

## Effect of different spacing of *Ailanthus excelsa* on performance of Lentil varieties in Bundelkhand region

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ARTICLE INFO	ABSTRACT
<p><b>Original Research Article</b>            Received on April 17, 2024            Revised on April 25, 2024            Accepted on May 23, 2024            Published on May 27, 2024</p> <p><b>Article Authors</b>            Prabhat Tiwari,            Pradyumna Deshmukh,            R. P. Yadav, M. J. Dobriyal</p> <p><b>Corresponding Author Email</b>  <a href="mailto:prabhatbhu033@gmail.com">prabhatbhu033@gmail.com</a></p>	<p><b>ABSTRACT</b></p> <p><i>Ailanthus excelsa</i> based agroforestry offer farmers greater economic benefits, enhance soil health, address the decrease in national forest coverage (33%), and supply raw materials for both industries and the rural community's domestic needs. During the research, two different spacing of <i>Ailanthus excelsa</i> examined were 5 m × 4 m and 5 m × 3 m with two different growing conditions, namely sole cropping and intercropping. The data analysis indicates that the lentil varieties cultivated in open conditions had superior development and production characteristics compared to those produced under agroforestry. An analysis was conducted on various growth and yield characteristics of lentil varieties revealing a notable impact of growing conditions on both plant growth and yield parameters. The findings indicate that parameters such as plant height, number of primary branches, number of root nodules per plant at 90 DAS, dry matter accumulation, number of pods per plant, number of days taken to physiological maturity, number of days taken to 50% flowering, straw yield, grain yield, biological yield were greater in IPL 316 variety over L 4727 under sole cropping as well as in agroforestry. <i>Ailanthus excelsa</i> based agroforestry gave higher net returns compared to sole cropping.</p>
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India's population has grown to nearly 1.43 billion and continues to rise daily. The demand for food, fodder, and fuel is putting pressure on natural resources in arid and semi-arid regions. Agroforestry presents a promising solution for achieving social, economic, and ecological sustainability (Pantera *et al.*, 2021). It can help increase India's forest cover from 25% to 33% across various agro-climatic zones. Intercropping agricultural crops with timber trees in woodlots offers advantages over growing only trees, such as lower establishment costs, income during the trees' dormant period, and more efficient use of resources

(Korwar *et al.*, 2014). Agroforestry can enhance food security by providing direct food sources and improving soil fertility, as well as generating cash for purchasing food (Sahoo *et al.*, 2020). Approximately 1.8 billion people globally depend on agroforestry products and services, with about 43% of the world's farmland featuring at least 10% tree cover (Raj *et al.*, 2024). There is a growing recognition of the need for agroforestry across various regions in the country, especially given challenges like soil degradation, deforestation, rising population pressures (both human and livestock), and a declining land-to-person ratio.

Integrating fast-growing tree species into agricultural fields is crucial for increasing tree cover and meeting the raw material demands of wood-based industries (Boruszewski *et al.*, 2021). *Ailanthus excelsa*, also known as Mahaneem or Maharukh, is a significant Multi-Purpose Tree (MPT) that is commonly found across India. To address the needs of both human and livestock populations while preserving land and natural resources, integrating *Ailanthus excelsa* into farming systems is particularly beneficial for agroforestry on degraded soils in arid and semi-arid ecosystems (Verma *et al.*, 2024). This tree is economically important and is being cultivated for uses such as fodder, matchwood, and softwood in these regions (Pal *et al.*, 2023). In the Bundelkhand region, lentil (*Lens culinaris*) is a crucial rain-fed rabi crop. Intercropping lentil varieties with *Ailanthus excelsa* offers an effective way to meet the pulse needs of the area. Consequently, this study aimed to identify the most suitable lentil variety to grow alongside different spacing of *Ailanthus excelsa* in the semi-arid conditions of Bundelkhand.

