



Growth studies of wheat varieties with application of organic fertilizers under *Casuarina junghuhniana* based agroforestry system

Shivam, Sandeep Arya, Chhavi Sirohi, Ishu Redhu, Karishma Nanda, Visha Jain, G.B. Rawale and Prajjwal Gujral

© Indian Society of Agroforestry 2025

ABSTRACT: A study was conducted at the research farm of the department of forestry, CCSHAU, Hisar, during Rabi 2022–2023 to evaluate the impact of organic fertilizers on the morphological growth parameters of wheat varieties grown under a *Casuarina junghuhniana* based agroforestry system planted at 5m × 3m spacing. Four wheat varieties (WH 1270, WH 1184, WH 1142, and WH 1124) were cultivated with three fertilizer treatments: T1 (recommended dose of nitrogen (RDN) through inorganic fertilizers), T2 (farmyard manure at 17.5 t/ha), and T3 (vermicompost at 8 t/ha). During the study period, tree height, girth and crown spread were increased by 5%, 5.8% and 5.1%, respectively. Plant population at 20 DAS was maximum in WH 1142 with T1 (RDN) under control conditions (369.3). With varying levels of organic fertilizer, the wheat crop in control conditions took fewer days to 50% flowering (91.9) and days to maturity (143.1) than the casuarina based agroforestry system. Treatment T1 (RDN) took the longest number of days to reach 50% flowering (100.7) and maturity (151.2) among all three treatments. Plant height and dry matter accumulation were also lower under the casuarina based agroforestry system compared to the control, with observations taken at 30-day intervals. These findings suggest that inorganic fertilizers may be more successful at enhancing wheat growth under casuarina based agroforestry system, but additional studies into long-term soil health and sustainable practices with organic fertilizers are needed.

Research Article

ARTICLE INFO

Received: 15.05.2024

Accepted: 01.09.2025

Keywords:

Dry matter accumulation,
Farm Yard Manure,
Morphology,
Tree growth,
Vermicompost

1. INTRODUCTION

Agroforestry combines woody perennials with livestock, arable crops, or feed to improve soil health, encourage resource efficiency, and boost agricultural production, livelihoods, and resilience (Fahad *et al.*, 2022). Agroforestry systems serve several purposes, including increasing agronomic productivity, producing a variety of food and non-food items together, and offering ecosystem services (Lehmann *et al.*, 2020). Agroforestry systems support sustainable agriculture and food supply by offering ecosystem services, food diversity, and economic viability (Raj *et al.*, 2019). With an estimated 1.3% to 1.8% yearly rise in industrial roundwood consumption predicted through 2030, there is an increasing need for wood as a raw material globally (Gardiner and Moore, 2014). This results in the captive industrial cultivation and agroforestry of various commercial tree species, including poplar, eucalyptus, melia, dalbergia, teak, bamboo, and casuarina trees, outside of the forest region (Madiwalar & Parthiban, 2023 ; Chavan *et al.*, 2016).

More than 90% of the industrial round wood used in India's pulp and paper industry originates from quickly expanding species that are grown outside of forests (Nayana *et al.*, 2021). *Casuarina junghuhniana* planting material has been becoming more popular in recent years due to characteristics such as short rotation tree species, drought endurance, blister bark disease and superior coppicing ability compared to *Casuarina equisetifolia* (Kumar *et al.*, 2017). *Casuarina junghuhniana* is a pioneering, fast-growing multipurpose actinorhizal tree species that is widely employed for soil reclamation and wasteland improvement (Keerthika *et al.*, 2021; Karthikeyan *et al.*, 2009). It is also used for soil reclamation and is widely adopted by Indian farmers (Saravanan *et al.*, 2012).

