Production guidelines for flax

(*Linum usitatissimum L.*)

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

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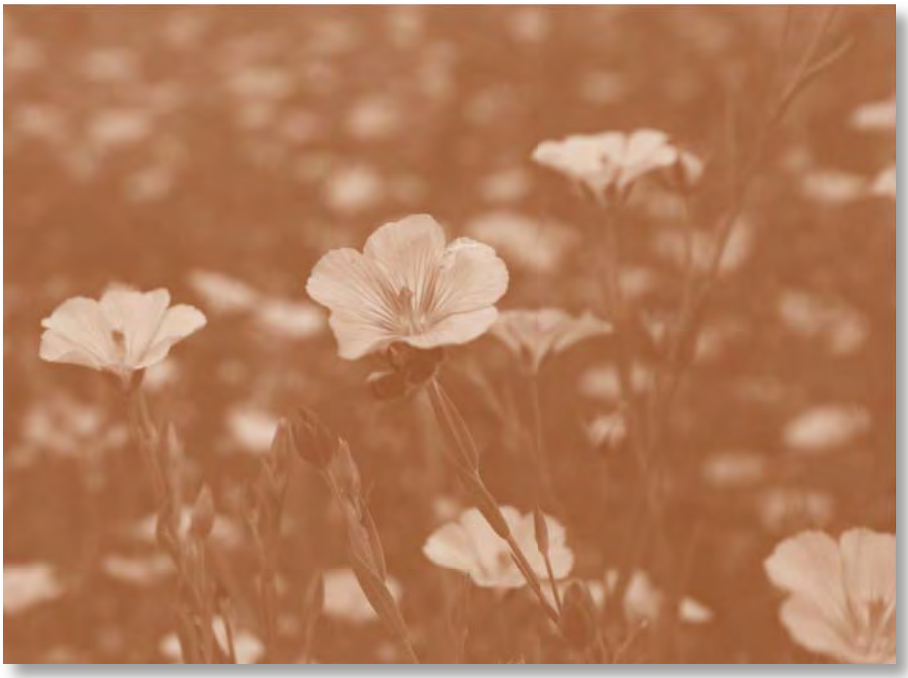

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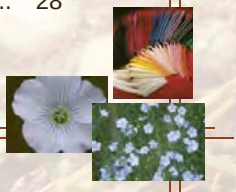


Part I: General aspects

1 CLASSIFICATION

Fibre flax, linseed and linola™ refer to the same plant, *Linum usitatissimum,* which belongs to the Linaceae family.

Flax fibre is obtained by stripping the bark or "bast fibres" from the stem of the linseed plant.

Linseed refers to brown or yellow-seeded types containing 35 to 45 % oil and 18 to 26 % protein. Linseed oil is possibly the most widely available botanical source of Omega-3 fatty acids, which makes it extremely valuable.

Linola™ is a high-quality oilseed crop developed from the linseed plant by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) in Australia. It has a registered trademark. It differs from linseed in that it has yellow seed and produces a vegetable oil with a lower level of linolenic fatty acid and higher proportion of linolenic fatty acid. The oil produced is a polyunsaturated edible oil suited to a range of food uses. Linola lacks the high quantity of Omega-3 fatty acids of conventional linseed. This makes it less nutritional, but more stable at high temperatures and it is used in the making of margarines, cooking oils, etc. Linseed varieties that have low linolenic levels and brown seeds are not regarded as linola but are considered edible.



2 ORIGIN AND DISTRIBUTION

Linseed originated from India and was first domesticated in the so-called “Fertile Crescent”. The Fertile Crescent is a historical, crescent-shaped region in the Middle East incorporating the Levant (area in the Middle East, south of the Taurus Mountains), Mesopotamia and ancient Egypt.

Flax is among the oldest fibre crops in the world. The use of flax for the production of linen dates back 5 000 years. Pictures on tombs and temple walls depict the flowers of flax plants. The “fine linen” mentioned in the Bible has been satisfactorily proven to have been spun from flax.

