

Effect of Seasonal Pruning on Shoot Growth and Lac Yield in Different Varieties of Ber (*Ziziphus mauritiana*)

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Research Article

Keywords: Pruning schedule, *Ziziphus mauritiana*, Kusmi lac, Rangeeni lac, shoot regeneration, broodlac yield, agroforestry systems, lac insect settlement

Posted Date: October 31st, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-6991654/v1>

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Agroforestry Systems on January 28th, 2026. See the published version at <https://doi.org/10.1007/s10457-025-01409-z>.

Abstract

Lac, a natural resin of considerable economic value, is secreted by the tiny insect *Kerria lacca*, which thrives on selected host plants. Among these, fruit-bearing ber (*Ziziphus mauritiana*) varieties play a pivotal role, particularly in tribal regions where lac cultivation significantly supports rural livelihoods. Pruning is a crucial agronomic intervention that affects shoot growth characteristics, which in turn influence lac insect settlement and resin production. This study investigates the effect of two seasonal pruning schedules—February (for winter Kusmi crop) and October (for rainy season Rangeeni crop)—on shoot development and lac yield across 23 ber varieties. Experiment was conducted during 2020–21 and it followed a randomized block design in factorial mode (RBD), considering pruning time and ber variety as factors, with Kusmi and Rangeeni lac yields and morphological traits as variables, replicated thrice. Each block included all pruning × variety combinations in a randomized layout. Results indicated that February pruning significantly improved shoot regeneration, showing a 58% increase in shoot number, and yielded 9% more Kusmi lac compared to October pruning. A strong inverse correlation was found between average shoot diameter and broodlac yield ($r = -0.798$ for February and 0.360 for October), suggesting that finer shoots are more conducive to lac insect settlement. These findings highlight the importance of optimal pruning timing to enhance lac productivity and demonstrate that integrating fruit-bearing ber varieties into lac-based agroforestry systems offers dual economic benefits—resin and fruit—providing resilience even in years of lac crop failure. Both genetic (varietal traits) and environmental (seasonal) factors were found to significantly affect lac insect development and resin yield.

Introduction

Lac cultivation is a traditional agro-based activity that plays a crucial role in supporting the livelihoods of rural and tribal communities in India. It offers a renewable, eco-friendly, and sustainable source of income, particularly in resource-constrained regions. The lac insect (*Kerria lacca*) thrives on specific host plants, among which ber (*Ziziphus mauritiana*) holds special significance due to its adaptability to semi-arid climates and its dual-purpose utility—producing both edible fruits and serving as a host for lac insects. This dual-functionality makes ber an ideal component of agroforestry system, allowing farmers to diversify income through both fruit and lac production.

Among the various agronomic interventions, pruning is recognized as a key determinant of success in such integrated systems. Pruning directly affects canopy architecture, light penetration, and shoot regeneration—factors crucial for both fruit production and lac insect settlement. The emergence of new shoots after pruning is particularly important for lac cultivation, as *Kerria lacca* preferentially settles on tender, actively growing branches for feeding and resin secretion.

Empirical evidence supports the multifaceted benefits of pruning. Ram et al. (2005) demonstrated that pruning secondary branches at 20 cm above ground level significantly improved dry matter and crude protein yields. Moreover, pruning at 40 cm enhanced dry leaf biomass, fruit yield, and fuel wood output in

ber trees. The resilience of *Ziziphus mauritiana* in marginal environments has also been highlighted (Shashi et al., 2022), and pruning has been shown to positively influence vegetative growth, flowering, and yield in multiple cultivars (Nanthakumar and Balakrishnan, 2021).

Pruning promotes shoot quality and also facilitates better nutrient allocation within the plant, improving photosynthetic efficiency and reducing intra-canopy competition. In addition, properly pruned trees experience better air circulation and light interception, reducing susceptibility to fungal diseases and improving overall harvest efficiency. From the perspective of lac cultivation, pruning has been linked to increased lac yield due to improved airflow and light availability, which favor insect settlement and resin secretion (Ghosal and Mishra, 2009).