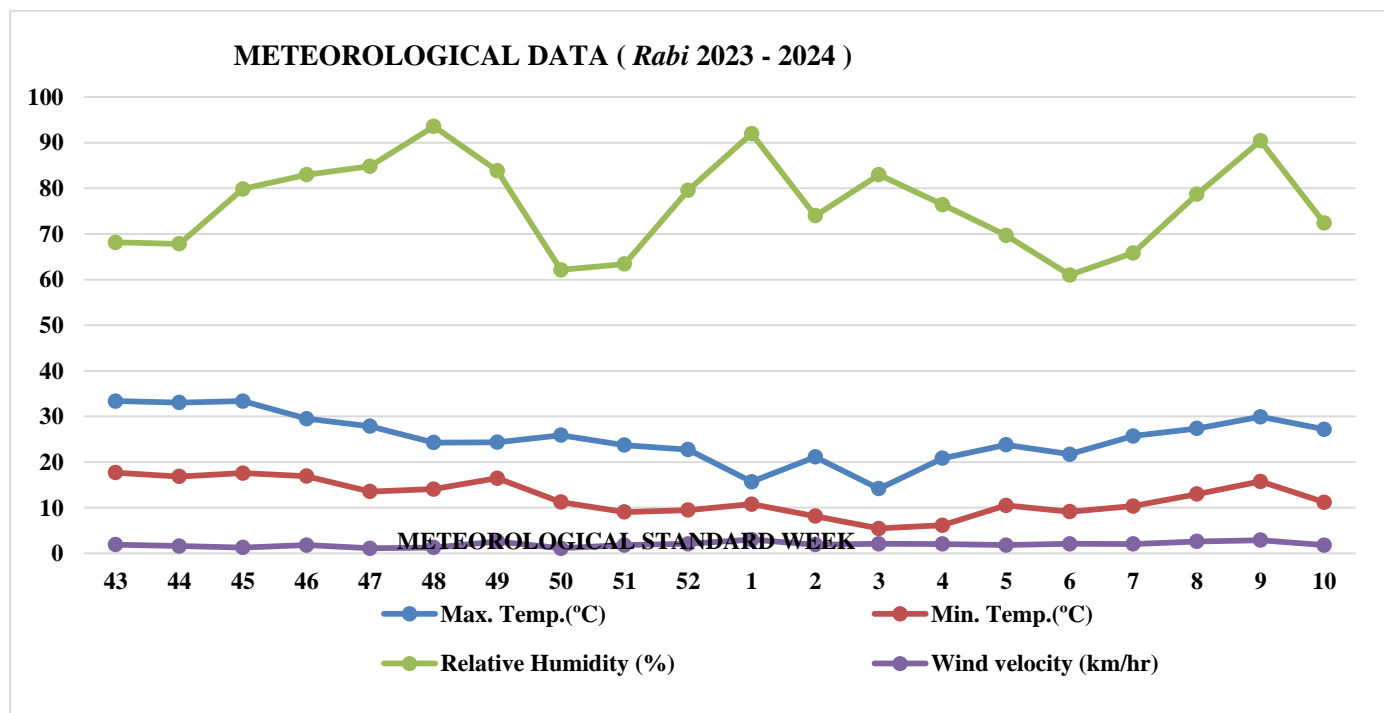
## Material and Methods

### Study Site

The study was conducted in a 4-year-old *Ailanthus excelsa* plantation at the Forestry Research Farm Bhojla, located at Rani Lakshmi Bai Central Agricultural University in Jhansi. This site is situated at an elevation of 284 meters above sea level and falls under agro-climatic zone VIII. The annual rainfall in this region ranges from 870 to 1000 mm, with an average annual temperature of 25.8 °C (fig. 1). The soil is characterized as dry, stony, and shallow, predominantly composed of granite, gneiss, and white sandstone, with low organic matter content.

### Experimental Details

The study was conducted using a two-factor factorial randomized block design consisting of two factors with three replications *i.e.* tree spacing and lentil varieties.



**Fig 1. Meteorological data during Rabi 2023-24 (Source: IGFRI, Jhansi)**

Factor - I (tree spacing) consisted of one open field,  $S_0$  - *Lens culinaris* sole cropping and two spacing of *Ailanthus excelsa*  $S_1$  - *Ailanthus excelsa* (5x4 m) + *Lens culinaris* and  $S_2$  - *Ailanthus excelsa*

(5x3 m) + *Lens culinaris*. Factor - II (Lentil varieties) consisted of  $V_1$  - IPL 316 and  $V_2$  - L 4727. The crops were cultivated using the prescribed set of techniques and practices.

