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Production technology and industrial uses of dual purpose linseed (*Linum usitatissimum*): An overview

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ABSTRACT

Flax (*Linum usitatissimum* L.) is a *rabi* crop of India, grown both for seed and fibre since very long time. The varieties, which are grown for seed and fibre both, are known as dual purpose linseed. In India, oil flax is under cultivation in 16 states, while dual purpose linseed is being grown in few pockets. As climatic conditions of the country does not suit much for the cultivation of fibre flax, but dual purpose linseed varieties like 'Gaurav', 'Jeevan', 'Nagarkot', 'Shikha', 'Rashmi', 'Meera', and 'Parvati' may be grown in Himachal Pradesh, some districts of Punjab, Bihar and Uttar Pradesh, *Tawa* command area of Madhya Pradesh and Kota command area of Rajasthan. A good crop of dual purpose linseed can be obtained by sowing of these varieties under irrigated situation (2-3 irrigations) during last week of October to mid November using 50- 60 kg seed/ha at a row distance of 20 cm, fertilizer application of 60- 90 kg N + 13.2- 17.6 kg P + 25- 33.3 kg K/ha along with need based plant protection measures. Development of improved varieties having quality fibre with good seed yield, refining agro-techniques, proper post-harvest technologies especially retting and scutching techniques along with the testing of quality standards and suitable government policies are essential for the promotion of this crop in India.

Key words: Double purpose linseed, Bast fibre, Flax fibre, Fibre making

Flax (*Linum usitatissimum* L.) is a member of the genus *Linum* of family Linaceae and various parts of the plant have been used to make fabric, dye, paper, plastic, medicines, fishing nets, hair gels and soap. Flax fibers are amongst the oldest fiber crops in the world after silk (Narayan, 1987). The use of flax for the production of linen goes back to at least 5,000 years. Its fibre is pale yellow in colour, soft and lustrous but less flexible and stronger than cotton. It absorbs and releases water quickly making linen comfortable to wear in hot weather. The best grades are used for linen fabrics such as damasks, lace and sheeting. Coarser grades are used for the manufacturing of twine and rope. The quality papers like currency note and rolling paper for cigarettes are also made with the raw material of its fibre. The major producer of flax fibre is the erstwhile Soviet Union, but the world's best fibre comes from Belgium and adjoining countries.

Linseed is a shorter (< 50 cm technical height) and multi branched plant with high seed yield but poor quality and quantity of fibre, whereas fibre flax is tall and single stemmed with high quality and quantity of fibre and low seed yields. There are some varieties of linseed which yields both seed and fibre and are known as dual purpose linseed. Oil flax is the most common in India and is under cultivation in 16 states, but the agro-climatic conditions of Kangra valley of Himachal Pradesh, different elevations on Himalayas, some districts of Punjab, Bihar and Uttar Pradesh, *Tawa* command area of Madhya Pradesh and Kota command area of Rajasthan are suitable for the cultivation of fibre flax / dual purpose linseed. The lenin fabric manufacturers in India import the flax fibre from European countries owing to its superior quality. In order to make flax crop more remunerative as well as employment generating, the value addition properties of flax with respect to industrial, medicinal and textile uses need to be emphasized and targeted so that quality fibre may be produced with a view to reduce the import bill of fibre which is Rs 400 million annually at present.

Production technologies

Some farmers of Himachal Pradesh, Uttar Pradesh and *Kota* command area of Rajasthan are cultivating dual purpose linseed and utilizing its fibre for their domestic purposes. The yield level of the crop is very low ranging between 0.4- 0.5 t seed/ha and 0.2-0.3 t fibre/ha, while the production potential of these varieties is 1-2 t seed/ha and 0.7-1.1 t fibre/ha (Table 1). A number of field demonstrations have been conducted on production technologies of dual purpose linseed under real farm situations, but the farmers used to switch over to some other crops with the availability of inputs according to their domestic needs.