In lac-based agroforestry system, pruning also plays a physiological role by synchronizing host plant growth cycles with the developmental needs of *Kerria lacca*. Timely removal of over-matured or lignified branches stimulates the development of new, succulent shoots suitable for lac inoculation. Conversely, delayed or skipped pruning can result in hardened shoots, poor insect settlement, and decreased resin yield.

Two key seasonal pruning schedules are typically practiced, each aligned with a specific lac strain and production cycle:

- February Pruning: Conducted after harvesting the winter Kusmi lac crop; this encourages shoot growth by July, ideal for Kusmi lac inoculation.
- October Pruning: Carried out after harvesting the monsoon Rangeeni crop; it supports fresh shoot emergence for the subsequent Rangeeni lac cycle.

Despite its importance, adoption of pruning among farmers remains limited. Many growers still perceive that pruning as detrimental, leading to its neglect or improper implementation, thereby constraining lac productivity (Das and Kumar, 2013).

Prior research has shown that shoot characteristics such as diameter, length, and density—which are directly influenced by pruning—have significant correlations with broodlac yield in Swadi Palas, a variant of common palash (Ghosh et al., 2018). Tender, moderately thick shoots are ideal for insect settlement, while overly thick shoots or overly dense shoot growth can reduce efficiency by limiting settlement or increasing internal competition.

Despite the importance of pruning in lac cultivation, few studies have systematically evaluated how pruning timing influences shoot dynamics and lac yield across different *Ziziphus mauritiana* varieties. A critical knowledge gap persists regarding the interaction between pruning schedules and varietal traits, limiting evidence-based recommendations for farmers. Addressing this gap is essential to optimize pruning strategies and enhance lac productivity.

Here, we evaluate the effects of February versus October pruning on shoot growth in ber varieties, correlate shoot morphology with Kusmi and Rangeeni lac yields, and proposes optimized pruning protocols to enhance resin production without compromising fruit yield. These findings aim to strengthen the socio-economic rationale for lac-based agroforestry, particularly for income diversification among tribal farmers.

Materials and Methods

The study was conducted during 2020–21 at the Institute Research Farm of ICAR-National Institute of Secondary Agriculture (ICAR-NISA), Ranchi, Jharkhand, located at 23.35°N latitude and 85.33°E longitude, at an elevation of 2140 feet above mean sea level in the southern part of the Chotanagpur Plateau. The region experiences a subtropical monsoonal climate characterized by hot summers (24°C to 44.5°C) from March to May, and a well-distributed southwest monsoon (June–October) with an average annual rainfall of 1144 mm. Winters (November to February) are cold and dry, with temperatures ranging between 1.1°C and 33.5°C. The hilly topography and deciduous forest cover moderate the local climate.

The soil at the experimental site comprises alfisols (red gravelly and sandy soils) and ultisols (red and yellow soils), which are light in texture, strongly acidic (pH 4.5–5.0), and generally low in nitrogen (178 kg ha⁻¹) and phosphorus (45 kg ha⁻¹), but moderately rich in potassium (200 kg ha⁻¹). The water-holding capacity of the soil is relatively low (36%).

A factorial randomized block design (FRBD) with three replications was adopted, incorporating two main factors: pruning time (February, after the harvest of the winter Kusmi crop, and October, after the harvest of the monsoon Rangeeni crop) and 23 genotypes of *Ziziphus mauritiana* (ber varieties). Each plot represented a unique combination of pruning time and ber variety, randomly allocated within each block. The study aimed to evaluate the effects of seasonal pruning on shoot growth parameters and lac yield for both Kusmi and Rangeeni strains of *Kerria lacca*.

The 23 ber varieties used in the study were originally procured from ICAR-CAZRI, Jodhpur, and planted at the Institute Research Farm in 2006 with a spacing of 4 meters, following recommended agronomic practices. Pruning treatments were initiated when the plants reached 12 years of age to assess the impact on shoot regeneration and lac productivity.

