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A yield study on water retting and mechanical extraction of Indian linseed fibre (*Linum usitatissimum* var. RLC 92)

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ABSTRACT

Linseed (*Linum usitatissimum* L.) is cultivated across India predominantly as an oilseed crop, and its potential as a source of bast fibre for textile applications remains largely under-exploited. Unlike dedicated fibre-type flax cultivars, dual-purpose linseed genotypes combine seed and fibre production but are generally associated with a comparatively lower fibre content. The present study quantifies the stage-wise mass balance obtained during water retting and mechanical decortication of the Indian dual-purpose linseed variety RLC 92. Fifty kilograms of dry linseed stems were subjected to seven days of water retting followed by seven days of sun drying, mechanical scutching, and manual hackling. The process yielded 43.5 kg of retted, dried stem (87.0% of the initial weight), 8.5 kg of crude fibre after scutching (17.0%), and 6.2 kg of clean, textile-grade fibre after hackling (12.4%), comprising 3.8 kg of long-line fibre (7.6%) and 2.4 kg of tow (4.8%). The extraction sequence was also associated with a marked visual improvement, the stem colour changing from greenish-brown to a lustrous light greyish-golden shade. The observed recovery is discussed in relation to previously reported fibre-content ranges for fibre-type flax and dual-purpose linseed genotypes, confirming that dual-purpose Indian linseed can be processed into usable textile-grade fibre through conventional retting and mechanical extraction.

Keywords: Linseed, *Linum usitatissimum*, Water retting, Scutching, Hackling, Fibre yield, Mass balance, Bast fibre

1. Introduction

Linum usitatissimum L. is a self-pollinated crop grown for both oil and fibre, and its cultivated forms are broadly grouped into fibre-type flax, oil-type linseed, and dual-purpose linseed depending on the trait for which the crop has been bred and the agro-climatic conditions of the growing region. In India, the crop is grown mainly for its oil, and dual-purpose linseed genotypes with usable fibre potential occupy only a limited area of cultivation, even though every part of the plant, including the straw, can in principle be commercially valorised.

The straw obtained after seed harvest is frequently treated as agricultural residue and either burnt or left in the field, despite bast fibre being present in its outer stem tissue. Realising the fibre value of this straw requires a retting step to loosen the fibre bundles from the woody core, followed by mechanical scutching and hackling to separate and refine the fibre. While these unit operations are well documented for dedicated fibre-flax, quantitative process data — specifically, how much usable fibre is actually recovered at each stage — are scarce for Indian dual-purpose linseed genotypes, making it difficult to judge the practical feasibility of using such straw as a textile fibre source.

The present study addresses this gap by tracking the stage-wise mass balance of straw processed from the dual-purpose linseed variety RLC 92 (popularly known as “Nilam”), through water retting, sun drying, scutching, and hackling, and by comparing the resulting fibre yield with previously reported values for fibre-flax and other linseed genotypes.

2. Materials and methods

2.1 Plant material

Dry stems of the dual-purpose linseed variety RLC 92 were procured from the College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Bemetara, Chhattisgarh, India. A total of 50.0 kg of dry stem was used as the raw material baseline for the extraction process.

2.2 Water retting

The stems were water retted in a cemented retting tank located at the Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur. Retting was carried out at ambient (room) temperature for a period of seven days, after which the stems were removed from the tank.



Figure 1. Linseed Plant



Figure 2. Water Retting of Flax Fiber

2.3 Sun drying and mechanical extraction



Figure 3. Sun Dried, Scutching and Hackling of Flax Fiber

The retted stems were sun dried for seven days. The dried stems were then passed through a mechanical scutching machine to break and separate the woody core (shives/hurds) from the fibre. The scutched crude fibre was subsequently hackled manually using a flax hackling comb fitted with metal pins to remove residual shive and short broken fibrils, and to align the fibre bundles into finer, textile-grade fibre.

Hackling separated the fibre into a long-line fraction (premium quality) and a short tow fraction (coarser quality).

2.4 Yield calculation

The weight of material was recorded after each processing stage (pre-retting, post-retting and drying, post-scutching, and post-hackling). The percentage yield at each stage was calculated relative to the initial 50.0 kg raw stem weight using the following relation:

$$\text{Yield (\%)} = \left(\frac{\text{Weight at stage}}{\text{Initial raw stem weight}} \right) \times 100$$

3. Results

3.1 Stage-wise weight and yield

Table 1 presents the weight recorded at each processing stage together with the corresponding percentage yield relative to the initial raw stem weight. Water retting and the subsequent sun-drying cycle reduced the stem weight from 50.0 kg to 43.5 kg, a loss of 13.0% attrib-

utable to the dissolution of pectin and other water-soluble organic matter during retting. Mechanical scutching of the retted, dried stem separated 8.5 kg of crude fibre (17.0% of the initial stem weight) from 35.0 kg of woody shives. Manual hackling of this crude fibre further yielded 6.2 kg of clean, textile-grade fibre, corresponding to an overall yield of 12.4% of the initial raw stem weight.

