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Status, scope and prospects for linseed cultivation with special reference to Nagaland, Northeast India

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ABSTRACT

Linseed/ Flaxseed (*Linum usitatissimum*) popularly known as Alsi/Tisi in India is an important dual purpose (seed and fibre) *rabi* oilseed crop. Apart from numerous industrial applications, linseed is also emerging as a 'superfood' as more scientific research in the field of diet and disease points to its health protective properties. In India a total area of 1.7 lakh ha is under linseed cultivation with a total production of 1.1 lakh tonnes and productivity of 644 kg ha^{-1}. In Nagaland linseed is grown in an area of 5870 ha with a total production and productivity of 4770 metric tonnes and 813 kg ha^{-1} respectively contributing only 3.5 % and 4.3 % to the national area and production due to very low area coverage of the crop in the State. There is tremendous scope for area expansion of linseed in Nagaland, due to its potential to be adopted as an economical crop in rice based cropping systems under residual nutrients and moisture conditions. Rice is the major cereal crop and a staple food in Nagaland occupying a total area of 218810 ha out of which TRC/WRC paddy (Terraced rice cultivation/ wet rice culture) occupies 128070 ha. After harvesting of TRC/WRC paddy most of the lands are left fallow and these lands can be targeted for area expansion of linseed either as rainfed pure crop or *Paira/Utera* crop. Given the present applications scope of linseed in various industries and the prospects for area expansion in Nagaland, there is tremendous scope and opportunity for boosting the production and commercialization of the crop in the State.

1. Introduction

Linseed (*Linum usitatissimum*) popularly known as Alsi/Tisi in India is an important dual purpose (seed and fibre) *rabi* oilseed crop. The common names Linseed and Flax are used in Asia and North America respectively. Linseed contains 33 to 47% oil and due to its quick drying and water resistant properties linseed oil is used in a number of industrial applications viz., paints, varnishes, linoleum flooring, printing inks, oil clothes, patent leather, waterproof fabrics, soaps, etc. The oil cake contains 35 to 40% crude protein and is almost comparable to soyabean cake in nutritional value and is a potential alternate protein feed ingredient for livestock and poultry feed. Flax fibers are woven into a fabric generally known as linen Flax. The fiber is also used in manufacturing of twine, rope, webbing, canvas, laboratory papers, cigarette rolling paper and tea bags. For centuries flaxseed have been prized for its health-protective properties. In fact nowadays flaxseed/linseed has been growing in popularity as a 'Superfood' as more and more scientific research in the field of diet and disease research points to its health benefits. It is a rich source of omega-3 fatty acid: alpha linolenic acid (ALA), linoleic acid, oleic acid, digestible proteins, carbohydrates, lignans (phytoestrogen), dietary fibre and an array of antioxidants. Linseed is high in protein content and is a good plant protein source for vegetarians. The high omega-3 fatty acid (ALA)

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content in linseed helps reduce the risk of cardiovascular disease. Soluble dietary fibers found in linseed helps in regulating blood sugar levels whereas, insoluble fibers promotes bowel movement and digestive health. Linseed is also one of the richest sources of plant lignans, which interferes with sex hormone metabolism and prevents hormone receptor sensitive cancers like breast, endometrium and prostrate cancer. Linseed is a self-pollinated annual herbaceous plant with shallow root system and grows up to 1 to 4 ft height depending on variety. The stem is slender and narrow, leaves are glacous green, lanceolate, alternate and sessile and flowers are perfect and complete measuring 1.5 to 2.5 cm in dm and white or blue in color. The capsule/ seed ball is 5 to 9 mm in diameter and contains 4 to 10 compartments and each compartment contains 2 to 3 glossy brown or yellow seeds, which are flat and shaped like apple pip. The texture of seed is crisp and chewy with a plesant nutty taste (Carter, 1996). The cultivars grown for seed/oil purpose are short with more secondary branching whereas, those grown for fibre purpose are tall growing with less branching and well-developed root system. Linseed varieties in India are of two types viz., peninsular types with deep root system and alluvial types, which are shallow rooted with profuse tillering. According to Egyptian records cultivation of wild flax dates back 5000 years to the bronze age. Southwest Asia, including India, Afghanistan and Turkey, and Mediterranean region, including Asia Minor, Egypt Algeria, Spain, Italy and Greece, has been proposed as the centre of origin for small seeded oil purpose and bold seeded fibre purpose types respectively (Millam *et al.,* 2005).