A standardized pruning protocol was followed across all treatments, which involved the removal of lac-inoculated, weak, diseased, or dead branches. To ensure uniform regrowth and reduce the risk of disease, slant cuts were made to prevent water accumulation at the cut surface. Pruning in February was carried out during the dormant phase of the plant to stimulate new shoot emergence by July, aligning with the inoculation period for the Kusmi lac crop. In contrast, October pruning was undertaken after the harvest of the rainy season Rangeeni crop—though not a common farmer practice, it was selectively applied to certain branches to generate broodlac for the upcoming Vaisakhi cycle.

Measurement of Shoot Growth Parameters

To assess vegetative growth, the following shoot traits were measured:

- Maximum Shoot Diameter (mm): Measured at the basal point using a digital caliper.
- Number of Shoots per Branch: Total count of newly emerged shoots from each pruning point.
- Average Shoot Diameter (mm): Mean shoot diameter per branch, reflecting growth uniformity and vigor.

All data were standardized on per 10 mm of branch diameter to maintain consistency across treatments. These metrics were selected based on their relevance to lac insect settlement and fruit-bearing potential.

Lac Yield Assessment

Lac yield was assessed at broodlac maturity, identified by the appearance of a yellow spot at the posterior end of the lac cell. Inoculated branches were harvested using sharp, sterilized tools to ensure clean cuts and minimize plant damage. Harvesting was conducted in January–February for the winter *kusmi* crop and in October–November for the rainy season *rangeeni* crop. Only lac-inoculated branches were included in the yield assessment. Total lac yield was recorded in kilograms per plant.

Statistical Analysis

All collected data were statistically analyzed using OPSTAT and Microsoft Excel. Descriptive statistics (mean, standard deviation, coefficient of variation) were computed to describe variability among treatments. Analysis of Variance (ANOVA) was conducted to determine the significance of differences between pruning times, ber varieties, and their interactions with respect to shoot growth and lac yield.

In addition, Pearson's correlation coefficients were calculated to examine the relationships between shoot growth parameters and broodlac yield. This helped identify the key morphological traits associated with enhanced lac productivity.

Results and Discussion

Effect of Pruning on Shoot Growth

The influence of seasonal pruning (February and October) on shoot growth was assessed across 23 *Ziziphus mauritiana* (ber) varieties by evaluating three key parameters: maximum shoot diameter, number of shoots per branch, and average shoot diameter per 10 mm branch diameter (Table 1). Pruning conducted in February significantly enhanced vegetative growth compared to October pruning. Trees pruned in February produced shoots with more favorable characteristics- moderate diameter and higher shoot density- ideal for *Kusmi* lac inoculation. These results can be attributed to the dormant physiological state of the tree during winter, which allows for efficient wound healing and robust shoot

emergence in the subsequent growing season. In contrast, October pruning resulted in reduced shoot proliferation, larger average shoot diameters, and fewer new shoots per unit branch diameter. This may be due to less unfavorable environmental conditions and depleted carbohydrate reserves after the monsoon growing season. Similar findings were reported by Ghosal (2009), who observed that late pruning (e.g., May) reduced both the length and diameter of new shoots compared to pruning performed in February.

Table 1
Shoot growth parameter in February and October pruning *ber varieties*

S N	Factors	Max shoot diameter per 10 mm branch diameter	No of shoot per 10 mm branch diameter	Av shoot diameter per 10 mm branch diameter
Factor A (Variety)				
1	Dandan	3.74	2.98	2.85
2	Aliganj	5.35	2.83	3.49
3	F1 Seb x Katha	4.64	1.70	3.53
4	]Bagwadi	5.37	1.92	4.26
5	Illaichi	4.71	1.32	3.10
6	Thornless	4.27	1.87	3.06
7	Maharwali	4.56	1.64	3.52
8	Kali	5.56	1.64	3.66
9	Cazri Gola	5.69	1.58	3.36
10	Reshmi	5.25	1.64	3.99
11	Katha	4.83	1.62	3.73
12	F1 Seb x Gola	4.89	1.79	3.53
13	BC1 Seb x Tikadi	4.61	1.59	3.75
14	Chhuara	5.17	1.17	3.83
15	Umran	6.38	1.49	4.95
16	Tikadi	7.75	2.77	4.41
17	Jogia	5.02	1.48	3.90
18	Banarsi Karka	6.09	1.91	5.05
19	ZG-3	6.09	1.91	5.05
20	Seb	5.19	1.40	4.34
21	Sanaur 5	5.73	1.91	4.31
Significant at 5% probability level ($p < 0.05$)				