The use of flax fibre in the manufacturing of cloth in northern Europe dates back to Neolithic times. In North America, flax was introduced by the Pilgrim Fathers. Currently, most flax produced in the USA and Canada is seed flax for the production of linseed oil or flaxseed for human consumption.

FIG. 1: Ripe linseed capsules

3 PRODUCTION LEVELS AND AREAS

3.1 South Africa

Flax is a new crop in South Africa. Currently only about 500 ha of flax is cultivated in the Overberg area in the Western Cape Province.

3.2 Internationally

TABLE 1: World linseed production (2005–2006)

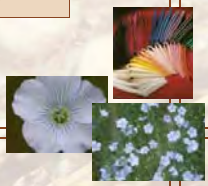
Country	Seed harvested (million tons)
Canada	1,035
China	0,475
United States	0,442
India	0,220
Ethiopia	0,077
Russian Federation	0,077
United Kingdom	0,058
France	0,054
Bangladesh	0,050
Argentina	0,036

(Source: FAO statistics)

TABLE 2: World fibre flax production

Country	Production (million tons)
China	0,470
France	0,090
Russian Federation	0,060
Belarus	0,060
United Kingdom	0,028
Czech Republic	0,017
Spain	0,012
Ukraine	0,012
Poland	0,011
Egypt	0,009

(Source: FAO statistics)



4 MAJOR PRODUCTION AREAS IN SOUTH AFRICA

The major flax production areas in South Africa are in the Eastern and Western Cape and Eastern Free State.

FIG. 2: Harvested fibre flax

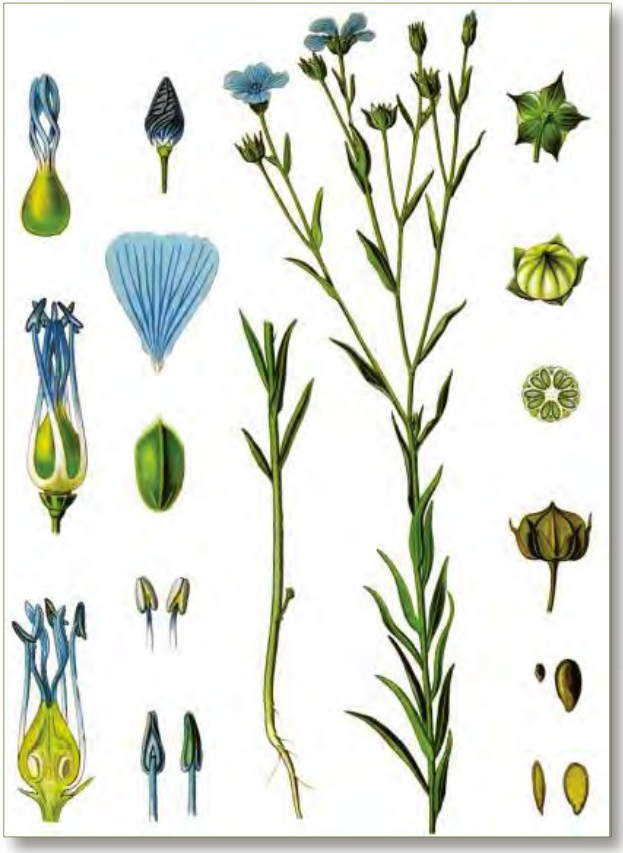


FIG. 3: Morphology of the flax plant

5 DESCRIPTION OF THE PLANT

5.1 General

Flax is an erect annual plant that grows up to 120 cm tall, with slender stems. The leaves are alternate, greyish 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

FIG. 4: Branched linseed plant

FIG. 5: Unbranched fibre flax plant

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.

5.2 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. ALA (alpha-linolenic acid) 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 an 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 an ALA content of 2 % compete with sunflowers for processing into margarine and cooking oil.