The varieties of Wheat includes WH 1270, WH 1184, WH 1142, and WH 1124 are high-yielding wheat varieties developed by CCS Haryana Agricultural University, India, for cultivation in northwestern plains. These varieties are known for their good grain quality, disease resistance, and adaptability to diverse agro-climatic conditions. WH 1270 and WH 1184 are recent introductions with improved rust resistance (Khan *et al.*, 2024; Bhukal *et al.*, 2023), while WH 1142 and WH 1124 are earlier releases recognized for their stable performance and suitability for timely

✉ Sandeep Arya
sandeeparyahau@gmail.com

Department of Forestry, CCS Haryana Agricultural University, Hisar 125004

sown irrigated conditions (Devi *et al.*, 2022; Singh *et al.*, 2015).

The rice-wheat cropping system in northwest India is facing problems, yet sustainable intensification of technology and awareness-building can assist in solving these food security issues (Dhanda *et al.*, 2022). Farmers need more options for growing wheat and rice and improving input efficiency. This will help spread resource-conserving technologies, ensure affordable food, and improve livelihoods (Gupta *et al.*, 2015). The most promising organic farming techniques must be developed to bridge the knowledge gap. By introducing agroforestry, this might help reduce the yield gap with conventional agriculture and increase sustainability (Santiago-Freijanes *et al.*, 2021).

2. MATERIALS AND METHODS

The study was carried out in the semi-arid region of north-western India at the research facility of the department of Forestry, CCSHAU, Hisar, which is geographically located at 29° 10' N latitude and 75° 43' E longitude at an elevation of 215.2' m above mean sea level. The region experiences a subtropical monsoonal climate with 350–400 mm of annual rainfall on average, 70–80% of which falls between July and September, with mean maximum temperatures ranging from 40 to 45 °C. The experimental trial was conducted on an already established 2 year and 2 month old *Casuarina junghuhniana* tree planted at a spacing of 5m × 3 m at the research farm in the Department of Forestry, CCS HAU, Hisar. In the interspaces of the trees, four wheat varieties (WH 1270, WH 1184, WH 1142, and WH 1124) were cultivated in three replications during the Rabi season of 2022–2023. Three fertilizer treatments were applied: T1 (recommended dose of nitrogen (RDN) through inorganic fertilizers), T2 (farmyard manure at 17.5 t/ha), and T3 (vermicompost at 8 t/ha).

Growth studies of casuarina trees

The Nikon Forestry 550 laser rangefinder was used to measure the height of casuarina trees from the base to the tip of the tree. At the time of sowing and after the wheat crop was harvested, measurements were obtained in meters up to one decimal and for the girth measurement, the circumference of the selected standing trees was measured in centimeters up to two decimal places using a measuring tape at a height of 1.37 meters (DBH) above ground level. The average values of crown spread (m) in north-south and east-

west directions were measured and presented in meters before planting and after wheat crop harvest.

Growth parameters of the wheat crop

At 20 days after sowing (DAS), plants were counted in randomly selected 1 m² plots, and averages were calculated to determine plant population per square meter. Five plants per plot were randomly tagged to measure height at 30, 60, 90, and 120 DAS. The height of each plant was measured from the base of the stem to the top of the topmost totally opened leaf with a measuring scale and the average of all five plants was determined. For days to 50% flowering, data were gathered and recorded for each wheat variety when 50% of the spike or head was visible in the plots. When 75% of the plants in the field became yellow, the dates of maturity were visually checked and recorded for each variety. Wheat crop plants of one-metre row length were collected at 30-day intervals from three distinct points in each plot to examine dry matter accumulation in grams during the study period. These samples were first sun-dried before being dried in an oven at 60 °C for approximately 24 hours to attain a uniform weight.

3. RESULTS AND DISCUSSION

Growth studies of *Casuarina junghuhniana*

Data on the height, girth and crown spread of casuarina trees are shown in Table 1. Before sowing the wheat crop, tree height, GBH and crown spread were 7.9 m, 31.82 cm and 3.9 m, respectively. During the study period, tree height increased by 5.06%, girth at breast height by 5.81% and crown spread by 5.13%, as shown in Fig. 1. The mean height, girth at breast height and crown spread of casuarina were 8.3 m, 33.67 cm and 4.1 m, respectively, after harvesting the wheat crop. Similar findings were also reported by Ramesh *et al.* (2023) and Kumar *et al.* (2019) in terms of height increment and other tree growth parameters.