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The improved production techniques of dual purpose linseed will certainly be helpful in changing the production status of flax (linseed), which will ultimately improve the economic status of the farmers of the country.

Varieties

Though, no variety exclusively for flax fibre has so far been released in the country, but some exotic varieties like 'Bellinka', 'Araine', 'Aoyagi', etc. are under evaluation. However, eight dual purpose varieties of linseed have been released till date for their cultivation in different agro-climatic conditions of the country (Table 1). All of them except 'Pratap Alsi-1' were released by Central Variety Release Committee, New Delhi. In the field studies conducted at Kanpur, 'LCK 8605' and 'Gaurav' gave significantly higher seed yield than 'Shikha', but 'Shikha' recorded maximum fibre yield followed by 'Gaurav' (Chaudhary and Verma, 1994). Field evaluation of dual purpose linseed varieties ('Rashmi', 'Shikha', 'Meera' and 'Nagarkot') conducted at Palampur, Kota and Kanpur revealed that 'Rashmi' is best for seed yield and 'Shikha' for fibre yield at Kanpur, whereas 'Nagarkot' at Palampur and 'Meera' at Kota were the best for both seed and fibre yield (Anon, 2001). 'Jeevan' among the dual purpose linseed varieties and 'Ayogi' in flax type were observed superior to all in respect of quality. However fibres of 'Meera' and 'Rashmi' were stronger among all. In general, the dual purpose linseed varieties bred in warm climates were inferior in fibre fineness than those bred in cold climates.

Table 1. Location specific dual purpose linseed varieties of India

Variety	Year of release	Duration (days)	Yield (kg/ha)	Oil content (%)	Areas of adaptability
Gaurav	1987	137-140	1,050 (S) 950 (F)	43	Uttar Pradesh (UP) excluding Bundelkhand, Bihar, West Bengal (WB) and Assam
Shikha	1997	135-140	1,233 (S) 1,033 (F)	42	UP (excluding Bundelkhand), Bihar, WB and Rajasthan (Kota command area)
Rashmi	1999	135-140	1,003 (S) 719 (F)	41	
Meera	2000	135-140	1,439 (S) 1,011 (F)	42	
Parvati	2001	140-146	1,600 (S) 1,026 (F)	42	
Jeevan	1988	175-180	1,090 (S) 1,100 (F)	45	Himachal Pradesh (HP) and Punjab
Nagarkot	1995	165-170	1,150 (S) 950 (F)	43	HP, Punjab, Haryana, UP, WB, Assam, and Rajasthan (Kota command area)
Pratap Alsi- 1	2007	129-135	1,997 (S) 834 (F)	41	Rajasthan (Kota command area)

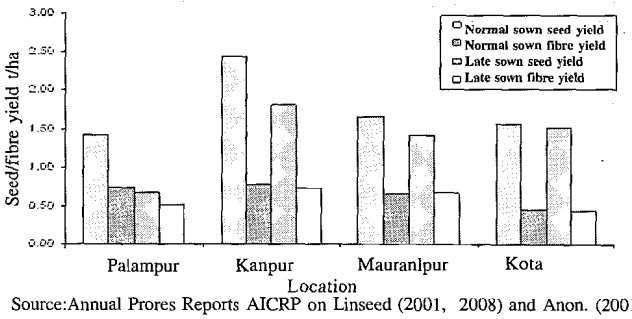
S: seed; F: fibre

Sowing time

Dual purpose linseed is generally sown during first fortnight of October in colder and hilly regions like Himachal Pradesh, which can be delayed up to first week of November in Gangetic plains and Central part of the country. Crop sown during first fortnight of October at Palampur and mid November at Kota provided higher seed and fibre yield. Optimum sowing time provided better quality fibre at both the locations (Anon, 2001).

