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Effect of organic manures on growth and yield of *Raphanus sativus* L. under Melia based agroforestry system: A case study from North Western Himalaya

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ABSTRACT: An agroforestry experiment was conducted to investigate the effect of planting conditions and various combinations of organic manures on the performance of radish under a 14-year-old *Melia composita* plantation, namely, A_1 (8m × 4m) and A_2 (sole crop). The experiment took place at the experimental farm of the Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India, during the months of September to November, 2020. The treatment combinations of organic inputs were as follows: T_1: Control, T_2: Recommended Dose of FYM (100%), T_3: 100% FYM + Jeevamrut (20 litres/bigha), T_4: 100% FYM + Jeevamrut (30 litres/bigha), T_5: 100% FYM + Jeevamrut (40 litres/bigha), T_6: 100% FYM + Jeevamrut (50 litres/bigha), and T_7: 100% FYM + Jeevamrut (60 litres/bigha). The experiment was laid out in a Randomized Block Design (Factorial) with three replications. The study aimed to explore the possibilities of successfully cultivating *Raphanus sativus* as an intercrop under the *Melia composita* based agroforestry system and in open field conditions. The results of the present study revealed that the *Raphanus sativus* crop grown under the *Melia composita* based agroforestry system exhibited lower growth and yield compared to the open field condition. On the other hand, among different combinations of organic manures, the application of 100% FYM + Jeevamrut at the rate of 60 litres/bigha was found to be the best treatment combination for the growth and yield of the radish crop.

Keywords: Agroforestry, *Melia composita*, Radish, FYM, Jeevamrut.

INTRODUCTION

Agroforestry has long been a way of life in India, with the planting and protection of various trees deeply embedded in our national, religious, and cultural ethics. Many cultures in our country still practice tree worship, and planting and caring for trees are regarded as noble deeds. Currently, agroforestry is practiced on an area ranging from 17.45 to 25.32 million hectares in India (Rizvi *et al.*, 2014). The choice of intercrop in agroforestry is based on its ability to thrive under modified microclimatic conditions, such as relief from high temperatures (Saneinejad *et al.*, 2014), increased solar influx reflectivity, enhanced evapotranspiration, and reduced heat transfer, thereby mitigating temperature effects (Declet-Barreto *et al.*, 2013; Doick, 2013; Liu *et al.*, 2019). Additionally, considerations include the competition generated by trees through their root systems, canopy cover, and allelopathy (Batish *et al.*, 2007).

Melia composita is an indigenous, multipurpose, fast-growing, and valuable timber species that has emerged as one of the best tree species for agri-silviculture systems. Found at altitudes ranging from 1200 to 1800 meters, it is native to tropical moist deciduous forests in Sikkim, the Himalayas, North Bengal, Upper Assam, Khasi Hills, North Circle, Deccan, and the Western Ghats. This tree is renowned for producing multi-purpose wood suitable for making packing cases, cigar boxes, pencils, matchboxes, and ply boards. The wood of *M. composita* is in high demand in wood-based

industries. With a calorific value exceeding 5000 kcal/kg, it also serves as a reliable source of firewood. The industrial and ecological significance of *M. composita* has led to large-scale plantations by farmers with different intercrops (Parthiban *et al.*, 2009). The flowers are considered good foraging sources for bees. Since *M. composita* tends to develop strong lateral branching, it is recommended to prune it from the first year onwards to maintain a smooth, straight bole. Melia is an excellent choice for agroforestry. However, good silvicultural practices are essential to reduce the shade impact of canopies, which might otherwise harm light-demanding crops during the summer season. Due to its deep rooting, it has minimal impact on intercrop cultivation.

Radish (*Raphanus sativus* L.) belongs to the family *Brassicaceae*. It is a popular root vegetable in both tropical and temperate regions. It is a fast-growing winter crop and produces large biomass in a short time (Decateau, 2000). Radish is grown for its young tender tuberous root which is consumed either cooked or raw. It is a good source of Vitamin C (ascorbic acid) and minerals like calcium, potassium and phosphorus (Dixon, 2007). It has got refreshing and diuretic properties. In homeopathy, it is used for neurological, headache, sleeplessness and chronic diarrhea. The roots are also useful in urinary complaints and piles. The leaves of radish are a good source for extraction of protein on a commercial scale and radish seeds are a potential source of non-drying fatty oil suitable for soap making and edible purposes.

