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Comparative Performance of Different Tree-Crop Combinations Under Agrihortisilviculture System.

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ABSTRACT

The effect of hedgerows of mulberry (*Morus alba* "M-5") and peach (*Prunus persica*) was evaluated on the performance of lentil (HPL-5) under rainfed conditions, after six years of establishment of tree species. The lentil crop was grown in alleys comprising different combination of mulberry and peach thereby constituting six tree-crop combinations. The maximum plant height (32.95 cm), number of plant (58.72 m^{-2}) and grain yield (1.80 t ha^{-1}) of lentil was recorded in treatment T_6 (under controlled condition). All the growth and yield parameters except crop maturity of lentil were found to increase with the increase in distance from the tree row. Lentil showed comparatively higher value for all the growth and yield parameters on south direction of mulberry and peach tree row as compared to the north. Height and diameter of mulberry and peach were recorded maximum in T_5 (mulberry + lentil) and T_4 (peach + lentil), respectively. Highest fruit yield (1.70 t ha^{-1}) and pruned wood biomass yield (0.94 t ha^{-1}) were recorded in T_4 (peach + lentil). Treatment T_5 produced highest branch wood (2.54 t ha^{-1}) and leaf fodder yield (1.20 t ha^{-1}) of mulberry. Based on biomass productivity and output diversification, different tree-crop combination are found suitable in the following order of preference: peach + mulberry + lentil -T_3> one peach tree surrounded by two mulberry tree + lentil - T_1> one mulberry tree surrounded by two peach tree+ lentil-T 2 > peach + lentil - T_4 > mulberry + lentil -T_5 > only lentil -T_6 and thus can be replicated under similar agroecological conditions.

Keywords:

Agrihortisilviculture, hedgerows, lentil, mulberry, peach, tree-crop combination

INTRODUCTION

Over large areas in the Western Himalayas, farmers practices agrihortisilviculture system for production of fruits and grains and also the much needed fodder and fuel or wood for packaging material (Toky et al. 1989). Ecological interaction between trees and crops have a beneficial effect on soil fertility through addition of organic matter, recycling of nutrients and as a protective barrier against soil erosion or as wind breaks. Combination of crops and trees raise biomass production because difference in rooting depth enable uptake of more water and nutrients (Ong et al. 1991). However, in most of the cases, tree-crop combinations have been known to cause reduction

in growth and yield of annual crops (Verma et al. 2002). The fruit like Mango, Sapota, Jackfruit, Citrus, Peach and Guava can be grown with *Casuarina, Leucaena, Dalbergia and Albizia* under agrihortisilviculture system (Chauhan et al. 1997). Hedge row inter cropping is widely investigated in the tropical region of the world but the tree- crop combinations which have been included in this study have scarcely been explored in the temperate zone of Western Himalaya. Therefore, the present investigation was undertaken to study the performance of lentil, peach and mulberry under six different combinations including control (only lentil) to select the best combination for upscaling under similar edapho-climatic conditions.

MATERIALS AND METHODS

The work was carried out at Nauni (Solan) in the mid-hills of Himachal Pradesh (30° 51'N, 76°11'E) at an altitude of 1250m amsl. The climate is transition between sub-humid sub-tropical to sub-temperate. The average annual temperature ranges from 3°C to 32°C. May and June are the hottest months while December and January are the coldest. The study site receives an average annual rainfall of 1150 mm; most of which is concentrated in the monsoon period (June –August). The soil of the experimental site was sandy loam, slightly basic in reaction (7.29), and medium in organic carbon (0.79%), available N (442 Kg/ha), P (35 Kg/ha) and K (364 Kg/ha). Light intensity in mulberry and peach canopy was measured with the help of Lux meter on cloudy days (Blackman and Wilson, 1951). It was observed that percent relative illumination below the mulberry was 59 percent to north of tree row and 65 percent to south of the tree. Below peach canopies the percent relative illumination was found to be 50 percent to northern portion of tree row and 54 percent to southern portion of tree. Soil moisture was determined at 0-30cm-soil depth with the help of neutron soil moisture probe at monthly intervals (November-May) during lentil crop season. In the month of November at the sowing time of lentil, soil moisture content was observed 4.58 percent which subsequently showed different values of 9.79 percent in December, 15.58 percent in January, 17.22 percent in February and 17.96 percent in March, 8.30 percent in April and 4.16 percent in May at the time of lentil harvesting..