Sowing

Flax / dual pxurpose linseed requires high seed rate for better crop growth, which varies from 60-80 kg/ha. Optimum seed rate for fibre production varied between 60-75 kg/ha at Kanpur (Chaudhary and Verma, 1994, and Husain *et al.*, 2003), but seed yield was significantly higher at 50 kg seed rate (Table 2). Dual purpose linseed 'KL 187' sown 20 cm apart using 62.5 kg seed/ha at Palampur produced significantly higher seed and fibre yields along with quality



Source:Annual Prores Reports AICRP on Linseed (2001, 2008) and Anon. (2001)

Fig. 1. Seed and fibre yields in relation to sowing time

fibre measured in terms of fineness and length of fibre as compared to 50 kg seed/ha and 25 cm row spacing (Anon, 2001). Dual purpose linseed 'Rashmi' provided higher net return at 15-20 cm row spacing than 25 cm row spacing at Kanpur (Singh and Husain, 2003). Thus, it would be advantageous to use 60 kg seed/ha, if seed and fibre both are important, but a seed rate more than 60 kg/ha produce quality fibre than lower seeding rates.

For proper germination, seeds should be placed 2-3 cm below the soil surface in furrows as deeper sowing may

Table 2. Impact of seed rate on seed/ fibre yield (t/ha) and fibre fineness of dual purpose linseed

Seed rate	Palampur			Kanpur		
(kg/ha)	Seed yield	Fibre yield	Fibre fineness (Tex)	Seed yield	Fibre yield	Fibre fineness (Tex)
50	0.96	0.51	4.34	1.60	0.85	4.98
75	1.10	0.63	3.09	1.58	0.92	4.90
100	0.85	0.67	2.33	1.34	0.97	4.38
125	0.68	0.73	2.21	1.09	1.08	3.88
CD (P=0.05)	0.09	0.05	-	0.05	0.06	-

Source: Annual progress report, AICRP on Linseed (2000-01)

Table 3. Impact of nitrogen application on seed, fibre yield (t/ha) and fibre fineness

Nitrogen	Palampur			Kanpur		
(kg/ha)	Seed yield	Fibre yield	Fibre fineness (Tex)	Seed yield	Fibre yield	Fibre fineness (Tex)
0	0.59	0.49	3.5	1.09	0.80	4.9
20	0.79	0.58	3.1	1.40	0.93	4.7
40	1.03	0.69	2.8	1.52	1.00	4.5
60	1.18	0.77	2.6	1.60	1.05	4.0
CD (P=0.05)	0.09	0.05	-	0.05	0.06	-

Source: Annual progress report, AICRP, 2000-01

result in staggered emergence with irregular growth and poor yield as well as fibre quality. Thinning operation is necessary to maintain optimum plant population in lines. This operation may be carried during first weeding. Singh and Husain (2003) recoded optimum yields of seed and fibre from dual purpose linseed 'Rashmi' when thinning was done during 20-25 DAS at a narrow plant spacing of 2-4 cm apart.

Fertilizer application

The first attempt on the effect of different salts on Indian linseed was made by Howard and Khan (1924), who observed positive impact of spraying sodium nitrate and its mixing in upper layer of alluvial soil. Application of phosphorus (P) hastens root development and promotes its deep penetration, which prevents lodging and takes care of the plant during times of moisture stress (Richharia, 1950). Optiz and Egglhuber (1940) reported that potassium (K) could increase the effect of N fertilizers and mitigate the injurious effect of excessive N and opined that oil flax (linseed) requires more N than fibre flax. However, recent studies under AICRP on Linseed revealed that dual purpose linseed and seed type linseed respond equally to the fertilizer application. Application of recommended dose of fertilizer *i.e.*, 60- 90 kg N + 13.2- 17.6 kg P + 25- 33.3 kg K/ha (irrigated) could be helpful in realizing the yield potential of dual purpose varieties. Application of 5 t FYM/ha can save 25% of inorganic fertilizer. Badiyala *et al.* (1998) observed a significant increase in the plant height, grain as well as fibre yield due to application of 90 -13.1 kg N-P/ha along with 10 t FYM /ha over lower doses. Application of 60 kg N/ha brought significant increase in the seed and fibre yield and fibre fineness of dual purpose linseed 'Rashmi' over its lower rates at Kanpur (Husain *et al.*, 2003). Similar results were also observed at Palampur (Table 3). Application of 75 - 26.4 - 25 kg N-P-K brought significant increase in the seed and fibre yield and fibre fineness of 'KL -187' over its lower rates at Palampur (Anon, 2001) and justifies the importance of P and K application for this crop.