S N	Factors	Max shoot diameter per 10 mm branch diameter	No of shoot per 10 mm branch diameter	Av shoot diameter per 10 mm branch diameter
Factor A (Variety)				
22	Kaithali	4.60	1.58	3.44
23	Banarsi Pewandi	4.07	1.67	2.97
	CD 5%	1.22*	0.71*	0.83*
Factor B (Pruning time)				
	Feb Pruning	5.17	2.18	3.35
	Oct Pruning	5.10	1.38	4.22
	CD=	0.36 ^{ns}	0.21*	0.25*
Significant at 5% probability level ($p < 0.05$)				

Among the 23 varieties, several stood out under February pruning conditions. The variety 'Tikadi' recorded the highest maximum shoot diameter (7.75 mm) and the greatest number of shoots per 10 mm branch diameter (2.77), indicating vigorous growth. 'Banarsi Karka' and 'ZG-3' also performed well, with maximum shoot diameters and average shoot diameters of 6.09 mm and 5.05 mm respectively reflecting uniform and healthy shoot development across branches. The variety 'Dandan' showed a notably highest number of shoot (2.98).

Previous research supports these findings. Khan and Hossain (1992) recommended medium to severe pruning for maximizing fruit quality and yield in ber cultivar 'Narikeli,' as it promoted the growth of healthy, productive shoots. Similarly, Kumar et al. (2014) reported that moderate pruning intensity (around 30%) was optimal for balancing vegetative growth and reproductive output in ber cv. 'Banarasi Karaka.' While heavier pruning (e.g., 60%) can stimulate vigorous shoot regeneration, it may lead to reduced fruit yield due to excessive vegetative dominance.

These findings underline the importance of adopting an appropriate pruning schedule and intensity to optimize shoot traits favorable for both lac insect settlement and fruit production in ber-based agroforestry systems.

Effect of Pruning on Lac Yield

Lac yield performance was evaluated using the output (OP) ratio of broodlac for both the winter *Kusmi* and the rainy season *Rangeeni* crops. The results demonstrated that February pruning led to higher broodlac productivity, with an average OP ratio of 6.0 for *Kusmi* lac, compared to 5.5 for *Rangeeni* lac

under October pruning. This confirms that pruning during the dormant period (February) provides optimal conditions for shoot regeneration and subsequent lac insect settlement (Fig. 1).

Among the 23 ber (*Ziziphus mauritiana*) varieties assessed, certain genotypes exhibited notably higher *Kusmi* lac yields. 'Mahrawali' recorded the highest broodlac output ratio of 8.9, followed closely by 'Banarsi Pewandi' (8.4), 'F1 Seb × Gola' (8.2), 'Thornless' (8.1) and 'Katha' (8.0), indicating their superior suitability for winter *kusmi* lac cultivation. Interestingly, varieties like 'Katha' followed by Mahrawali', F1 'Seb x Gola', 'Thornless' and 'Cazri Gola' showed balanced performance across both pruning seasons with average broodlac output ratios of 7.8, 7.7, 7.6, 7.4 and 7.3 respectively, making them potential candidates for dual-season lac production.

However, it was also observed that some varieties with high-performing shoot growth, such as 'Tikadi' and 'F1 Seb × Katha', exhibited comparatively lower lac yields. This suggests that while robust vegetative traits are essential, the physiological compatibility of shoot tissue with *Kerria lacca*- including bark softness and nutrient content- is equally critical. This observation is consistent with findings by Ghosh et al. (2014), who noted that both intrinsic factors (e.g., varietal traits) and extrinsic factors (e.g., environmental conditions) significantly influence lac insect development and resin production.