The agroforestry system comprised of lentil as arable crop, peach as fruit tree and mulberry as fuel/ fodder components. The mulberry and peach trees were planted in row at a spacing of 10 x 5 m. The arable crops lentil (HPL-5) was sown at a spacing of 25-30 cm with seed rate 30 kg ha^{-1} under rainfed condition during rabi (winter) season, as per recommended practices. The following tree-crop combinations viz; one peach tree surrounded by two mulberry tree + lentil (T_1), one mulberry tree surrounded by two peach tree+ lentil (T2), peach + mulberry + lentil (T_3), peach + lentil (T_4), mulberry + lentil (T_5) and only lentil (T_6) formed the six treatment combinations. Lentil crop grown in the alleys was observed for growth and yield parameters at varied distances D_1 (1m away from tree row), D_2 (2m away from tree row) and D_3 (4m away from tree row) under different directions viz. DR_1 (north of tree row) and DR_2 (south of tree row) after six years of establishment of mulberry and peach. Mulberry diameter was measured at five cm. height above the ground level whereas; peach diameter was recorded five cm. above the graft union. For other parameters standard methods were applied to record the data. The experiment was laid out in Randomized Block Design and replicated thrice. The data on growth and yield of lentil, mulberry and peach, thus collected were subjected to statistical analysis as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

The highest plant height was recorded in T_4 (28.71 cm) and minimum in T_2 (27.74 cm). Plant height was also observed to increase from distance D_1 to D_3 and the increase was significantly higher in direction DR_2 over DR_1 (Table 1). Treatment T_6 i.e. open control showed maximum (58.72) number of plants per square meter and treatment T_2 the minimum (51.17) (Table 1). The increase in distance from tree row tended a significant increase in number of plants m^{-2}. The number of plants per square meter were found to be higher in direction DR_2 (55.33 plants m^{-2}) than DR_1 (54.20 plants m^{-2}).

Table 1: Growth and yield of lentil as influenced by mulberry and peach under agrihortisilviculture system

Tree-crop combination	Growth parameters			Yield attributing traits				
	Plant height (cm)	No. of plants (m^{-2})	Crop maturity (days)	No. of pods ($plant^{-1}$)	1000 grains weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Harvest index (%)
T_1 (one peach tree surrounded by two mulberry tree+ lentil)	28.36	53.39	131.80	56.17	20.29	1.23	3.63	25.28
T_2 (one mulberry tree surrounded by two peach tree+ lentil)	27.74	51.17	132.60	54.44	19.60	1.10	3.34	24.74
T_3 (peach + mulberry + lentil)	28.56	54.56	131.20	57.17	20.42	1.28	3.83	25.09
T_4 (peach + lentil)	28.71	54.94	131.00	57.94	20.55	1.31	3.91	25.13
T_5 (mulberry + lentil)	29.02	55.83	129.60	59.22	20.71	1.38	4.06	25.32
T_6 (only lentil)	32.95	58.72	123.30	61.50	24.51	1.80	4.42	28.91
$CD_{0.05}$	0.24	0.39	0.39	0.34	0.06	0.10	0.40	0.14
Distance from tree row								
D_1 (1 meter)	28.60	51.86	131.40	55.00	20.48	1.19	3.42	25.58
D_2 (2 meter)	29.32	54.94	130.00	57.64	21.01	1.35	3.88	25.66
D_3(4 meter)	29.75	57.50	128.20	60.58	21.55	1.52	4.29	26.00
$CD_{0.05}$	0.16	0.27	0.28	0.24	0.04	0.08	0.22	0.10
Direction from tree row								
DR_1 (North)	29.10	54.20	130.20	57.22	20.88	1.32	3.79	25.63
DR_2 (South)	29.34	55.33	129.60	58.26	21.15	1.36	3.94	25.86
$CD_{0.05}$	0.14	0.22	0.23	0.20	0.02	NS*	NS	0.08