Irrigation

Dual purpose linseed requires 2-3 irrigations for its optimum production and quality of the fibre. The crop grown on red sandy soil of Bangalore, Karnataka gave 23.78, 47.51 and 21.55% higher seed, fibre, and oil yield with two irrigations at 40 and 65 DAS than 60 and 90 DAS, respectively (Nagaraja *et al.*, 1997).

Weed management

Weeds not only impede the growth of the young plants and reduce yield, but also very often get harvested with the crop, which interfere with the retting process and deteriorate quality of fibre in particular. Mostly, all the weeds of *rabi* season compete with the crop grown for either seed or fibre purpose and their management during 3-6 weeks after sowing provides optimum yield (Husain *et al.*, 2009). Pre emergence application of pendimethalin @ 1 kg /ha provide good control of most of the weeds, whereas isoproturon 75 WP @1 kg/ha + 2, 4-D (sodium salt) @ 0.5 kg/ha manage the weeds properly in the standing crop, but reduce the plant height over isoproturon alone (Husain *et al.*, 2003). In the areas where

isoproturon has become tolerant for the control of *Phalaris minor*, clodinafop 80 g/ ha may be used (Anon, 2008).

Insect- pests and disease management

Flax is attacked by numerous insect- pests right from germination to its maturity. Termite (*Odentotermes obesus*), cut worm (*Agrotis* sp.) and red backed cut worm (*Euxoa ochrogaster*) during seedling stage; semilooper (*Plusia orichalcea*), leaf miner (*Chromatomyia horticola*), Bihar hairy caterpillar (*Spilosoma obliqua*), flax flea beetle (*Longitarsus parvulus* and *Aphthona euphorbiae*), thrips (*Thrips angusticeps* and *T. lunaris*) during vegetative phase and bud fly (*Dasyneura lini*) and gram pod borer (*Helicoverpa armigera*) during reproductive stage of the crop are of economic importance (Malik,1999). Wilt (*Fusarium oxysporum* f. *lini*), powdery mildew (*Odium lini*), rust (*Melampsora lini*) and Alternaria blight (*Alternaria lini*) are the most important diseases of linseed at different stages of the crop (Saharan, 1999). Straw of wilt affected plants require shorter time for retting as compared to healthy straw and manufactural value decreases by 50-60% (Kolte and Fitt, 1997). The spore of rust on the stem portion renders the straw unfit for scutching, which adhere firmly to the fibre and impede its spinning. The fibres become brittle and break in the process of scutching (Flor, 1935).

An integrated approach for the management of insect-pests and diseases, like growing of resistant cultivar like 'Jeevan', 'Nagarkot' and 'Meera', treating seed with *Trichoderma viride* (4 g/kg seed) or Topsin M (2.5 g/kg seed), crop rotation and sowing at optimum time, help in combating the wilt and rust diseases. Need based application of pesticides is essential for a healthy crop rearing.

Harvesting

It is important to harvest flax crop at optimum stage. If the plants are harvested early, the fibre is finely textured and soft but weak and the yield is low, whereas more lignifications take place and fibre looses fineness in late harvesting. It would be advantageous to harvest the crop at yellow ripe stage of stem, when lower two third portion of the stem is defoliated *i.e.* capsule maturity stage without loss of fibre as well as seed quality (Scheer-Triebel *et al.*, 2000 and Gupta *et al.*, 2006). Thereafter, plants are tied into bundles of suitable diameter and sent for threshing.

