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Performance of turmeric (*Curcuma longa* L.) and soil characteristics under different agroforestry tree species in Uttarakhand, India

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Abstract
A field experiment was carried out to evaluate the growth, yield, quality attributes and soil characteristics under different agroforestry tree species at Agroforestry Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar during April 2015 to January 2016. The experiment was laid out in a Randomized block design (RBD) with twelve treatments and three replications. Results indicated that growth parameters were increased under different agroforestry tree species as compared to control, yield of turmeric reduced under different agroforestry tree species as compared to control. However, the quality attributes of turmeric increased under different agroforestry tree species as compared to control. The maximum growth of turmeric was recorded under T4 treatment whereas yield was highest under T1 (control) followed by T11 (*Dalbergia sissoo*) and T12 (*Anthocephalus cadamba*). The maximum plant height and LAI were recorded under T4 (*Terminalia bellirica*) treatment. Soil organic carbon and NPK content were also higher in T4 (*Terminalia bellirica*) treatment. It is also observed that the yield of turmeric highest under control treatment but it was not significant as compared to other treatments and quality attributes of turmeric and soil characteristics was greatly influenced by different agroforestry tree species.

Keywords: Agroforestry, turmeric, yield, Lai and turmeric quality

Introduction
The rising population of humans and animals, along with their ever-increasing food, fodder and fuel needs which exerts a great pressure on the stabilizing elements of agro-ecosystems. Among different approaches to counteract this problem, agroforestry or woody perennial based intercropping system has proved itself as a key component of sustainable agriculture. So, agroforestry has become an important land-use system not only to meet the food and wood requirement of the people but also protect the earth from environmental hazards. It is also noted that sustainable agroforestry can upsurge resilience against change in the environment, to enhance carbon sequestration and also to generate income, which will result in improving the livelihood of small and subsistence farmers. Agroforestry is defined as a sustainable land use system that maintains or increase total yield by combining food crops with perennial tree crops and/ or livestock on the same unit of land either alternately or at the same time using management practices that suits the social and cultural characteristics of the local people and economic and ecological condition of the area. The role and scope of agroforestry are also studied in way of biodiversity conservation, yield of goods and services to society, augmentation of the carbon storages in agroecosystems, enhancing soil fertility and providing social and economic well-being to people. Agroforestry system gives diversification, creates a green cover for carbon sequestration and increases the nutrient uptake and their efficient utilization management practices that lead to improved organic matter status of the soil increased nutrient cycling and better soil productivity. Ecological interactions between trees and crops in agroforestry system are beneficial because, leguminous trees have a beneficial effect on soil fertility through nitrogen fixation, greater organic matter production, and recycling of nutrients. Tree plays various functions, including shading crops to reduce evapotranspiration, erosion control and nutrient cycling (Young, 1997) [37]. The planting of trees along with crops improves soil fertility, controls and prevents soil erosion, controls waterlogging, checks acidification and eutrophication of streams and rivers, increases local biodiversity, decreases pressure on natural forests for fuel and provides fodder for livestock. The fertility of our land is decreasing rapidly due to intensive cropping and cropping with poor management. Under this situation, it is necessary to find out the suitable alternate options for raising crops. So, there is no scope for expanding forest and crop area. In that situation, the combined production of field crops with perennial trees may be a viable option to improve the

Productivity of land, and the being called multilayer agro-forestry system. It is generally assumed that the total production is several times higher than that of an annual crop system or forestry alone because growth resources viz. light, nutrient, water are used efficiently in this system. In fact, it is highly productive and sustainable systems provide continuous production around the year. However, this system is one kind of insurance of the farmers against the risks of total crop failure in case of mono cropping. Shade-loving spices e.g. turmeric and ginger grew well under agro-forestry system. Turmeric (*Curcuma longa*) is one of the most important and ancient spices of Indian sub-continent.

