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Tree-crop interactions in *Melia composita-Tagetes erecta* based agroforestry system

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ABSTRACT

There are numerous studies on tree-crop interactions but there seems to be little attempt in literature to reveal the interactions between *Melia composita* and *Tagetes erecta* in the agroforestry system. Thus, current study was conducted in the experimental area of Division of Silviculture and Agroforestry of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during the year 2017-18 to investigate the effect of tree component on the growth and yield of marigold and vice-versa. An attempt was also made to estimate benefit: cost of the systems. The treatment consisted of two varieties of marigold (Pusa Narangi Gainda and Pusa Basanti Gainda) grown under *Melia composita* at three distances from the tree (upto 1.2 m, 1.2-2.4 m, 2.4-3.6 m), pure tree plantation and sole crops of both the varieties. The experiment was laid in Randomized Block Design with six replications. The growth and yield parameters of marigold *viz*., plant height, plant spread, number of branches per plant and above ground biomass (fresh and dry), number of flowers per plant and flower yield per plant were significantly influenced by the distance from the *Melia composita* trees. In Pusa Narangi Gainda, the highest values of above said parameters 82.21 cm, 43.10 cm^2, 12.66, 2.42 kg and 0.43 kg, 36.91 and 257.14 g respectively were recorded in the plants growing in open and lowest at < 1.2 m distance from the under canopy. In Pusa Basanti Gainda also the maximum values of plant height, plant spread, number of branches per plant, above ground fresh biomass, above ground dry biomass, number of flowers per plant and flower yield per plant78.24 cm, 38.41 cm^2, 11.25, 1.81 kg, 0.26 kg, 36.15 and 234.02 g respectively) were recorded in the plants growing outside the tree canopy and minimum at < 1.2 m distance under canopy. The growth and yield of the variety Pusa Narangi Gainda under canopy at < 1.2 m, 1.2-2.4 m and 2.4-3.6 m from the tree was better than the variety Pusa Basanti Gainda at each respective distance. There was decrease in growth and yield of both the varieties under trees compared to their respective controls (sole crop). There was no effect of marigold crop on growth performance of trees when grown together with crop compared to its control (sole plantation). Both agroforestry systems had less B:C ratio owing to lower revenue of trees as these were in initial stages of growth. However, cultivation of marigold (both varieties) with *Melia composita* plantation in the form of agroforestry system enhanced the net returns compared to pure tree plantation. It shows marigold is one of potential crops for agroforestry in Jammu subtropics. Study implies that inter-cultivation of *Melia composita* with marigold in the form of agroforestry be encouraged to enhance the income of the farmers.

1. Introduction

Agroforestry is sustainable land management system which involves introduction and /or retention of woody components such as trees, shrubs, bamboos, canes, palms along with agricultural crops including pasture/ animals, simultaneously or sequentially on the same unit of

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land and time, to satisfy the ecological as well as socio-economic needs of the people (Dhyani *et al.,* 2009). Agroforestry is now recognized as an important part of the 'evergreen revolution' movement in the country. India launched National Agroforestry Policy in 2014 and became the first country in the world to have a National Agroforestry Policy. The policy is not only seen as crucial to India's ambitious goal of achieving 33 per cent tree cover but also to mitigate greenhouse gas (GHG) emissions from atmosphere with potential of ameliorative consequences at local, regional and global level. There is now impetus on growing fast growing, multipurpose and short rotation trees in agroforestry to increase the economic and ecological benefits from agroforestry.*Melia composita* Willd. is one such fast-growing species which is an indigenous, fast growing and multipurpose tree. The tree has multifarious uses like pulpwood, timber, fuel wood and plywood. Its wood is used in packing cases, ceiling planks, agricultural implements, pencils, match boxes, splints and musical instruments. It is also grown as a shade tree in coffee and tea plantations. Notably, the wood is also resistant to termite attacks further enhancing its value and longevity. Due to its multifarious uses it can fit as a suitable species for agroforestry programme (Saravanan *et al.*, 2013).It belongs to the family Meliaceae and is naturally grown in deciduous forests with elevation ranging 600-1,800 m. It grows on a variety of soils and prefers deep, fertile and sandy loam soils. The distribution of *Melia composita* ranges from Indo-Malaysia to Australia and Western Ghats of India. The species performs exceedingly well attaining the harvestable size within 6-8 years. Now the species is increasingly being cultivated by the farmers in northern parts of India in the form of agroforestry.

