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Doubling the farmer's income through intercropping turmeric (*Curcuma longa* L.) under mandarin based agroforestry system in South-Eastern Rajasthan

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Abstract
A field experiment was conducted during the June 2017 to March 2018 to study "Intercropping Turmeric (*Curcuma longa* L.) Under Mandarin based Agroforestry System in South-Eastern Rajasthan" at the Instructional farm, Fruit Science, College of Horticulture and Forestry, Jhalawar, Agricultural University, Kota (Rajasthan). Six years old plantations of mandarin (*Citrus reticulata* Blanco.) at 6 x 6m spacing were used for intercropping of five varieties of Turmeric (*Curcuma longa* L.) as an intercrop viz. 'Kesar, Sugandham, Gujarat Navsari Turmeric-1, Chittor local and Udaipur local' planted at 30 x 45 cm were selected for the present study laid out in randomized block design with three replications. Highest benefit cost ratio was found in T_3 (Mandarin + *Curcuma longa* L. var. GNT-1) (2.92) followed by T_1 (Mandarin + *Curcuma longa* L. var. Sugandham) (2.70). Higher benefit cost ratio also revealed that GNT-1 and Sugandham varieties of Turmeric should be grown under Mandarin based Agroforestry system in South-Eastern Rajasthan as an intercrop with the spacing of 30 x 45 cm.

Keywords: *Turmeric*, mandarin, intercropping, cost of cultivation, net returns and benefit cost ratio

Introduction
Agroforestry is one of the land husbandry practices gaining importance as an approach for diversifying traditional agriculture. It has proved itself a key component of sustainable agriculture and has become popular in helping to address the crisis in the supply of wood, fuel and fodder and to preserve fragile ecosystems, latest findings have shown favour after effect of this system in drastic improvement of produce quality based food and also enhanced quality crops including improvement of soil conditions. Agroforestry can be defined as an approach to land use that incorporates trees into farming systems, and allows for the production of trees and crops or livestock from the same piece of land in order to obtain economic, environmental, ecological and cultural benefits (Thevathasan *et al.*, 2004) [11]. Intercropping is a way to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, increases the quantity and quality of products and reduction damage by pests, diseases and weeds.

Mandarin (*Citrus reticulata Blanco.*) is most common among citrus fruits grown in India. It occupies nearly 40 per cent of the total area under citrus cultivation in India. The most important commercial citrus species in India are the mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*) sharing 38.76, 23.82 and 23.92 per cent respectively of all citrus fruits area and 38.76, 29.94 and 21.05 per cent production in the country. Mandarin are mostly grown in the states of Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa, West Bengal, Rajasthan, Nagaland, Mizoram, Arunachal Pradesh (Anon. 2015-16) [1].

The genus *Curcuma longa* L. (Zingiberaceae) contains many taxa of economic, medicinal, ornamental and cultural importance. India is the largest producer of turmeric in the world (93.7% of the total world production) (Sasikumar, 2005) [8]. It is used mainly for domestic use as a condiment and occupies 6% of the total area under spices in the country. About 92% of the produce is consumed in the domestic market and 8% exported annually. Maximum area under turmeric is in Andhra Pradesh followed by Maharashtra, Tamil Nadu, Orissa, Karnataka and Kerala. The genus *Curcuma longa* L. (Zingiberaceae) contains many taxa which are economically important as food, condiment and as colouring, medicinal and ornamental materials. It is found throughout the South and South East Asia with a few species extending to China, Australia and the South Pacific. The highest diversity is

concentrated in India and Thailand, with at least 40 species in each area, followed by Myanmar, Bangladesh, Indonesia and Vietnam.