Turmeric (*Curcuma longa* L.) is a perennial herbaceous plant of the family, Zingiberaceae, having its importance as a spice, flavoring agent, colorant and its use in most of the systems of medicine in the treatment of various diseases. It is native in south-east India. The active components in turmeric possess a broad spectrum of biological activities with various beneficial properties such as antibacterial, antifungal, anti-parasitic, anti-mutagen, anti-inflammatory, hypolipidemic, lipoxygenase and protease-inhibitor effects, besides being effective in reactive oxygen species scavengers and lipid peroxidase inhibitors (Khanna, 1999) [10]. Turmeric has an intrinsic property of imparting a typical flavor and color due to the presence of the chemical curcumin. Turmeric rhizome contains around 3% curcumin, 2.2% α–phellandrene, 1.5% terpinolene and other essential oils. These essential oils/alkaloids have very good medicinal properties. Among them, curcumin is very important diarylheptanoid with anti-inflammatory, antiviral and antioxidant properties. Though a large number of studies unequivocally identified the numerous pharmaceutical actions of curcuminoids (Khanna, 1999) [10], its acceptance as a "wonder compound" is slowly forthcoming. Turmeric is a medicine for a range of diseases and conditions, including those of the skin, pulmonary and gastrointestinal systems, aches, wounds, sprains and liver disorders. It thrives in well-drained, fertile, sandy and clayey, black, red or alluvial loams rich in humus. It grows well under partial shade but thick shade condition affects yield of turmeric adversely (Singh and Edision, 2003) [27].

Turmeric is a potentially important medicinal and aromatic oil yielding herb which has great demand in ayurvedic industry and for culinary uses in India (Kirtikar and Basu 1988) [13]. Although Nair *et al.* (1991) [19], recommended growing of turmeric and ginger (Zingiber officinale Roscoe; Zingiberaceae) in coconut based land-use systems, there is little information available on the performance of turmeric in the understorey of different agroforestry tree species together. Against this backdrop, a field experiment was undertaken to explore the feasibility of different tree-turmeric based agroforestry in Terai region of India and to evaluate the performance of turmeric with respect to yield and quality and also soil characteristics under different agroforestry tree species. The specific objectives of the study were to assess the growth and productivity of understorey turmeric as influenced by different agroforestry tree species. This study is important because populations are increasing day by day and lands are decreasing due to industrialization, urbanization and some other developmental activities. So, there is a need to fulfill the demand of population. Hence, this can be achieved by adoption of agroforestry. Scanty researches are available on performance of yield under different agroforestry together. Therefore, this study will be helpful for the generation of more relevant data under different agroforestry tree species together.

Materials and Methods

Study site

The present study was conducted in the arboretum situated at Agroforestry Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2015-16. Pantnagar is located at 29^0 N latitude, 79.3^0 E longitude and at an altitude of 243.84 m above mean sea level in the *Terai* belt of Shiwalik range of Central Himalayan foothills. The climate and weather of Pantnagar is humid sub-tropical with cold winters and hot dry summers. The maximum daily temperature in summer may reach up to 42^0C and minimum temperature in winter may fall up to 0.5^0C. The mean annual rainfall is about 1450 mm, of which 80-90 per cent is received during the wet season (July and September). The plantation was 12 years old with a spacing of 4×4m (Square system). The entire plantations were regularly pruned up to five year to maintain them as a single stem.

Experimental design and treatments

The experiment was laid out in the Randomized Block Design (RBD) with single factor experiment. Twelve treatments were used in this study viz. T1- open field condition (sole crop), T2- *Adina cordifolia* + turmeric based agroforestry system, T3- *Albizzia procera* + turmeric based agroforestry system, T4- *Terminalia bellerica* + turmeric based agroforestry system, T5-*Emblica officinalis*+ turmeric based agroforestry system, T6- *Melia azederach* + turmeric based agroforestry system, T7-*Pterospermum acerifolium + turmeric* based agro-forestry system, T8- *Grevillea robusta + turmeric* based agro-forestry system, T9 -*Cassia fistula* + turmeric based agro-forestry system, T10-*Murraya koinigii* + turmeric based agroforestry system, T11- *Dalbergia sissoo*+ turmeric based agroforestry system, T12-*Anthocephalus cadamba* + turmeric based agro-forestry system with three replication. Turmeric (var. Pantpitabh) was used for the intercropping trial. The rhizomes of turmeric were planted to maintain a row to row distance of 60 cm and plant to plant distance of 20 cm. The depth of planting was 9-10 cm. The soils of the *Tarai* region are weakly developed with mollic epipedons and are classified as Mollisols. The soil of the experimental area belongs to Haldi silty clay loam as surface texture (Series 2) (Despandey *et al*., 1971) [5].

