**Performance of Wheat Varieties in Malia dubia (*Melia azedarach* L.) Based Agroforestry System in Bundelkhand Region**

**Abstract:**

The integration of suitable tree species with crops not only diversifies farm income but also helps in mitigating the adverse effects of climate change and erratic rainfall patterns. Successful agroforestry adoption depends largely on choosing the right tree species and understanding their interactions with companion crops. The use of Melia dubia in agroforestry systems is particularly advantageous due to its fast growth, nitrogen-rich leaf litter, and potential for carbon sequestration. The present study was carried out to evaluate the growth and yield performance of different wheat varieties under a Malabar Neem-based agroforestry system in the Bundelkhand region. The experiment was conducted at the Organic Research Farm, Bundelkhand University, Jhansi, Uttar Pradesh, during the rabi season of 2024. Three varieties of *Triticum aestivum* (DBW-303, HD-2967, and WH-1105) were sown at varying distances (0–1 m, 1–2 m, and open condition) from the tree base. Data were subjected to analysis of variance (ANOVA) using standard procedures to test the significance of treatment effects at 5% level. Observations were recorded on plant height, tillers per plant, spike length, number of grains per spike, 1000-grain weight, and grain yield. Results revealed that the proximity to the tree base negatively impacted wheat growth and yield due to shading effects. DBW-303 recorded the highest performance across both tree proximities and open conditions. Yield and related traits were significantly higher in open conditions, followed by 1–2 m distance, and lowest at 0–1 m. Among the varieties tested, DBW-303 showed the best performance across all parameters, particularly at 1–2 m and in open conditions, making it a suitable candidate for agroforestry in semi-arid regions like Bundelkhand. Proper spatial planning (≥2 m distance from tree base) can help reduce competition and enhance intercrop productivity in Melia dubia based agroforestry systems. This study emphasizes the importance of spatial management in agroforestry systems to optimize intercrop productivity.

**Keywords:**

Agroforestry system, Melia dubia, wheat varieties, yield performance, shade effect, tree-crop interaction

1. **Introduction**

Agroforestry is an intersection between agriculture and forestry as a promising and sustainable land use activity because of their potential to absorb atmospheric CO2 and store it in plant biomass and soil; some agroforestry practises have attracted increased attention for their net carbon sequestration impact (Satish et al., 2024). As a coping mechanism against the negative effects of climate change, agroforestry offers a unique opportunity to combine the twin goals of climate change adaptation and mitigation (Arya et al., 2023; Syed et al., 2023). Agroforestry has emerged as a vital land-use system in India, integrating trees, crops, and sometimes livestock on the same land unit to maximize productivity and sustainability (Nair, 1993). It plays a crucial role in improving livelihoods, conserving natural resources, and enhancing biodiversity, especially in semi-arid and degraded regions. The integration of suitable tree species with crops not only diversifies farm income but also helps in mitigating the adverse effects of climate change and erratic rainfall patterns (Kumar & Nair, 2004).

In the context of India’s Bundelkhand region—a drought-prone, semi-arid zone—agroforestry offers immense potential to restore soil health, conserve moisture, and generate sustainable income for smallholder farmers. However, successful agroforestry adoption depends largely on choosing the right tree species and understanding their interactions with companion crops (Sharma & Behera, 2009). Species selection must consider growth characteristics, light penetration, root competition, and compatibility with field crops.

Melia dubia is a promising tree species in industrial agroforestry and plantation systems across southern India and is popular for its fast growth and economic potential. Choosing a suitable intercrop for an agroforestry system determines the longevity and viability of the system (Hemalatha et al., 2025). This species is commonly known as Malabar Neem, is a fast-growing deciduous tree gaining popularity in agroforestry systems for its economic and ecological benefits. It belongs to the family Meliaceae and is cultivated widely across southern and central India for its high-quality timber, which is in demand by the plywood and packaging industries (Patil et al., 2011). Unlike traditional neem (*Azadirachta indica*), Malabar Neem grows rapidly and has a relatively sparse canopy, making it more suitable for intercropping compared to densely foliated trees.

The use of *Melia dubia* in agroforestry systems is particularly advantageous due to its fast growth, nitrogen-rich leaf litter, and potential for carbon sequestration. However, even with its relatively open canopy, competition for light, water, and nutrients can impact the performance of intercrops such as wheat. Tree-crop interaction is complex, and studies have shown that shade from trees can significantly reduce growth and yield in light-demanding crops (Jose, 2009). Therefore, a systematic evaluation of crop performance at different distances from the tree base is essential for optimizing agroforestry productivity.

Wheat (*Triticum aestivum* L.) is a major winter cereal crop in India, occupying a significant portion of the rabi season cropping area. It is highly sensitive to light availability and shows marked variations in growth and yield under shaded conditions (Singh & Chauhan, 2011). The adoption of wheat in agroforestry systems requires careful consideration of spatial arrangement and varietal adaptability. Some varieties may tolerate partial shade better than others, and yield reductions can vary depending on the proximity to trees.