**Table 1. Effect of different spacing of *Ailanthus excelsa* on growth parameters of lentil varieties**

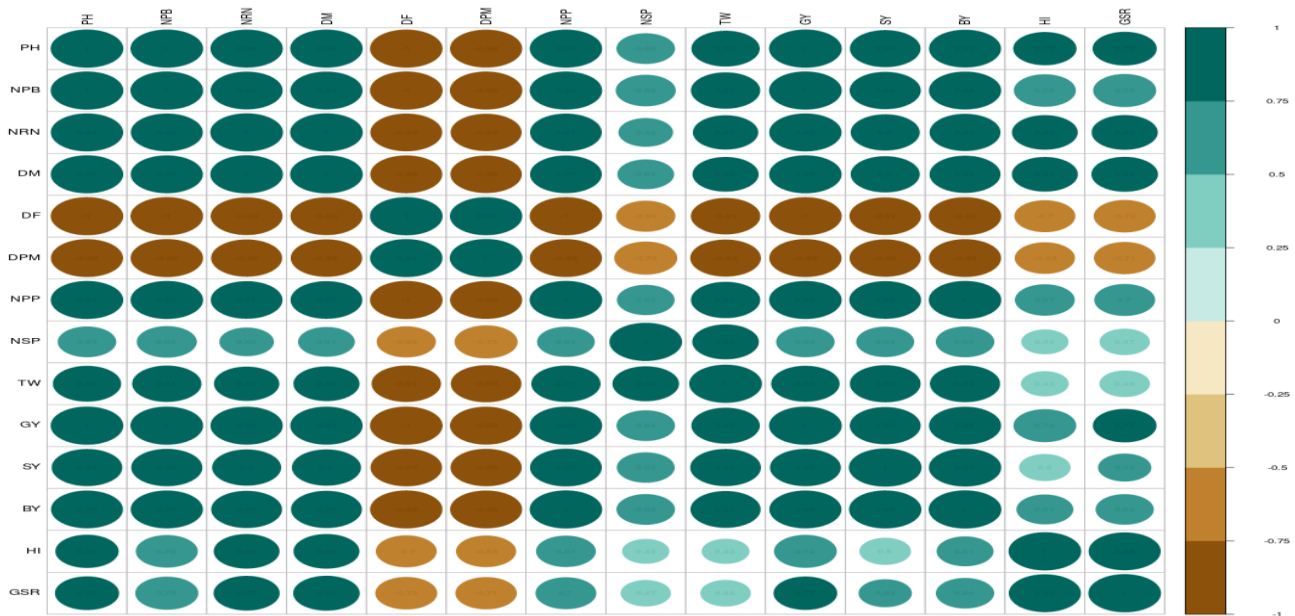
Treatment	Plant Height (cm)	No. of Primary Branches (Plant <sup>-1</sup> )	No. of Root Nodules at 90 DAS (Plant <sup>-1</sup> )	Dry Matter Accumulation (g Plant <sup>-1</sup> )	Days to 50% Flowering	Days to Physiological Maturity
<b>Spacing</b>						
S <sub>0</sub>	36.76	5.31	1.23	9.46	77.43	125.1
S <sub>1</sub>	34.1	4.87	1.07	8.42	86.9	131.55
S <sub>2</sub>	32.93	4.65	1.02	8.13	92.56	135.02
SEm±	0.25	0.06	0.01	0.99	1.97	1.14
CD (P= 0.05)	0.8	0.19	0.03	0.34	6.29	3.64
<b>Lentil Varieties</b>						
V <sub>1</sub>	35.01	5.03	1.12	8.77	83.71	128.6
V <sub>2</sub>	34.18	4.85	1.1	8.57	87.55	132.51
SEm±	0.2	0.05	0.01	0.08	1.61	0.93
CD (P= 0.05)	0.65	0.15	NS	NS	NS	2.97

**Table 2. Effect of different spacing of *Ailanthus excelsa* on yield parameters of lentil varieties**

Treatment	No. of Pods (Plant <sup>-1</sup> )	No. of Seeds (Pod <sup>-1</sup> )	Test Weight (g)	Grain Yield (kg ha <sup>-1</sup> )	Straw Yield (kg ha <sup>-1</sup> )	Biological Yield (kg ha <sup>-1</sup> )	Harvest Index (%)	Grain to Straw Ratio
<b>Spacing</b>								
S <sub>0</sub>	86.93	1.53	22.15	1002	1729	2731	36.70	0.58
S <sub>1</sub>	76.48	1.49	22.12	918	1661	2579	35.62	0.55
S <sub>2</sub>	69.03	1.49	22.08	878	1559	2437	36.01	0.56
SEm±	1.21	0.02	0.2	9.73	18.29	17.95	0.38	0.01
CD (P= 0.05)	3.88	NS	NS	31.07	58.37	57.31	NS	NS
<b>Lentil Varieties</b>								
V <sub>1</sub>	79.42	1.54	22.14	946	1675	2621	36.08	0.56
V <sub>2</sub>	75.54	1.46	22.09	919	1624	2543	36.14	0.56
SEm±	0.99	0.01	0.16	7.94	14.93	14.66	0.31	0.01
CD (P= 0.05)	3.17	0.05	NS	25.37	47.66	46.79	NS	NS