Marigold (*Tagetes erecta*) is also one of the most important commercial flower crops grown all over the world and in India as well; accounting for more than half of Nation's loose flower production (Sreekanth *et al.*, 2006). The scope floriculture in Jammu and Kashmir has increased tremendously, which is evident from the increase in area to 255 ha in 2015-16 against only 80 ha in 1996 (Sheikh *et al.*, 2015). Marigold varieties Pusa Narangi Gainda and Pusa Basanti Gainda has caught the attention of the farmers of Jammu and Kashmir, especially of Jammu region (Prasad *et al.*, 2017). Given the commercial viability of Marigold as a flower crop and the fast-growing nature of *Melia composita*, the introduction of marigold within *M. composita* agroforestry systems holds significant promise for enhancing farmers' livelihoods.. Further literature review reveals that studies on tree-crop interactions in *Melia composita* and *Tagetes erecta* based agroforestry are almost non-existent. Therefore, the present investigation was carried out to study the tree-crop interactions between marigold and *Melia composita* and investigate benefit-cost of the system.

2. Material and Methods

Study site

The study was carried out at experimental area of Division of Silviculture and Agroforestry of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu located at Chatha (Jammu). The site is located at 32^0-40′ N latitude and 74^0-58′ E longitude with an altitude of 332 m above mean sea level. The annual rainfall ranges from 1100 mm to 1250 mm. The soil was sandy loam in texture. The climate of the study site is subtropical.

Experimental layout and conduct

An agroforestry system comprising of *Melia composita*+ *Tagetes erecta* was developed to study the tree crop interactions. At the beginning of the experiment the age of plantation was 1.5 years. The spacing of *Melia composita* was 4 m x 6 m. Two varieties of *Tagetus erecta* (Pusa Narangi Gainda and Pusa Basanti Gainda) were grown as intercrop. Nursery raised seedlings of marigold varieties were transplanted at spacing of 40 cm x 40 cm in the system during the month of November with plot sizes of 1.2 m x 4 m at different distances from the tree up to 1.2 m, 1.2-2.4 m and 2.4-3.6 m. At the time of transplanting the nutrients nitrogen, phosphorus and potassium was given in the form of urea (120 kg/ha), DAP (100 kg/ha) and MOP (100 kg/ha) respectively. Data were recorded for various growth parameters from November – March during study period. In case of trees, data were recorded at the beginning and end of the experiment. Sole crops of marigold were grown separately as control and sole *Melia composita* plantation was also selected for the experiment. The height of trees was measured using Abney's level and DBH was measured using wooden tree calipers. The volume of trees was estimated by considering the tree as composed of different sections (logs) of 0.5m length each and estimating volume of each section from its mid diameter. The last (top most) section of the tree was assumed to be conical and its volume was estimated using the formula of volume of cone. The volume of all the sections of each tree was added to estimate volume of the tree as a whole. The treatment details for different objectives are given below:

Objective 1: Growth and Yield of *Tagetes erecta* as influenced by distance of cropping from tree

This objective was fulfilled by using eight treatments: T_1 (Pusa Narangi Gainda grown upto 1.2m distance from the tree), T_2 (Pusa Narangi Gainda grown at 1.2-2.4m distance from the tree), T_3: (Pusa Narangi Gainda grown at 2.4-3.6m distance from the tree), T_4 (Pusa Basanti Gainda grown at 0-1.2m distance from the tree), T_5 (Pusa Basanti Gainda grown at 1.2-2.4m distance from the tree), T_6 (Pusa Basanti Gainda grown at 2.4-3.6m distance from the tree), T_7 : Control (Pusa

Narangi Gainda grown in open without trees) and T_8: Control (Pusa Basanti Gainda grown in open without trees)

Objectives 2*:* Growth of *Melia composita* in different systems

The treatments for this objective included: T_1 (*Melia composita* with Pusa Narangi Gainda), T_2 (*Melia composita* with Pusa Basanti Gainda) and T_3-Control (*Melia composita* without marigold)

Statistical design

Randomised Block Design was used to analyse the data in both to fulfill both the objectives with plot size of 1.2 m x 4 m and 6 replications.

