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GROWTH AND PRODUCTION ABILITY OF MEDICINAL HERBS UNDER AGROFORESTRY SYSTEM AND EFFECT OF ORGANIC MANURES

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SUMMARY

The aim of the present investigation was to explore the possibilities of growing medicinal and aromatic herbs, viz. *Ocimum basilicum* and *Tagetes minuta* and to find out the effects of organic manures, i.e. vermicompost, FYM and enriched manure on the growth performance and productivity of medicinal herbs, intercropped between hedgerows of *Morus*, an important fuel and fodder tree species under agroforestry conditions. The findings indicate that the application of organic manures improves performance and production efficiency of medicinal herbs intercropped with trees. The distance of the crop from *Morus* hedgerows also affected the growth and yield of intercropped herbal crops. Out of the three organic manures; comparatively higher yields were obtained in treatments receiving enriched manure than vermicompost and FYM. Use of organic manures did not substantially influence rate of photosynthesis in herbal plants. The data of the present investigation suggest that medicinal and aromatic plants can be grown successfully in combination with *Morus* hedgerows.

***Key words*: Agroforestry, alley cropping, economic yield, intercrops, production efficiency**

INTRODUCTION

In India, increasing population pressure and eventual constraints in the availability of food, fodder, fuel, timber and other minor forest produce are among the major concerns of the society today. This calls for an increase in area, both under forest as well as under agriculture, which may not be feasible *per se* for land being a limited resource. Intensification of agriculture did help to meet these ever increasing demands to certain level at the cost of quality of natural resource. Sustainable agriculture is a relatively recent response to this decline in quality of natural resource base associated with the modern agriculture, leading to major adjustments in conventional agriculture and thus resulting in evolution of alternative farming systems. The main focus is on the reduction or elimination of agrochemical inputs to assure adequate plant nutrition and plant protection through organic nutrient sources and integrated pest management. It has been proved in the last two decades that agroforestry has the potential to improve the socio-economic conditions of the farmers (Dutt and Thakur 2004). Different agroforestry systems have been developed and numerous tree crop combinations have been tried by researchers all over the world, with an eye on increasing the economic situation of the farmers (Chauhan *et al.* 1997, Gillespie *et al.* 2000, Rao *et al.* 2004, Thakur and Kumar 2006, Thakur *et al.* 2007). In the recent years, there has been emphasis on diversification and a shift from growing traditional food crops towards high value cash crops such as medicinal and aromatic plants, which are in great demand by the pharmaceutical industries in India and abroad. The information with regards to minimizing the competition between annual and perennial

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crops will be highly useful. There are reports, which indicate cultivation of some medicinal and aromatic plants along with trees (Chauhan 2000, Singh and Singh 2003, Rao *et al.*2004, Thakur and Dutt 2004, Thakur *et al* 2007), however, there is practically no information available on the use of organic manures for growing medicinal herbs with different multipurpose tree species. Such combinations, integrating multipurpose perennials and high value cash crops need to be explored for better returns, diversified produce and resource sharing. There is need to find out the effectiveness of organic manures to enhance the production ability of medicinal and aromatic herbs. Therefore, an attempt has been made to evaluate growth and production ability of medicinal herbs in mixed planting with *Morus alba* under agroforestry condition.

MATERIALS AND METHODS

The experimental site is located between 30°51'N latitude and 76°11'E longitude, with an elevation of 1200 m above mean sea level, which represents transitional zone between subtropical and sub-temperate region of the state of Himachal Pradesh. The area receives an annual rainfall of 1150 mm, most of which is received during the months from July to August each year. Soil of experimental site is sandy loam having soil pH of 6.5, organic carbon (1.53%), available nitrogen (257.15 kg ha^{-1}), available phosphorus (27.20 kg ha^{-1}) and available potassium (145.60 kg ha^{-1}).

Four year old *Morus alba* trees planted with east to west orientation, plant x plant spacing of 1.5, 2.0 and 2.5 m and row x row spacing of 6 m was maintained as hedgerows at stem height of 1.5 m. Two medicinal and aromatic herb species namely *Ocimum basilicum* L and *Tagetes minuta* L were grown as intercrops in the spaces between hedgerows. Seedlings of these herb species were raised in nursery beds of size 3 x 1.5 m in the second week of May 2005 and 2006, respectively. Uniform and healthy seedlings of *O. basilicum* and *T. minuta* were planted in the first week of July by maintaining 40 x 30 cm spacing between rows and plants. Light irrigations were given after transplanting to facilitate seedling establishment. The experimental plots were kept free of weeds. Organic manures namely, vermicompost, farm yard manure and enriched manure (trade name Biogold) were applied after 15 days of transplanting to all the plots having *O. basilicum* and *T. minuta*, except control. These manures were applied @ 100 g per plant and spread evenly. Light irrigation was given after hoeing. The chemical characters of organic manures are shown in table 1 given below.