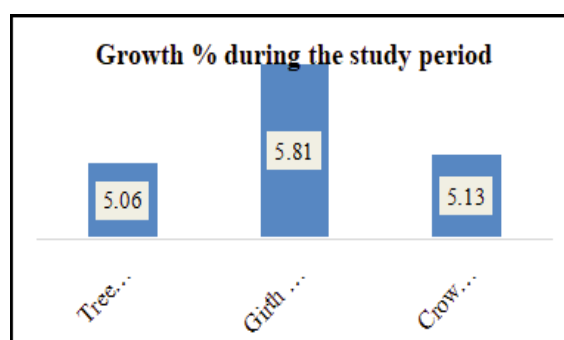


Fig.1. Bar graph showing percentage increment in tree growth parameters during study period

Table 1. Tree growth parameters at initial and harvest stages of wheat crop

Time	Tree Height (m)	Girth at BH (cm)	Crown spread (m)
Before sowing of wheat (November 2022)	7.9	31.82	3.9
After harvesting of wheat (April 2023)	8.3	33.67	4.1

Growth parameters of the wheat crop

Plant population

Plant population/m² at 20 DAS showed significant variation under casuarina based agroforestry system compared to the control, as shown in Fig. 2. With varied levels of organic fertilizers, plant population was significantly higher in control conditions (313.3) compared to casuarina based agroforestry system (262.2). This might be defined as increased competition for photosynthetically active radiation (PAR) between trees and crops in an agroforestry based system, which hampered crop germination and establishment. The genetic impact or adaptability of a particular variety may be the reason for the differences in response of varieties in different planting geometry,

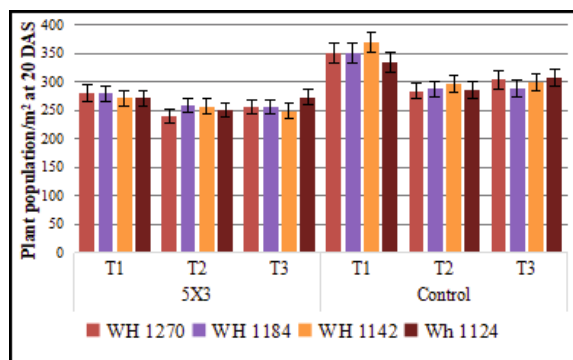


Fig. 2: Effect of different organic treatments on plant population/m² at 20 DAS on different wheat varieties under AFS and control