3. Results

3.1 Growth and yield attributes of marigold varieties under open conditions

Growth attributes

In open conditions (Table 1), the plant height, plant spread, flower size and duration of flowering in Pusa Narangi Gainda (82.21 cm, 43.10 cm^2, 6.41 cm and 60.16) was significantly higher than Pusa Basanti Gainda (78.24 cm, 38.41 cm^2, 5.08 cm and 55.16). However, number of branches per plant and number of flowers per plant in Pusa Narangi Gainda was at par with those of Pusa Basanti Gainda respectively (Table 1).

Table 1. Effect of trees on growth attributes of marigold varieties Pusa Narangi Gainda and Pusa Basanti Gainda

Variety	Distance from tree	Plant height (cm)	Plant spread (cm^2)	Number of branches per plant	Days taken to bud formation	Number of flowers per plant	Flower size (cm)	Duration of flowering
Pusa Narangi Gainda (V_1)	<1.2 m (T_1)	66.55	31.05	7.16	39.83	21.24	5.18	44.33
	1.2-2.4 m (T_2)	68.54	35.15	8.40	42.93	26.50	5.53	48.50
	2.4-3.6 m (T_3)	70.47	37.09	9.26	45.00	30.07	5.55	53.83
	Mean	68.52	34.43	8.27	42.58	25.93	5.42	48.88
Pusa Basanti Gainda (V_2)	<1.2 m (T_4)	59.45	28.96	7.56	47.03	23.28	5.40	41.33
	1.2-2.4 m (T_5)	63.69	30.58	7.76	51.70	24.27	5.77	47.33
	2.4-3.6 m (T_6)	66.49	33.01	9.00	55.43	29.28	5.45	51.50
	Mean	63.21	30.85	8.10	51.38	25.61	5.54	46.72
Pusa Narangi Gainda (V_1)	Control (open) (T_7)	82.21	43.10	12.66	56.55	36.91	6.41	60.16
Pusa Basanti Gainda (V_2)	Control (open) (T_8)	78.24	38.41	11.25	69.31	36.15	5.08	55.16
	$CD_{0.05}$	3.75	3.34	1.87	0.86	2.43	0.60	2.32

Yield attributes

Under open conditions the flower weight, flower yield per plant, flower yield per hectare, above ground fresh biomass and above ground dry biomass of Pusa Narangi Gainda (6.60g, 257.14 g, 15187.50 kg, 2.42 kg and 0.43 kg) was statistically higher than Pusa Basanti Gainda (5.56 g, 234.02 g, 13687.50 kg, 1.81 kg and 0.26 kg) (Table 2).

Table 2. Effect of trees on yield attributes of marigold varieties Pusa Narangi Gainda and Pusa Basanti Gainda

Variety	Distance from tree	Flower weight (g)	Flower yield per plant (kg)	Flower yield (kg/ha)	Fresh Above-ground biomass (kg)	Dry Above-ground biomass (kg)
PusaNarangiGainda (V_1)	<1.2 m (T_1)	4.45	95.53	6145.83	0.98	0.22
	1.2-2.4 m (T_2)	5.00	134.62	8416.66	1.21	0.28
	2.4-3.6 m (T_3)	6.01	180.25	11419.16	1.79	0.35
	Mean	5.48	136.80	8660.55	1.32	0.28
Pusa Basanti Gainda (V_2)	<1.2 m (T_4)	3.98	92.72	5604.16	0.78	0.17
	1.2-2.4 m (T_5)	5.03	121.05	7291.66	1.02	0.21
	2.4-3.6 m (T_6)	6.01	175.04	10520.83	1.36	0.24
	Mean	5.00	129.60	7805.55	1.05	0.20
Pusa Narangi Gainda (V_1)	Control (open) (T_7)	6.60	257.14	15187.50	2.42	0.43
Pusa Basanti Gainda (V_2)	Control (open) (T_8)	5.56	234.02	13687.50	1.81	0.26
	$CD_{0.05}$	0.39	7.27	812.50	0.50	0.09