Table 1. Physico-chemical characteristics of organic manures

Characters	Name of organic manures		
	Vermicompost	FYM	Enriched manure
pH	8.10	7.68	7.00
Organic carbon (%)	13.50	28.00	17.00
Available nitrogen (%)	1.30	0.90	1.50
Available phosphorus (%)	0.56	0.70	1.50
Available potassium (%)	0.84	1.50	2.00

The experiment was laid out in a randomized block design (factorial) with 3 within row spacing, 3 organic manures, control without organic manures was maintained for comparison, 2 medicinal and aromatic herbs having separate control without trees and manures and 3 replications. The plot consisted of two central rows of hedgerow trees; six rows of medicinal herbs as intercrops between 2 tree hedgerows and half of the crop rows in central place on both side of the tree hedgerows. Plot size varied with the hedgerow plant spacing. Experiment was conducted for two consecutive years during 2005 and 2006. Treatment details are tree spacing + organic manures, i.e. $T_1 - T_3$ (tree spacing 1.50, 2.00, 2.50 m, respectively + vermicompost), $T_4 - T_6$ (tree spacing 1.50, 2.00, 2.50 m + enriched manure), $T_7 - T_9$ (tree spacing 1.50, 2.00, 2.50 m + FYM), T_{10} (control).

Plant height of *O. basilicum* L. and *T. minuta* L. growing as sole as well as intercrops with and without organic manures was determined with the help of scale from the ground level to the top of the highest shoot of the plant for all the treatments. Plant height was measured at 90 days after transplanting. Each value is the mean of three replications, five plants per replication. The fresh weight of flowering heads of *O. basilicum* L. and *T. minuta* L. was measured by removing the

flowering heads from the rest of the plant and weighed. Five randomly selected plants per replication were used to determine the fresh weight of the flowering heads. The yield of economic parts refers to the fresh weight of flowering heads and the fresh weight of the leaves. This was calculated by adding the fresh weight of the flowering heads and the fresh weight of leaves. The impact of hedgerows and organic manures on the oil yield of herb species was also determined. The leaves and flower heads/inflorescence of both the herb species were harvested from three randomly selected plants for each treatment. The fresh weight of the leaves and inflorescence was recorded in the laboratory. The oil extraction of the herb was carried out by Hydro distillation using Clevenger apparatus. The oil so recovered was measured in a calibrated measuring cylinder. The oil content was recorded on volume/weight basis. The estimated oil yield (L ha^{-1}) was estimated on the basis of per cent oil content in the herb (leaves + flower heads together) yield per plant and was converted into L ha^{-1} on the basis of estimated herb yield (q ha^{-1}). The photosynthetic rate of medicinal and aromatic plants was measured with the help of LCA 4 portable photosynthesis system (ADC.UK.). The precalibrated and programmed portable photosynthesis system was taken to the field. Five randomly selected leaves per replication were used for observation. The leaf was enclosed in the leaf chamber and observations were recorded. The leaf was then replaced with another leaf. The procedure continued for the remaining treatments. The measurements for photosynthesis were made between 10:00 to 13:00 hours.

The entire data were analyzed statistically using the technique of analysis of variance for factorial randomized block design in accordance with the procedure outlined by Gomez and Gomez (1984). The significance of treatment combinations was judged by F test. $LSD_{0.05}$ level of probability was worked to test significance of difference between two treatment means.

RESULTS AND DISCUSSION

Plant height and number of flower heads: The height of *O. basilicum* was significantly affected by different plant spacing within the hedgerows and three different types of organic manures applied. The maximum (58.8 cm) average height was recorded in treatment T_6 (enriched manure) during the year 2005 whereas, the maximum (62.0 cm) height during the experimental year 2006 was again recorded in treatment T_6 (Table 2). The minimum (51.7 cm) average height was recorded in treatment T_7 during 2005. Similarly, the minimum (56.7cm) average height of *O. basilicum* was recorded in treatment T_7 during 2006. The critical differences were statistically significant between the treatments during both the experimental years. Hedgerows with east – west orientation suppressed height of *O. basilicum* but the height of the intercrop increased as the distance of the crop from the hedgerows increased from D_1 (0-1m) to D_3 (2-3 m). The effect of organic manure is also evident from the fact that despite the influence of hedgerow on the plant height, all the plots receiving organic manures recorded significantly higher average height as compared to the control (Table 2). In case of *T. minuta*, the plant height did not seem to be affected by *Morus* hedgerows and organic manures. The difference in plant height among all the treatments was statistically non-significant during both the experimental years (Table 2).