2. Global area and production scenario

Flax is grown in over 47 countries for the purpose of oil and fibre production occupyimg an area of 41.42 lakh ha with a total production of 33.39 lakh tonnes and average productivity of 806 kg ha^{-1} globally (FAO, 2023). In South West Asia and Canada linseed is primarily cultivated for oil purpose whereas, in Russia, China, Egypt and Nothwestern European Coast it is mainly cultivated for high quality fibre covering an area of 2.40 lakh hectares with total production of 8.68 lakh tonnes and productivity of 3613 kg ha^{-1} (Dixit, 2020). In India linseed is grown primarily for seed/oil purpose, although in temperate hill regions like Jammu and Kashmir and Himachal Pradesh it is also cultivated for fibre purpose on a small scale. Globally, India, with a total area and production of 1.7 lakh ha and 1.1 lakh tonnes respectively (Directorate of Economics and Statistics, 2023), holds 5th position both in terms of acerage and production followng China (2.6 lakh ha and 3.4 lakh tonnes), Canada (4.04 lakh ha and 3.46 lakh tonnes), Kazakhstan (13.66 lakh ha and 7.76 lakh tonnes) and Russian Federation (14.92 lakh ha and 13.00 lakh tonnes) however, in terms of productivity India ranks 4th in position with a productivity of 604 kg ha^{-1} following Canada (857 kg ha^{-1}), Russian Federation (871 kg ha^{-1}) and China (1308 kg ha^{-1}) [FAO, 2023]. The productivity of linseed has substantially increased from 533 kg ha^{-1} to 642 kg ha^{-1}during the last 5 years (2017-18 to 2021-22) (Directorate of Economics and Statistics, 2023), due to release of improved high yielding varieties and improved agro-production and protection technologies. The major linseed producing states in India are Madhya Pradesh, Jharkhand, Uttar Pradesh, Chhattisgarh and Odisha accounting for 80% of area and 79% of production (Directorate of Economics and Statistics, 2023). Madhya Pradesh has the largest area (0.47 lakh ha) and production (0.37 lakh tonnes) followed by Jharkhand (0.46 lakh ha and 0.28 lakh tonnes), Uttar Pradesh (0.26 lakh ha and 0.15 lakh tonnes) and Chhattisgarh (0.13 lakh ha and 0.05 lakh tonnes) whereas, in terms of productivity Rajasthan holds first position with a productivity of 1066 kg ha^{-1}followed by Bihar and Madhya Pradesh with productivity of 848 and 783 kg ha^{-1} respectively (Directorate of Economics and Statistics, 2023). According to FAO report, there has been a10-60% decline in linseed production over the last decade almost everywhere in the world, which could have been due to lower returns from the crop compared to most other grains and oilseeds as well as due to removal of subsidies for growing this crop. However, significant increase in linseed production especially in Eastern Europe has been noticed at the same time also there are signs that linseed has once again taken a prominent position in crop science studies indicated by the recent assembly and publication of flax nuclear genome sequence (Wang *et al.,* 2012). In India there has been a significant decrease in acreage (39.6 %) and production (27.2 %) of linseed during the last five years (2017-18 to 2021-22) however, during the same period a significant increase in productivity (20.5 %) has been recorded (Directorate of Economics and Statistics, 2023) this indicates that the present status of linseed production in the country could be increased 2-3 fold by upscaling the area coverage of the crop.