3.2 Growth and yield attributes of Pusa Naragi Gainda and Pusa Basanti Gainda under tree canopy versus open conditions

Growth attributes

Under canopy the plant height, plant spread, number of branches per plant, days taken to bud formation, number of flowers per plant, flower size and duration of flowering in Pusa Narangi Gainda at each respective distance viz., < 1.2 m, 1.2-2.4 m and 2.4-3.6 m from the tree was statistically lower compared to its control-open conditions (Table 1). The value of these pre-said parameters at distance of 2.4-3.6 m from the tree was superior to < 1.2 m and 1.2-2.4 m respectively (Table 1). In Pusa Basanti Gainda, also the plant height, plant spread, number of branches, days taken to bud formation, number of flowers per plant and flowering duration of Pusa Basanti Gainda was statistically lower under all distances from tree compared to its control-open condition (Table 1). Surprisingly, under tree canopy the flower size of Pusa Basanti Gainda was significantly superior to its control and 1.2-2.4 m distance from the tree but statistically at par at with < 1.2 m and 2.4-3.6 m distances from the tree (Table 1).

Yield attributes

The flower weight, flower yield per plant, flower yield per hectare and above ground fresh biomass of Pusa Narangi Gainda under the tree canopy was statistically lower under all distances from tree compared to its control-open condition (Table 2). The above ground dry biomass of Pusa Narangi Gainda was statistically lower at < 1.2 m and 1.2-2.4 m distance from tree compared to its control (open condition). However, the above ground dry biomass at 2.4-3.6 m distance was statistically at par with its control (Table 2). Under canopy the flower weight, flower yield per plant, flower yield per hectare, above ground fresh biomass and above ground dry biomass of this variety was in order 2.4-3.6 m > 1.2-2.4 m > less than 1.2 m distance from the tree (Table 2).

Interestingly, under the tree canopy the flower weight of Pusa Basanti Gainda was statistically higher at 2.4-3.6 m distance from tree compared to its control (open condition). However, at < 1.2 m and 1.2-2.4 m the flower weight was lower but statistically at par with its control (Table 2). The flower yield per plant and flower yield per hectare in Pusa Basanti Gainda was statistically lower at all distances from tree compared to its control (open condition). The fresh above ground biomass of Pusa Basanti Gainda was found to be statistically lower at < 1.2 m and 1.2-2.4 m distance from tree compared to its control (open condition) (Table 2). However, the above ground fresh biomass at 2.4-3.6 m distance was statistically at par with its control (Table 2). The above ground dry biomass of Pusa Basanti Gainda at 1.2-2.4 m and 2.4-3.6 m distance from tree was statistically at par with its control (open condition). However, at < 1.2 m the above ground dry biomass was statistically lower compared to its control (Table 2).

3.3 Comparison of growth and yield attributes of marigold varieties under tree canopy

Growth attributes

Under tree canopy the plant height of Pusa Narangi Gainda was significantly higher than that of Pusa Basanti Gainda at respective distances from the tree viz., < 1.2 m, 1.2-2.4 m and 2.4-3.6 m (Table 1). However, the plant spread of Pusa Narangi Gainda was statistically at par with Pusa

Basanti Gainda at < 1.2 m distance from the tree and statistically higher than Pusa Basanti Gainda at 1.2-2.4 m and 2.4-3.6 m distance from the tree respectively (Table 1). The number of branches and flower size of Pusa Narangi Gainda was statistically at par with Pusa Basanti Gainda at.< 1.2 m, 1.2-2.4 m, 2.4-3.6 m distances from the tree. Pusa Basanti Gainda took significantly higher number of days for bud formation than that of Pusa Narangi Gainda at respective distances of < 1.2 m, 1.2-2.4 m and 2.4-3.6 m under the tree canopy. At each respective distance the number of flowers and flower size in variety Pusa Narangi Gainda was at par with that of variety Pusa Basanti Gainda). Under the tree canopy, Pusa Basanti Gainda had significantly higher duration of flowering at 1.2-2.4 m and 2.4-3.6 m distance from tree compared to Pusa Narangi Gainda at the respective distances (Table 1). However, duration of flowering at < 1.2 m distance from tree in both the varieties was statistically at par.