5.3 Fibre flax

Fibre flax varieties are all almost unbranched and can reach a height of 1,2 m. Flax fibre consists of bundles of fibres or fibre strands. Each bundle consists of 10 to 40 individual fibres that are about 30 mm long and 0,02 mm in diameter. These flax fibres are bound together end to end by pectin to form bundles and a strand is 60 to 90 cm long. Flax fibre 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 fibre is stronger than cotton fibre, rayon and wool, but weaker than ramie.

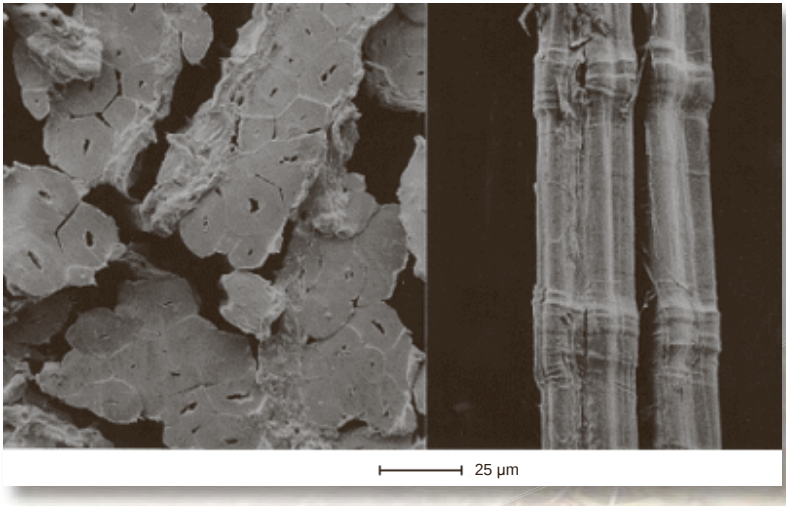


FIG. 6: Fibres under a microscope



6 CULTIVARS

The ARC-IIC has evaluated some linseed and fibre flax varieties imported from the United Kingdom and The Netherlands, because no flax or linseed varieties are available locally. These imported varieties were evaluated at different localities in the Eastern and Western Cape Provinces.

6.1 Information on linseed varieties tested under South African conditions

ABACUS	A leading variety with a unique combination of high seed yield and early maturity. It produces vigorous lateral branches which link to form a dense and even capsule canopy
Origin	UK
Oil content **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	Medium-high Medium Very high Medium-good Early White Brown Medium-small
Notes	

BILTON	
Origin	The Netherlands
Oil content **Height** **Seed yield** **Standing ability** **Earliness and maturity** **Flower colour** **Seed colour** **Seed size**	1,3 % higher than that of Oscar (very high) Medium High Good Medium to late-maturing variety Blue Brown Medium-small
Notes	Straw length and strength – longer straw variety with stiffest straw strength

GEMINI	
Origin	UK
Oil content **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	Medium-high Medium Probably high Good Medium-late Blue Brown Medium-small
Notes	Very low ALA – should be < 2 % Competes with sunflowers for manufacturing margarine

INGOT	A yellow-seeded specialist-food market variety with vigorous canopy development
Origin	UK
Oil content **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	Medium Medium-medium tall High Good Medium-medium late Blue Ochre yellow Medium-medium small
Notes	

LASER	A dependable white-flower variety which has a premium combination of good oil content and a relatively high ALA content
Origin	UK
Oil content **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	Medium-high Medium Usually high Good Medium-medium early White (star shaped) Brown Small
Notes	Oil has fairly high ALA – usually 63-65 % Good all-round agronomic characteristics. Reselected seed became available in 2007



LINUS	A reliable variety with an excellent combination of good agronomic characters and high gross output
Origin	UK
Oil content **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	Medium Medium Medium Good Medium-medium early Blue Brown Small
Notes	Good all-round agronomic characteristics