The orange based agroforestry system offers a better livelihood to farmers due to relatively low input costs, flexible labour requirements, compatibility with understory crops, higher productivity or profitability etc. Inter-cultivation of compatible seasonal crops with orange is essential for generating continuous supplementary income and compensating for the loss of production arising from drought, cold and other causes like climate change. The orange tree canopy modifies the microclimate and influences the physiological processes of under Storey crops. As the tree canopy becomes wider, the Photosynthetic Active Radiations (PAR) and temperatures decrease while humidity under the canopy increases. PAR under the canopy is crucial in producing grains. In many tropical cropping systems, turmeric is grown as field crop, horticultural crop, plantation crop and can be well intercropped. Jaswal *et al.* (1993) [4] found that turmeric cultivation was more remunerative than ginger, as an intercrop with poplar trees, at a spacing of 5m x 5m. Turmeric rhizome yield under partial shade was higher, but the highest cured yield was obtained when the crop was grown under fully open conditions as a monocrop, obviously due to the positive effect of fully incident light enhancing dry matter accumulation. Higher solar energy input under fully open conditions helps in higher crop growth rate during bulking of the rhizomes (Latha *et al.* 1995) [5].

Ghosh and Pal (2010) [3] conducted an inter-cropping trial on 3-year-old Mosambi sweet orange orchard planted at 5 × 5 m spacing and growing under rainfed laterite soil to identify the suitable and profitable intercrops. The intercrops grown were cowpea, ridge gourd, groundnut, radish, black gram, okra, amaranthus and cluster bean. The results of three years of investigation indicated that number of fruits was Maximum in Mosambi with groundnut followed by okra. Fruit weight was highest with cowpea closely followed by groundnut and black gram. Fruit quality and N, P and K values in leaves of Mosambi did not significantly differ among the intercrop treatments. Highest net return was calculated from Mosambi + groundnut combination (Rs. 35,820.0/ha) followed by Mosambi+okra (Rs. 22,520.0/ha) and Mosambi+cowpea (Rs. 22,420.0/ha). Highest bio-mass was obtained from cowpea (68 q/ha) followed by groundnut (54 q/ha) and black gram (35 q/ha). Nitrogen concentration in the orchard soil was improved due to growing of leguminous crops while phosphorus and potassium were depleted in all the cases.

Choudhary *et al.* (2015) [2] evaluated performance of two rhizomatous crops turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) under rain fed conditions as sole crops and with 15-year old well established stands of forest tree species located at the research farm of ICAR Research Complex for NEH Region, Research Centre, Basar, Arunachal Pradesh. The average illumination below the canopies varied from 72.00 to 79.20% of incident radiation on turmeric and 71.70 to 78.80% of incident radiation on ginger. Turmeric and ginger were cultivated in the inter row spaces of 24 and 12 Multipurpose trees (MPTs), respectively. Turmeric and ginger did not perform well under as many as 18 and 5 MPTs, respectively. Turmeric, in association with nitrogen fixing tree species and did not significantly reduce its productivity. Leaf area and leaf area index was significantly higher under than the sole turmeric crop. However, multipurpose trees had significantly negative effect on the growth and yield attributes of ginger crop. The reduction in yield of ginger ranged from 11.30 to 31.30%. It may be inferred that turmeric cultivation was more profitable than the ginger and both the crops showed highest benefit: cost ratio 3.10 and 2.36, respectively under based agro forestry systems in comparison to the other multipurpose trees based agro forestry systems.

Pandey *et al.* (2016) [7] conducted an experiment under support irrigated conditions at NAU, Navsari (Gujarat) during 2013 and 2014. The nine year old plantation of Sapota (*Manilkara acharas* (Mill.) Fosberg) with seven year old plantation of Jatropha (*Jatropha curcas* L.) was used for the present intercropping study. Two crops with two varieties *viz*. Ginger **(***Zingiber officinale* L var. Navsari local and *Zingiber officinale* L. var. Udaipur local**)** and Turmeric **(***Curcuma longa* L. var. Sugandham and *Curcuma longa* L. var. Guj. Navsari Turmeric- 1) was selected for the study. Significantly higher B: C ratio was noted in intercropping of ginger with Sapota + Jatropha or Jatropha based agro-forestry systems as compared to sole cropping or intercropping under Sapota, whereas in intercropping of turmeric with Sapota or Sapota + Jatropha agro-forestry systems as compared to Intercropping under Jatropha or sole cropping. Overall economic analysis states that the total cost of production found higher in case of ginger but net income as well as BCR observed higher in case of turmeric.

