3367331 tones (FAOSTAT, 2020). Major

producers are Canada, Argentina, USA, Poland, Uruguay, Romania, Ethiopia, USSR, China and India (Jhala *et al.* 2010).

As of right now, 13 Indian states—Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar, Odisha, Karnataka, Nagaland, Assam, West Bengal, Himachal Pradesh, and Rajasthan—are engaged in the cultivation of linseed. Currently, linseed is grown on roughly 3.420 lakh ha, contributing 1.537 lakh tones to the global economy. The yield of 449 kg/ha, which is our country's yearly production of oilseeds, is far lower than the global production of 21.23 kg/ha. tones from 21.12 million acres at a yield of 1006 kg per hectare (Anonymous, 2017a). But there is a big difference in production has increased in states like Rajasthan (2006 kg/ha), Bihar (846 kg/ha), Nagaland (689 kg/ha), and Assam (517 kg/ha) is comparable to both the world (1006 kg/ha) and Asia (608 kg/ha).

Economic Importance
Linum usitatissimum L. occupies an important position in world market because of its multiple trade use. It is a valuable crop and every part of the plant has specific economic importance.

Flax fibre applications
Among all the textile fibres, flax fibre is one of the most natural and environmentally beneficial. Strength, fineness, and durability are the defining qualities of flax fibres. Compared to cotton and jute, they are more glossy, durable, less flexible, and resistant to environmental change. This fibre mixes well with others like wool, silk, cotton, etc. Fibre bundles resemble blonde hair. Since the threads are so sturdy, they are also used to make fishing lines, nets, and other items like shoes. The fibre is widely utilised in the production of mats, carpets, blankets, and twine. Strong ropes, shipping cord, twines, and cordage are made from rougher, coarser-grade fibres and are crucial for the aeronautical industry.

The greatest grades of flax fibres are used to make "linen" or "linso-fabrics," which are textiles used to make clothing such as suits, shirts, and bedsheets, curtains, damask, laces, etc. Blended fabrics made of flax-jute (Linju) and flax-cotton (Linco) exhibit higher quality than 100 percent cotton or jute fabrics (Pandey and Dayal, 2010).

Pulverized sugars
The woody base of the branch and the short fibres are being used as raw cellulose for producing high-quality paper once the stalk's fibre has been extracted. To improve the paper's quality, the pulp must include and over 20% strong virgin wood fibre. Pulp sweeteners are the extra-strong fibre that must be added to the pulp. A tiny amount of flax fibre can be used in place of virgin wood fibres because it is stronger and longer than all other virgin wood fibres. This pulp can be used to create paper of all grades and levels of economic worth that is used to make currency notes, airmail, parchment paper, good writing paper, cigarette paper, and straw boards.

Geotextiles (Insulation)
In order to manufacture insulation batts (fibre wadded into sheets) with similar insulation characteristics to fibre glass batts for the purpose of insulating walls and ceilings, coarse and fine flax fibres are combined and treated.

Polymer composites
Flax fibres can be utilised in place of fibre glass in the production of plastic composite applications since they are less expensive and heavier (car dashboards, fencing materials, septic tanks etc.). Due to their significance in the environmentally friendly usage of paper and plastic, flax fibre is more commonly referred to as the "plastic crop" (Vittal *et al.*, 2010).

Wax
Different organic solvents are used to extract wax for commercial purposes from the cortical tissues. The shoe polish industry uses this wax (Gill, 1987).

Industrial grade commercial oil
Due to the presence of di- and tri-unsaturated fatty acids, linseed oil is a flexible "drying oil" that goes through polymerization. As a result, when exposed to oxygen in the air, it transforms into a solid state. Linseed oil can be used on its own or combined with other oils, solvents, resins, etc. thanks to the polymer-forming capabilities. Linseed oil in its raw state dries slowly. It tends to yellow and has poor colour retention. Linseed oil has been subjected to heat modification, which involves heating it to various high temperatures in order to enhance its drying and colour retention capabilities.