MARMALADE	A yellow-seeded, high-palatability specialist-food market variety
Origin Oil content Height Seed yield Standing ability Maturity Flower colour Seed colour Seed size	Canada (Breeder) Medium-high Medium Usually high Medium-medium good Medium early Blue Yellow Small
Notes	Niche market demand for human consumption (especially organic crops) because of good appearance and palatability of seed

SUNRISE	A reliable variety with an excellent combination of good agronomic characteristics, high seed yield and early maturity
Origin **Oil content** **Height** **Seed yield** **Standing ability** **Maturity** **Flower colour** **Seed colour** **Seed size**	University of Saskatchewan, Canada Medium-high Medium Usually high Medium good-good Early Blue Brown Small
Notes	Increasingly popular in Europe, especially in the UK, because of a combination of performance and early maturity

TALON	This variety's low branches form a deep, high-yielding capsule canopy. It has good frost resistance for early drilling and performs well under a wide range of conditions
Origin	UK
Oil content	Medium
Height	Medium
Seed yield	Usually high
Standing ability	Medium good-good
Maturity	Medium-late
Flower colour	Blue
Seed colour	Brown
Seed size	Medium-medium small
Notes	Has a stiff stem base and low branches which form a deep, flexible capsule canopy. Consistently yields well under a wide range of conditions Improved reselected seed will be available for 2006



6.2 Information on fibre flax varieties tested under South African conditions

ARIANE	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	High Medium-high High Medium-medium high Medium Medium-high
Notes	

EVELIN	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	Medium-high High High Medium-high Medium High
Notes	

ELECTRA	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	High High High Medium-high Medium-late High
Notes	

HERMES	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	Medium-high High High Medium-high Medium Medium-late
Notes	

MARYLIN	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	Medium-high High High Medium-high Medium Medium
Notes	Can be planted for fibre and seed

VIOLA	
Origin	The Netherlands
Height **Fibre yield** **Fibre quality** **Standing ability** **Earliness and maturity** **Seed yield**	Medium-high High High Medium-high Medium Medium
Notes	



7 CLIMATIC REQUIREMENTS

7.1 Temperature

Fibre flax and linseed cultivars like cool, moderate coastal climates. Linseed cultivars do well under moderately cold conditions, however, fibre flax cultivars grow best in cool, moist climates. Their cultivation is normally confined to low elevations, however, they can be grown successfully up to 770 m above sea level. Seedlings can withstand a temperature of -4 °C, but very high temperatures (exceeding 32 °C) shorten flowering, thereby affecting seed yield.

7.2 Rainfall

Flax and linseed can be grown under irrigated and rainfed conditions.

Under rainfed conditions, flax and linseed need 450 to 750 mm of rain spread evenly through the growing season.

8 SOIL REQUIREMENTS

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.



Part II: Cultivation practices

1 PROPAGATION

Flax and linseed are mainly grown from seed and rarely vegetatively from stem cuttings.

2 SOIL PREPARATION

2.1 Conventional tillage

Because of its small seed size, linseed requires a fine, firm seedbed. Plant in moist soil and avoid sowing deeper than 5 cm. Avoid crusting soils because of low seedling vigour.

2.2 Minimum and zero tillage

Minimum and zero-tillage practices are attractive, because these provide protection from erosion, increase the soil organic matter and improve moisture retention. In addition, crusting problems and sun scald are reduced, consequently improving the stand of flax.

3 PLANTING

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.

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.

Fibre 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.



4 FERTILISATION

Soil tests and experience should guide fertilisation practices. Nutrient levels in the soil vary greatly among regions and with soil types, cropping history and fertiliser use.

Flax is very sensitive to fertiliser applied with the seed and even low rates sometimes cause seedling damage.