Materials and Methods

A field experiment entitled "Intercropping Turmeric (*Curcuma longa* L.) under Mandarin based Agroforestry System in South-Eastern Rajasthan" was conducted at the Fruit Research Farm, College of Horticulture and Forestry, Jhalrapatan city, Jhalawar (Agriculture University, Kota) during June, 2017 to march, 2018. Geographically, District Jhalawar falls in Zone-V i.e. Humid south eastern plains, which extends over 6.32 Lac hectare land area among 23°4' to 24°52' N (latitude) and 75°29' to 76°56' E (longitude) in South Eastern Rajasthan. The climate of Jhalawar is typically sub-humid and characterized by extremes of temperature both summer and winter with high rainfall and moderate relative humidity. Major kharif crops of the district are soybean, maize and pulses, while in rabi, wheat, mustard, coriander and garlic are main crops. The district has attained premier position in cultivation of mandarin orange. The climate of the zone is sub-humid and sub-tropical characterized by mild winter and warm summer associated with relatively high humidity during the month of July to September. The region has mean annual rainfall of 954.7 mm mostly received from South-West monsoon during last week of June to Sept. and sometimes receives scanty showers during winter season. Meteorological data showed that during the growing period of the crop the mean maximum and minimum temperatures ranged between 36.59 ^{0}C and 3.34 ^{0}C while, the mean maximum and minimum relative humidity ranged between 63.14 and 24.57 percent.

The gross realization in terms of rupees per hectare was worked on the basis of the yield of each treatment. The price of economic yield of particular crop was accounted on the basis of the prevailing market price. The net returns per hectare were calculated by deducting the cost of cultivation from gross return per hectare. The benefit cost ratio was calculated as per following formula:

$$\text{Benefit cost ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

Result and Discussion

The result on cost of cultivation, net returns, gross income and benefit cost ratio (B: C) affected by sole turmeric and intercropping under Mandarin based agroforestry system are presented in the Table – 1.0. The Turmeric intercrop under Mandarin based Agroforestry system recorded higher benefit cost ratio as compared to sole Turmeric in all respective treatments, however benefit cost ratio of Mandarin sole (T_0) was found intermediate. Highest benefit cost ratio was found in T_3 (Mandarin + *Curcuma longa* L. var. GNT-1) (2.92) with the spacing of 30 x 45 cm for turmeric as an intercrop whereas lowest was found in T_7 (*Curcuma longa* L. var. Kesar sole) (1.29). Compared to all respective treatments as per varieties of the turmeric studied, treatments with turmeric var. GNT-1 recorded higher benefit cost ratio.

The data pertaining to cost: benefit ratio revealed that maximum benefit cost ratio was obtained in that GNT-1 and Sugandham variety of Turmeric, which showed highest gross, return (Table – 1.0). It is evident from results that the intercropping of turmeric showed higher benefit cost ratio as compared to sole crop. The reason can be adaptability of turmeric as intercrop in Mandarin in regard of their development, nutrient requirement as well as light and moisture conditions which showed better productivity and higher economic yields and returns as compared to sole cropping. Similar results were also observed by Pandey *et al.* (2016) [7] in intercropping of ginger and turmeric and Jatropha-Sapota based agroforestry system and Solanki *et al.* (2014a.) [10] in tuber medicinal crops and Similar result has also been found by Nayak *et al.* (2014) [6] in agri-silviculture system.

It can be concluded that Mandarin can be grown with turmeric without significant yield reductions. The intercropping was found to stabilize yield advantages and economic returns. Therefore, depending on performance and priority of farmers, intercropping mandarin with turmeric may become important practice to increase yield and reduce risks associated with environmental and price fluctuations in south- eastern Rajasthan.

Table 1: Economics of Turmeric cultivation under Mandarin based Agroforestry system in South-Eastern Rajasthan