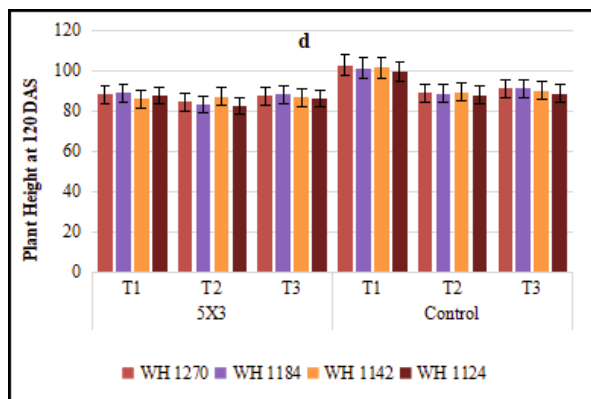
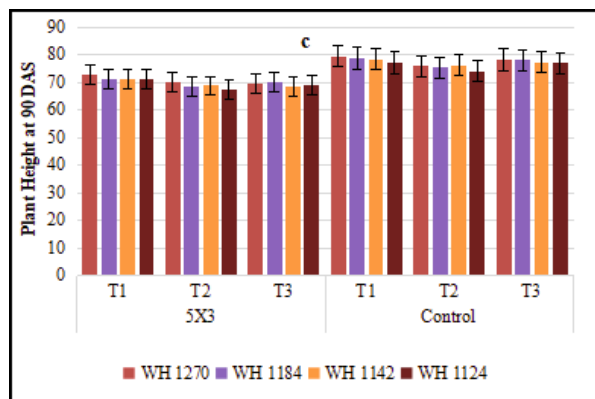
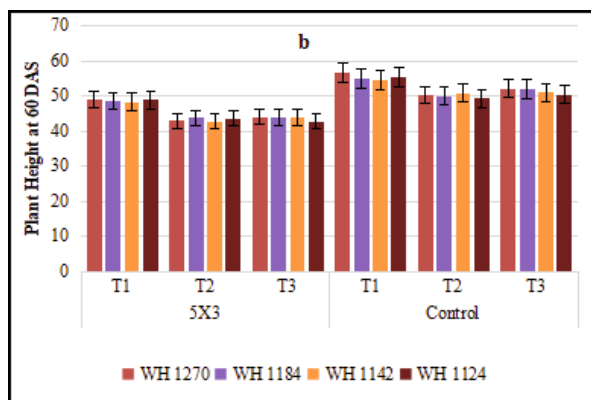
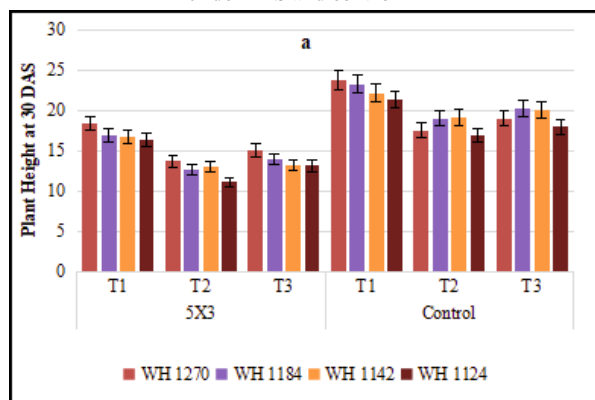


Fig. 3 (a-d): Effect of different organic treatments on plant height at 30, 60, 90 and 120 DAS on different wheat varieties under AFS and control

as reported by Sirohi *et al.* (2020) under a 5-year-old *Casuarina equisetifolia* based agroforestry system. The effects of treatments were also observed to be significant on plant population, as treatment T1 (RDN) resulted in significantly higher plant population (313.3), followed by T3 (Vermicompost) (279.2) and the least plant population was recorded with T2 (FYM) (270.3), irrespective of varieties. Plant population didn't change significantly among wheat varieties. Maximum plant population/m² at 20 DAS (396.3) was observed in wheat variety WH 1142 with T1 (RDN) under control conditions. Superior results of T1 (RDN) may be due to the greater availability of nutrients by inorganic fertilizers compared to organic fertilizers at the early stages of wheat, as reported by Ibrahim *et al.* (2008) and Kumar *et al.* (2017).

Plant Height

Plant height at all the observed intervals showed significant variation under casuarina based agroforestry system as compared to control (Fig. 3). With varied levels of organic fertilizers, plant height at all the observed interval was significantly higher in control conditions (20.1, 52.4, 77.3 and 93.4 cm at 30, 60, 90 and 120 DAS, respectively) compared to casuarina based agroforestry system (14.5, 45.3, 69.9 and 86.4 cm at 30, 60, 90 and 120 DAS, respectively). These findings are consistent with those of Sirohi *et al.* (2012) and Rao *et al.* (2016). They found that the

agroforestry system significantly reduced wheat plant height compared to the control, due to lower light availability. Effect of treatments were also observed significant at all recorded durations as treatment T1 (RDN) was resulted in significantly higher plant height, followed by T3 (Vermicompost) and least plant height was recorded with T2 (FYM), irrespective of varieties. Wheat variety WH 1270 showed maximum plant height at all recorded intervals, among all the wheat varieties. Similar findings were reported by Ibrahim *et al.* (2008) and Kumar *et al.* (2017) on the effect of organic fertilizers on wheat plant height and stated that better availability of nutrients, particularly nitrogen, to the wheat crop, which translocates maximum photosynthesis from source to sink and accumulates in individual plant parts, resulting in higher crop height.