**Table 3. Economics of *Ailanthus excelsa* - *Lens culinaris* based agroforestry system**

Treatment	Cost of Cultivation (₹ 1000)	Gross Returns (₹ 1000)	Net Returns (₹ 1000)	B: C Ratio
<b>Spacing</b>				
S <sub>0</sub>	36.2	66.1	29.9	1.82
S <sub>1</sub>	105.7	290.1	184.4	2.74
S <sub>2</sub>	123.6	321.6	198	2.6
SEm±	-	1.83	1.83	0.02
CD (P= 0.05)	-	5.84	5.84	0.05
<b>Lentil Varieties</b>				
V <sub>1</sub>	87.8	229.5	141.7	2.61
V <sub>2</sub>	87.8	222.4	134.6	2.53
SEm±	-	1.49	1.49	0.01
CD (P= 0.05)	-	4.77	4.77	0.04



**Fig 2. Correlation between plant growth and yield parameters as influenced by *Ailanthus excelsa* tree spacing and lentil varieties**

### Statistical Analysis

The experiment involved the evaluation of various crop growth and yield parameters, and the resulting data was analyzed using statistical techniques. For each variable, the average values were determined, and then analysis of variance (ANOVA) was done to evaluate the impact of the treatments. The least significant difference (LSD) test was used to compare the means of various treatments, with a significance threshold of  $p < 0.05$ .

### Results and Discussions

#### Plant Growth Parameters

The data regarding the growth parameters of lentil varieties cultivated as sole crops and at various spacing of *Ailanthus excelsa* are shown in Table 1. Among different tree spacing, growth attributes of lentil varieties analyzed for parameters like plant height (36.76 cm), number of primary branches per plant (5.31), dry matter accumulation (9.46 g), number of root nodules per plant at 90 DAS (1.23), earlier number of days taken to 50 % flowering (77.43), and earlier number of days taken to maturity (125.1) recorded significantly higher in  $S_0$  i.e., open conditions compared with *Ailanthus excelsa* based agroforestry system. Further, wider spacing in between trees played a key role as  $S_1$  i.e. *Ailanthus excelsa* (5 m  $\times$  4 m) on growth attributes

as compared to closer spacing (5 m  $\times$  3 m) in  $S_3$ . In wider spacing i.e.  $S_1$ , plant height (34.1 cm), number of primary branches per plant (4.87), dry matter accumulation (8.42 g), number of root nodules per plant at 90 DAS (1.07), earlier number of days taken to 50 % flowering (86.9), and earlier number of days taken to maturity (131.55) were reported. Among two lentil varieties  $V_1$  and  $V_2$ , significantly highest growth parameters were observed in  $V_1$  (IPL 316) like plant height (35.01), number of primary branches per plant (5.03), dry matter accumulation (8.77 g), number of root nodules per plant at 90 DAS (1.12), earlier number of days taken to 50 % flowering (83.71), and earlier number of days taken to physiological maturity (128.6) in comparison with L 4727. The intercropping of pulse crops with fast-growing trees mitigates nitrogen depletion, optimizes land utilization, and alters soil fertility, hence enhancing land productivity, income, livelihoods, and sustainability. The reduced light availability in closer spacing, relative to wider spacing and open conditions, may be a contributing factor. The reduction in number of root nodules per plant with advancing growth stages is associated with the crop's senescence phase, characterized by the swift transference of nutrients. These findings underscore the necessity of considering tree geometry to enhance nitrogen fixation and yield in lentil cultivation within an *Ailanthus excelsa* based agroforestry system.

The analogous decline in growth characteristics of intercrops in agroforestry was documented by (Rani *et al.*, 2015, Rajalingam *et al.*, 2016 and Parekh *et al.*, 2005). Nandal and Singh (2005) reported that green gram and lentil are shade-sensitive, resulting in poor branching and pod set in pulses. In sole cropping, the days to physiological maturity were reduced due to optimal light availability for crops in open conditions. Parasriya *et al.* (2022) reported identical findings, indicating that sole cropping of *Vigna radiata* achieved fewer days to physiological maturity than intercropping with *Melia dubia* in the Bundelkhand region.