Yield attributes

The trees had significant influence on flower weight of marigold, flower yield per plant, flower yield per hectare and above ground fresh and dry biomass (Table 2). Under tree canopy the flower weight of Pusa Narangi Gainda was significantly at par with Pusa Basanti Gainda at 1.2-2.4 m, 2.4-3.6 m distance from the tree, whereas at < 1.2 m distance the flower weight of Pusa Narangi Gainda was statistically higher than Pusa Basanti Gainda. Under tree canopy the flower yield per plant, flower yield per hectare in Pusa Narangi Gainda was significantly higher than Pusa Basanti Gainda at each respective distance from the tree viz., < 1.2 m, 1.2-2.4 m, 2.4-3.6 m. The above ground fresh biomass of Pusa Narangi Gainda was statistically at par with Pusa Basanti Gainda at respective distance viz., < 1.2 m, 1.2-2.4 m and 2.4-3.6 m under the tree canopy while the above ground dry biomass of Pusa Narangi Gainda was at par with Pusa Basanti Gainda at < 1.2 m, 1.2-2.4 m distance respectively. However, at 2.4-3.6 m distance the above ground dry biomass of Pusa Narangi Gainda was statistically higher than Pusa Basanti Gainda (Table 2).

3.4 Effect of marigold crop on the growth of *Melia composita*

Table 3 depicts tree growth characteristics at the time of planting of marigold as well as at harvest time of marigold crop.

Table 3. Tree characteristics at planting time of marigold crops and after harvest of marigold crop

Tree characteristics at planting time of marigold					
Treatment	**Height (m)**	**DBH (cm)**	**Crown width (m)**	**Stem volume (m^3)**	**Above ground wood biomass (kg/tree)**
T_1 (Tree with Pusa Narangi Gainda)	7.2	11.25	6.05	0.065	83.90
T_2 (Tree with Pusa Basanti Gainda)	7.3	9.94	4.82	0.052	64.56
T_3 (only tree)	7.9	11.90	6.37	0.067	94.53
CD	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**
Tree characteristics after harvest of marigold crops					
Treatment	**Height (m)**	**DBH (cm)**	**Crown width (m)**	**Stem volume (m^3)**	**Above ground wood biomass (kg/tree)**
T_1 (Tree with PusaNarangiGainda)	8.1	12.77	6.87	0.069	92.16
T_2 (Tree with PusaBasantiGainda)	8.1	10.91	5.47	0.053	70.80
T_3 (only tree)	8.6	13.41	7.25	0.070	102.61
$CD_{0.05}$	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

The difference between treatments for each respective characteristic (height, DBH, crown width, stem volume and above ground wood biomass of the tree) at the time of marigold planting was non- significant (Table 3) showing that trees used for different treatments were uniform in these characteristics. At the time of harvest also the respective tree characteristic in each treatment was statistically at par amongst different treatments (Table 3). This implies that intercropping of trees with marigold (Pusa Narangi Gainda and Pusa Basanti Gainda) did not have significant on the studied tree growth characteristics.

The gross returns per hectare were highest in sole Pusa Narangi Gainda crop (Rs.3,03,740) followed by *Melia composita*+Pusa Narangi Gainda based agroforestry system (Rs.2,83,973), *Melia composita*+Pusa Basanti Gainda based agroforestry system (Rs.2,27,528), sole Pusa Basanti Gainda crop (Rs.2,05,312) and pure tree crop (1,10,653) respectively (Table 4).