MATERIALS AND METHODS

Study site. The present study was conducted at the experimental farm of the Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India. The experimental site is situated in the mid-hill zone of Himachal Pradesh at 30° 51' N Latitude and 76° 11' E Longitude, with an elevation of 1200 meters above mean sea level and a slope of 7-8 percent. The climate of the study area is sub-tropical, receiving an annual rainfall of 1100 mm. The average annual temperature is 17.4˚C. The soil in the area belongs to the Typic Eutrochrept subgroup, as per the soil taxonomy of the USDA. The soil has a gravelly sandy loam texture, and the pH of the top layer of the soil (15 cm) is neutral, containing a high level of organic matter.

The experiment consisted of structural and functional components, namely, *Melia composita* Willd. trees as woody perennials and *Raphanus sativus* as an intercrop in the agri-silviculture system. Additionally, the impact of different doses of FYM and Jeevamrut on the performance of the radish crop, grown with and without M. *composita*, was studied. The experiment was designed for the intercropping of radish (variety: Japanese white) with *M. composita*, which was planted in 2006. The experiment consisted of two planting conditions, namely, A_1 under the tree canopy (8m × 4m) and A_2 in an open field (without trees). It was conducted in a Randomized Block Design (Factorial) with seven treatments and three replications. The treatments for the radish crop included: T_1 (Control), T_2 (Recommended Dose of FYM (100%) (12 kg/plot)), T_3 (100% FYM + Jeevamrut (20 litres/bigha) (12 kg/plot + 150 ml)), T_4 (100% FYM + Jeevamrut (30 litres/bigha) (12 kg/plot + 225 ml)), T_5 (100% FYM + Jeevamrut (40 litres/bigha) (12 kg/plot + 300 ml)), T_6 (100% FYM + Jeevamrut (50 litres/bigha) (12 kg/plot + 375 ml)), and T_7 (100% FYM + Jeevamrut (60 litres/bigha) (12 kg/plot + 450 ml)). The growth and yield traits of radish, such as leaf length, leaf width, root length, root diameter, and root yield, were recorded before the final harvest by randomly selecting 5 plants in each replication and treatment.

Statistical analysis. The recorded data of the present study were analyzed by Statistical Package for Social Science data (SPSS) IBM software version 16.

RESULTS AND DISCUSSION

A. Effect of planting conditions and organic manures on leaf length (cm) of radish grown under Melia based agrisilviculture system

The effect of treatments and planting conditions had significantly affected the leaf length of radish (Table 1). Among the planting conditions, the plants grown under open field condition (A_2) recorded maximum (23.44 cm) leaf length, while minimum (21.44 cm) leaf length was observed inside tree canopy (A_1). Taking into consideration the application of manures, the application of 100 per cent FYM + Jeevamrut at the rate of 60 litres/bigha (T_7) resulted in higher (25.77 cm) leaf length followed by (24.52 cm) 100 % FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), whereas minimum (18.90 cm) leaf length was recorded under control condition (T_1). The results indicated that the leaf length of *Raphanus sativus* was higher in open condition than under trees. Hasan *et al.* (2013) found similar results in *Raphanus sativus* and Mallick *et al.* (2013) in strawberry under the Lohakat tree (*Xylia dolabriformis*). The cumulative effect of planting conditions and treatments (A × T) registered non-significant effect on leaf length of radish.

B. Effect of planting condition and organic manures on leaf width (cm) of radish grown under Melia based agrisilviculture system

Data presented in Table 2, depicted that both treatment and planting condition exhibited significant impact on the leaf width of *Raphanus sativus*. The maximum (6.42 cm) leaf width was recorded in *Raphanus sativus* plants grown under open field condition (A_2) while minimum leaf width (6.08 cm) was observed inside tree canopy (A_1). Among different doses of organic manures, the application of 100 per cent FYM + Jeevamrut at the rate of 60 litres/bigha (T_7) resulted the widest (7.42 cm) leaf width followed by (7.02 cm) 100 % FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), whereas minimum leaf width (5.11 cm) was recorded under control condition (T_1). The results indicated that leaf width of *Raphanus sativus* was higher in open condition than under trees. Similar results were found by Hasan *et al.* (2013) in *Raphanus sativus* and Alam *et al.* (2012) in different summer vegetables along with multipurpose trees. Cumulative effect of planting conditions and treatments (A × T) registered non-significant effect on leaf width of *Raphanus sativus*.