Table 1. Stage-wise processing weight and yield (%) relative to initial raw stem weight

S. No.	Process Stage	Weight (kg)	Yield (%) [(stage wt./50.0) × 100]
1	Initial raw stem (pre-retting) baseline	50.0	100.0
2	Post-retting and sun-dried stem	43.5	87.0
3	Post-scutching crude fibre	8.5	17.0
4	Post-hackling fine (textile-grade) fibre	6.2	12.4

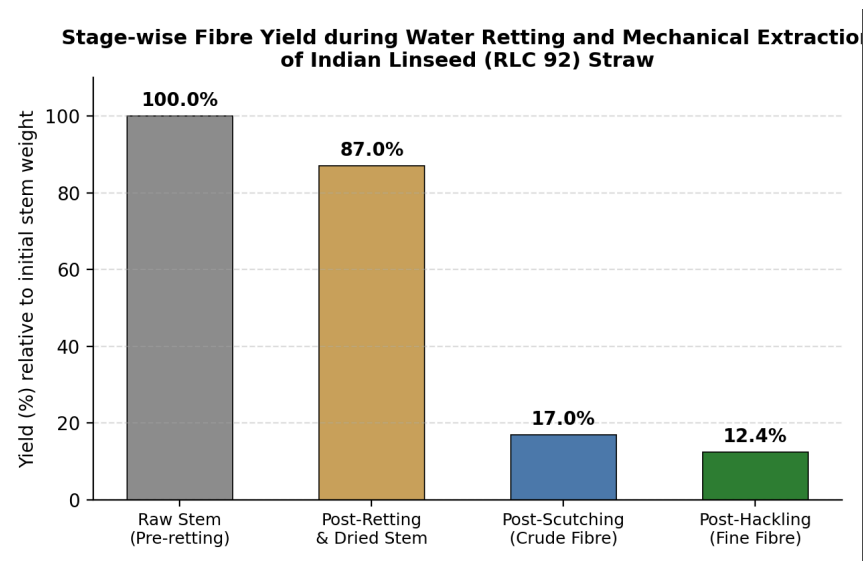


Figure 1. Stage-wise fibre yield (%) during water retting and mechanical extraction of RLC 92 straw

3.2 Fine fibre fractionation

The 6.2 kg of fine fibre obtained after hackling was further categorised by fraction, as shown in Table 2. Long-line fibre, representing the premium-quality, well-aligned fraction, accounted for 3.8 kg (7.6% of the initial stem weight), while the coarser short-tow fraction accounted for 2.4 kg (4.8%). An additional 2.3 kg was removed as hackling waste, consisting of short, broken fibrils and dust.

Table 2. Fractionation of hackled fine fibre

Fibre Fraction	Weight (kg)	% of Initial Stem Weight
Long-line fibre (premium quality)	3.8	7.6
Short tow fibre (coarser quality)	2.4	4.8
Hackling waste (broken fibrils/dust)	2.3	4.6

3.3 Visual and qualitative observations

A distinct colour change was observed over the course of processing: the initial greenish-brown dry stems turned into a lustrous, light greyish-golden fibre after the completion of the seven-day water retting and seven-day sun-drying cycle, indicating adequate microbial retting action. Scutching removed the majority of the woody shive, and the subsequent manual hackling completely detangled the fibre bundles, producing fibre that was clean, smooth, non-sticky, and well aligned in parallel.

4. Discussion

The 13.0% weight loss recorded during water retting and drying is consistent with the mechanism of water retting reported in flax, in which the dissolution of pectin and other water-soluble constituents from the stem accounts for a measurable reduction in dry weight during the retting period (Ruan *et al.*, 2015) [1].

The overall fine fibre yield of 12.4% obtained for RLC 92 lies at the lower end of the 10–28% yield range reported across fibre-type flax varieties (Pisupati *et al.*, 2021) [2], but is closely comparable to values reported specifically for dual-purpose and oil-type linseed genotypes. Rennebaum *et al.* (2002) [3] reported a technical-stem fibre content ranging from 15.3% to 30.3% (median 24.4%) across eleven dual-purpose linseed genotypes evaluated over three growing seasons, while Sankari (2000) [4] reported an average bast-fibre content of only 16.9% among linseed genotypes, explicitly noting that seed-type linseed does not compete with dedicated fibre-flax in fibre yield. The comparatively lower recovery obtained for RLC 92 in the present study is therefore consistent with its classification as a dual-purpose, seed-priority genotype rather than a cultivar bred specifically for fibre production.

The long-line fraction recovered in this study (7.6% of the initial stem weight) is lower than the long-line hackled fibre yields of up to 18% of straw mass reported by Grégoire *et al.* (2021) [5] for bast fibre crops processed on optimised, dedicated scutching–hackling equipment. This difference suggests that the manual hackling process used in the present study, while adequate for generating usable long-line fibre, leaves scope for improvement through mechanised hackling and optimised process parameters, which could improve the long-line-to-tow ratio in future work.

Overall, the stage-wise mass-balance approach adopted in this study provides a reproducible quantitative framework for evaluating the extraction efficiency of under-utilised Indian linseed genotypes, and can serve as a baseline against which the effect of retting duration, retting method, and mechanical processing parameters may be assessed in subsequent studies.

5. Conclusion

Water retting for seven days, followed by sun drying, mechanical scutching, and manual hackling, converted 50 kg of dual-purpose Indian linseed (RLC 92) straw into 6.2 kg of clean, textile-grade fibre, an overall yield of 12.4%, of which 7.6% was recovered as premium long-line fibre. These findings demonstrate that dual-purpose Indian linseed straw, although lower yielding than dedicated fibre-flax, can be successfully converted into usable textile-grade bast fibre using conventional water retting and mechanical extraction, supporting its viability as an under-utilised fibre resource for further textile processing such as blended yarn spinning.

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