Dry matter accumulation

Similar to plant height, dry matter accumulation/mrl (meter-row-length) also varied with different organic fertilizers under casuarina based agroforestry system as well as in control (Fig. 4). Dry matter accumulation at all recorded interval were also found significantly higher in control condition (32.9, 64.2, 136.3 and 252.9 g/mrl at 30, 60, 90 and 120 DAS, respectively) as compared to casuarina based agroforestry system (26.5, 52.3, 109.8 and 203.8 g/mrl at 30, 60, 90 and 120 DAS, respectively).

These findings are consistent with those of Sirohi *et al.* (2012) and Rao *et al.* (2016). They found that agroforestry system had a significant impact on dry matter accumulation when compared to a control due to lower radiation interception under agroforestry system. Effect of treatments on dry matter accumulation at all recorded interval were also observed significant at all recorded durations as treatment T1 (RDN) was resulted significantly higher dry matter accumulation, followed by T3 (Vermicompost) and least dry matter accumulation was recorded with T2 (FYM), irrespective of varieties. Varietal difference on dry matter accumulation was found non-significant at all intervals. Similar findings were reported by Kumar *et al.* (2017), Gosal *et al.* (2018) and Zhang *et al.* (2018). Lower dry matter in T2 (FYM) and T3 (Vermicompost) may be due to limited nitrogen, unlike T1 (RDN), where nitrogen boosted metabolism, growth, and photosynthesis.

Days to 50% flowering and days to maturity

Wheat varieties grown under casuarina based agroforestry system took significantly higher number of days to 50% flowering and days to maturity (98.8 and 152.8 days, respectively) as compared to wheat varieties grown in control conditions (91.9 and 143.1 days, respectively), irrespective of treatments as shown in Fig. 5. Similar results were reported by