Utilizing fruit-bearing ber varieties for lac cultivation presents a dual-benefit strategy. Even if a lac crop fails due to environmental factors or pest issues, fruit production continues to provide income support- an important consideration for risk-averse smallholders.

Relative Performance of February and October Pruning

A comparative analysis of shoot development across pruning schedules revealed distinct physiological responses. February pruning resulted in a significantly higher number of shoots per 10 mm branch diameter (2.18) than October pruning (1.38), emphasizing its benefit for lac insect settlement and fruiting. While the maximum shoot diameter was slightly higher in February, the average shoot diameter was greater in October (4.22 mm) as compared to February pruning (3.35 mm), likely due to the formation of fewer, but thicker, shoots (Table 1).

These patterns indicate that February pruning enhances shoot quantity-critical for lac inoculation- whereas October pruning may favor larger shoot size. Both pruning timings have practical implications, depending on the goal: lac productivity, fruit production, or both. This aligns with observations by Ghosal (2009), who reported reduced shoot growth in late-pruned trees compared to those pruned in February.

Correlation between Shoot Traits and Broodlac Yield

To further explore how shoot traits influence lac yield; Pearson's correlation coefficients were calculated. A strong negative correlation was found between average shoot diameter and broodlac yield under both pruning seasons ($r = -0.798$ for February pruned; $r = 0.360$ for October pruned). This suggests that excessively thick shoots may not favor lac insect settlement, potentially due to hardened bark or lignified tissues that hinder feeding and resin secretion.

Table 2
Correlating among broodlac yield over pruning schedule on shoot traits in ber

Shoot Characteristic	Max shoot diameter		Number of shoots		Avg. shoot diameter	
	Feb	Oct	Feb	Oct	Feb	Oct
Correlation of February pruned Kusmi broodlac yield	-0.534**	-	-0.426**	-	-0.798**	-
Correlation of October pruned Kusmi broodlac yield	-	0.173	-	-0.511**	-	0.360*

For $p < 0.05$, critical $r \approx \pm 0.352$, for $p < 0.01$, critical $r \approx \pm 0.413$,

* & ** Significant at the 5% ($p < 0.05$) and 1% probability level ($p < 0.01$)

In addition, a moderate negative correlation was observed between the number of shoots and lac yield ($r = -0.426$ in February and $r = -0.511$ in October pruning), implying that excessive shoot density may lead to intra-plant competition for nutrients, ultimately reducing lac productivity. Interestingly, average shoot diameter during October pruning showed a weak but positive correlation with lac yield ($r = 0.360$), possibly due to the maturity and better nutrient accumulation in fewer, thicker shoots prior to inoculation.

These findings underscore the importance of maintaining a balance between shoot number and thickness. Pruning strategies should aim to generate moderately thick, actively growing shoots, particularly through February pruning, to optimize broodlac yield.

Conclusion

The study highlights the critical importance of pruning in improving lac productivity on ber trees. February pruning emerges as the most effective for *Kusmi* lac, promoting vigorous shoot regeneration by July, while October pruning, though less common, can be selectively used to generate early broodlac for the Rangeeni crop- provided shoot quality is carefully managed to prevent excessive thickening.

To maximize lac yield and tree health, the adoption of scientific pruning techniques—such as the selective removal of diseased and senescent branches—should be encouraged. Extension efforts must focus on educating farmers about synchronizing pruning with lac inoculation schedules: February for *Kusmi* and October for Rangeeni.

Integrating strategic pruning into ber-based lac agroforestry systems offers a sustainable model for livelihood diversification. By enabling synchronized production of both fruit and lac, such systems enhance resource-use efficiency, ecological balance, and economic resilience. Promoting these integrated practices among tribal and smallholder communities can significantly strengthen income

security and rural empowerment. Further research is recommended to explore genotype-specific pruning responses and long-term effects on lac productivity.

Declarations

Ethical approval

This article does not contain any studies with human participants or higher animals performed by authors. The lac insect used in the study are cultured at Institute Research Farm, ICAR-NISA, Ranchi for research purpose and that there is no need to take any ethical approval.