Measurement of crop growth, yield, and quality

To evaluate turmeric growth, data were collected at 90 and 180 days after planting (DAP). A quadrat area of 1×1 m^2 was selected for the collection of data from each agroforestry system with their replication. Five plants were randomly selected for data collection of the following parameters: height of the turmeric plant, number of leaves per plant, leaf area index. The leaf area of turmeric leaves was recorded using graph paper and leaf area index (LAI) calculated by the formula as suggested by (Watson, 1947) [36]. Number of fingers, size of mother rhizome and size of rhizome was estimated by randomly selected rhizomes. Turmeric was harvested on January 2016 after 280 days of planting when leaves turned yellowish and started drying up and fell down on the earth. At the time of harvesting, the turmeric rhizomes were collected from each agroforestry system. The collected rhizomes were washed in water, drained out the water and the weight was measured for fresh yield. The samples were then oven dried at 70^0 C until constant weight. Cured yield was calculated by boiling the turmeric and then it was converted into powder through the grinder. For quality assessment of turmeric, curing per cent was determined by the method of

Krishnamurthy *et al*. (1975) [14]. Curcumin content was determined as per the procedure described by Manjunath *et al.* (1991) [17]. The soil samples were collected randomly from 0-20cm after harvesting of turmeric. Soil pH measured in 1:2.5 soil: water suspension (Jackson 1958) [8]. Soil organic carbon was determined by modified Walkley and Black (1934) [35] method as described by Jackson (1967) [9]. Available soil nitrogen was determined by Kjeldahl method (Jackson 1958) [8], available phosphorus by Bray No.1 extraction followed by reduced moly date blue color estimation method (Watanabe and Olsen 1965) [34] and available potassium by neutral normal ammonium acetate solution followed by flame photometry (Jackson 1958) [8]. The data for different parameters were analyzed using *SPSS 16.0* software.

Results and discussion

Growth attributes of turmeric

Growth attributes of turmeric under different agroforestry tree species showed (Table 1) that maximum height of turmeric was recorded under T4 and T3 treatments at 90 and 180 days after sowing. However, minimum height was recorded under T1 (control) treatment followed by T8 treatment. Results of the study also revealed that highest plant height was recorded under agroforestry system as compared to open farming system at all growth stages. Which is attributed to turmeric is a shade demanding crop and it requires shade for its optimum growth. Under agroforestry system due to less population of weeds, the competition for nutrient between crop and weed will be less, as a result, the plant height will be more under agroforestry system as compared to open farming system. Similar finding was also reported by Padmapriya and Chezhiyan (2009) [21]; Khani NP. (2015) [11] that height of turmeric crop under the shade was higher than open system. Singh, H.P. (2016**)** also reported that the height of turmeric crop under agroforestry was higher than open farming due to less population of weed and less competition for nutrient under agroforestry system as compared to open farming system between turmeric crop and weed. Significantly highest plant height under heavy shade in okra was also reported by Ali (1999).

The maximum number of leaves was recorded under T4 (7.30) followed by T7 (7.26) and T5 (7.20) treatment and minimum under T1 (4.44) followed by T2 (6.15) and T9 (6.18) treatment at 90 days after sowing. However at 180 days after sowing, it was also highest under T4 (11.60) followed by T7 (11.20) and T5 (10.71) treatment and lowest in T1 (5.42) followed by T2 (8.58) and T3 (9.66) treatment. The highest no of leaves was recorded under T4 and T7 treatment. It may be due to the dense canopy of tree and resulting in more shade and as it has been reported that turmeric is a shade loving crop that is why no of leaves was highest under agroforestry as compared to open system (Miah, 2001) [18].

The maximum number of fingers was recorded under T4 (8.4) followed by T7 (8.3) and T3 (7.5) treatment and minimum under T10 (5.3), T5 (5.6) and T11 (5.6) treatment. Maximum no of finger was reported under agroforestry system as compared to open system. It may be due to continuous litter fall under agroforestry which contributes to high nutrient content in soil as a result maximum no of fingers under agroforestry system as compared to open (without tree).