C. Effect of planting condition and organic manures on root length (cm) of radish grown under Melia based agrisilviculture system

Perusal of the data (Table 3) revealed that, planting conditions and organic manures had significant effect on root length of *Raphanus sativus*. Among different planting conditions, the maximum (14.96 cm) root length was recorded in plants grown under open field condition (A_2), whereas the minimum (14.26 cm) root length was recorded inside the tree canopy (A_1). Among different combinations of organic manures, the maximum (17.49 cm) root length was recorded in 100 per cent FYM + Jeevamrut at the rate of 60 litres/bigha (T_7) followed by (16.26 cm) 100 % FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), whereas minimum (12.00 cm) root length was recorded under control condition (T_1). When compared to *Melia composita*, the maximum root length was reported in sole cropping in this experiment. It appears that the radish crop grown under *Melia composita* tree has less light availability than sole cropping, resulting in lower growth attributes.

Table 1: Effect of planting conditions and organic manures on leaf length (cm) of radish grown under Melia based agrisilviculture system.

Leaf length (cm)			
Treatments / Planting condition	**A_1**	**A_2**	**Mean**
T_1	17.43	20.37	18.90
T_2	19.15	21.24	20.19
T_3	20.65	21.51	21.08
T_4	21.28	23.70	22.49
T_5	23.37	24.86	24.12
T_6	23.76	25.28	24.52
T_7	24.43	27.10	25.77
Mean	21.44	23.44	
CD(0.05)			
Planting condition (A)	0.66		
Treatment (T)	1.24		
A × T	NS		

Table 2: Effect of planting condition and organic manures on leaf width (cm) of radish grown under Melia based agrisilviculture system.

Leaf width (cm)			
Treatments / Planting condition	**A_1**	**A_2**	**Mean**
T_1	4.88	5.33	5.11
T_2	5.26	5.67	5.47
T_3	5.67	6.01	5.84
T_4	6.18	6.37	6.27
T_5	6.47	6.72	6.60
T_6	6.93	7.11	7.02
T_7	7.15	7.69	7.42
Mean	6.08	6.42	
CD(0.05)			
Planting condition (A)	0.10		
Treatment (T)	0.19		
A × T	NS		

Table 3: Effect of planting condition and organic manures on root length (cm) of radish grown under Melia based agrisilviculture system.

Root length (cm)			
Treatments / Planting condition	**A_1**	**A_2**	**Mean**
T_1	11.89	12.11	12.00
T_2	12.61	13.17	12.89
T_3	13.66	14.03	13.84
T_4	14.19	14.63	14.41
T_5	14.87	15.93	15.40
T_6	15.71	16.81	16.26
T_7	16.91	18.06	17.49
Mean	14.26	14.96	
CD(0.05)			
Planting condition (A)	0.35		
Treatment (T)	0.65		
A × T	NS		

Rahman (2006) found similar results for *Solanum melongena* and Rani *et al*. (2015) under poplar based agroforestry system. Cumulative effect of planting conditions and treatments (A × T) registered non-significant effect on root length of radish.

D. Effect of planting condition and organic manures on root diameter (cm) of radish grown under Melia based agrisilviculture system

It is evident from the data presented in Table 4, that planting conditions and organic manures had significant effect on root diameter of *Raphanus sativus*. It has been noticed that the maximum (4.75 cm) root diameter was observed in *Raphanus sativus* plants grown under open field condition (A_2) though minimum (4.63 cm) were recorded inside the tree canopy (A_1). On the other hand, among different treatments, treatment (T_7) 100 per cent FYM + Jeevamrut at the rate of 60 litres/bigha resulted maximum (5.39 cm) root diameter followed by (5.15 cm) 100 % FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), whereas minimum (4.03 cm) root diameter was recorded under control condition (T_1). When compared to plants grown under *Melia composita* trees, the higher root diameter and other growth and yield attributes of *Raphanus sativus* under sole cropping could be attributable to better availability of light in an open condition. Wadud *et al.* (2002) found similar results with Red Amaranth. Mallick *et al.* (2013) in strawberry under different multipurpose tree species and Alam *et al.* (2012) in different vegetables. Combined effect of treatments and planting conditions (A × T) registered non-significant effect on root diameter of radish.