Despite the growing popularity of Melia dubia in commercial agroforestry, limited research exists on the performance of wheat varieties under its canopy, particularly in the Bundelkhand region. Most existing studies focus on poplar or eucalyptus-based systems, leaving a research gap in understanding how Malabar Neem affects cereal crop production. This makes it necessary to generate localized, evidence-based recommendations to promote farmer adoption and optimize yields under such systems.

Therefore, the present study was conducted to evaluate the growth and yield performance of selected wheat varieties under a Melia dubia-based agroforestry system in Jhansi, Uttar Pradesh. The specific objectives were to assess how tree-induced shade affects various agronomic parameters of wheat and to determine the optimal distance from the tree base for intercropping. The findings aim to contribute to the broader understanding of tree-crop interaction and provide practical insights for designing more efficient agroforestry systems in semi-arid regions.

**2. Materials and Methods**

**2.1 Experimental Site**

The field experiment was conducted during rabi 2024 at the Organic Research Farm, Karguan Ji, Department of Agroforestry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), located at 25.4486° N latitude and 78.5696° E longitude. The region has a semi-arid climate with hot summers and moderate winters.

**2.2 Experimental Design and Treatments**

The study was laid out in a factorial randomized block design (FRBD) with three replications. Treatments included three wheat varieties (DBW-303, HD-2967, WH-1105) and three distances from the Melia dubia tree base (0–1 m, 1–2 m, and open condition).

**2.3 Data Collection**

Growth and yield parameters were recorded at maturity:

* Plant population per m2
* Plant height (cm)
* Number of tillers per plant
* Spike length (cm)
* Grains per spike
* 1000-grain weight (g)
* Grain yield (g)

**2.4 Statistical Analysis**

Data were subjected to analysis of variance (ANOVA) using standard procedures to test the significance of treatment effects at 5% level.

**3. Results and Discussion**

**3.1 Plant Population (plants/m²)**

The plant population of *Triticum aestivum* was significantly influenced by the proximity to *Melia dubia* (Malabar Neem) trees (Table 1). The highest plant population (47.00 plants/m²) was recorded in the open condition (T8), which was significantly superior to treatments under the tree canopy. At the closest distance (0–1 m), a sharp decline in plant population was observed, with the lowest count (21.66 plants/m²) in DBW-303 (T5), followed by HI-3386 (T1) and HI-8759 (T3). These results are consistent with earlier findings that tree-induced shade reduces seedling emergence and establishment due to limited light and moisture availability near the tree base (Sanchez, 1995; Jose, 2009).

**3.2 Plant Height (cm)**

Plant height was significantly affected by shade (Table 2). The maximum height (105.22 cm) was recorded in HI-3386 under open conditions (T7), while the shortest plants were observed under closer spacing at 0–1 m from the tree base. At this spacing, the tallest variety was HI-8759 (79.80 cm), followed by HI-3386 and DBW-303. At 1–2 m, heights increased across all varieties, indicating a recovery from shade stress. These findings agree with Singh & Chauhan (2011), who reported that light interception under tree canopies inhibits stem elongation in cereals.

**3.3 Number of Tillers per Plant**

Tillering was not significantly influenced by tree proximity (Table 3). The average number of tillers per plant ranged from 6.49 (HI-8759 at 1–2 m, T4) to 7.36 (DBW-303 in open, T9). This suggests that tillering may be less sensitive to mild shade compared to other yield components. Similar observations were reported by Ong et al. (1996), indicating that tiller initiation in wheat is moderately tolerant to low light, especially in well-managed soils.

**3.4 Spike Length (cm)**

Spike length was significantly affected by tree proximity and varietal response (Table 4). The longest spike (13.91 cm) was recorded in DBW-303 under open conditions (T9), which was statistically at par with T5 (12.33 cm) and T6 (13.04 cm). The shortest spikes (10.12 cm) were recorded in HI-3386 at 0–1 m (T1). These reductions under the tree canopy are consistent with findings by Rao et al. (1998), who emphasized the effect of limited light on spikelet development in wheat.

**3.5 Number of Grains per Spike**

No significant differences were observed in the number of grains per spike (Table 5), although the maximum value (33.62) was recorded in DBW-303 (T9) and the minimum (29.25) in DBW-303 under shade (T5). This may be attributed to the genetic resilience of the varieties and suggests that grain set in wheat is less affected by partial shade. Earlier studies also support the notion that moderate shade does not necessarily impair grain number unless the stress is prolonged or coincides with reproductive stages (Muthuri et al., 2005).

**3.6 1000-Grain Weight (g)**

Thousand-grain weight was significantly influenced by shade and distance from the tree base (Table 6). DBW-303 recorded the highest 1000-grain weight (41.25 g) under open conditions (T9), followed closely by other treatments at 1–2 m distance. The minimum value (30.34 g) was observed in HI-8759 (T3) at 0–1 m distance. The reduction in grain weight under tree shade can be linked to poor grain filling due to reduced photosynthate availability, consistent with reports by Toky and Bisht (1992). Similarly, Gawali et al. (2015), Gill et al. (2009), Dufour et al. (2013) and Artru et al. (2017).