4.1 Nitrogen

Flax often responds well to the application of nitrogen (N) fertiliser when the available soil N is low. For flax, an N rate of 35 to 80 kg/ha should be used, unless more specific information, such as a valid soil test, indicates otherwise. Select a rate from within this range, based on moisture conditions. Use the lower end of the recommended range when soil moisture is low and the yield is expected to be limited. Use the higher recommended range when the soil moisture has to be maintained at optimal levels. An important rule is not to place the N directly with the seed.

4.2 Phosphorus

Apparently the flax plant prefers high soil P levels obtained from the fertilisation of preceding crops to high P levels obtained from the application of a high rate of P to the flax crop itself. Rates of about 35 kg/ha are recommended on soils with a low P content. The P must not be placed in direct contact with the seed.

4.3 Other nutrients

Fe – iron-deficient flax is chlorotic early in the season and usually appears as irregular patterns on the field. Such symptoms may disappear later in the season.

Zn – zinc-deficient plants are chlorotic and the growing tips tend to die, whereafter axillary buds develop to form many branches.

5 IRRIGATION

Flax is an excellent choice for irrigated crop rotation because it is not prone to *Sclerotina* stem rot that affects canola, sunflower, peas and beans. The major effect of irrigation on flax is to promote a second or third flush of flowers and to maintain adequate moisture for plant growth until all the flowers have developed seeds.

In nonrestricting soils (medium-textured soils that are amenable to plenty of moisture) flax develops a short, branched taproot, encompassing a rooting zone of 1 m. Root development is nearly completed by the flowering stage. In irrigated lands, flax takes approximately 70 % of its water requirements from the top half of the root zone.

Over the growing season, crop water use can be as high as 750 mm. During the seedling stage, water use will range from 1 to 3 mm per day, rising to a high of 7 mm per day during the flowering stage. The critical water requirement period is from flowering to just prior to seed ripening. Therefore, to maximise yield and oil content, adequate soil moisture must be maintained during this period.

FIG. 7: The result of insufficient irrigation on flax

6 WEED CONTROL

Weeds can be a serious problem in flax if left uncontrolled. Early removal of weeds is necessary to minimise crop losses as a result of weed competition. Weeds are controlled more easily by herbicides in the seedling stage than at any other growth stage and early treatment usually decreases the risk of damage to the flax crop.

No herbicide is registered for weed control in flax in South Africa.

FIG. 8: Weeds in flax field

7 PEST CONTROL

Flax may be infested by various insect pests from the time of emergence to maturity. To keep damage low, fields should be examined regularly and control applied when infestations reach the economic threshold.

Earth and sand mites can cause damage to newly planted seed and to seedlings. Sowing pretreated seed can prevent this.

Insect pests that may occur on locally cultivated flax are bollworms, ants and stainers. Bollworms can cause serious yield losses when feeding on the young fruit of the linseed plants.

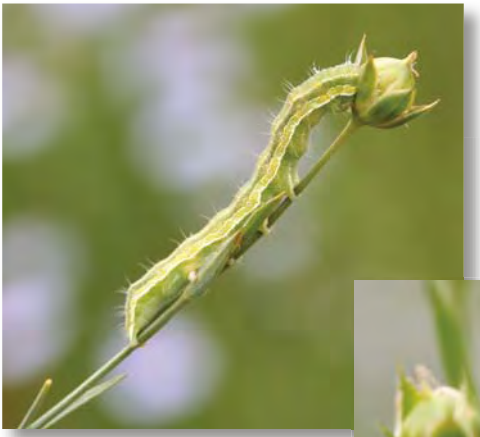
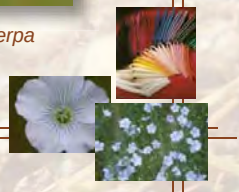


FIG. 9: American bollworm *(Helicoverpa armigera)*

FIG. 10: American bollworm *(Helicoverpa armigera)*



8 DISEASE CONTROL

Seed must be treated with a recommended fungicide. Seed treatment reduces seed decay and seedling blight, increases plant vigour and can increase the plant stand by up to 100 %.