Commercial-grade oil for food
Due to the high levels of linolenic acid, a polyunsaturated fatty acid, which makes the oil very vulnerable to oxidation and increases its drying property and imparts a pungent flavour and rancidity, linseed oil is not suitable for human consumption. Additionally, the oil is unfit for food use due to the mucilage's laxative qualities in the seed coat. Numerous novel flax seed types with low levels of alpha-linolenic acid (25–30%) have been discovered in India. It manufactures premium polyunsaturated food oil created using plant breeding methods. Australia's 1984 invention of a new variety of linseed has the trademark LinolaTM (Srivastava, 2009). Another edible linseed type created in 1990/91 is called Canada (Srivastava, 2009). Some farmers are

economically and socially compelled to grow linseed exclusively for a number of years. There are some groups of people who Use only linseed oil for cooking and baking. It is essential to create linseed varieties with food-grade oil for these. Bhaba Atomic Research Centre (BARC) and All India Coordinated Research's collaborative research has helped the public. Five genotypes have been established for the Linseed Project (AICRP), namely TL11, TL26, TL27, TL36, and TL43. Linolenic acid concentration is less than 1% (Srivastava, 2018).

Consumption by people

Many linseed-based recipes have been standardized due to the presence of a higher concentration of omega-3 fatty acids (alpha-linolenic acid), which promotes good health and decreases cholesterol levels while providing cardio vascular advantages. To add value and create a variety of nourishing meal preparations, crushed seeds and flour are employed (Chauhan *et al*., 2017). However, the mucilage in the seed coat's laxative qualities renders linseed oil in edible. Greater levels of linolenic acid, which oxidises and releases unpleasant aromas when it becomes rancid. So on a very limited scale, it is utilized by a small part of the population for culinary purposes as flax seed breads, bagels, and fried food items. (Anonymous, 2006). Linseed is a traditional food additive that is used to make chutney powder in Karnataka and some areas of Maharashtra. In Himachal Pradesh, it is also employed to fry several meals. (Preethi *et al*., 2016).

Dietary value

Numerous essential minerals and nutraceuticals found in linseed show promise as health benefits for both humans and animals. Eight essential amino acids are included in it: isoleucine, leucine, lysine, methionine, phenylanine, threonine, tryptophan, and valine. This is the finest herbal source of omega -3 and omega -6 fatty acids, and it also contains carbs, vitamins, minerals, and crude fibre (Anonymous, 2010). These nutrients and other substances are advised by health professionals for improved health. With 130 grams (one cup) of ground flax seeds, you can get 585 kcal of energy, 26.0 grams of protein, 53 grams of total fat, a lot of dietary fiber (36.0 grams), a lot of total carbohydrates (38.0 grams), and all the vitamins and minerals your body needs (Anonymous, 2003). Due to its nutritional content, which includes components that are good for your health including alpha linolenic acid, lignan, and polysaccharides, it has received a lot of interest in recent years (Bozan and Temelli, 2008). Alpha-linolenic acid, an omega-3 fatty acid, is a precursor for the production of longer-chain polyunsaturated fatty acids, primarily eicosapentaenoic and decosahexaenoic acids, which have an impact on the biophysical characteristics of the cell membrane and are necessary for healthy cell function (Preethi *et al*., 2016).

Considering it as a source of food

The residue left behind after the linseed seed's oil has been extracted is referred to as cake, and it is brown in colour. This cake's initial composition includes 21.78 percent non-nitrogenous extract, 29.37 percent lipids, 27.78 percent protein, 7.02 percent fibre, 3.40 percent ash, and 10.65 percent total humidity (Gutierrez *et al*., 2010). Consequently, it is a tasty, high-protein feed for livestock. Although linseed meal is used as an addition in baking items, it is fed to cattle to improve their health and increase the gloss of their coats (Coskuner and Karababa, 2007). However, phytic acid, cyanogenic glucoside, and goiterogen in linseed limit the use of linseed cake as animal feed because these are unnutritional components. The hazardous components should therefore be removed from grain or seeds during processing.

Mucilage

By precipitating aqueous extract of the seed (which has been soaked in water for 24 hours), linseed mucilage, which is found in the seed coat, can be produced. When completely dry, it is a white, fibrous substance that is friable. When dissolved in water, it produces a high viscosity solution. It contains xylose, glucose, galactose, arabinose, ramnose, and galacturonic acid in a heterogeneous mixture of polysaccharides. Linseed mucilage is employed in food products as a thickening and emulsifier by taking use of its physical characteristics as a water-soluble emulsifier, thickener, and binder. The potential use of linseed as a functional food ingredient sparked a lot of curiosity. According to Coskuner and Karababa (2019), the mucilage made from flax seeds has emulsifying qualities extremely similar to gum arabic and is comparable to guar gum in its ability to bind water. Mucilage serves as an ademulcent and a helpful base for eye ointments in the cosmetic and pharmaceutical industries.

