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Yield of Turmeric Varieties [*Curcuma longa* (L.)] Under Eucalyptus (*Eucalyptus tereticornis*) Based Agroforestry System in Chhattisgarh Plain, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted during the year 2022-23 and 2023-24 in Kharif seasons at the Herbal Garden of IGKV, Raipur, Chhattisgarh. Two production systems were studied: F1 involved sole Turmeric, while F2 involved Eucalyptus intercropped with Turmeric in both the production system used FRBD (Factorial Randomized Block Design). Eight turmeric varieties were used: T1 - Suranjana, T2 - Selam, T3 – Chhattisgarh Haldi-1, T4 – Chhattisgarh Haldi-2, T5 – Roma, T6- Ranga, T7- NDH-98 and T8- Sonali. The pooled rhizome fresh yield data for year 2022-23 and 2023-24 year shows that F2 (Eucalyptus + turmeric) (19.76 t/ha) yielded significantly less than F1 (Sole turmeric) (21.73 t/ha). Among varieties, Chhattisgarh Haldi-2 (25.18 t/ha) and NDH-98 (24.65 t/ha) recorded the maximum yield, while the lowest yield was recorded in Sonali (16 t/ha). A significant result found in production system and crop variety which showed that performance of varieties depended on the cropping system.

Keywords: Turmeric; eucalyptus; varieties; yield; production system.

1. INTRODUCTION

Agroforestry covers 8.2 percent of India's total geographical area, amounting to 25.32 million hectares [1]. Agroforestry is a sustainable land use system where woody perennials are deliberately integrated with crops and/or animals within the same management unit, either spatially or temporally. This approach offers significant diversification in agriculture, providing fuel, fodder, fruits, fibers, and supplementary products, while also stabilizing ecosystems by increasing tree cover and enhancing carbon sequestration potential [2].

The major turmeric producing states are Telangana, Maharashtra, Tamil Nadu, Andhra Pradesh, and Karnataka. In Tamil Nadu, Erode district is the largest in turmeric cultivation, contributing 24.14% of the total area and 33.37% of the total production. Tamil Nadu shares 14.04% of the total production. Turmeric is grown as a Kharif crop [3].

Chhattisgarh also has a good position in turmeric production. In the year 2022-23, the total area under turmeric was 12,195 ha, and production was 110057 million tonnes. Raipur also holds a good position in turmeric production. In the year 2022-23, the total area under turmeric was 720 ha, and production was 2460 million tonnes [4].

Integrated nutrient management (INM) strategies, which involve the combined use of chemical fertilizers and organic manures, have been found to enhance crop yields significantly compared to using either type of fertilizer alone. This integrated approach has synergistic effects that improve the chemical, physical, and biological properties of soil, leading to better soil organic matter content and nutrient status. Ultimately, INM practices contribute to maintaining or even enhancing soil fertility in the long term, supporting sustained crop productivity [5].

Eucalyptus is a fast-growing Multipurpose Tree (MPT) that has gained popularity in India. It is a promising short-duration tree cultivated for timber, fuelwood, essential oil, and pulp. Large-scale plantations of eucalyptus species are established with care in various sectors, including roadside and canal-side plantations. These plantations are crucial for obtaining bole wood production and play a significant role in the plantation industries [6].

In India, eucalyptus is cultivated for its habits and short-duration benefits as Multipurpose Trees (MPTs) for timber, fuel, essential oil, and pulp. Large-scale plantations of eucalyptus species are taken care of in various sectors, including roadside and canal-side plantations, farm forestry, to obtain bole wood production and pulp, as well as for aesthetic values. Eucalyptus tereticornis, with its lesser rotation period, better coppice ability, and adaptability to soil and climate, is widely planted in India [7].