Rust and *Fusarium* wilt are the two most frequent diseases associated with flax. Rust is recognised by the presence of a bright orange, powdery substance (pustules). Rust pustules develop on the underside of leaves and on stems and bolls.

9 HARVESTING

9.1 Linseed

Linseed is considered to be fully matured when 75 % of the bolls have turned brown.

FIG. 11: Linseed ready to be harvested

Flax may be harvested by straight combining or by cutting with a swather and threshing later with a combine or by hand. The latter is recommended as it assures drier seed for threshing.

Trials in the various potential linseed production areas in the Western Cape and Eastern Cape have shown that some varieties give yields of more than 2 tons of linseed per hectare.

9.2 Fibre flax

Three stages are recognised in the ripening process of fibre flax:

- Stems totally green – when pulled at this stage the fibres are very fine but also very weak.
- Stems yellow – the fibres are long and supple at this stage and most suitable for processing.
- Stems brown – at this stage stems are strong but brittle; the fibres are too short and unsuitable for processing.

Fibre flax is harvested by a special pulling machine or may be pulled by hand. The flax is left in the field until dry, when the seed is threshed in such a way as to prevent breaking of the straw.

Under South African conditions fibre yield is more or less 25 %, which is equal to about 2 tons of fibre per hectare.

FIG. 12: Fibre flax ready to be harvested

FIG. 13: Harvested fibre flax



Part III: Post-harvest handling

1 POST-HARVESTING PRACTICES

1.1 Retting

Before the flax fibres can be spun into linen, they must be separated from the rest of the stalk. The first step in this process is called “retting”. Retting is the process of rotting away the inner stalk, leaving the outer fibre intact. In this process, the pectin that holds the fibre bundles together and attached to the central core of the stem, is dissolved.

There are several methods of retting flax. It can be retted in a pond, stream, field or container. When the retting is complete, the bundles of flax feel soft and slimy and quite a few fibres stand out from the stalks.

Pond retting is the fastest. It involves placing the flax in a pool of water that will not evaporate. It usually takes place in a shallow pool that will warm up dramatically in the sun. The process may take from only a couple of days to a couple of weeks. Pond retting is traditionally considered inferior to other methods of retting, possibly because the product can become dirty and easily over-rets, which damages the fibre. This form of retting also produces a strong odour.

Stream retting is similar to pool retting, however, the flax is submerged in bundles in a stream or river. This generally takes longer than pond retting, normally 2 or 3 weeks, but the end product is less likely to be dirty, will not shrink as much and, because the water is cooler, is less likely to be over-retted.

Field retting is done by laying the flax out on a large field and allowing the dew to collect on it. This process normally takes a month or more, however, it is generally considered to provide the highest quality flax fibre. It also produces the least pollution.

Retting can also be done in a plastic rubbish bin or any type of water-tight container of wood, concrete, earthenware or plastic. Metal containers will not be effective, because an acid is produced during the

retting process that will corrode the metal. If the water is kept at 27 °C, the retting process takes 4 to 5 days under these conditions. Scum will collect at the top and an odour will be given off.

Nowadays the most accepted eco-friendly manner of retting is soaking the harvested flax in tubs of warm water for about a week.

1.2 Scutching

After retting, the straw is scraped away from the fibre by pulling the stems through hackles that comb the straw out of the fibre—a process called scutching.