As a fertilizer

In terms of nitrogen, phosphorus, and potassium delivery to soil, linseed oil cake is among the best nitrogenous fertilizers among oilcakes (4.7 percent N, 11.7 percent P2O5, 1.3 percent K2O) (Anonymous, 2011b). It offers slow-release nutrition, stimulation, and defense against soil nematodes, particularly Meloidogyne javanica, and insects. As a result, it also increases product quality, yields, and attributes like flavour, taste, and amino acid composition. Additionally, because of its germicidal characteristics, which enhance plant health and increase resistance to infection, it can be used as manure to protect soil from undesirable bacteria (Naik, 2017).

Linseed seed's chemical makeup

Small, flat, oval, brown, yellow, or dark brown coloured seed. Varieties, sizes, climates, and maturity all affect the makeup

of the seed. According to Khan et al. (2010) and Rahimi et al. (2011), the seed includes oil (36–48 percent), which is abundant in linolenic acid and other unsaturated fatty acids, as well as mucilage (approximately 6 percent), which is found in the seed coat. The seed contains all necessary ingredients, including crude fibre (5–10%), proteins (20–30%), fats (37–40%), minerals (2.4%), carbohydrates (28–9%), moisture (6.5%), calcium (170 mg/100 g), iron (370 mg/100 g), carotene (2.7 mg/100 g), thiamine (0.23 mg/100 g), riboflavin (0.07 mg/100 g), and niacin (1 mg/100). Although the composition of the amino acids is comparable to that of any other oilseed, the amount of lysine and the amount of methionine are both high, and the quality of the Compared to other rapeseed proteins, linseed protein is superior (Nagaraj, 2009). A minimum of three different types of phenolic compounds include lignans (secoisolariciresinol), flavonoids (35–70 mg/100 g), and phenolicacids (8–10 g/kg). Diglucoside, SDG; approximately 1–26 mg/g. Due to the inclusion of all necessary components, including dietary fibres, carbohydrates, and fats,Today, fried and powered seeds are used to a considerable extent in the production of foods for daily consumption.

Linseed oil

Oil makes between 30–45 percent of linseed seed. The oil obtained by cold pressing (mechanical extraction with reduced heat, which is produced by rotational friction) has a golden yellow colour, while an oil obtained by hot pressing (heat supply up to 2000 c) is yellowish brown. Freshly extracted oil has a viscid, recognizable odour, and an unappealing taste.

Cultural techniques

Linseed is solely a rabbi and cool season crop, necessitating moderate to cool temperatures throughout the growth season. This is typically limited to low elevations and the plains. Where the yearly precipitation is between 48 and 76 cm, it might grow. The yield, size, and oil content of seeds are significantly decreased if the crop is subjected to drought and high temperatures (about 32°C) during and after the flowering stage. Linseed may also grow on light to heavy rain fed marginal and sub marginal soil. Plants turn golden yellow as they age, and the seeds in their capsules start to rattle as they turn brown. Harvesting should take place at this time. The crop can yield 12–15 q/ha of seeds in an irrigated field.

Diseases with symptoms and causative agents

One of the main factors limiting linseed productivity is disease. All types of pathogens, including viruses, bacteria, fungi, and nematodes, infect the linseed crop. Linseed is susceptible to a variety of illnesses. However, rust, wilt, Alternaria blight, and powdery mildew are the main ones, causing losses of up to 80%, 80%, 27%, and 60%, respectively (Anonymous, 2005).

Rust (Melampsora lini)

On the leaves, stems, and capsules, rust disease manifests as bright-yellow or orange-colored uredia. Typically, uredia are circular on the leaves, elongated on the stems, and develop into pustules. Later, yellow-orange pustules cover the entire plant. Commonly, the disease affects the stem, but leaves are more seriously affected, dying off too soon.

Wilt (*Fusarium oxysporum* f. lini)

One of the worst diseases that affects linseed and results in significant loss is wilt. It grows during all phases of the plants' development. Cotyledons typically break off during the seedling stage of an infection. These leaves shrink throughout the growing stage and develop dark green or brownish markings. Premature ripening and vascular tissue coloration in the stem and root of infected plants are two symptoms. Plants that have died and lost their leaves are clearly visible in the field.

Alternaria blight (Alternaria lini and Alternaria linicola):

The crop suffers significant damage since all aerial parts of the plants are seriously afflicted. But disease manifests itself on the floral portions, especially close to the calyx, as a series of tiny dark brown lesions. These lesions are extensive and reach the stem on the young leaves, though. Eventually, these leaves wilt and dry out. Infested plants that are severely dehydrated in the field take on a burned appearance.

White mould (Oidium lini):

The primary sign of this illness is the growth of thin, whitish colonies of the pathogen on aerial components, particularly floral buds.

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