The net returns per hectare were highest in sole Pusa Narangi Gainda crop (Rs.2,26,230) followed by *Melia composita*+Pusa Narangi Gainda based agroforestry system (Rs.1,43,353), sole Pusa Basanti Gainda crop (Rs.1,27,802), *Melia composita*+Pusa Basanti Gainda based agroforestry system (Rs.86,908) and pure tree crop (Rs.28,140) respectively. The B:C ratio was highest (2.90) in sole Pusa Narangi Gainda followed by sole Pusa Basanti Gainda (1.64), *Melia composita*+Pusa Narangi Gainda based agroforestry system (1.01) followed, *Melia composita*+Pusa Basanti Gainda based agroforestry system (0.61) and pure *Melia composita* plantation (0.34) respectively (Table 4).

4. Discussion

In open conditions (Table 1), the growth and yield of Pusa Narangi Gainda was better than Pusa Basanti Gainda. SKUAST-J (2015) also reported that Pusa Narangi Gainda has better height of 65.75cm than Pusa Basanti Gainda which has a plant height of 60-70 cm. Further, the overall growth and yield performance of both varieties in open in the current study was better than under tree canopy at 2.4-3.6 m, 1.2-2.4 m and < 1.2 m distance from the tree respectively (Table 1). This might have resulted due to higher competition for light between trees and crop nearer to the trees under canopy, there by might have reduced the growth performance of marigold crop under canopy. Channabasappa *et al.* (2007) also reported lower yield in rice crop nearer to trees than under open conditions in *Acacia auriculiformis*+rice based agroforestry system. Prakash and Pant (2015) recorded lower plant height, plant spread and number of side stems in *Godetia grandiflora* crop nearer to trees than under open conditions in *Grewia optiva* based agroforestry system. Decrease in growth of crops nearer to trees was reported by Kaushal *et al*. (2006), Hadgu*et al*. (2009), Palsaniya *et al*. (2012) and Sarkar *et al.* (2014) respectively in *Grewia optiva* and wheat, *Faidherbia albida*+*Eucalyptus camaldulensis* and barley, Guava and barley, *Xylia dolabriformis*+radish+coriander based agroforestry systems respectively. The overall better growth and yield at 2.4-3.6 m distance from tree under canopy in both the varieties of marigold in the current could be due to higher production of photosynthates at the said distance compared to other distances (< 1.2 m and 1.2-2.4 m). Maih

Table 4. Economics of sole marigold crop, agroforestry and pure tree crop (Rs./ha)

System	Yield (q/ha)	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Sole Crop (Pusa Narangi Gainda)	151.87*	303740	77510	226230	2.90
Sole Crop (Pusa Basanti Gainda)	136.87*	205312	77510	127802	1.64
AFS (Pusa Narangi Gainda + *Melia composita*)	86.66*+36.88**	283973	140620	143353	1.01
AFS (Pusa Basanti Gainda + *Melia composita*)	77.91*+36.88**	227528	140620	86908	0.61
Pure Tree Crop	36.90**	110653	82514	28140	0.34

AFS- Agroforestry System, *- flower yield of marigold, **- fresh stem and branch biomass of trees

et al. (1999) also recorded lower production of photosynthates under low light conditions prevailing for longer periods, thus, resulting in low plant growth.