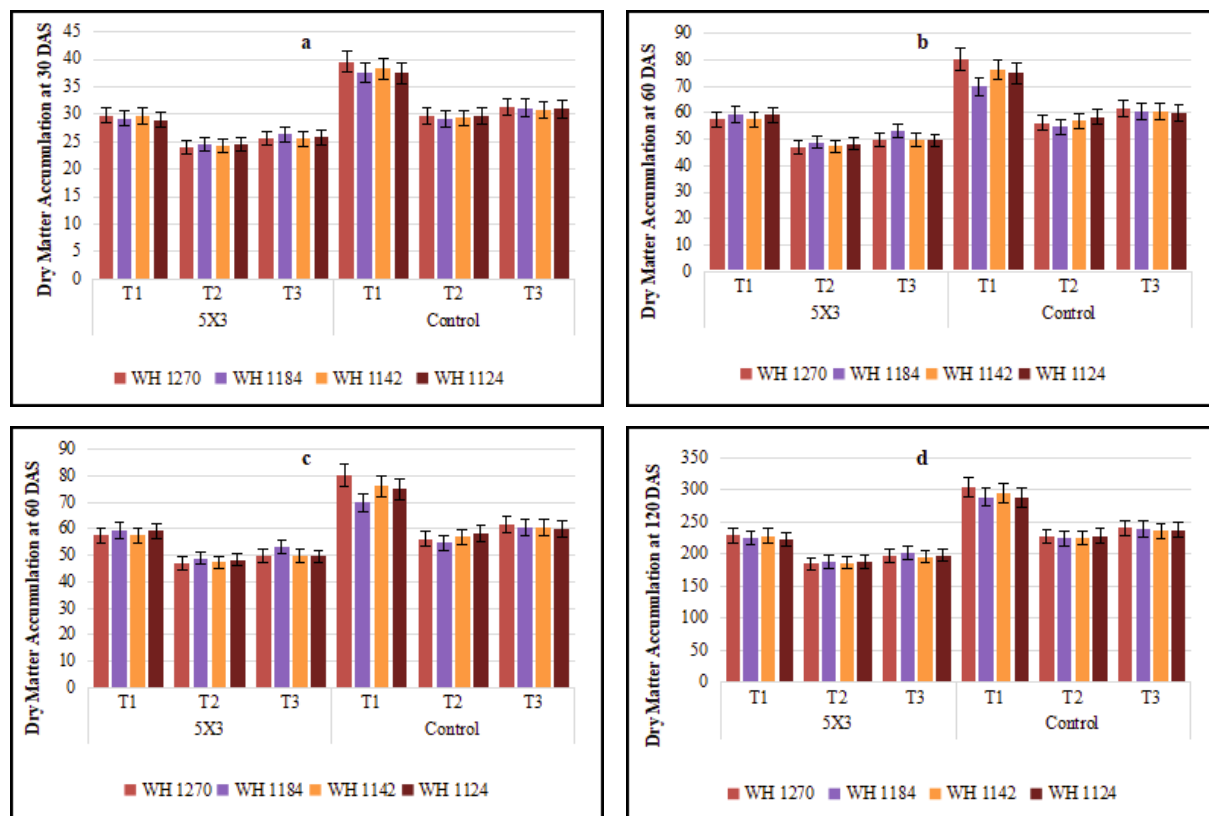


Fig. 4 (a-d): Bar graph showing the effect of different organic fertilizers on dry matter accumulation at 30, 60, 90 and 120 DAS on different wheat varieties under AFS and control

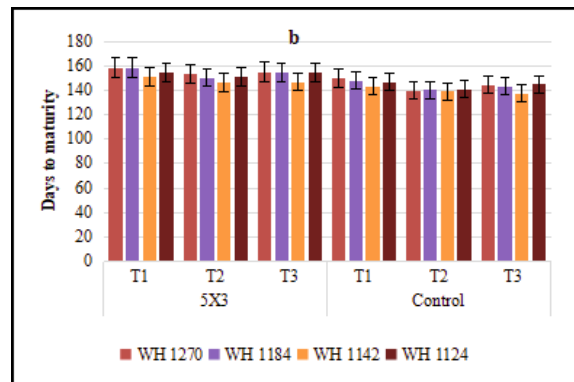
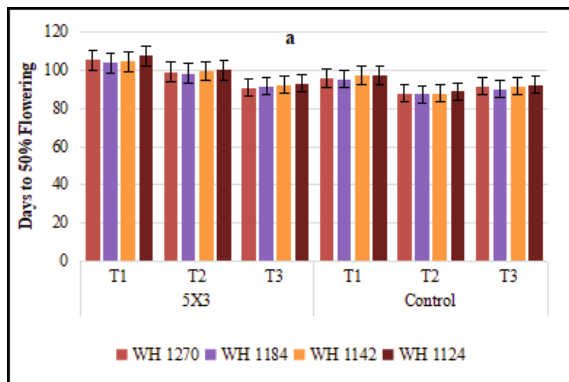


Fig. 5 (a-b): Bar graph showing the effect of different organic fertilizers on days to 50% flowering and days to maturity on different wheat varieties under AFS and control

Sirohi *et al.* (2012) and Rao *et al.* (2016) and concluded variation in days to flowering and maturity might be result of greater supply of nitrogen by agroforestry system compared to control. Treatment T1 (RDN) took higher number of days to 50% flowering (100.7) and days to maturity (151.2), among all three treatments. Wheat variety WH 1184 took least number of days to 50% flowering (94.4 days), while variety WH 1142 took least number of days to maturity (143.9 days), among all four wheat varieties. The delay in flowering and maturity under treatment T1 (RDN) might be attributed to a greater supply of nitrogen than organic fertilizers (T2 and T3) as reported by Kumar *et al.* (2017), Gosal *et al.* (2018).