Fibre making

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". After retting, there is a still straw or coarse fibre, remaining which requires dressing. Dressing the flax is the term given to removing the straw from the fibers. It consists of three steps, *breaking*, *scutching*, and *hackling*. The breaking breaks up the straw which is scraped from the fibers in the scutching process. Thereafter, fibre is pulled through hackles to remove the last bits of straw.

Retting

Retting is an important operation in the production system of flax fibre since improper retting results in poor quality fibre. Rotting is brought about by a complex enzymatic action of microbes naturally present in retting water. Microbes responsible for two systems of retting are different. The completely ret flax bundle feel soft as well as slimy and the inner woody part springs away from the fibres when wrapped around a finger. The stalk of flax / dual purpose linseed may be retted either under water or under dew. Bacteriological, chemical and enzymatic retting methods are also prevalent in advanced countries.

Under water retting, the bundles of straw are submerged, 8-10 cm below the surface of water. Mainly spore forming bacteria (*Clostridium butyricum*) carry out the process. The duration of retting depends upon the temperature of retting water, which is completed in 70-72 hours at optimum temperature of the water (23-27 ^{0}C). The retted straw with loosen fibre are then sun dried for 5-7 days to make it ready for scutching. There are three methods of under water retting namely; *pond, stream,* and *container retting*. Retting is best done in clear and slowly flowing water of canal and even rivulets. Pond retting is done in shallow pool of water, which produces dirty, over ret as well as damaged fibre of lower quality with in a week. Container (non metal) retting is done and takes 4 to 5 days for complete retting, if the water temperature is kept at 80°F. Stream retting takes longer time (2-3 weeks) than pond retting and is extensively practiced in Belgium. The end product of stream retting is of superior quality, pale yellow in colour and more silvery.

In dew retting (field retting), the flax is spread in a large field and is exposed to atmosphere to collect dew on it. The enzyme produced by fungi and bacteria cause decomposition of pectin hydrolysis. This method produces dark grey fibre of highest quality in a month or more and produces the least pollution. This method of retting is practiced in European continent.

Chemical retting shortens the retting process, but chemicals will affect the strength and colour of fibre. The chemicals used are soda ash, oxalic soda and caustic soda in warm / boiling water or in dilute H_2SO_4 solution. The bark of the stem is first scraped out and cut into pieces to maintain the uniformity. These pieces are completely im-

mersed in the solution of different concentrations of NaOH and HCl for ten hours, thereafter each of them are boiled for 30 minutes. The fibres are separated through washing the stems in cold water and thereafter dried to prevent further fermentation.

In enzyme retting, the stalks are immersed in enzyme mixture, which have cellulase, pectinase and hemicellulase activities. Lignin remains in middle lamellae after enzyme retting and would prevent separation of the fibre bundles.

Breaking, scutching and hackling

The scutching is defined as beating and scraping of the dried stems to separate the fibres. The fibre is separated from retted stalks either manually or mechanically by scutching machine. In manual separation, the small bundles of retted and dried stalk are beaten by hand mallet (*mungri*) on plain and hard surface to split out wooden part of the stalk to get fibre easily. This type of scutching can be done on small scale rightly at farmers' home. In mechanical separation, scutching is done with a classical scutching machine, which gives separately scutched flax and tows. Scutching process frees the bast bundles by removing the bark and woody portions of the stalk.

Subsequent to scutching, the first stage of fibre preparation is a combing process known as hackling. The hackling machine takes lengths of scutched flax and combs them between hank's successively finer pins. The product of the hackling process is called line fibre. Short fibres and fragments of fibres separated during the scutching and hackling process are recovered and marketed as "*scutch tow*" and "*machine tow*", respectively. The scutched long fibre is about 20-30 inches with an average diameter of 0.009 inches. The average length of the cleaned fibre is sorted out into grades according to quality, length and colour of the fibre.

Production economics

Since profitability is the prime concern of farmers, hence the economic analysis of the production of seed type and dual purpose linseed was computed on the basis of the feed back received from the crop growers. Cost of production of seed type and dual purpose was Rs 10,678 and Rs 14,995/ha under Kanpur (UP) conditions, whereas these were Rs 8,689 and Rs 13,052/ha in the vicinity of Palampur (HP), respectively (Table 4). Net monetary return from the dual purpose linseed was quite higher than seed type linseed (Rai *et al.*, 2000).