3. Global market trends and prospects

During the year 2021, linseed was the world's 871st most traded product with a total trade of $1.34B accounting for 0.0064 % of total world trade and registering a 36.4% increase in trade from 2020 ($981M) to 2021 ($1.34B). Russia was the top exporter of linseed during the year 2021 registering an export of $447M followed by Canada ($272M), Kazakhstan ($265M), Belgium ($82.8M), and Poland ($75M) accounting for 33.4, 20.3, 19.8, 6.19 and 5.61 % of global linseed exports respectively whereas, Belgium was the top importer of linseed registering an import value of $348M during the year 2021 followed by China ($317M),

United States ($130M), Germany ($109M) and Poland ($85M) accounting for 26, 23.7, 9.72, 8.15 and 6.35 % of global linseed imports respectively (Observatory of Economic Complexity, n.d.$_a$). During the year 2021, India was ranked 13th and 78th globally in terms of export and import of linseed registering a trade value of $13.5M and $153K respectively, with linseed registering 802nd and 1158th rank in terms of most exported and imported product respectively in India. Germany, United States and Netherland were major importers of linseed from India registering trade value of $4.09M, $3.14M and $3.11M respectively whereas major importers of linseed to India were Nepal, Switzerland and United Arab Emirates registering import value of $106K, $23.5K and $13.9K respectively (Observatory of Economic Complexity, n.d.$_b$). Based on geography the linseed market can be further segmented into North America, Europe, Asia-Pacific, South America and the rest of the world registering 38 %, 26 %, 20 %, 9 % and 7% of the overall market share respectively during 2021 (Industry ARC, n.d.). Asia-Pacific is expected to be the fastest-growing segment over the forecast period 2022-2027 (Industry ARC, n.d.). This region is the largest producer of linseed in the world with Kazakhstan, China, India and Australia as major producers in the region. Asia Pacific is also the largest consumer of linseed in the world with budding demand for linseed and its byproducts for domestic as well as industrial applications. The presence of developing countries like China and India with rapid population growth and urbanization, increasing geriatric population, growing number of middle class families with disposable income and the strong presence of linseed oil manifacturers and suppliers is expected to fuel the growth of linseed market in Asia Pacific during the forcasted period. Based on applications linseed market can be segmented into foods, beverages and supplements, cosmetics and beauty, pharmaceuticals, animal feeds ingredients, linen, paints, varnishes and lubricants, leather and other industries. Increasing awareness about the health benefits of linseed, increasing prevalence of diseases, changing consumer perception towards natural and organic ingredients, rising vegan population, increasing health conciousness and increasing disposable income and spending on premium lifestyle are major factors expected to propell market growth for fortified food and beverage, pharmaceutical, cosmetic and nutraceutical supplements industries. Global market for linseed oil from food application is anticipated to surpass $910M by 2028 at a CAGR of 5.5 % (Global Market Insights, 2022). During the year 2021 the food segment held the largest share owing to heavy consumption of linseed as a superfood and the food along with pharmaceutical and linen segment is estimated to grow with a CAGR of 4.2 % over the forecast period 2022-2027 (Industry ARC, n.d.). Rapid population growth, industrialization, urbanization and infrastructure development especially across emerging developing countries like China, India and Indonesia have led to a rapid rise in construction activities generating a high demand for linseed oil for its applications in flooring, painting and varnishing as well as for household applications. Linseed oil market surpassed $2.5B in 2021 and is estimated to grow to over 5.5% CAGR between 2021 to 2028 whereas, the raw linseed oil market is projected to reach over $1.25B by 2028 growing at a CAGR of 5% (Global Market Insights, 2022). Applications of linseed oil cake as a potential feed ingredient in livestock and poultry feeds as an alternative to conventional protein sources like soybean cake is another segment which can boost the market for linseed and its by products. Animal feed protein ingredient market exceeded $234B in 2022 and is expected to grow at 5.5 % CAGR from 2023 to 2032 due to increasing livestock production (Global Market Insights, 2023) to satisfy the increasing demand for animal products.