The trees had significant influence on flower weight of marigold, flower yield per plant, flower yield per hectare and above ground fresh and dry biomass in the present study (Table 2). Under tree canopy the flower weight of Pusa Narangi Gainda was significantly at par with Pusa Basanti Gainda at 1.2-2.4 m, 2.4-3.6 m distance from the tree, whereas at < 1.2 m distance the flower weight of Pusa Narangi Gainda was statistically higher than Pusa Basanti Gainda. Under tree canopy the flower yield per plant, flower yield per hectare in Pusa Narangi Gainda was significantly higher than Pusa Basanti Gainda at each respective distance from the tree viz., < 1.2 m, 1.2-2.4 m, 2.4-3.6 m. The above ground fresh biomass of Pusa Narangi Gainda was statistically at par with PusaBasantiGainda at respective distance viz., < 1.2 m, 1.2-2.4 m and 2.4-3.6 m under the tree canopy while the above ground dry biomass of Pusa Narangi Gainda was at par with Pusa Basanti Gainda at < 1.2 m, 1.2-2.4 m distance respectively. However, at 2.4-3.6 m distance the above ground dry biomass of Pusa Narangi Gainda was statistically higher than Pusa Basanti Gainda (Table 2). The overall better growth and yield at 2.4-3.6 m distance from tree under canopy in both the varieties of marigold in current study could be due to higher production of photosynthates at the said distance compared to other distances (< 1.2 m and 1.2-2.4 m). Maih *et al.* (1999) also recorded lower production of photosynthates under low light conditions prevailing for longer periods, thus, resulting in low plant growth. In current study the marigold crops (both varieties) at closer distance from the tree started early bud formation. Experimental findings of Prakash (2011) also exhibited similar results in *Grewia optiva-Calendula officinalis* based agroforestry system where mean flower bud initiation was early under canopy at 1 m distance from tree (32.83 days) compared to the open condition (36.91 days). Early bud initiation might be due to the higher temperature and soil moisture content under the tree canopy in winter season as compared to the open conditions. These results are in the line of Swaroop (1967) where he reported that half sunny location and higher moisture content initiate early flowering in moist soil. The growth and yield of the variety Pusa Narangi Gainda under canopy at < 1.2 m, 1.2-2.4 m and 2.4-3.6 m from the tree was better than the variety Pusa Basanti Gainda at each respective distance.

The intercropping of trees with marigold (Pusa Narangi Gainda and Pusa Basanti Gainda) did not have significant on the studied tree growth characteristics. Trees have higher canopy levels than crops, so light was not limiting factor for tree growth. *Melia composita* is a fast growing tree species and its roots probably have gone deeper in a span of 2 years of its growth. Hence, it might have drawn nutrients and moisture from layer deeper than from which the marigold crop was drawing. Thus, the competition for moisture and nutrients for trees from crop might have been almost non-existent due to which there was no significant effect of crop on growth of the trees. The current finding (no effect of crop on growth of trees) draws supports from findings of Bhagat (2017), Chaudhry *et al.* (2003) and Singh *et al.* (2018) in *Pongamiapinnata*-Brinjal, Poplar-wheat-maize, *Melia composita-Emblica officinalis* -masoor-groundnut based agroforestry systems respectively where there was no effect of crops on growth of *Pongamia pinnata*, Poplar and *Melia composita-Emblica officinalis*.

In the current study, the net returns per hectare were highest in sole Pusa Narangi Gainda crop followed by *Melia composita*+Pusa Narangi Gainda based agroforestry system, sole Pusa Basanti Gainda crop, *Melia composita*+Pusa Basanti Gainda based agroforestry system and pure tree crop respectively. The B:C ratio was also highest in sole Pusa Narangi Gainda followed by sole Pusa Basanti Gainda, *Melia composita*+Pusa Narangi Gainda based agroforestry system followed by *Melia composita*+Pusa Basanti Gainda based agroforestry system and pure *Melia composita* plantation respectively. This is in contrast with the findings of Sujatha *et al.* (2010) reported higher B:C ratio in arecanut+*Cymbopogon flexuosus* followed by arecanut+*Bacopamonnieri*,arecanut+*Ocimum basilicum*, arecanut+*Artemisia pallens* compared to pure arecanut. Higher B:C in sole crops of both varieties in the current study could be attributed to higher gross returns in both varieties owing their higher market prices concomitantly with lower cost of cultivation as compared to agroforestry systems based on both the varieties. Further the trees were quite young (about 2 years old) and consequently added a little revenue to gross returns of agroforestry system compared to their cost of cultivation. Intercropping of *Melia composita* plantation with marigold in the form of agroforestry enhanced the net returns compared pure tree plantation even when the trees were quite young showing potential for improvement in net returns with increasing age of the trees.

5. Conclusion

Intercropping of *Melia composita* plantations with marigold in the form of agroforestry system be carried out to increase the returns compared to pure plantations. Broader implications of the study is that intercropping of pure tree plantations with suitable crop varieties can enhance farmers' income. In future, temporal studies on of marigold with *Melia composita* need to be carried out to estimate long-term interactions.

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