Treatment	Yield/ha		Cost of various products (Rs/ha)			Total cost of production (Rs/ha)	Gross returns (Rs/ha)		Total Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Mandarin (Fruit)	Turmeric (Rhizome)	Rhizome	FYM & NPK	Cost of Cultivation		Mandarin (Fruit)	Turmeric (Rhizome)			
T_0	152.68	0.00	0.00	19172	57550	76722	183216	0.00	183216	106494	2.38
T_1	148.70	84.96	70000	18695	65075	153770	203532	237888	416328	262558	2.70
T_2	156.69	72.69	70000	18695	65075	153770	203532	203532	391560	237790	2.54
T_3	147.36	97.56	70000	18695	65075	153770	203532	273168	450000	296230	2.92
T_4	149.85	77.14	70000	18695	65075	153770	203532	215992	395812	242043	2.57
T_5	154.96	78.34	70000	18695	65075	153770	203532	219352	405304	251534	2.63
T_6	0.00	77.76	70000	18695	40302	128997	0.00	217728	217728	88731	1.68
T_7	0.00	59.64	70000	18695	40302	128997	0.00	166992	166992	37995	1.29
T_8	0.00	78.9	70000	18695	40302	128997	0.00	220920	220920	91923	1.71
T_{19}	0.00	61.79	70000	18695	40302	128997	0.00	173012	173012	44015	1.34
T_{10}	0.00	66.50	70000	18695	40302	128997	0.00	186200	186200	57203	1.44

Note: T_0: Mandarin sole, T_1: Mandarin + *Curcuma longa* L. var. Sugandham, T_2: Mandarin + *Curcuma longa* L. var. Kesar, T_3: Mandarin + *Curcuma longa* L. var. GNT-1, T_4: Mandarin + *Curcuma longa* L. var. Udaipur local, T_5: Mandarin + *Curcuma longa* L. var. Chittor local, T_6: *Curcuma longa* L. var. Sugandham sole, T_7: *Curcuma longa* L. var. Kesar sole, T_8: *Curcuma longa* L. var. GNT-1 sole, T_9: *Curcuma longa* L. var. Udaipur local sole, T_{10}:*Curcuma longa* L. var. Chittor local sole, Rate of rhizome propogule = 35.00Rs/Kg, Whole sale price of Mandarin = 12.00Rs/Kg, Whole sale of Turmeric (Fresh) = 25.00Rs/Kg, Price of Nitrogen = 6.50Rs/Kg, Price of Phosphorus = 8.00 Rs/Kg, Price of Potassium = 12.00 Rs/Kg, Price of FYM = 1500.00Rs/Ton, Labour Charges = 207.00Rs/day, Price of Fungicide = 1400.00Rs/Kg, Price of Insecticide = 600.00 Rs/Kg, Price of Weedicide = 1200.00 Rs/Kg, Price of Irrigation = 100.00Rs/hr