### Plant Yield Parameters

Yield parameters of two lentil varieties showed better performance in open condition as compared to different spacing of *Ailanthus excelsa* (table 2). As maximum number of pods per plant (86.93), number of seeds per pod (1.53), test weight (22.15 g), grain yield (1002 kg ha<sup>-1</sup>), straw yield (1729 kg ha<sup>-1</sup>), biological yield (2731 kg ha<sup>-1</sup>), harvest index (36.7 %) and grain to straw ratio (0.58) was recorded in S<sub>0</sub> i.e., sole cropping condition. In intercropping under *Ailanthus excelsa* better yield parameters were recorded in wider spacing of S<sub>1</sub> (5 m × 4 m) *viz.*, maximum number of pods per plant (76.48), number of seeds per pod (1.49), test weight (22.12 g), grain yield (918 kg ha<sup>-1</sup>), straw yield (1661 kg ha<sup>-1</sup>), biological yield (2579 kg ha<sup>-1</sup>) harvest index (35.62 %) and grain to straw ratio (0.55). Among two lentil varieties, V<sub>1</sub> (IPL 316) has recorded significantly highest number of pods per plant (79.42), number of seeds per pod (1.54), grain yield (946 kg ha<sup>-1</sup>), straw yield (1675 kg ha<sup>-1</sup>) and biological yield (2621 kg ha<sup>-1</sup>). Positive correlations were observed between several plant growth and yield parameters, such as plant height, no. of primary branches per plant, number of root nodules per plant at 90 DAS, dry matter, number of pods per plant, number of seeds per pod, test weight, grain yield, straw yield, biological yield, harvest index and grain to straw ratio. The correlogram (fig. 2) showed significant positive correlations between different parameters studied ( $p \leq 0.05$ ). The spatial geometry of the trees indicated a decrease in the number of pods per plant as the distance between the trees diminished. This is probably due to the trees with greater density competing more vigorously for resources.

The reduced pod count per plant in various spatial geometries may also signify the inferior growth of intercrops relative to sole cropping. These findings closely align with previous studies that demonstrated the adverse effects of tree spatial geometry on the growth of intercropped species, noting that the highest pod count per plant occurred in sole crop compared to intercropped varieties. The improved light, nutrition, and moisture availability may result from reduced competition between trees and crops in wider spacing compared to closer spacing. The decrease in pulse production due to intercropping was previously documented by (Nandal and Hooda, 2005). A comparable pattern of results was also documented by (Ravi *et al.*, 2009, Kaushik *et al.*, 2023, Ahlawat *et al.*, 2021, Deshmukh *et al.*, 2020, Mehta *et al.*, 2023 and Ranawat *et al.*, 2024) when different intercrops were cultivated under *Ailanthus excelsa* based agroforestry.

### Economics of *Ailanthus excelsa*- *Lens culinaris* based Agroforestry System

The current result (table 3) indicates that the *Ailanthus excelsa*-based agroforestry system yielded greater net returns than sole cropping. The cost of cultivation, gross return, and net return (both with and without trees) evidently escalated with the rising density of trees per hectare across various systems. Among the tree spacing, the highest net returns were observed in S<sub>2</sub>, whereas the highest B: C ratio was observed in S<sub>1</sub>. Among the lentil varieties, V<sub>1</sub> gave highest net returns and B: C ratio in comparison with V<sub>2</sub>. However, among two varieties V<sub>1</sub> gave higher economics returns so it can be intercropped with *Ailanthus excelsa* based agroforestry system. The results are consistent with prior research undertaken by (Baul *et al.*, 2023) when wheat was intercropped under *Ailanthus excelsa*.

### Conclusion

The research indicated a substantial impact of spacing and lentil varieties on multiple plant growth and yield characteristics. Lentil varieties cultivated in open conditions provide superior development and yield parameters. Likewise, in an agroforestry system, plants cultivated using wider spacing demonstrated superior growth and yield characteristics.

The experiment and preceding discussion suggest that lentil varieties cultivated in open fields exhibited superior growth and yield attributes compared to those intercropped with *Ailanthus excelsa*. The wider spacing mitigates the issue of significant yield decrease. Cultivating leguminous crops, such as lentils, not only generates supplementary revenue for farmers but also mitigates the risk of total crop failure to some degree. The IPL 316 lentil variety may be advocated for agroforestry for intercropping under *Ailanthus excelsa* in the Bundelkhand region. Intercropping of lentil varieties with *Ailanthus excelsa* gives high profitability in terms of economic returns.

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