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Some Factors Affecting Flax Fiber Yield and Quality

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ABSTRACT

Flax (*Linum usitatissimum* L.) being an ancient crop, has performed a significant role throughout human history. Flax important come from the fact that it is high in fiber and omega-3 fatty acids as well as phytochemicals named lignans. The principal use of flax was industrial, manufacturing textiles from fiber and paints and varnishes from oil. However, in the last decades decline in flax cultivation has been due to research findings suggesting that the flax raw material provides a variety of industrial and health benefits. Flax fiber gains more and more applications, like in the automobile and construction industries as a recyclable composite material. Recent studies have focused on improving quality and increasing the productivity of flax fiber. In this work, depending on previous studies different factors that influence the quality and yield of fiber flax are presented. These include sowing date, sowing rate, harvest time, and retting process. Several sowing dates influence fiber quality and yield. Different aspects of retting process, with an explanation of retting water quality. Harvest fiber flax at mid-stages of maturity significantly affects the fiber yield and quality.

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1. INTRODUCTION

There are various sources of plant fiber obtained from various parts of plant, such as the seeds (cotton, kapok, milkweed), stems (flax, jute, hemp, ramie, kenaf, nettle, bamboo), and leaves (sisal, manila, abaca), fruit (coir) and other grass fibres. Flax (*Linum usitatissimum* L.*)* as one of the oldest fibre crops in the world is the source of industrial fibers that currently processed in long-line and short-line fibers. Long line fiber is used in manufacturing high value linen apparel, while short staple fiber has historically been the waste from long line fiber and used for lower value products (Butorac et al., 2018).

Flax is among the oldest fiber crops in the world. The use of flax for the production of linen dates back 5 000 years. Flax is an erect annual plant that grows up to 120 cm tall, with slender stems. The leaves are alternate, grayish green, slender lanceolate, 2 to 4 cm long and 3 mm broad. The flowers are bright blue or white, 1.5 to 2.0 cm in diameter, with five petals. The fruit is a round, dry capsule, 5 to 9 cm in diameter, containing several glossy brown or yellow seeds shaped like an apple pip. The seeds are 4 to 7 mm long and become sticky when wet. The colour of the seeds depends on the variety. Flax is one of the few plant species capable of producing truly blue flowers, although not all flax varieties produce blue flowers. The flax plant has one short, branched taproot, which may extend to a depth of 1 m, with lateral roots stretching 30 cm. The life cycle of the flax plant consists of a 60 to 80-day vegetative period, 25 to 40-day flowering period and a maturation period of 40 to 60 days. Water stress, high temperatures and disease can shorten any of these growth periods.

1.1. Linseed

The linseed plant has a bushy nature and is about 80 cm high. Because a single inflorescence is produced on each branch, it has several branches in order to produce more seed. What makes the oil of linseed so exceptional is the Omega-3 fatty acid content. Linseed oil is possibly the most widely available botanical source of Omega-3. Alpha-linolenic acid (ALA) is the important Omega-3 fatty acid in linseed, which is of considerable benefit to humans and animals. Linseed varieties vary in their ALA content, from varieties with ALA content of 2 %, which makes them unsuitable for the Omega-3 market, to ALA-rich varieties (60 % ALA) which are extremely suitable for the Omega-3 human food and animal feed markets. Varieties with ALA content of 2 % compete with sunflowers for processing into margarine and cooking oil.

1.2. Fiber Flax

Fiber flax varieties are all almost unbranched and can reach a height of 1.2 m. Flax fiber consists of bundles of fibers or fiber strands. Each bundle consists of 10 to 40 individual fibers that are about 30 mm long and 0.02 mm in diameter. These flax fibers are bound together end to end by pectin to form bundles and a strand is 60 to 90 cm long. Flax fiber consists of 43 to 47 % cellulose and 21 to 23 % lignin and is soft and supple but not as flexible as cotton or wool. Flax fiber is stronger than cotton fiber, rayon and wool, but weaker than ramie.