2. MATERIALS AND METHODS

The field experiment was carried out at the Indira Gandhi Krishi Vishwavidyalaya's Herbal Garden in Raipur (C.G.) from 2022 to 2023 as well as in 2023-24. Raipur is located in the mid-Eastern region of Chhattisgarh with a latitude of 21^{o}16'N, longitude of 81^{o}36'E, and elevation of 289.56 meters above mean sea level. The weekly average maximum and minimum temperatures throughout crop growth ranged from 39.51°C to

27.14 °C and 28.52 °C to 8.31 °C, respectively. The average maximum weekly temperature was 39.51 ^{0}C, while the average lowest weekly temperature was 8.31 ^{0}C. Throughout the trial, the weekly mean maximum and lowest relative humidity ranged from 92.71% to 50.34% and 80.85% to 15.14%, respectively. During the experiment, the average maximum and minimum weekly rainfall were 30.34 mm and 0.16 mm. The experiment was carried out in a Factorial RBD design, with three replications containing eight treatment combinations and two production systems assigned to eight crop varieties. Each treatment combination was randomly duplicated three times. NPK were applied at a dosage of 120kg N, 60kg P, and 60kg K per ha-1 in the form of urea, single superphosphate, and murate of potash. Turmeric rhizomes were manually sown using an experimental design in a cropping system with row and plant spacing of 40cm×30cm, eight varieties, and three replications. Sowing was completed in 2.5 m×2.5 m areas using AFS and a single crop.

3. RESULTS AND DISCUSSION

The present investigation entitled "Production Potential of Turmeric Varieties [*Curcuma longa* (L.) and Soil Health Under Eucalyptus (*Eucalyptus tereticornis*) Based Agroforestry System in Chhattisgarh Plain" has been carried out during kharif season, 2022-23 and 2023-24 at Herbal Garden, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh.

The yield attributes of turmeric, specifically the fresh weight (t ha-1) at harvest, are crucial parameters for assessing turmeric yield. The data pertaining to the fresh weight (t ha-1) of rhizomes are presented in Table 1 and Fig. 1 and Fig. 2.

The results of the fresh weight of rhizome for the different treatments during the year 2022-23 and 2023-24 growing seasons, as well as the Pooled Mean were recorded. The production system had a significant effect on the fresh weight of rhizome, where the sole turmeric (F1) producing significantly heavier rhizome than the Eucalyptus + Turmeric system (F2). The mean fresh weight of rhizome was 21.73 t ha-1 for F1 and 19.76 t ha-1 for F2.

The crop variety also had a significant effect on the fresh weight of rhizome. Chhattisgarh Haldi-2 (T4) produced the heaviest rhizome per plant, with a mean of 25.18 t ha-1, followed by NDH-98 (T7) 24.65 t ha-1 and Suranjana (T1) 23.64 t ha-1 while Sonali (T8) produced the lowest rhizome fresh weight, with a mean of 16 t ha-1.

The interaction effect of production system and crop varieties on fresh weight of rhizome of crop based on mean data recorded significant effect in both the year.

Table 1. Rhizome yield fresh weight (t ha-1) as affected by production system and turmeric varieties under Eucalyptus-based agroforestry system

Treatments	Fresh weight (t ha^{-1})		
	2022-23	2023-24	Pooled
Factor A (Production system)			
F_1- Sole turmeric	21.12	22.34	21.73
F_2- Eucalyptus+turmeric	18.64	20.87	19.76
SEm±	0.82	0.822	0.821
CD @ 5%	1.671	NS	1.672
Factor B (Crop varieties)			
T_1 –Suranjana	22.78	24.50	23.64
T_2 –Selam	16.74	18.46	17.60
T_3 -Chhattisgarh Haldi-1	19.78	21.50	20.64
T_4 -Chhattisgarh Haldi-2	24.32	26.04	25.18
T_5 –Roma	16.88	18.60	17.74
T_6 –Ranga	19.65	21.37	20.51
T_7 -NDH-98	23.79	25.51	24.65
T_8 –Sonali	15.14	16.86	16.00
SEm±	1.641	1.644	1.642
CD @ 5%	3.343	3.349	3.345