* NS : Not Significant

Crop took maximum time (132.60 days) to mature in treatment T_2 whereas, minimum number of days (123.30) in treatment T_6. The distance of the crop from the tree row influenced the crop maturity significantly which was lesser at D_3 (128.20 days), followed by D_2 (130.00 days) and D_1 (131.40 days). The effect of direction on the crop maturity was observed to be statistically significant and took 129.60 days to mature the crop in DR_2 and 130.20 days in DR_1 direction.

It was observed that growth characters of lentil crop namely plant height, number of plants and crop maturity experienced more depressing effect in association with peach as compared to mulberry. This may have occurred due to the reason that during the period of March and April when lentil crop attain maximum growth, the peach trees also become active and coincidence of flowering and fruit set. Such a situation might have exerted severe competition for light, soil moisture and nutrients.

The influence of treatments, distance and

direction of the crop followed the trend as was evident in case of number of plants (Table 1). Maximum number of pods per plant was recorded in treatment T_6, whereas, treatment T_2 gave the lowest value. Test weight (weight of 1000 grains) was significantly decline due to various treatments when compared with control i.e. T_6 (Table 1). Among various treatments, maximum value was observed in treatment T_5 (20.71 g). Distance of the crop as well as direction from the tree row exerted significant effect on this character showing highest (21.55 g) value in D_3 and lowest (20.48 g) in D_1. Direction DR_2 (21.55 g) gave higher value over DR_1 (20.88 g).

Highest grain yield was recorded in Lentil sole crop T_6 (1.80 t ha^{-1}) followed by T_5 (1.38 t ha^{-1}) and minimum (1.10 t ha^{-1}) in T_2. Distance of the crop from the tree row showed highest value of 1.52 t ha^{-1} at D_3 followed by D_2 (1.35 tha^{-1}) and D_1 (1.19 t ha^{-1}). On the other hand direction of the crop from the tree row gave statistically non-significant results (Table 1).

Highest (4.42 t ha^{-1}) straw yield was observed in T_6 as compared to all other tree-crop combinations (Table 1). Straw yield was noticed to increase with the increase in distance from tree row exhibiting minimum value (3.42 t ha^{-1}) at D_1 then followed an increasing trend at D_2 (3.88 t ha^{-1}) and D_3 (4.29 t ha^{-1}). Growing of lentil in DR_2 showed higher value (3.94 t ha^{-1}) over DR_1 (3.79 t ha^{-1}), but displayed statistically non-significant results. Treatment T_6 indicated significantly higher (28.91 percent) harvest index compared to other treatments. With the increase in distance from D_1 to D_3 the harvest index increased significantly. Direction DR_2 has shown significantly higher value (25.86 percent) than DR_1 (25.63 percent).

Yield attributes viz. number of pods, test weight (thousand grain weight), grain yield, straw yield and harvest index were observed to increase with the increase in distance from tree row. These characters exhibited significantly higher values in south direction of tree row as compared to north of tree row. In general, yield attributes were suppressed by different mulberry-peach combinations over control however; peach association caused more reduction in yield than mulberry which can be ascribed to increased competition for site resources as both components have similar active growth period. Harvest index due to different tree-crop combinations showed significantly lesser value as compared to control, and also harvest index showed increasing trend with the increase in distance from tree row vis-à-vis higher values in south direction of tree row as compared to north, thereby indicating higher values of grain yield than straw as harvest index is a function of grain yield divided by grain plus straw yield. The lower crop growth and yield near to tree rows as compared to open plots are in line with the findings of Huxley et al (1989), Lal (1989) and Maiti et al. (1993).The lower lentil crop yield due to peach is in line with the findings of Rao and Coe (1992). Reduced field crop yield at closer proximity to trees had also been reported by Khybri et al. (1992), Sharma (1992) and Panwar et al.(2013). The higher crop yield on southern direction is well supported by the findings of Dhillon et al. (1984) and Puri and Bangarwa (1992).