The leaf area index (LAI) was also maximum in T4 (5.12 %) and T7 (4.92 %) and minimum in T1 (4.24) and T8 (4.25) treatment. Green leaf area is the primary source of food production through the process of photosynthesis by the plants. The simple assumptions about differences ranges of LAI values in different agroforestry system are closely related to leaf area and plant population density. This can be explained by more extensive the leaf area, leaf density or plant population density, the higher the value of LAI. This can happen due to the more extensive and dense, the more leaves shade each other so that the area of leaves will accumulate and become larger. This is consistent with the statement Koesmaryono, (1996) [12], which explained that the increase in plant populations will increase the value of LAI.

Yield and quality attributes of turmeric

The data for yield and quality attributes of turmeric are presented in Table 2. The maximum size of mother rhizome was recorded under T9 (20.78 cm^2) and T7 (19.63 cm^2) treatment whereas minimum in T11 (13.5 cm^2) and T1 (13.58 cm^2) treatment. The maximum size of rhizome was recorded under T1 (410.35 cm^2) and T11 (409.33 cm^2) treatment. Minimum size of rhizome was recorded under T4 (261.33 cm^2) and T8 (325.65 cm^2) treatment. Curcumin percentage was highest under T4 (4.10 %) and T7 (4.02 %) treatment whereas lowest under T1 (3.05 %) and T2 (3.36 %) treatment. Curing percentage was also recorded maximum under T4 (27.52 %) followed by T7 (26.65 %) and T6 (26.35 %) treatment. Minimum curing percentage was recorded under T10 (24.36 %) followed by T11 (23.65 %) and T8 (23.97 %) treatment. Curcumin percentage was highest under T4 (34.43% then open) and T7 (31.80% then open) treatment whereas lowest under T1 treatment. The results of curcumin content (%) in turmeric rhizome indicated the positive effect of shade on curcumin synthesis, translocation, and assimilation in the rhizome. The reason for decreased curcumin content under open system may be due to increase in weight and volume of fresh rhizome without proper corresponding synthesis of curcumin as reported by Rao *et al.* (1975) [22]. Agroforestry contributes a high level of soil fertility due to the addition of litter as a result curcumin content was high under agroforestry as compared to open. Higher curcumin content in turmeric crop with the application of organic amendments was also observed by Rao and Swamy (1978) [24]. Sharma *et al.* (2002) also obtained the highest curcumin content in turmeric rhizome mainly because of application of 10 t ha^{-1} of farm yard manure than application of 60 kg K_2O ha^{-1} (4.61%). Curing percentage was also recorded maximum under T4 followed by T7 and T6 treatment and minimum in T11 treatment. The probable reason for low curing percentage might be because of high moisture content and less lignification of rhizomes. Similar results are in general agreement with those obtained by Rao and Reddy (1977) who reported that crop grows under a higher fertility level of N, P and K recorded a lower curing percentage.

Maximum fresh yield of rhizome was recorded under T1 (22.63 t ha^{-1}) followed by T11 (21.55 t ha^{-1}) and T12 (21.03 t ha^{-1}) treatment whereas minimum under T5 (16.58 t ha^{-1}) followed by T7 (16.88 t ha^{-1}) and T3 (17.35 t ha^{-1}) treatment. The similar trend of yield was also recorded for a cured yield of turmeric. Maximum fresh yield and cured yield of rhizome were recorded under T1 followed by T11 and T12 treatment whereas minimum under T5 followed by T7 and T3 treatment. The maximum fresh and cured yield was observed under the open system as compared to different agroforestry system. It might be due to the reduced level of photosynthesis rate. Even though turmeric is a partially shade loving crop, a higher level of shade had a negative effect on yield. The results are with the conformity of Ridley (1912) who

Table 1: Growth parameters of turmeric at 90 and 180 day after sowing.