**3.7 Grain Yield (g/plot)**

Grain yield was significantly affected by tree proximity and varietal performance (Table 7). The highest yield (42.46 g/plot) was recorded in DBW-303 under open conditions (T9), followed by 40.25 g in HI-8759 (T8) and 37.30 g in DBW-303 at 1–2 m (T6). The lowest yield (22.15 g) was observed in DBW-303 at 0–1 m (T5). These results highlight the substantial influence of tree-induced competition for light and resources. Grain yield showed a clear trend of increasing with distance from the tree base (D1 < D2 < Open), confirming the importance of spatial arrangement in agroforestry systems. Similar conclusions were drawn by Nair (1993) and Singh et al. (2010) in wheat-based agroforestry studies. Reduction in the grain yield of wheat in all the varieties at different distances is well supported by the findings of Hossain et al. (2006), Bisht et al. (2017), Kumar et al. (2019), Gawali et al. (2015), Satyawali et al. (2018), Chauhan et al. (2012), Yadav et al. (2018), Gill et al. (2009), Dufour et al. (2013) and Artru et al. (2017).

**Table 1: Effect of Melia dubia trees on plant population of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **Plant Population per m2** |
| T1 | 24.66 |
| T2 | 25.66 |
| T3 | 27.33 |
| T4 | 35.33 |
| T5 | 21.66 |
| T6 | 38.66 |
| T7 | 39.33 |
| T8 | 47.00 |
| T9 | 42.00 |
| C.D. (0.05) | 15.54 |
| SE(m)**±** | 5.14 |

**Table 2: Effect of Melia dubia trees on plant height of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **Plant height (cm)** |
| T1 | 78.22 |
| T2 | 84.23 |
| T3 | 79.80 |
| T4 | 82.44 |
| T5 | 74.08 |
| T6 | 80.18 |
| T7 | 105.22 |
| T8 | 97.56 |
| T9 | 94.08 |
| C.D. (0.05) | 10.32 |
| SE(m)**±** | 3.41 |

**Table 3: Effect of Melia dubia trees on no. of tillers plant-1 of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **No. of Tillers plant-1** |
| T1 | 7.06 |
| T2 | 7.22 |
| T3 | 6.91 |
| T4 | 6.49 |
| T5 | 7.13 |
| T6 | 7.17 |
| T7 | 7.01 |
| T8 | 7.12 |
| T9 | 7.36 |
| C.D. (0.05) | NS |
| SE(m) **±** | 0.33 |

**Table 4: Effect of Melia dubia trees on spike length of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **Spike length (cm)** |
| T1 | 10.12 |
| T2 | 11.02 |
| T3 | 10.32 |
| T4 | 11.14 |
| T5 | 12.33 |
| T6 | 13.04 |
| T7 | 11.48 |
| T8 | 12.02 |
| T9 | 13.91 |
| C.D. (0.05) | 2.01 |
| SE(m) **±** | 0.66 |

**Table 5: Effect of Melia dubia trees on no. of grains spike-1 of wheat (*Triticum aestivum***

**L.)**

|  |  |
| --- | --- |
| **Treatments** | **No. of Grains spike-1** |
| T1 | 29.36 |
| T2 | 31.01 |
| T3 | 29.69 |
| T4 | 32.03 |
| T5 | 29.25 |
| T6 | 30.90 |
| T7 | 32.80 |
| T8 | 30.48 |
| T9 | 33.62 |
| C.D. (0.05) | NS |
| SE(m) **±** | 1.51 |

**Table 6: Effect of Melia dubia trees on 1000 grain weight of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **1000 grain weight (g)** |
| T1 | 34.73 |
| T2 | 35.02 |
| T3 | 30.34 |
| T4 | 34.29 |
| T5 | 35.57 |
| T6 | 38.79 |
| T7 | 39.82 |
| T8 | 39.04 |
| T9 | 41.25 |
| C.D. (0.05) | 4.63 |
| SE(m) **±** | 1.53 |

**Table 7: Effect of Melia dubia trees on grain yield of wheat (*Triticum aestivum* L.)**

|  |  |
| --- | --- |
| **Treatments** | **Grain yield (g)** |
| T1 | 24.72 |
| T2 | 30.23 |
| T3 | 22.69 |
| T4 | 32.24 |
| T5 | 22.15 |
| T6 | 37.30 |
| T7 | 35.72 |
| T8 | 40.25 |
| T9 | 42.46 |
| C.D. (0.05) | 8.31 |
| SE(m) **±** | 2.74 |

**Conclusion**

The performance of wheat varieties under the influence of Melia dubia trees showed significant variation in most growth and yield attributes. Plant population, plant height, spike length, 1000-grain weight, and grain yield were all adversely affected under the tree canopy, especially at closer distances. Among the varieties tested, DBW-303 showed the best performance across all parameters, particularly at 1–2 m and in open conditions, making it a suitable candidate for agroforestry in semi-arid regions like Bundelkhand. Proper spatial planning (≥2 m distance from tree base) can help reduce competition and enhance intercrop productivity in Melia dubia-based agroforestry systems.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

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