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# Quantitative assessment of allelopathic interference and spatial impact of *Azadirachta indica* A. Juss on the biomass production of major rabi crops in the semi-arid Bundelkhand Region

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**Abstract**
In the diverse agro-climatic zones of India, *Azadirachta indica* (Neem) is a cornerstone species for agroforestry due to its high adaptability and medicinal value. However, the biological phenomenon of allelopathy—the release of biochemicals that inhibit neighbouring plants—poses a challenge to understorey productivity. This study evaluates the impact of *A. indica* on the biomass of Wheat (*Triticum aestivum*), Chickpea (*Cicer arietinum*), Lentil (*Lens esculenta*), Barley (*Hordeum vulgare*), and Mustard (*Brassica campestris*). Field investigations revealed that biomass parameters were significantly suppressed within a 1m radius of the tree base. Proximity to the tree significantly reduced plant height and seed weight across all species, while vegetative biomass showed varying degrees of resilience.

**Keywords:** *Azadirechta indica*, biomass, crops, plant height, seed weight, root weight, shoot weight

## Introduction
Agroforestry is a traditional method of farming that incorporates woody perennials and annual crops into an integrated production system. In India, *Azadirachta indica* is widely grown across states like Uttar Pradesh and Madhya Pradesh. It is an ideal species for farm boundaries to establish windbreaks. Molisch (1937) coined the term to describe all the chemical interactions among plants (microbes and higher plants), stimulatory as well as inhibitory.
Despite its benefits, trees release secondary metabolites known as "allelochemicals" into the environment through leaching, root exudation, and decomposition. These chemicals can lead to reduced crop yields. This research focuses on the Bundelkhand region to quantify the spatial "interference zone" of Neem.

## Materials and Methods
The study was conducted at the Institute of Agriculture Sciences, Bundelkhand University, and Jhansi to elucidate the biomass of winter crops of Bundelkhand region namely, wheat, chickpea, lentil, mustard and barley under *Azadirechta Indica* plantations.

- **Experimental Design:** Biomass studies were conducted under ten-year-old Neem plantations.
- **Spatial Measurements:** Observations were recorded at three horizontal distances from the tree base: 1m, 2m, and 3m.
- **Parameters:** Data collected included plant height, seed weight, shoot weight, root weight, and plant population.
- **Statistical Analysis:** Data were analyzed using Randomized Block Design (RBD) and ANOVA.

## Results: Biomass Production Data
The following section describes the quantitative impact of *A. indica* on the five test crops. In all cases, values for growth parameters increased as the distance from the tree base increased.
Wheat was highly sensitive to the proximity of the tree, showing significant reductions in almost all growth and yield attributes near the trunk.

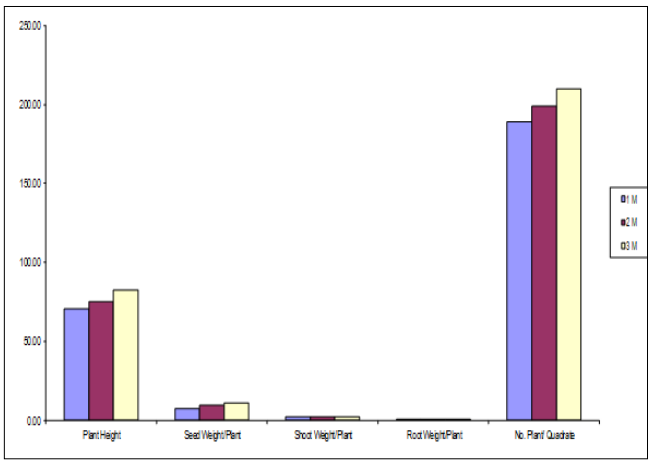


**Fig 1:** Biomass Production of Wheat (*Triticum aestivum*)

Barley displayed significant spatial variation in vegetative biomass and population density, though seed weight variation remained statistically comparable.

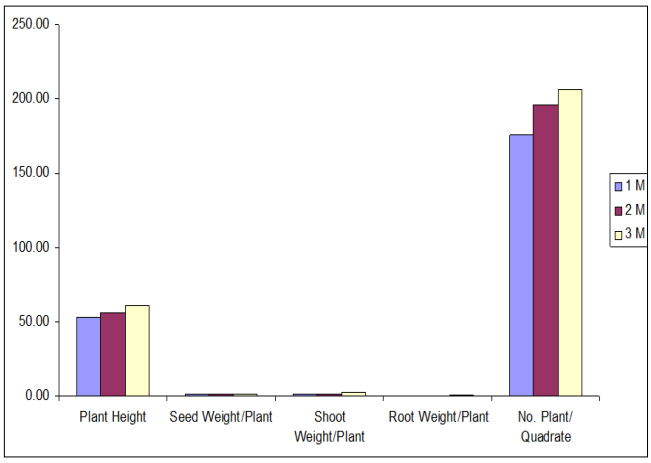


**Fig 2:** Biomass Production of Barley (*Hordeum vulgare*)

Chickpea demonstrated selective sensitivity, where primary yield indicators were affected while vegetative weights were not significantly altered.