Economic herb yield: The economic yield or the herb yield includes the yield of inflorescence/flower heads and leaves. The perusal of data (Table 3) clearly explains the effect of *Morus* hedgerows, organic manures and respective distances on the economic yield of herb species. The effect of organic manures is clear from the fact that the application of the entire three organic manures enhanced herb yield in comparison to control despite the presence of hedgerows. For example, the minimum (36.80 q ha^{-1} and 39.29 q ha^{-1}) herb yield was recorded in T_{10} during 2005 and 2006 respectively, where no manure was added to *O. basilicum* plots; whereas all other organic manure treatments registered significantly higher yield in comparison to treatment T_{10}. Whereas a maximum (51.00 q ha^{-1} and 52.20 q ha^{-1}) herb yield was recorded in T6 during 2005 and 2006, respectively at a plant spacing of 2.50 m within the hedgerows. A critical appraisal of the data (Table 3) reveals that at 2.5 m plant spacing, the effectiveness of organic manures was in the order Enriched manure > vermicompost >FYM. The respective average herb

Table 2. Effect of *Morus* hedgerows and organic manures on height (cm) of *Ocimum basilicum* and *Tagetes minuta*. D_1 (0-1 m), D_2 (between 1-2 m) and D_3 (between 2-3 m) are growing areas of herb plants from *Morus* rows.

Treatments	*Ocimum basilicum*								*Tagetes minuta*							
	Year 2005				Year 2006				Year 2005				Year 2006			
	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean
T_1	38.9	56.0	63.3	52.7	41.3	63.5	71.0	58.6	106.9	131.5	145.1	127.9	101.8	131.9	142.9	125.5
T_2	39.3	54.6	62.8	52.3	40.8	62.5	70.5	57.9	109.3	135.2	146.7	130.4	111.0	133.7	145.8	130.2
T_3	40.6	61.1	65.1	55.6	44.7	67.8	71.8	61.4	113.7	144.8	143.7	134.1	109.8	140.2	134.0	128.0
T_4	38.4	62.2	66.2	55.6	46.0	62.7	73.8	60.8	104.6	126.6	149.6	126.9	105.4	139.3	141.6	128.8
T_5	40.7	61.9	64.1	55.6	46.3	67.1	70.5	61.3	111.4	138.8	143.0	131.1	110.5	135.0	147.7	131.1
T_6	43.3	63.8	69.3	58.8	47.8	64.6	73.8	62.0	108.3	145.9	142.9	132.4	115.6	140.0	138.0	131.2
T_7	35.2	56.2	63.8	51.7	41.9	60.4	67.8	56.7	97.3	124.5	152.1	124.6	97.2	125.9	148.6	123.9
T_8	38.3	58.1	63.3	53.2	40.9	57.7	69.3	55.9	112.6	135.3	146.4	131.4	109.2	135.1	139.1	127.8
T_9	38.3	57.3	64.1	53.2	41.4	63.7	70.0	58.4	109.9	133.6	144.3	129.3	111.6	137.3	140.1	129.6
T_{10}	52.6	52.6	52.6	52.6	57.0	57.0	57.0	57.0	135.1	135.1	135.1	135.1	137.8	137.8	137.8	137.8
Mean	40.6	58.4	63.5		44.8	62.6	69.6		107.6	135.1	145.9		110.0	135.6	141.6	
$CD_{0.05}$	T (4.20), D (2.30), T x D (7.28)				T (3.67), D (2.01), T x D (6.36)				T (NS), D (7.08), T x D (NS)				T (NS), D (4.22), T x D (13.35)			

Table 3. Effect of *Morus* hedgerows and organic manures on economic yield (q ha^{-1}) of *Ocimum basilicum* and *Tagetes minuta*. D_1 (0-1 m), D_2 (between 1-2 m) and D_3 (between 2-3 m) are growing areas of herb plants from *Morus* rows.

