

The Resurgence of Flax (Linseed): Balancing dual-purpose Agronomy

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SUMMARY

Flax (*Linum usitatissimum* L.) is considered one of the ancient agricultural plants of mankind, and has been categorized in the past into two different types: the short, bush-type used for growing linseed oilseeds and the tall, single-stem type for bast fiber textile production. But the growth of the present day eco-industries, together with changing market demands, has spurred a remarkable comeback of dual-purpose agronomy of flax. Dual-purpose agriculture refers to obtaining both economically valuable seed oils and commercial fibers from a single field crop. It involves a very careful manipulation of all agronomic factors, such as choice of proper cultivars, careful nitrogen application, proper plant density, and timely harvesting windows. This paper offers a thorough review of the reasons behind the comeback of flax and its dual-purpose agronomy.

INTRODUCTION

The use of flax for agriculture spanned continents, from its emergence at the beginning of civilization in the Fertile Crescent and throughout the world because of its incredible usefulness (Moyses *et al.*, 2023). Its scientific name is *Usitatissimum*, which means "the most useful." It was once known for being the most useful plant since it was used as a fiber for clothing (linen) and as oil (Stavropoulos *et al.*, 2023). However, in the middle of the twentieth century, there was a marked reduction in the cultivation of flax because of cheaper synthetic petro-fibers such as polyester and vegetable oils like soybeans and canola. In the present time, the concept of agricultural landscapes is going through a major paradigm shift. It is because of the growing pressure of industrial decarbonization, the price fluctuations of artificial fertilizers, and the rising market demand for omega-3 fatty acids produced by plants that *Linum usitatissimum* has once again attracted attention. Flax is not viewed through the prism of mono-culture anymore. Instead, there is a new emphasis on a dual-use approach – an intricate method which allows harvesting a high-quality oleaginous food/industrial commodity as well as natural fibers from just one acre of land.

Understanding Dual-Purpose Flax

To effectively cultivate flax for both purposes, one needs to know the two sharply differing physiological characteristics of oil flax and fiber flax. For instance, the fiber flax is naturally selected to be very tall and can grow up to 80 to 110 centimeters with an unbranched stalk that has little and top-heavy inflorescences to increase the length of the bast fiber found in the stalk cortex (Moyses *et al.*, 2023). On the other hand, oil flax, also known as linseed, is short and thick with plenty of secondary branches.

Traditional Fiber Flax	Traditional Seed Linseed	Dual-Purpose Ideotype
Tall (80-110 cm)	Short (~40-60 cm)	Medium (70-80 cm)
Single Stem	Highly Branched	Moderate Branching
Low Seed Yield	High Seed Yield	Balanced Fiber & Seed

Dual-purpose agronomy seeks an intersection between these two extremes. The objective is to produce a plant that achieves a medium height (roughly 70 to 80 cm) with moderate secondary branching. This biological tightrope is managed primarily through three foundational agronomic levers:

Seeding Density and Row Spacing

In the production of monolithic fibers, there is an application of excessively high planting densities in order to enforce apical dominance such that the plants will not branch but grow upward in a straight manner. In seed flax production, relatively low planting densities are applied to promote spatial branching. In the dual-purpose system, a medium planting density ranging from 50 to 70 kg/ha and narrow row spacing, about 15 to 20 cm, is utilized.

Nitrogen Management

Nitrogen (N) is the primary driver of vegetative biomass, but it is also the greatest risk factor for dual-purpose growers. High nitrogen inputs (75–150 kg/ha), which are common in specialized seed production to

support heavy branching, cause dual-purpose flax stems to become weak and structurally unstable (M Nitrogen (N) is the key factor for vegetative growth, but at the same time, it becomes the biggest risk factor for dual-purpose farmers. The increased use of nitrogen (from 75 to 150 kg/ha), which is widespread in seed production and is needed to stimulate branching, leads to making flax plants more vulnerable and structurally fragile (MDPI, 2026). This leads to lodging, i.e., crop bending or breaking down due to wind or rain, which results in the complete loss of the fiber qualities and makes it impossible to harvest (MDPI, 2026). Insufficient use of nitrogen prevents stem growth and, thus, negatively impacts fiber yield. Specialists advise using a well-balanced moderate amount of nitrogen (from 30 to 50 kg/ha) with abundant potash fertilization to strengthen stalks. This leads to lodging, or bending down of the plant due to wind or rainfall, which completely destroys fiber quality and renders mechanical harvesting very difficult (MDPI, 2026). On the other hand, insufficient nitrogen retards stem elongation, leading to low fiber production. Agronomists advise for a precisely balanced moderate use of N, usually limited to 30-50 kg/ha with an abundance of K supply for strengthening the structural cell wall of the stalk.