E. Effect of planting condition and organic manures on yield (q/ha) of radish grown under Melia based agrisilviculture system

The data on the effect of planting conditions and organic manures on yield of *Raphanus sativus* grown under *Melia composita* based agrisilviculture system have been presented in Table 5. It is evident from the data that among planting conditions, the higher (318.48 q/ha) yield was recorded under open field condition (A_2), whereas, the lower (308.38 q/ha) yield were recorded inside tree canopy (A_1). On the other hand, among different combinations of organic manures, treatment (T_7) 100 per cent FYM + Jeevamrut at the rate of 60 litres/bigha registered a higher (364.45 q/ha) yield followed by (353.33 q/ha) 100 % FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), whereas, lower (194.89 q/ha) yield was recorded under control condition (T_1).

Table 4: Effect of planting condition and organic manures on root diameter (cm) of radish grown under Melia based agrisilviculture system.

Root Diameter (cm)			
Treatments / Planting condition	**A_1**	**A_2**	**Mean**
T_1	3.96	4.10	4.03
T_2	4.17	4.29	4.23
T_3	4.39	4.48	4.44
T_4	4.60	4.70	4.65
T_5	4.88	4.96	4.92
T_6	5.08	5.22	5.15
T_7	5.30	5.47	5.39
Mean	4.63	4.75	
CD(0.05)			
Planting condition (A)	0.04		
Treatment (T)	0.07		
A × T	NS		

Table 5: Effect of planting condition and organic manures on yield (q/ha) of radish grown under Melia based agrisilviculture system.

Yield (q/ha)			
Treatments / Planting condition	**A_1**	**A_2**	**Mean**
T_1	187.56	202.22	194.89
T_2	282.22	291.11	286.67
T_3	308.89	318.22	313.56
T_4	333.33	342.22	337.78
T_5	340.00	346.67	343.33
T_6	348.89	357.78	353.33
T_7	357.78	371.11	364.45
Mean	308.38	318.48	
CD(0.05)			
Planting condition (A)	9.31		
Treatment (T)	17.42		
A × T	NS		

A. **B.** **C.**

Fig. 1. A. Radish grown under tree canopy. **B.** Radish grown under open condition. **C.** Harvesting and weighing Radish.

It's probable that because there is more light available in open condition than under *Melia composita* based agrisilviculture system, where the quantity of PAR reaching the crops was limited by the presence of a tree canopy. Miah *et al*. (2008) observed yield reductions in field crops when intercropped with trees on tomato cultivars grown under Neem based agrisilviculture system. Combined effect of planting conditions and treatments (A × T) had non-significant effect on the yield of *Raphanus sativus*.

CONCLUSIONS

Based on the outcomes of the present investigation, it can be inferred that the growth performance of radish was better under open conditions as compared to the agroforestry system. Reductions in growth and yield parameters of radish were observed in the presence of the tree (*Melia composita*). Tree proximity had a negative impact on crop performance, but the minimal losses in productivity due to the integration of the crop with tree components may be compensated by multiple tree products. Different organic manures influenced the growth and yield of radish in terms of leaf length, leaf width, root length, root diameter, and root yield. Among the different doses of organic manures, the application of 100 percent FYM + Jeevamrut at the rate of 60 litres/bigha (T_7), followed by 100 percent FYM + Jeevamrut at the rate of 50 litres/bigha (T_6), proved to be the best treatment combination for the growth and yield parameters of *Raphanus sativus* L.

FUTURE SCOPE

Agri-silvicultural systems, which integrate agriculture and forestry, can provide several benefits. The presence of *Melia composita* trees could contribute to improved microclimatic conditions, such as reduced temperature extremes and increased humidity, which may positively affect radish growth. Trees like *Melia composita* may have the potential to enhance soil fertility through nutrient cycling and organic matter decomposition. Improved soil conditions can benefit radish growth and yield.

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Conflict of Interest. There is no conflict between authors.

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