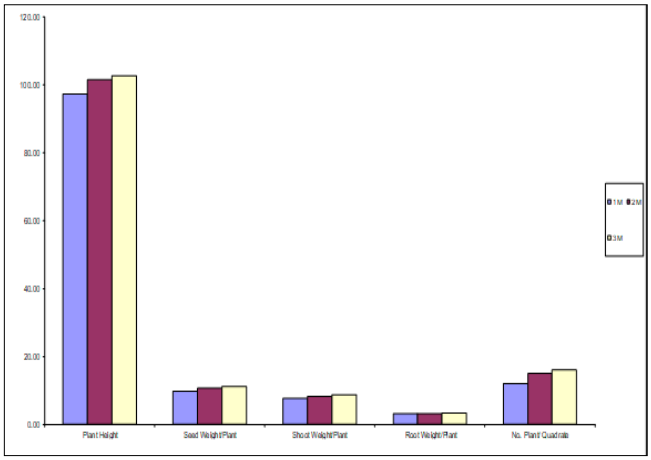

**Fig 3:** Biomass Production of Chickpea (*Cicer arietinum*)

Lentil, the "interference zone" was primarily reflected in the plant population and seed weight, whereas vegetative development reached a statistical plateau.

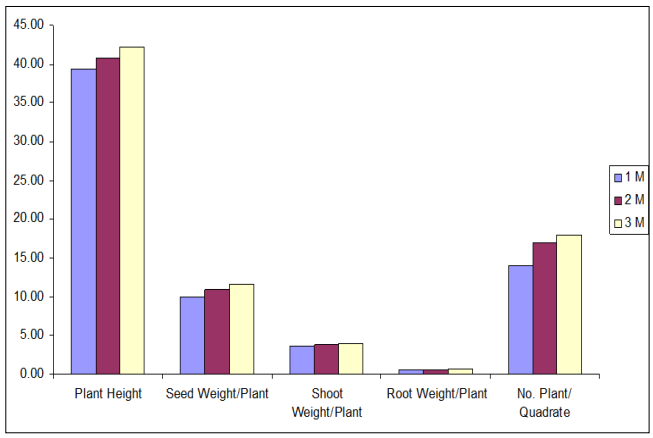


**Fig 4:** Biomass Production of Lentil (*Lens esculenta*)

Mustard growth was significantly stunted in height and seed yield near the tree base, though its dense vegetative structure showed resistance to the spatial effect.

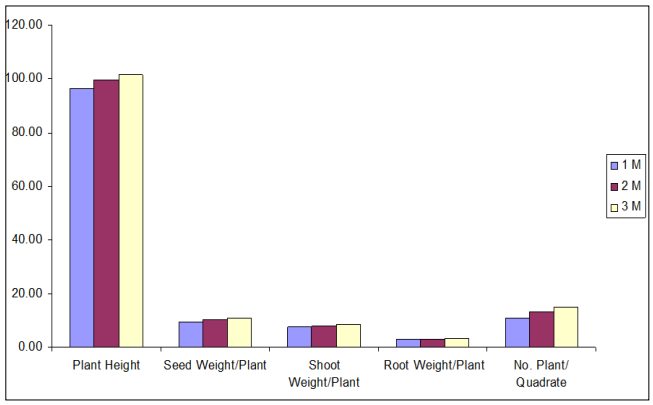


**Fig 5:** Biomass Production of Mustard (*Brassica campestris*)

## Discussion

The results confirm that *A. indica* exerts a localized inhibitory allelopathic influence that significantly limits crop growth near the tree base. Cereals like Wheat and Barley were more significantly affected across multiple parameters compared to pulses like Lentil. Interestingly, soil analysis beneath the canopy showed enrichment of Organic Carbon and total Nitrogen. This suggests that the spatial inhibition within the 1m radius is largely due to biochemical interference (allelochemicals) rather than a lack of nutrients. Results of present study agree with findings of studies made by Puri and Bangawa (1992) [6]; Melkania (1984) [4] & Joshi and Prakash (1920). Most of the agroforestry species produce a good amount of leaf, litter and debris that are rich in allelochemical content. Agroforestry researchers had not paid due attention on allelopathic properties of agroforestry species. Puri and Bangawa (1992) [6] have found that neem has no effect on the yield of wheat (Triticum aestivum) if grown 5 m apart from the main stem. Some studies suggest a direct role of neem allelochemicals on crop plants. Melkania (1984) [4] found inhibition of germination of seeds of barnyard grass (*Echinochloa crusgalli*), buckwheat (*Fagopyrum sagttatum*), soybean (*Glycine max*), and turnip (*Brassica napa*) by leachates of leaf, wood, and leaf litter. Maize (*Zea mays*), mustard (*Brassica campestris*), pea

(*Pisum sativum*), and wheat germination was also inhibited by litter extract (Joshi and Prakash, 1992) [3]. Ashrafi *et al* (2009) [1], also observed allelopathic effect of n-hexane, acetone and water-soluble extracts of *A. indica* on 6 weeds and found of acetone extract of A. indica shoots inhibited the germination of root and shoot of all the 6 test plant species. Bano *et al* (2012) [2] also reported that aqueous leaf extract of Neem had different allelopathic effect for different concentrations with minimum effect of lower concentration and maximum effect at higher concentration.

**Conclusion**

The study confirms that *Azadirachta indica* possesses potent allelopathic properties that negatively affect the biomass of major Rabi crops within its immediate vicinity. However, this effect diminishes as the distance from the tree base increases. Farmers are encouraged to manage the 1-meter "interference zone" by maintaining adequate spacing or selecting highly resistant varieties. Further long-term studies are recommended to fully evaluate tree-crop compatibility in sustainable agroforestry models.

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