4. CONCLUSION

The morphological growth parameters exhibited reduced outcomes under casuarina based agroforestry system and all varieties faced significant shading effect, limiting on morphological growth. Wheat varieties exhibited the most significant response to treatment T1 (RDN), as evidenced by results of plant height and dry matter accumulation. However, treatment T1 (RDN) also led to delayed growth duration of the wheat crop. In contrast, treatment T3 (Vermicompost) resulted in an earlier growth period for the wheat crop.

ACKNOWLEDGMENT

This investigation is part of the first author's M.Sc. dissertation. The Department of Forestry at CCS Haryana Agricultural University, Hisar, is acknowledged by the authors for providing all research facilities.

REFERENCES

Bhukal, S., Rani, E., Verma, V. and Rani, D. (2023). Awareness and Knowledge of the Farmers about Wheat Varieties of CCSHAU. *International Journal of Education and Management Studies*, 13(4), 499-503.

Chavan, S.B., Uthappa, A.R., Sridhar, K.B., Keerthika, A., Handa, A.K., Newaj, R. & Chaturvedi, O.P. (2016). Trees for life: Creating sustainable livelihood in Bundelkhand region of central India. *Current science*, 994-1002.

Devi, S., Singh, V. and Anon, N. (2022). Evaluation of wheat genotypes for yield potential under combined drought and heat stress conditions. *Journal of Cereal Research*, 13(3).

Dhanda, S., Yadav, A., Yadav, D.B., & Chauhan, B.S. (2022). Emerging issues and potential opportunities in the rice-wheat cropping system of North-Western India. *Frontiers in Plant Science*, 13, 832683.

Fahad, S., Chavan, S.B., Chichaghare, A.R., Uthappa, A.R., Kumar, M., Kakade, V. & Poczai, P. (2022). Agroforestry systems for soil health improvement and maintenance. *Sustainability*, 14(22), 14877.

Gardiner, B., & Moore, J. (2013). Creating the wood supply of the future. In *Challenges and Opportunities for the World's Forests in the 21st Century* (pp. 677-704). Dordrecht: Springer, Netherlands.

Gosal, S.K., Gill, G.K., Sharma, S. and Walia, S.S. (2018). Soil nutrient status and yield of rice as affected by long-term integrated use of organic and inorganic fertilizers. *Journal of Plant Nutrition*, 41(4), 539-544.

Gupta, R.K., Naresh, R.K., Hobbs, P.R., Jiagu, Z., & Ladha, J.K. (2003). Sustainability of post-Green Revolution agriculture: The rice-wheat cropping systems of the Indo-Gangetic Plains and China. *Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts*, 65, 1-25.

Ibrahim, M., Hassan, A., Iqbal, M. and Valeem, E.E. (2008). Response of wheat growth and yield to various levels of compost and organic manure. *Pakistan Journal of Botany*, 40(5), 2135-2141.

Karthikeyan, A., Deeparaj, B., & Nepolean, P. (2009). Reforestation in bauxite mine spoils with *Casuarina equisetifolia* frost. and beneficial microbes. *Forests, trees and livelihoods*, 19(2), 153-165.

Keerthika, A., Parthiban, K.T., & Kumar, D.S. (2021). Understanding cultural ecosystem services of multifunctional agroforestry. *Current Science*, 121(12), 1610-1618.

Khan, H., Mohan, D. and Singh, G. (2024). Pursuing wheat yield maximization in north-western plains of India. *Journal of Cereal Research*, 16(2).

Kumar, N., Rao, O.P., Singh, M., Singh, P. and Khan, S. (2017). Effect of fertilizer and organic manures on growth and yield attributes of wheat and paddy variety under casuarina (*Casuarina equisetifolia*) based agrisilviculture system. *International Journal of Pure Applied Bioscience*, 5(5), 879-887.