2. FACTORS AFFECTING YEILD AND QUALITY OF FLAX FIBER

2.1. Climate Conditions

The commercialized European varieties are spring varieties adapted to seaside climate and long days. The flax does not tolerate negative temperatures in the beginning of the growth and, on the contrary, high temperatures accelerate maturity of flax and the elongation of fiber does not appear and the quality is reduced (Butorac et al., 2010). Seedlings can withstand a temperature of -4 °C, but very high temperatures (exceeding 32 °C) shorten flowering, thereby affecting seed yield.

Flax and linseed can be grown under irrigated and rain fed conditions. Under rain fed conditions, flax and linseed need 450 to 750 mm of rain spread evenly through the growing season.

2.2. Soil Requirement

Flax/linseed can be cultivated successfully in the same types of soil that are suitable for wheat. The best soils, apart from the alluvial kind, are deep friable loams that contain a large part of organic matter and have a pH ranging between 5 and 7. Heavy clays are unsuitable, as are soils of a gravelly or dry, sandy nature.

2.3. Sowing Date

Flax is normally planted in the winter rainfall areas from mid-May to mid-June after the first winter rains. Planting time is very important and late planting (later than mid-June) can reduce the yield considerably (Grant and Bailey,1993).

Early-sown flax generally results in the highest yields, highest oil content and best straw quality (Easson and Long, 1992). Study the effect of sowing date on fiber yield and quality of Flax (*Linum usitatissimum* L.*)* and he states that, Sowings on 12 April and 26 April produced higher straw and fiber yields and had higher fiber quality than earlier or later sowings under good soil conditions. Field establishment is sensitive to the soil conditions following sowing (Easson and Long, 1992).

2.4. Sowing Rate

Fiber flax varieties are sown at 65 kg/ha, while linseed is sown at 50 kg/ha. This lower plant population allows the plant room to form an abundance of branches. After reaching the two-leaf stage and hardening by exposure has taken place, seedlings can withstand temperatures as low as -4 °C for short periods without damage. Flax should be sown shallowly, 2.5 to 4.0 cm deep, in rows 15 to 20 cm apart. In the case of zero-tillage practices a row spacing of up to 30 cm is acceptable(Berglund and Zollinger, 2002; Easson and Long, 1992). State that plant counts of about 1800/m^2 are a suitable compromise between high fiber yield and quality.

The harvest time of fiber flax is influenced by climatic conditions, varieties, stages of maturity and the crop's final use. In addition, the time of harvesting of fiber flax affects the quality of the fibers. Harvesting may be performed at three stages of crop development: (a) when the flowers begin to appear; (b) when the plants are in full flower or fruit; (c) when all the plants are fully mature. Harvesting is usually carried out at the second stage when about half of the plants have fully developed fruit. The yield then is good and the quality of fiber is excellent (Das et al., 2014; Butorac et al., 2018). Presents in his study the effect of three stages of maturity (Green, Yellow, and full ripening) on the agronomic traits (stem yield, stem yield after retting, total fiber yield, share of total fiber, long fiber yield, share of long fiber) and quality of flax fiber. According to his results of the two-years research into the agronomic traits of fiber flax, significant differences were established among the stages of maturity under his study and The highest values of investigated traits were recorded when the fiber flax were harvested in the green ripening. it is necessary to indicate that harvesting at the first stage may result in lower seed, stem and fiber yields (Van Sumere, 1992). In addition, during retting and scotching, several problems, such as uneven retting and difficulties in removing the shives may occur. By the second stage of maturity, all fibers in the stem have formed, and as a result, flax should be preferentially harvested at this stage or the third stage.

Fiber fineness, length and strength are the most important processing properties and determine the quality and suitability of flax fibers as a textile raw material for yarn and fabric manufacturing. Harvesting of flax at different maturities provides a diversity of products. Flax that is harvested too early – (green) - produces very fine but weak fibers. On the other hand, in (over-mature flax, the stems) are strong but brittle and produce too high a proportion of undesirable short fibers (Ahmad et al., 1984). When the flax is yellow, the fibers are long and supple, and therefore ideal for further processing. Therefore, the finest fibers are obtained by harvesting the crop following a full flowering with the stem and leaves green or at medium fiber fineness when half to a third of the seed bolls are yellow and brown with fully developed seeds (Muir and Westcott, 2003).