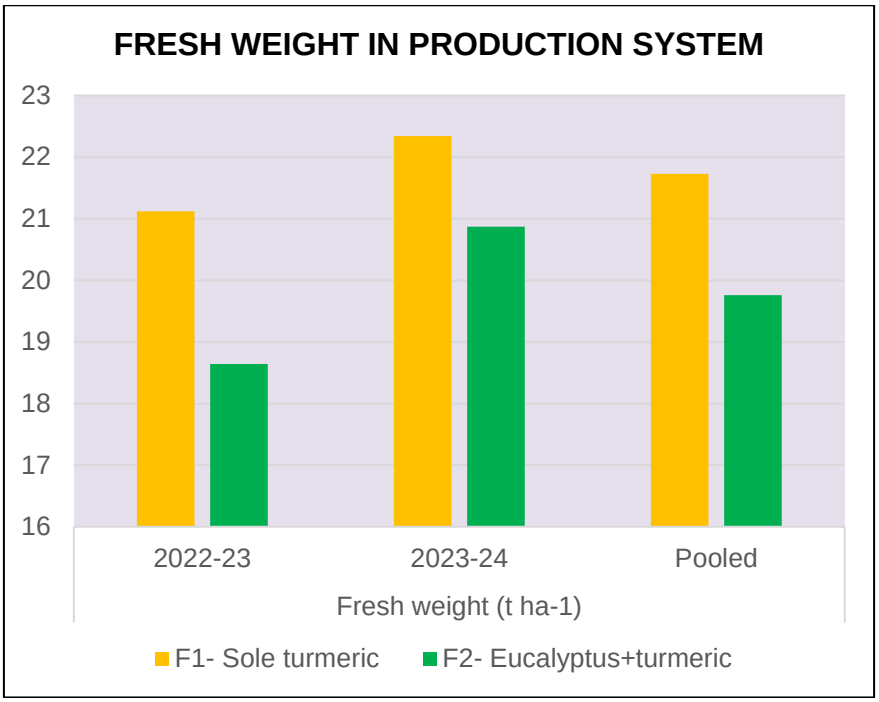

Fig. 1. Fresh weight (t ha^{-1}) at harvesting stage of turmeric as influenced by control farming and *Eucalyptus tereticornis* based agroforestry system in production system