Kumar, T., Kumari, B., Arya, S. and Kaushik, P. (2019). Effect of different spacings of Eucalyptus based agroforestry systems soil nutrient status and chemical properties in semi-arid ecosystem of India. *Journal of Pharmacognosy and Phytochemistry*, 8(3), 18-23.

- Lehmann, L.M., Smith, J., Westaway, S., Pisanelli, A., Russo, G., Borek, R. & Ghaley, B.B. (2020). Productivity and economic evaluation of agroforestry systems for sustainable production of food and non-food products. *Sustainability*, 12(13), 5429.
- Madiwalar, A.F., & Parthiban, K.T. (2023). Evaluation of Cultural Ecosystem Services of Pulpwood Multifunctional Agroforestry: A Case Study from the Foothills of the Nilgiris, Western Ghats, India. *Appl. Ecol. Environ. Res*, 21, 2611-2624.
- Nayana, H. (2020). Assessment of early growth performance of melia dubia cav. Clones (doctoral dissertation, keladi shivappa nayaka university of agricultural and horticultural sciences, shivamogga (cof, ponnampet)).
- Raj, A., Jhariya, M.K., Yadav, D.K., Banerjee, A. & Meena, R.S. (2019). Agroforestry: a holistic approach for agricultural sustainability. *Sustainable agriculture, forest and environmental management*, 101-131.
- Ramesh, K.R., Deshmukh, H.K., Sivakumar, K., Guleria, V., Umedsinh, R.D., Krishnakumar, N. & Senthil, K. (2023). Influence of eucalyptus agroforestry on crop yields, soil properties, and system economics in Southern Regions of India. *Sustainability*, 15(4), 3797.
- Rao, O.P., Chhavi, S. and Verma, S.K. (2016). Growth and yield attributes of wheat and paddy intercropped under Dalbergia sissoo Roxb. based agri-silvicultural system on partially improved salt affected soil in Faizabad District. *Indian Forester*, 142(5), 481-486.
- Santiago-Freijanes, J.J., Mosquera-Losada, M.R., Rois-Díaz, M., Ferreiro-Domínguez, N., Pantera, A., Aldrey, J.A., & Rigueiro-Rodríguez, A. (2021). Global and European policies to foster agricultural sustainability: agroforestry. *Agroforestry Systems*, 95(5), 775-790.
- Saravanan, T.S., Rajendran, K. and Santhaguru, K. (2012). Selection of suitable biofertilizers for production of quality seedlings of *Casuarina equisetifolia* using decomposed coir pith compost in root trainers. *Asian journal of experimental biological sciences*, 3(4): 752-761.
- Singh, V., Singh, B., Panwar, I.S., Verma, S., Dalal, M., Saharan, R., Solanki, Y., Bishnoi, O. and Karwsara, S. (2015). WH 1124: A new wheat variety for late sown irrigated conditions in north west plain zone of India. *Journal of Cereal Research*, 7(1).
- Sirohi, C., Bangarwa, K.S., Dhillon, R.S. and Ahlawat, K.S. (2020). Casuarinas for Green Economy and Environmental Sustainability IUFRO Working Party 2.08.02 Improvement and Culture of Nitrogen-Fixing Trees IUFRO Taskforce Forest Biomass Network. In Proceedings of the Sixth International Casuarina Workshop Krabi, pp. 68-76.
- Sirohi, C., Rao, O.P. and Rana, B.S. (2012). Varietal comparison of wheat and paddy under *Populus deltoides* based agri-silvicultural system in sodic soil. *Indian Journal of Forestry*, 35(3), 291-294.
- Zhang, D., Du, G., Sun, Z., Bai, W., Wang, Q., Feng, L. and Zhang, L. (2018). Agroforestry enables high efficiency of light capture, photosynthesis and dry matter production in a semi-arid climate. *European Journal of Agronomy*, 94, 1-11.