FIG. 14: Retted fibre flax before schutching
(Photo: Van de Bilt Zaden)

FIG. 15: Flax fibre
(Photo: Van de Bilt Zaden)

Part IV: Production schedules

Activities	January	February	March	April	May	June	July	August	September	October	November	December
Soil sampling				X								
Soil preparation				X	X							
Planting					X							
Fertilisation					X	X	X					
Irrigation					X	X	X	X	X	X		
Pest control					X	X	X	X	X	X		
Disease control					X	X	X	X	X	X		
Weed control					X	X	X	X	X	X		
Harvesting										X	X	
Marketing	X	X	X	X	X	X	X	X	X	X	X	X

Part V: Utilisation

1 LINSEED

The natural qualities of flax make it a desirable oil and fibre commodity for manufacturers seeking alternative solutions to chemical and plastic-based products. From the oil, manufacturers create environment-friendly products such as linoleum flooring and some paints and stains. Flax straw in partially or completely processed form is used in the manufacturing of fine papers and industrial fibre products such as the interior panelling of some cars.

Seen as a health-promoting ingredient, premium quality flax is rapidly being taken up by the expanding functional food market. Functional foods are those food products that have been fortified with a health ingredient. Flax with its high alpha-linolenic fatty acid content, ample fibre and cancer-combating lignins is a unique functional food.

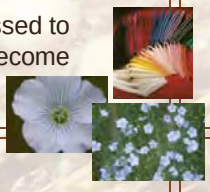
2 FIBRE FLAX

2.1 Pulp sweeteners

When paper is recycled, it must be repulped before it can be made into paper. Each time the paper is recycled, it loses some of its strength. Paper strength is important in many applications and often 20 % or more of strong virgin wood fibre must be added to recycled paper pulp to give the necessary strength. The extrastrong fibre that is added to the pulp mix is referred to as a “pulp sweetener”. Because flax fibres are considerably stronger and longer than virgin wood fibres, a smaller quantity of flax fibre can be used to replace the virgin wood fibre used to strengthen recycled paper pulp.

2.2 Geotextiles

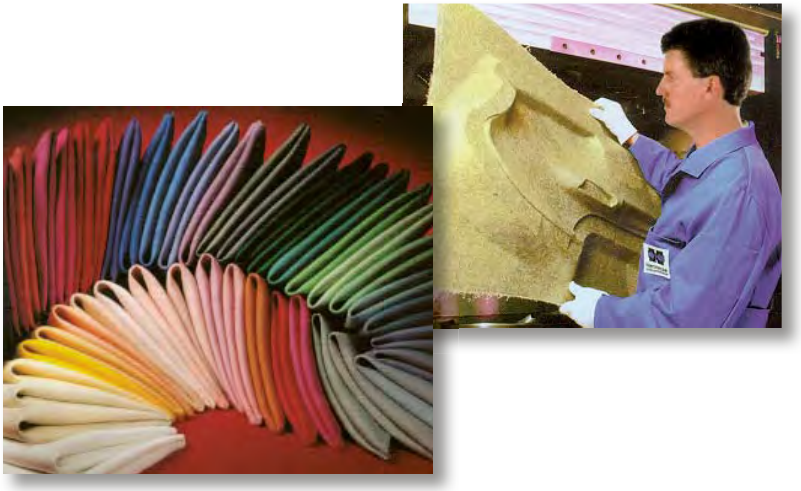
Insulation: Flax fibres remain quite stiff and coarse when processed to a limited extent. When processed more aggressively the fibres become



quite soft and fine. A combination of coarse and fine flax fibres can be blended and processed to produce insulation batts with similar insulation properties to the fibreglass batts frequently used to insulate walls and ceilings.

2.3 Plastic composites

Many everyday plastic products contain fibreglass to give strength, reduce weight and/or reduce costs. When plastic resin is combined with another material, the resultant product is called a plastic composite. Tractor fenders, car dashboards, decking, fencing materials, sewer pipes and septic tanks are only a few of the products that are being made from plastic composites. Researchers have found that flax fibres can be used instead of fibreglass in many plastic composite applications. Flax fibres are generally cheaper and lighter in weight, and impart more springiness than fibreglass. In addition, the use of flax fibres is less energy consuming in the manufacturing process. Flax fibres also decompose or burn more easily than fibreglass.



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