2.5. Rettting Process

2.5.1. Dew retting

It is most effective in climates with heavy night-time dews and warm daytime temperatures. In this procedure, the harvested stalks are windrowed in the field, where the combined action of bacteria, sun, air, and dew produces fermentation, dissolving much of the stem material surrounding the fiber. Within two to three weeks, depending upon climatic conditions, the fiber can be separated. Dew-retted fiber is generally darker in color and of poorer quality than water retted fiber. Dew retting is usually less uniform than the water retting. It is affected by the fungal colonization along the plant stems (Akin et al., 1998). Moreover; there is risk of over-retting due to the proliferation of cellulolytic fungi (Henriksson et al., 1997). Microbiological retting in water bodies is the cheapest and it is widely practiced method for the commercial extraction of jute fibers in Asian countries (Munshi and Chattoo, 2008).

2.5.2. Water retting

Bundles of stalks are submerged in water. The water, penetrating to the central stalk portion, swells the inner cells, bursting the outermost layer, thus increasing absorption of both moisture and decay-producing bacteria. Retting time must be carefully judged; under-retting makes separation difficult, and over-retting weakens the fiber. Natural water retting employs stagnant or slow-moving waters, such as ponds, bogs, and slow streams and rivers. The stalk bundles are weighted down, usually with stones or wood, for about 8 to 14 days, depending upon water temperature and mineral content. Tank retting: allows greater control and produces more uniform quality. The process, usually employing concrete vats, requires about four to six days and is feasible in any season. In the first six to eight hours, called the leaching period, much of the dirt and colouring matter is removed by the water, which is usually changed to assure clean fiber. Waste retting water, which requires treatment to reduce harmful toxic elements before its release, is rich in chemicals and is sometimes used as liquid fertilizer (Pari et al., 2015).

2.5.3. Retting Water

Water plays a dominant role in determining the quality of the fiber. Several physic-chemical properties of water, namely; pH, hardness, metal contents, and microbial parameters play important role for obtaining good quality fiber (Ahmad et al., 2003). Retting is a biochemical process in which a series of reactions occurring water. Analysis of retting water revealed the presence of decomposed products such as organic acids (acetic, lactic, butyric, ketoglutarics, etc.), acetone, ethyl alcohol, butyl alcohol, and various gases. Accumulation of organic acids and other products released during retting causes hindrance to the growth and activity of the microorganisms in stagnant water. Retting does not produce any toxic substances, and the materials released during the process are fully biodegradable. However, the quality of water after retting becomes degraded transitorily. The microbial load increases excessively and the water becomes discolored (Haque et al., 2002). Very fast moving water removes the materials released during retting quickly, but it carries away the microbial population along with it (Munshi and Chattoo, 2008). During retting, a bacterial succession occurs: the first to grow is aerobic bacteria, which by consuming all the oxygen present creates an anaerobic environment for the anaerobic bacteria to grow (Tamburini et al., 2004). In areas where water is scarce, retting is carried out in same water bodies repeatedly. In those cases, good-quality fiber is obtained in first few charges, but with a progress of retting, fiber quality deteriorates (Biswas, 2005). Retting is best carried out in slow moving clear water (canal, river, etc.) with low contents of iron and calcium. The presence of iron, particularly ferrous iron, is not desirable as it imparts a dark colour to the fiber.

3. CONCLUSION

The quality and yield of fiber flax can be controlled by:

1\ proper practice of cultivation,

2\ harvester should preserve the fiber quality during harvest operation: like controlling the harvesting rate and speed, in addition to product moisture content should match the moisture content that required at harvesting time.

3\ Retting time must be carefully judged.

Further researches and different harvesting technologies are needed due to high heterogeneity among crops.

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