4. Status of linseed cultivation in Nagaland

The main oilseed crops grown in Nagaland are rapeseed and mustard, soybean, linseed, sesamum, sunflower, groundnut and perilla with a total oilseed area of 69030 ha and total oilseed production of 71720 metric tones (Table. 1) out of which rapeseed/mustard, soybean and linseed collectively accounts for 85 and 90 % of the total oilseeds acreage and production (Directorate of Economics and Statistics, 2021$_a$). Among the oilseed crops, rapeseed/mustard with an area of 27510 ha and soybean with an area of 25190 ha covers approximately 39.9and 36.5 % of the total oilseed area in the State whereas, in terms of production soybean ranks first with a total production of 31870 metric tonnes followed by rapeseed and mustard with a total production of 28060 metric tonnes accounting for 44.4 and 39.1 % of the total oilseed production in the state respectively. Linseed is the next important oilseed crop in Nagaland with an area and production of 5870 ha and 4770 metric tonnes respectively and productivity of 813 kg ha^{-1} (Directorate of Economics and Statistics, 2021$_a$). Major linseed growing districts in Nagaland are Dimapur, Mokokchung, Phek, Wokha, Peren and Mon together accounting for 73 % of the total linseed area as well as production in the state (Table. 2). Dimapur district holds the highest area and production of 1130 ha and 930 metric tonnes respectively followed by Mokokchung district (770 ha and 630 metric tonnes), Phek district (660 ha and 530 metric tonnes) and Wokha district (590 ha and 480 metric tonnes) [Directorate of Economics and Statistics, 2021$_a$]. The importance and potential of linseed to be adopted as an economical crop in rice based sequential cropping has been well marked because of its ability to grow even in marginal and poor exhausted soils. Linseed in Nagaland is mostly

grown on residual moisture and nutrients on rice fallows after harvesting of rice where, the land is ploughed during the month of November or December depending on harvesting of rice followed by broadcasting of linseed @ 20 to 25 kgs/ha. Fertilizers like DAP are used by some farmers and generally most of the intercultural operations are excluded and the crop is havested from February to March. Linseed is grown primarily for seed/oil purpose in Nagaland and varieties like Ruchi, Padmini and Neelam are used. Improved varieties T-397, Shekhar and Kota Barani Alsi-4 have also been distributed to farmers during frontline demonstrations conducted by ICAR-AICRP Linseed, Medziphema Centre in Dimapur, Mokokchung and Mon district with good yield performance. After harvesting of the crop the straw is usually burned or used as mulch for cassava and maize.

5. Prospects for linseed area expansion in Nagaland

Linseed, although the third most important oilseed crop in Nagaland with respect to area and production, covers only 8.5 and 6.5 % of total oilseeds area and production in the state contributing only 3.5 and 4.3 % to national area and production respectively. The productivity of the crop in the state (813 kg ha^{-1}) is almost at par with other major linseed growing states in the country however, due to very low area coverage of the crop the contribution of the state to national production is almost negligible. There is tremendous scope for area expansion inorder to boost the production of linseed in the state. Rice is the major cereal crop and a staple food crop in Nagaland occupying a total area of 218810 ha (Table. 3) out of which Jhum paddy occupies 90740 ha and TRC/WRC (Terraced rice cultivation/ wet rice culture) paddy occupies 128070 ha Directorate of Economics and Statistics, 2021_b). After harvesting of TRC/WRC paddy, some of the rice fallows are used for cultivation of oilseed crops like rapeseed/mustard and sunflower, however, most of the TRC/WRC areas are left fallow and these lands can be targeted for area expansion of linseed cultivation. Linseed, being a crop which is usually grown on marginal and sub marginal lands on residual moisture, can be suitably grown as a sequence crop on these TRC/WRC fallows, following early or medium maturing paddy varieties, as these are usually heavy soils with have sufficient residual moisture. Another opportunity for area expansion of linseed in the State is the introduction of *Paira*/*Utera* linseed crop in TRC/WRC fields. Relay cropping of linseed in standing paddy crop is known as *Paira/Utera* system, which covers 25% of linseed area in India. In this system land preparation is excluded and the crop is grown on residual nutrients and moisture where, the seeds are broadcasted in standing paddy crop at 10 to 15 days (flowering to dough stage) before harvesting of paddy. With respect to land preperation and sowing of rabi crops after TRC/WRC, specially in those areas where traditional long duration paddy varieties are used, delay in sowing of succeeding rabi crops is a major issue since the turn around time after harvesting of TRC/WRC paddy is more and this coupled with the use of long duration traditional TRC/WRC paddy cultivarsfurther aggravates the problem resulting in delayed sowing and lower yields of suceeding rabi crops. The major potential and scope of *Paira/Utera*linseed *crop*, in context of Nagaland, is that the exclusion of land preparation in *Paira/Utera* linseed crop will ensure that the crop in sown in timein standing paddy crop, specially traditional long duration paddy cultivars, resulting in optimum yield of linseed crop. The productivity of linseed under *Paira*/*Utera* system is generally lower compared to pure linseed crop however, with proper management practices like adoption of improved varieties and supplemental nutrient management the yield of *Paira/Utera* crop can be optimised and additionally due to lower management and cost involved in *Paira/Utera system* benefit cost ratio of this system is almost comparable to that of pure linseed crop. Frontline demonatrations conducted during 2018-2019 by ICAR-AICRP Linseed, Medziphema Centre reported lower cost of cultivation (Rs. 6100 ha^{-1}) under *utera* system compared to rainfed system (Rs.10100 ha^{-1}) resulting in higher average benefit cost ratio of 3.37 under *utera* system compared to rainfed system which recorded average benefit cost ratio of 2.81 despite recording higher net returns of Rs. 18300 ha^{-1} as compared to net returns of Rs. 14475 ha^{-1}recorded under *Paira/Utera system*.