Conflict of interest

On behalf of all authors, the corresponding author state that there is no conflict of interest.

Funding

This study was funded by Indian Council of Agricultural Research, New Delhi, India under institute project.

Author Contribution

•Jyotirmoy Ghosh (JG): Conceptualization, experimental planning and layout, data compilation, and manuscript writing focusing on the breeding aspects. •Soumen Ghosal (SG): Data analysis and manuscript writing related to agroforestry perspectives. •Vaibhav D. Lohot (VDL): Contribution to manuscript writing on physiological aspects of pruning and shoot development. •Nawalesh K. Sinha (NKS): Manuscript writing with emphasis on biochemical aspects relevant to lac insect–host interactions

Acknowledgement

Authors are thankful to Director, ICAR- National Institute of Secondary Agriculture for providing facilities and funds for conducting this work.

Data availability

The corresponding authors can provide the data supporting the findings of the study upon reasonable request.

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Figures

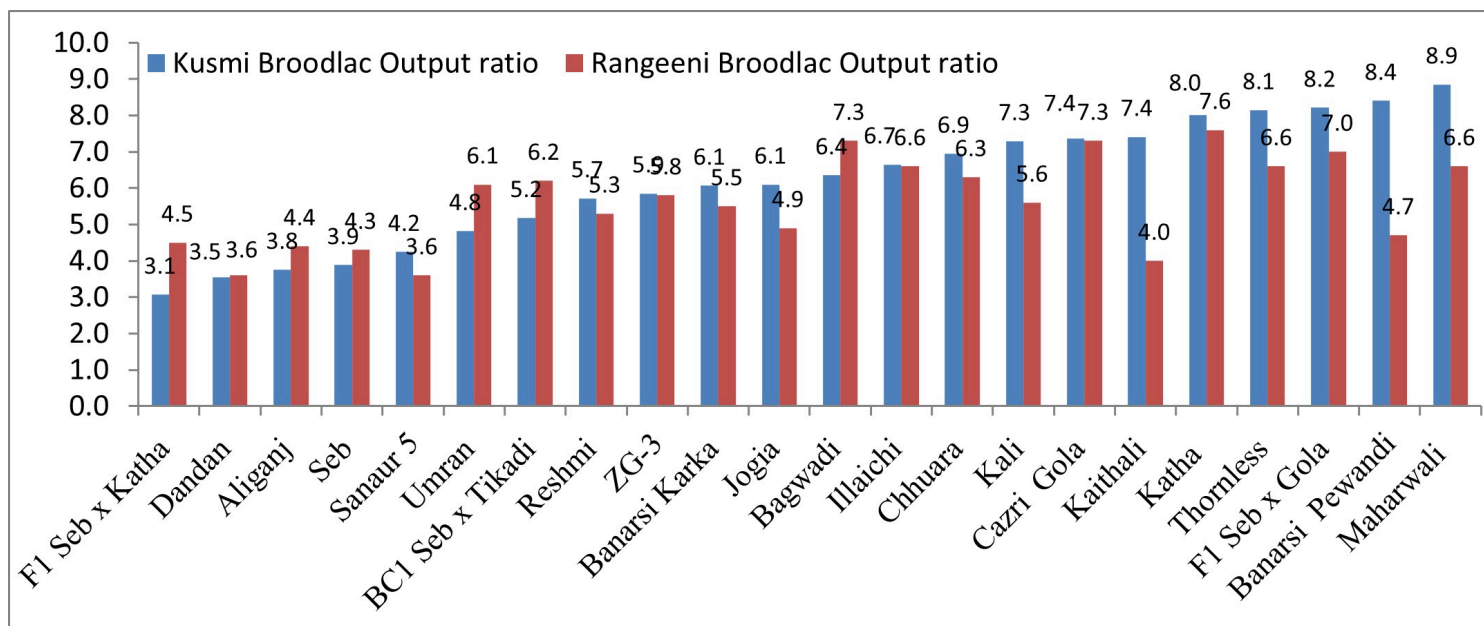


Figure 1

Kusmi and rangeeni broodlac yield output ratio