Tree-crop combination had significant influence on tree diameter growth; however, variation in height growth due to different treatments was statistically non-significant (Table 2). Maximum diameter growth was observed in treatment T_5 (11.69 cm) and minimum in T_1 (9.34 cm). Crown spread was found to be influenced significantly in west and north directions whereas; it remained statistically non-significant in east and south directions. In west direction it was noticed to be maximum in treatment T_5 (0.60 m) followed by T_3 (0.52 m), T_2 (0.45 m) and minimum in T_1 (0.32 m). Crown development in north direction followed the pattern opposite to west showing highest value in T_1 (0.52m) followed by T_2(0.42m), T_3(0.40m)and minimum in T_5(0.35m).

Peach height growth was not influenced significantly due to various tree-crop treatments (Table 2). However, diameter growth exhibited statistically significant difference. Maximum diameter was obtained in treatment T_4 followed by T_3, T_1 and T_2 showing their respective values of 7.60, 7.24, 6.69 and 6.52 cm. Crown spread was observed to be influenced significantly in west, north and south directions whereas, it was found to

Table 2: Growth and yield of Peach and Mulberry under different tree-crop combination

Tree-crop combinations	Growth and Development												Yield			
	Mulberry						Peach						Mulberry		Peach	
	Height (m)	Diameter (cm)	Crown Spread (m)				Height (m)	Dia. (cm)	Crown Spread (m)				Branch wood (t ha^{-1})	Leaf fodder (t ha^{-1})	Fruit (t ha^{-1})	Pruned wood (t ha^{-1})
			E	W	N	S			E	W	N	S				
T_1 (one peach tree surrounded by two mulberry tree+ lentil)	2.05	9.34	0.40	0.32	0.52	0.45	2.30	6.69	1.20	1.10	1.12	0.70	2.09	0.85	1.60	0.68
T2 (one mulberry tree surrounded by two peach tree+ lentil)	2.25	9.55	0.42	0.45	0.42	0.50	2.70	6.52	1.10	1.15	0.95	1.25	2.25	0.96	1.57	0.62
T_3 (peach + mulberry + lentil)	2.28	10.85	0.48	0.52	0.40	0.48	3.05	7.24	1.30	1.20	1.00	1.35	2.39	1.15	1.66	0.76
T_4(peach + lentil)	-	-	-	-	-	-	3.20	7.60	1.35	1.60	1.10	0.90	-	-	1.70	0.94
T_5 (mulberry + lentil)	2.32	11.69	0.55	0.60	0.35	0.55	-	-	-	-	-	-	2.54	1.20	-	-
T_6 (only lentil)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CD $_{0.05}$	NS	0.32	NS	0.09	0.06	NS	NS	0.20	NS	0.14	0.08	0.12	0.28	0.18	NS*	0.15

* NS : Non Significant

be statistically non-significant in east direction. In north and south direction it was maximum in T_1 (1.12 m) and T_3 (1.35 m) treatments whereas, minimum in T_2 (0.95 m) and T_1 (0.70 m) respectively.

Branch wood and leaf fodder yield of mulberry was affected by different tree-crop treatments (Table 2). Treatment T_5 produced highest branch biomass yield (2.54 t ha^{-1}) whereas, treatment T_1 recorded the lowest value (2.09 t ha^{-1}). Leaf fodder yield exhibited the trend similar to branch wood yield showing maximum (1.20 t ha^{-1}) value in treatment T_5 and minimum (0.85 tha^{-1}) in T_1.

The effect of different tree-crop treatments on fruit yield of peach have shown statistically non-significant results (Table 2) however, higher fruit yield in treatment T_4 (1.70 t ha^{-1}) over T_1 (1.60 tha^{-1}), T_2 (1.57 t ha^{-1}) and T_3 (1.66 t ha^{-1}). A further analysis of the data showed significantly higher (0.94 t ha^{-1}) pruned wood biomass yield in T_4 over T_3 (0.76 t ha^{-1}), T_1 (0.68 t ha^{-1}) and T_2 (0.62 tha^{-1}).