6. Conclusion

Given the present national and international scenario of linseed in terms of applications scope as raw materials in various industries and given the prospects for area expansion of linseed in Nagaland, there is tremendous scope and opportunity for boosting the area coverage, production and commercialize of the crop in the State by adopting the crop either as rainfed pure crop in TRC/WRC fallows in sequence with short/medium duration paddy cultivars or as a *Paira/Utera* crop in TRC/WRC fallows as a relay crop in long duration traditional paddy cultivars. Utilization of these TRC/WRC fallows in the state withsuitable technology interventions will not only add to enhancing farmer's income but also contribute towards national area and production of this important oilseed crop.

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Table 1. Area and production of oilseed crops in Nagaland during the year 2020-21

Crop	Area (Ha)	% of Total Oilseeds Area	Production (MT)	% of Total Oilseeds Production
Rapeseed/ Mustard	27510	39.9	28060	39.1
Soyabean	25190	36.5	31870	44.4
Linseed	5870	8.5	4770	6.7
Sesamum	3750	5.4	2320	3.2
Sunflower	2730	4.0	1770	2.5
Perilla	2560	3.7	1560	2.2
Groundnut	1060	1.5	1130	1.6
Castor	360	0.5	240	0.3
Total	69030		71720	100.0

(Source: Directorate of Economics and Statistics, 2021_a)

Table 2. Area, production and productivity of linseed in Nagaland during the year 2020-21

District	Area (Ha)	% of Total Area	Production (MT)	% of Total Production	Productivity kg ha^{-1}
Dimapur	1130	19.3	930	19.5	823
Mokokchung	770	13.1	630	13.2	818
Phek	660	11.2	530	11.1	803
Wokha	590	10.1	480	10.1	814
Peren	580	9.9	470	9.9	810
Mon	560	9.5	450	9.4	804
Kohima	470	8.0	380	8.0	809
Tuensang	360	6.1	290	6.1	806
Zunheboto	280	4.8	230	4.8	821
Longleng	250	4.3	200	4.2	800
Kiphire	220	3.7	180	3.8	818
Total	5870		4770		

(Source: Directorate of Economics and Statistics, 2021_a)

Table 3. Area under paddy cutivation in Nagaland during the year 2020-21

District	Area (Ha)		
	Jhum Paddy	TRC/WRC Paddy	Total Area
Dimapur	9040	41950	50990
Mon	15880	7420	23300
Wokha	10040	10580	20620
Peren	6300	12390	18690
Tuensang	10010	7620	17630
Phek	1620	15970	17590
Mokokchung	9290	7820	17110
Kohima	5130	11680	16810
Zunheboto	9200	5850	15050
Kiphire	8430	3780	12210
Longleng	5800	3010	8810
Total Area	90740	128070	218810

(Source: Directorate of Economics and Statistics, 2021_b)