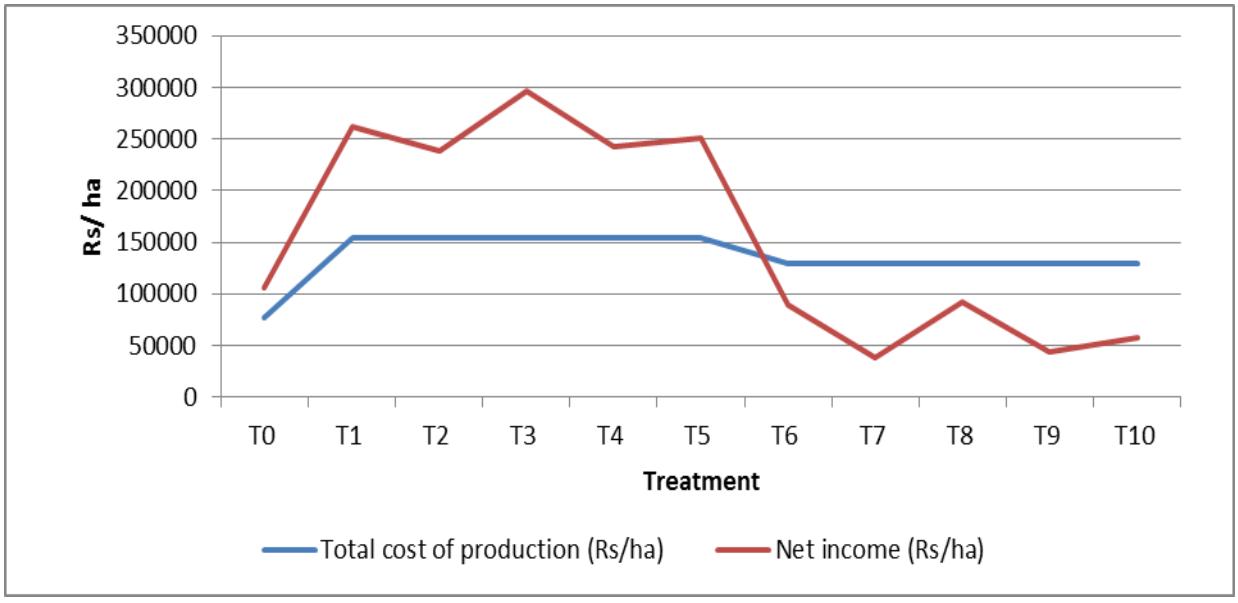
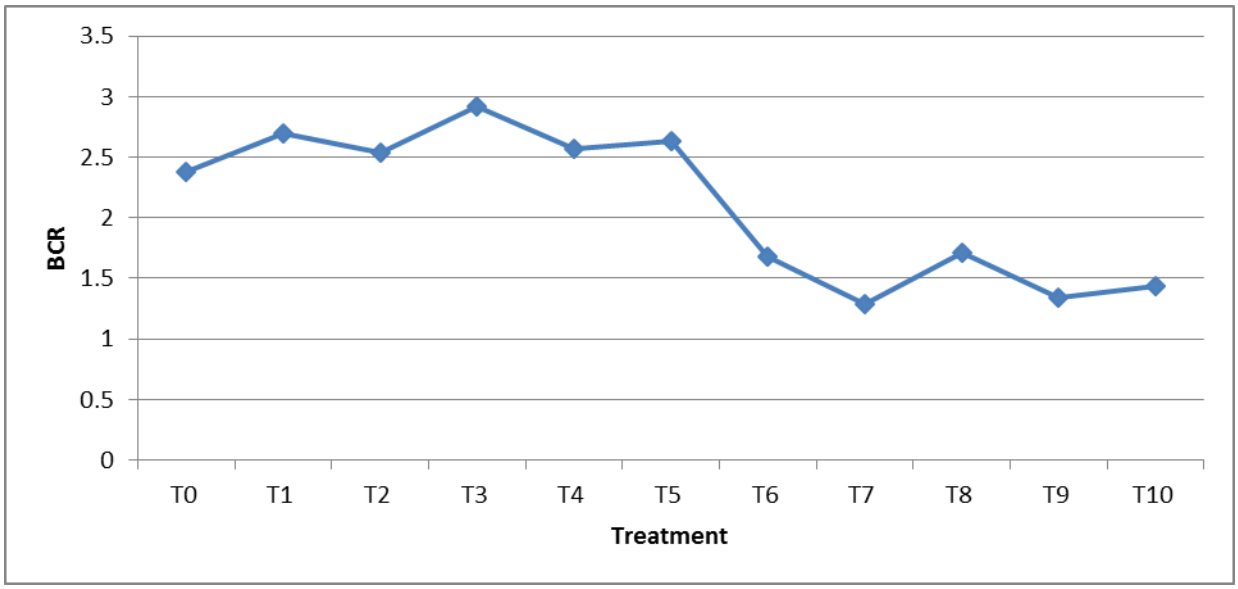


Fig 1: Evaluation of Mandarin based Agroforestry system in South-Eastern Rajasthan with cost of cultivation and net income (Rs/ha.)



Note: T_0: Mandarin sole, T_1: Mandarin + *Curcuma longa* L.var. Sugandham, T_2: Mandarin + *Curcuma longa* L.var. Kesar, T_3: Mandarin + *Curcuma longa* L.var. GNT-1, T_4: Mandarin + *Curcuma longa* L.var. Udaipur local, T_5: Mandarin + *Curcuma longa* L.var. Chittor local, T_6: urcuma longa L. var. Sugandham sole, T_7: *Curcuma longa* L.var. Kesar sole, T_8: *Curcuma longa* L.var. GNT-1 sole, T_9: *Curcuma longa* L. var. Udaipur local sole, T_{10}: *Curcuma longa* L. var. Chittor local sole

Fig 2: Evaluation of Mandarin based Agroforestry system in South-Eastern Rajasthan with benefit: cost ratio (Rs/ha.).

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