Treatments	Plant Height at 90 DAS	Plant Height at 180 DAS	No of Leaves at 90 DAS	No of Leaves at 180 DAS	No of fingers	LAI (%)
T1	83.84	89.25	4.44	5.42	5.8	4.24
T2	93.20	105.89	6.15	8.58	6.2	4.88
T3	91.80	102.87	6.82	9.66	7.5	4.86
T4	98.78	108.13	7.30	11.60	8.4	5.12
T5	90.70	99.64	7.20	10.71	5.6	4.53
T6	89.65	101.21	7.13	10.15	6.2	4.68
T7	98.64	107.25	7.26	11.20	8.3	4.92
T8	84.62	95.26	6.74	9.96	5.9	4.25
T9	89.25	97.52	6.18	10.15	7.2	4.36
T10	85.65	102.32	6.70	9.83	5.3	4.72
T11	90.11	99.35	6.71	9.88	5.6	4.43
T12	89.25	97.52	6.46	9.98	6.4	4.28
SEm±	1.42	1.48	0.54	0.70	0.11	0.70
LSD (p=0.05)	4.20	4.40	NS	2.07	0.36	0.21

*NS= Non-Significant

Table 2: Yield and Quality attributes of turmeric under different Agroforestry tree species.

Treatments	Size of mother rhizome (cm^2)	Size of rhizome (cm^2)	Curcumin (%)	Curing (%)	Fresh yield ($t\ ha^1$)	Cured Yield ($t\ ha^{-1}$)
T1	13.58	410.35	3.05	24.35	22.63	6.05
T2	14.84	385.10	3.36	26.35	19.32	5.02
T3	15.62	402.31	3.45	26.00	17.35	5.32
T4	14.35	261.33	4.10	27.52	18.63	5.62
T5	16.15	404.36	3.85	25.36	16.58	4.65
T6	17.25	368.36	3.56	26.35	18.21	4.88
T7	19.63	358.64	4.02	26.65	16.88	4.85
T8	16.47	325.65	3.98	23.97	18.35	5.67
T9	20.78	405.32	3.95	25.68	19.88	5.32
T10	16.20	344.65	3.58	24.36	18.65	5.64
T11	13.05	409.33	3.77	23.65	21.55	5.89
T12	15.98	401.36	3.44	23.88	21.03	5.68
SEm±	0.22	5.18	0.04	0.40	0.24	0.07
LSD (p=0.05)	0.72	17.16	0.13	1.15	0.85	0.21

observed that turmeric grew luxuriantly in shade, but it produced higher and better rhizomes yield in the open ground which is exposed to full sunlight. Turmeric crop grows well under partial shade conditions, but thick shade affects the yield of rhizome adversely (Sundararaj and Thulasidas, 1976) [32]. Similar results have been also reported by Srikrishnah and Sutharsan (2015) [31] who reported that 50 % shade level is suitable for the cultivation of turmeric. Jaswal *et al.* (1993) also observed that turmeric yield was highest under 5×3m poplar spacing as compared to open system

Table 3: Soil properties (0-20 cm depth) under different agroforestry system of experimental soil.

Treatments	pH	SOC (%)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)
T1	7.51	0.62	230.22	15.36	134.23
T2	7.41	0.93	285.35	16.25	138.64
T3	7.46	0.88	266.35	16.52	145.32
T4	7.21	0.98	301.25	18.36	158.65
T5	7.26	0.91	280.34	16.85	144.52
T6	7.38	0.96	294.31	17.32	149.35
T7	7.42	0.89	278.35	16.54	149.32
T8	7.35	0.86	272.51	16.02	142.36
T9	7.36	0.92	292.34	17.65	151.34
T10	7.34	0.91	291.52	17.24	149.36
T11	7.25	0.93	294.32	17.85	156.54
T12	7.40	0.89	281.25	17.69	153.25
SEm±	0.09	0.01	3.31	0.21	1.88
LSD(P=0.05)	NS*	0.03	9.78	0.63	5.56

*NS= Non-Significant

Soil characteristics under different agroforestry tree species

Data for soil properties under different tree species are presented in Table 3 and it clearly highlights the effect of different agroforestry tree species on soil properties. The maximum soil pH was recorded under control (open) treatment T1 (7.51) followed by T3 (7.46) T7 (7.42) and T2 (7.41) however minimum in T11 (7.25) and T7 (7.26) treatment. The highest per cent of soil organic carbon was recorded under the T4 treatment (0.98%) followed by T6 (0.96%), T2 and T11 (0.93%), T5 and T10 (0.91). The minimum SOC was observed under the open (control) treatment (0.62) treatment. The maximum available nitrogen was observed under the treatment T4 (301.25 kg ha^{-1}) followed by T11 (294.32 kg ha^{-1}), T6 (294.31 kg ha^{-1}) and T9