CONCLUSIONS

It is inferred from the present studies that lentil growth and yield was influenced adversely by peach association as compared to mulberry. Peach has been shown to cast more shade than mulberry. Closer distance of the crop from tree row adversely affected all growth and yield parameters of lentil. Both tree species suppressed crop growth and productivity on the north side in comparison to south direction of the tree row. In general, it was deduced from the study that distance of the crop from tree row accounted for most of the experimental variability compared with tree-crop treatments or direction. Based on productivity and output diversification, different tree-crop combinations are found suitable in the following order of preference: $T_3 > T_1 > T2 > T_4 > T_5 > T_6$ and thus can be replicated under similar agroecological conditions.

REFERENCES

Blackman GE and Wilson GL 1951 Physiological and ecological studies in the analysis of plant environment VI. The constancy for different species of a logarithmic relationship between net assimilation rate and light intensity and its ecological significance. *Ann Bot* **15:** 67.

Chauhan VK, Mishra VK and. Khosla PK 1997 Growth and productivity evaluation of an agrihortisilviculture system. *J Tree Sci* **16(2):** 69-74.

Dhillon MS, Singh S, Atwal AS and Dhillon GS 1984 Developing agricultural practices: Effect of *Dalbergia sissoo* and *Acacia nilotica* on the yield of adjoining crops. *Ind J Ecol* **11(2):**249-253.

Gomez KA and Gomez AA 1984 Stastical procedure for Agricultural Research. John Willey and Sons, Inc. New York, 680 p.

Huxley P, Darbhofer T, Pinney A, Akunda, E and Gatama D 1989 The Tree/Crop Interface: a project designed to generate experimental methodology. *Agrofor Abst* **2(4):** 127-145.

Khybri ML, Gupta RK., Ram S and Tomar HPS 1992 Crop yields of rice and wheat grown in rotation as intercrops with three tree species in the outer hills of Western Himalaya. *Agrofoestry System* **17:** 193-204.

Lal R 1989 Agroforestry systems and soil surface management of a tropical alfisol. Parts I-VI. *Agrofoestry System* **8(1):** 1-6; 7-29; **8(2):** 97-111; 113-132; **8(3):** 197-215; 217-238; 239-242.

Maiti S, Majhi SK., Chatterjee B.N, Ghosh SK and Pal SK 1993 Biomass productivity of *Leucaena leucocephala* in sub-humid sub-tropics under alley cropping system. *In :* Agroforestry for rural needs (eds.D.K. Khurana and P.K. Khosla). ISTS, Solan, HP, India. Pp 666-680.

Ong CK, Odongo JCW, Marshall F and Black CR 1991 Water use by trees and crops: five hypotheses. *Agroforestry Today* **3:** 7-10.

Panwar, P, Pal S, Chakravarty S and Alam M 2013 soil quality & Production of low land paddy under agrisilviculture systems in acid soil of West Bengal. *Range*

Managment & Agroforestry 34 (1) : 51-57.

Puri, S and Bangarwa KS 1992 Effects of trees on the yield of irrigated wheat crop in semi-arid regions. *Agroforestry System* **20:** 229-241.

Rao MR and Coe R 1992 Agroforestry field experiments: evaluating the results of agroforestry research. *Agroforestry Today* **4(1):** 4-9.

Sharma KK 1992 Wheat cultivation in association with *Acacia nilotica (L.) Willd ex. Del.* field bund plantation- a case study. *Agroforestry System* **17:** 43-51.

Toky OP, Kumar P and Khosla PK 1989 Structure and function of traditional agroforestry systems in the western Himalaya-II. Nutrint Cycling. *Agroforestry System* **9(1):** 71-79.

Verma KS, Kaushal R and Sood R 2002. Tree-crop interaction studies in agrihortisilviculture of system of agroforestry: Macronutrients and soil moisture. *J Tree Sci* **21:** 70-80.