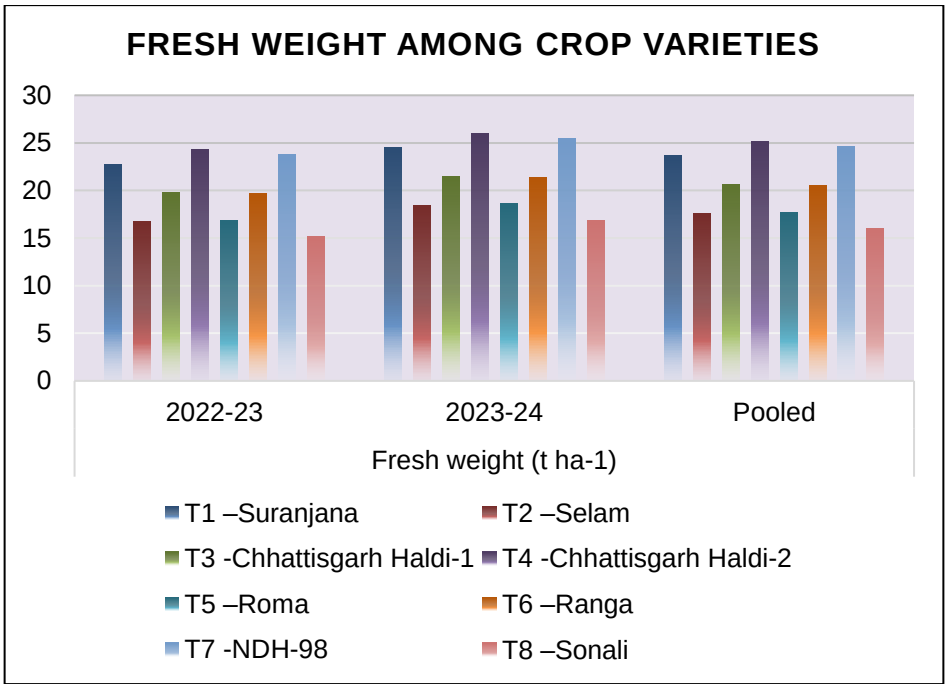

Fig. 2. Fresh weight (t ha^{-1}) at harvesting stage of Turmeric as influenced by control farming and *Eucalyptus tereticornis* based agroforestry system among crop varieties

The observed differences in the fresh weight of rhizome among the treatments can be attributed to the different production systems and crop varieties used in the experiment. The sole turmeric (F1) may have provided a more favorable environment for rhizome growth and development, resulting in heavier rhizome per plant compared to the Eucalyptus + Turmeric

(F2). The different crop varieties used may have also had varying rhizome yield potential, with some varieties producing heavier rhizome per plant due to genetic traits such as tuber size and weight. The fresh weight of rhizome per plant serves as an indicator of the suitability of the various production systems and crop varieties for supporting turmeric yield formation. Heavier rhizome crops point to treatments that conditioned the plant growth environment in a way that promoted higher rhizome yield. Other factors such as soil fertility, water availability, and pest and disease pressure may have also influenced the fresh weight of tuber plant. Similar result was also found by Painkra et al. [8] and Sahu et al. [9] Tirkey et al. [10] also observed that variety Ranga (V-1) produced maximum yield of 196.06 qha-1 as compare to variety Roma (V-2) 179.53 qha-1 in Chhattisgarh plain region.

Through important mechanisms like managing microclimate by providing shade, enhancing water retention and erosion control, and promoting soil health via nutrient-rich organic matter, eucalyptus boosts turmeric development in agroforestry systems. Its dense roots reduce competition for resources, fragrant oils keep pests away, and allelopathic substances inhibit weeds. By combining the production of lumber with medicinal crops, this symbiotic relationship increases turmeric yields, encourages sustainability, and diversifies farmers' revenue by building a resilient farming system.

4. CONCLUSION

The eucalyptus + turmeric system (F2) significantly outperformed other treatments in yield measures, including fresh weight for Sole turmeric (F1) over two years and in the mean. When comparing the crop varieties to other treatments, the crop variety Chhattisgarh Haldi-2 (T4) had the maximum fresh weight (t ha-1) at harvest in both years and in the mean data. Sonali (T8) had the lowest fresh weight (t ha-1) across all growth stages in both years and on the mean data. • According to the pooled mean rhizome yield data for two years, the turmeric crop grown with solitary turmeric (F1) produced significantly more rhizomes (21.73 t/ha) than the Eucalyptus + Turmeric cropping system (F1), which yielded 19.76 t/ha.

5. FUTURE SCOPE

The following relevant suggestions are recommended to highlight the future scope of the problem:

1. Similar research ought to be carried out in different tree species based AFS.
2. It is not advised to use the Sonali variety of turmeric in an agroforestry-based intercropping system because it demonstrated the lowest production and quality of tubers in Central Plain of Chhattisgarh.
3. Rather than growing turmeric as a single crop, producers should choose an agroforestry-based intercropping system that combines eucalyptus with turmeric to increase both the productivity and quality of the rhizome.
4. By offering financial incentives, more farmers may choose to use the eucalyptus + turmeric agroforestry system, increasing revenues and making better use of available resources.
5. For increased output and financial gains, optimize the plant shape and spatial arrangement of eucalyptus trees and the turmeric crop.
6. When intercropping turmeric with eucalyptus, select high-yielding varieties such as Chhattisgarh Haldi-2 or NDH-98 for optimal rhizome output.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I hereby declare 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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