(292.34 kg ha^{-1}). The minimum available nitrogen was recorded under the T1 treatment (230.22 kg ha^{-1}). Maximum available phosphorus was observed under the treatment T4 (18.36 kg ha^{-1}) followed by T11 (17.85 kg ha^{-1}), T12 (17.69 kg ha^{-1}) and T9 (17.65 kg ha^{-1}) whereasa minimum in T1 (15.36 kg ha^{-1}) treatment. The maximum available potassium was also observed under the treatment T4 (158.65 kg ha^{-1}) followed by T11 (156.54 kg ha^{-1}), T12 (153.25 kg ha^{-1}) and T9 (151.34 kg ha^{-1}). The minimum available potassium was recorded under the T1 treatment (134.23 kg ha^{-1}). The lower soil pH under different agroforestry trees than the open plots might be due to the substantial addition of organic matter to the surface soil under trees and the release of organic acid during decomposition of litter. Similar results and trends of variation in soil pH under agroforestry systems in comparison to crop fields have been reported by Prasadini and Sreemannarayana (2007) [25]. Similar findings were recorded by Kumar *et al*. (2008) [16] who found that due to the addition of organic matter to the surface soil and release of organic acid during litter decomposition had resulted in a decrease of soil pH. The highest SOC per cent was observed under the different agroforestry system as compared to open. This may be because of trees generally have lignified cells in its plant parts such as litter, small branches, bark, roots etc. which may lead to the biochemical stabilization of organic carbon in the soil and hence leads to the improvement in SOC content of soil under agroforestry as observed by Six *et al.* (2002) [30]. The results obtained in the present study are in conformity with the findings reported by Bhardwaj *et al*. (2001) [3] and Ghimire (2010) [6]. The available N content in soil increased in different tree species under agroforestry over the open system which is attributed to the addition of organic matter in soil in the form of litter fall and fine root biomass. The release of nutrient into the soil through the process of mineralization of organic matter leads to an increase in the nutrient status of soil (Osman *et al*., 2001) [20]. Chaudhry *et al*. (2007) [4] also reported similar results under poplar based agroforestry systems. The maximum available P (kg ha^{-1}) was recorded under the different agroforestry system as compared to open system. This might be due to higher activity of acidic phosphatase enzyme under different tree species over the open system, as the organic anion exudation and acid phosphatase activity may lead to an increase in the mobilization of P in the rhizosphere. The similar result was reported by Ghimire (2010) [6]. Higher activity of phosphatase enzyme under the trees, as the organic anion exudation and acid phosphatase activity of tree roots has resulted to increase mobilization of phosphorus in the rhizosphere not only this greater phosphorus content could be due to nutrient pumping from deeper layer of soil by the tree species and is deposited to the surface soil layer through litter fall, small branches and twigs. The increase in soil phosphorus under tree based land-use system and forest cover has been reported earlier by Kumar and Chaudhuri (1997) [15]. Availability of potassium is increased under agroforestry as compared to treeless farming systems because of enhanced recycling of nutrients through biochemical process as reported by Hasan and Ashraful Alam (2006) [7]. The available soil potassium was higher under alley cropping system as compared to the open field as a result of release of organic acids due to organic matter accumulation under agroforestry and ultimately resulting in higher mineralization of potassium has been reported by Miah *et al.* (2001) [18]. Such findings have also been conferred by Bajpai *et al.* (2006) [2] who reported higher K content in soil as a result of higher organic matter.

Conclusion

The different growth parameters, yield attributes, and yield of turmeric were found higher under different agroforestry system as compared to an open system. Among the different agroforestry system, the maximum growth parameters of turmeric were recorded under T4 and T7 whereas yield attributes and yield was highest under T11 followed by T12. However, among all the treatments highest yield of turmeric was recorded under open system but the overall return or productivity will be higher under agroforestry system. The soil fertility status was also higher under agroforestry system. The maximum content of SOC and available NPK was recorded under the agroforestry system as compared to open system. However, among the different agroforestry tree species, it was higher in T4 and T6 treatments. So, the best agroforestry system in this study was (*Terminalia bellerica* + turmeric based agroforestry system,). The findings of this study were achieved based on one season trial, which may not be sufficient to assess the sustainability of the results. So, similar experiments should be repeated at least in another season so that result should be conclusive.

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