Harvesting and Desiccation Timings

The most difficult aspect to overcome in the practice of dual-purpose agronomy is that of the harvest time. The optimal fiber condition occurs at the "early green-yellow" stage, wherein the lower leaves start to fall off and the stem turns yellow, since the bast fibers are tough but not yet highly lignified (wooden). However, the maximum seed oil content and the omega-3 fatty acid concentration occur later, at the stage when the pods become dark bronze in color and have dried out completely. In order to be able to get both, dual-purpose crops are usually harvested at the "yellow-ripe" stage, when two thirds of the capsules have changed their color to brown. By this time, the seeds are physiologically mature, with the moisture level getting close to the critical 10%.

Why Flax is Reviving in Global Agriculture

Flax revival is not a random occurrence in global agriculture, but rather the result of specific market shifts and environmental factors. To begin with, microclimate instability has created a need to reconsider the practice of rotation planting. Flax is a highly adaptable annual crop characterized by a short growth period, which lasts between 90 and 120 days from germination to harvest (Moyse *et al.*, 2023). This means that it can be used in winter double cropping and as a quick maturing spring planting that avoids summer droughts.

On the other hand, the field of agriculture faces serious issues of topsoil degradation and weed resistance. Flax has an unusual root system that enables the crop to open up dense soil layers, becoming an ideal break crop for cereal rotations. Early-stage flax plants are susceptible to weed infestation due to their narrow canopy (MDPI, 2026). Nevertheless, later, fast-growing and having a special metabolite composition, flax changes the weed dynamics of fields and destroys the cycle of pests of continuous corn, wheat, or soybean fields.

Finally, the economics of farming have shifted. Relying on a single commodity output leaves farmers highly exposed to market collapses. A dual-purpose flax crop acts as a natural economic hedge. If global vegetable oil prices drop, the farmer can recoup margins through the fiber processing market, and vice versa.

Industrial Sustainability

Flax is considered one of the most sustainable industrial resources from an ecological point of view. Compared to traditional fiber plants like cotton, the cultivation of fiber flax needs minimal synthetic pesticides, herbicides, and water for irrigation. The plant naturally grows in a rainfed fashion in temperate climatic regions, thus reducing the blue water footprint of the textile industry chain. Furthermore, the transformation of the flax plant into a fiber involves a biologic process, which is called retting. This process is characterized by controlled decomposition of pectin and cellular connections between the valuable fiber, i.e., bast fiber, and the shive – the inner woody core of the flax stem. Modern sustainability strategies support "dew retting," which means laying out flax stems in the field to decompose by natural dew and microorganisms over the course of three to four weeks. In the automotive and aerospace manufacturing industries, the use of flax fiber is rapidly gaining ground as the best available bio-material to replace glass and carbon fiber materials. Embedded in polymers, flax composites produce lightweight and highly resilient panels for the construction of car body parts and interior dashboard components. In addition to making cars lighter—which improves their fuel/battery performance—flax composites allow for the environmentally friendly disposal of such vehicles, since they are easily burnt or decomposed without producing toxic micro-debris (Singh *et al.*, 2011).

Future Prospects

The future prospects of dual-purpose flax crop breeding and cultivation hinge greatly on genetic breeding and technological advances in the processing sector. Traditionally, the major challenge associated with dual-purpose growing was the processing aspect; conventional textile factories needed long and unbroken strands of fiber produced only by dedicated fiber flax varieties, while dual-purpose harvesting tended to produce short and entangled strands of fiber due to seed thrashing combines. Modern technology has invented "cottonization". The process of cottonization involves mechanical and enzymatic procedures that convert coarse and inconsistent strands of dual-purpose flax into short and consistent strands of fiber that can be processed on regular cotton equipment available today. This creates a multi-million dollar market avenue for dual-purpose fiber.

At the same time, scientists practicing molecular agronomy are utilizing genetic engineering techniques such as CRISPR to develop ideotypes that serve two purposes at once. Plant breeders are attempting right now to pinpoint the exact genetic marker that is responsible for plant height without affecting branch formation, thus producing crops with long stems suitable for the production of high-quality fibers and capable of bearing a strong terminal canopy of oilseed pods. In addition, the study of perennial flax species demonstrates enormous potential in providing permanent protection to fragile topsoil layers along with annual crops of oil and fiber (Tork *et al.*, 2024).

CONCLUSION

The re-emergence of flax entails much more than the mere rediscovery of an ancient plant; it is a conscious effort driven by scientific facts to meet the needs of modern sustainable industries. Although cultivating *Linum usitatissimum* in a way that will produce seeds and high-quality fibers at the same time is not an easy task, the agronomic plans that are currently at the disposal of modern farmers make this goal easily achievable. With the help of these plans that highlight the critical balance of the seeding rate, nitrogen use, and harvesting time, farmers will be able to shift from their monocultural reliance on one type of cultivation to a highly diversified one.

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