Constraints in commercialization of flax cultivation in India

Flax fibre production has to meet certain quality parameters as it is a crop of industrial utility. Besides development of improved varieties having quality fibre with good seed yield, refining agro-techniques, proper post-harvest technologies especially retting and scutching techniques along with the testing of quality standards are essential for promotion of this crop.The research related to improvement in scutching

Table 4. Production economic of seed type and dual purpose linseed at Kanpur and Palampur

Input	Kanpur				Palampur			
	Seed type		Dual purpose		Seed type		Dual purpose	
	No./ Quantity	Cost	No./ Quantity	Cost	No./ Quantity	Cost	No./ Quantity	Cost
Human labour (days)	84	3,948	162	7,614	54	3,240	113	6,780
Bullock labour (days)	3	240	3	240	4	400	4	400
Tractor power (hour)	10	1,250	10	1,250	10	1,400	10	1,400
Seed (kg/ha)	25	625	45	1,125	50	1,200	60	1,440
Fertilizers (kg/ha)	NP	1,245	NPK_{25}	1,557	N_{40}	306	N_{65}	497
Irrigation	3	750	4	1,000			2	50
Plant protection (Rs/ha)	1	200	1	200	1	292	1	292
Electric charges (Unit)			150	336			179	134
Rental value of land		2,000		2,000		1,500		1,500
Overhead charges		420		673		351		559
Cost of cultivation		10,678		14,995		8,689		13,052
Yield (t/ha)	1.4 (S)		1.23 (S) 1.03 (F)		1.2 (S)		1.3 (S) 1.2 (F)	
Net return		12,605		29,450		15,311		39,548
B: C ratio		2.18		2.84		2.76		4.03

S: seed, F: fibre, NP: $N_{90}P_{17.6}$

machines and standardization of quality parameters for the grading of fibre need to be addressed on priority basis. Retting and scutching of flax fibre is a hard task for the farmers, it would be better to provide incentives for the construction of small retting tanks and installation of scutching machines at village level so as to relieve farmers from this tedious job. The scutching machines may also be provided at farmers' cooperatives for community uses at cheaper rates. The retted and dried flax straw loose the perishable attribute and can be stored up to couple of months, hence, flax growers can use the machine at first cum first serve basis. An organized system of procurement of flax fibre may gear up the cultivation of this crop in the country.

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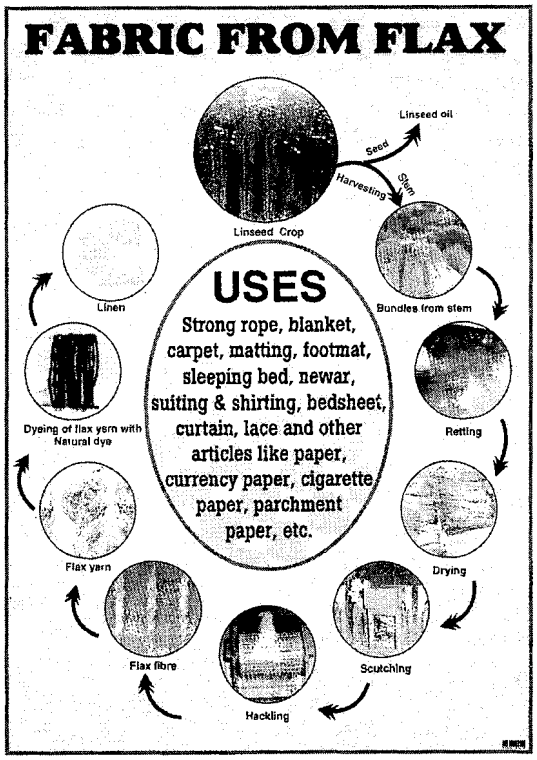

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