Treatments	*Ocimum basilicum*								*Tagetes minuta*							
	Year 2005				Year 2006				Year 2005				Year 2006			
	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean
T_1	27.39	39.29	59.76	42.15	28.22	39.01	64.19	43.81	14.11	19.37	25.45	19.64	14.66	21.86	26.01	20.84
T_2	30.16	43.44	62.80	45.47	31.26	44.27	65.85	47.13	14.66	21.86	26.56	21.03	16.05	25.18	27.67	22.96
T_3	32.37	46.20	67.23	48.60	33.03	46.48	67.23	48.97	15.49	23.24	27.94	22.23	16.32	26.01	27.67	23.33
T_4	28.50	40.39	64.19	44.36	29.33	38.46	67.51	45.10	13.83	20.47	25.73	20.01	14.66	22.69	28.50	21.95
T_5	32.09	43.71	66.12	47.31	32.65	45.10	70.55	49.43	15.49	23.79	27.67	22.32	17.43	23.52	29.88	23.61
T_6	35.69	49.25	68.06	51.00	35.69	50.35	70.55	52.20	17.15	27.94	28.77	24.62	18.81	28.22	30.16	25.73
T_7	27.39	38.73	59.76	41.96	27.11	37.07	64.74	42.98	12.45	18.54	23.52	18.17	13.56	21.03	23.79	19.46
T_8	28.77	40.95	63.08	44.27	29.33	40.39	64.19	44.64	14.39	21.03	24.62	20.01	14.66	23.52	24.35	20.84
T_9	31.26	43.44	65.02	46.57	31.54	44.82	65.02	47.13	15.77	21.86	25.18	20.93	15.49	21.86	26.28	21.21
T_{10}	36.80	36.80	36.80	36.80	39.29	39.29	39.29	39.29	21.30	21.30	21.30	21.30	22.96	22.96	22.96	22.96
Mean	31.04	42.22	61.28		31.76	42.52	63.91		15.47	21.94	25.67		16.46	23.68	26.73	
$CD_{0.05}$	T (3.77), D (2.07), TxD (6.54)				T (3.08), D (1.68), TxD (5.32)				T (1.82), D (0.99), Tx D (3.14)				T (2.11), D (1.15), Tx D (3.66)			

yields were 51.00>48.60>46.57 q ha^{-1} in the treatments T_6, T_3, and T_9 (Table 3). The values were significantly higher than the yield in control without manure and hedgerows. Higher average herb yields were recorded at distance away from the hedgerows. The values are statistically significant.

In *T. minuta*, higher yield was observed in the sole crop (control) as compared to some of the treatments. Like *Ocimum*, the presence of *Morus* hedgerows significantly affected the herb yield of *T. minuta*. The maximum (24.62 q ha^{-1}) and 25.73 q ha^{-1} herb yield was recorded in T_6 during 2005 and 2006, respectively (Table 3). Higher herb yield was obtained at wider spacing among trees as well as by the application of enriched manure (Table 3). The presence of hedgerows significantly reduced the herb yield in plants growing nearer to the hedgerows (Table 3). The critical differences between the treatments are statistically significant during both the experimental years

Estimated oil yield: Presence of *Morus* hedgerows and organic manures significantly affected oil yield of *O. basilicum* during the present study. Plants grown closer to the hedgerows exhibited more reduction in oil yield; however, a significant increase in oil yield with increase in distance from hedgerow line was evident (Table 4). The effect of organic manures, particularly enriched manure was seen from the fact that the oil yield *per se* was less under control, where no manures were applied to the crop but highest oil yield receiving enriched manure. The maximum (16.83 L ha^{-1}) oil yield was observed in T_6 in comparison to a minimum of 12.14 L ha^{-1} oil yield recorded in T_{10} during 2005 (Table 4). Similarly in 2006, the maximum (17.23 L ha^{-1}) oil yield was recorded in T_6 and the minimum (12.96 ha^{-1}) in T_{10}. It is clear from the data that the applied organic manures significantly improve oil yield of *O. basilicum* over control even in the presence of hedgerows (Table 4). In *T. minuta*, *the* maximum (11.33 L ha^{-1}) oil yield was observed in T_6 and the minimum (9.03 L ha^{-1}) oil yield was recorded in T_1 during the first year of experiment. However, in the second year the maximum (11.84 L ha^{-1}) and minimum (8.95 L ha^{-1}) oil yield was recorded in T_6 and T_7. The oil yield was lesser at closer distance (up to 1 m) from the hedgerows, which increased thereafter with the increase in distance up to 3 m away from the hedgerows. The values were significantly higher in plots provided with organic manure in comparison to plots without the application of manure (Table 4).

Photosynthetic status of herbs: The rate of photosynthesis in *O. basilicum* and *T. minuta* as affected by the *Morus* hedgerows as well as applied organic manures. The critical differences among various treatments were statistically non-significant, however, the application of organic manures was found to improve the rate of photosynthesis in *O. basilicum* and *T. minuta* during both the experimental years. The distance from the hedgerows did not seem to affect photosynthetic rates. Photosynthetic rates, irrespective of distance from the hedgerows, were comparatively higher in plots T_1 - T_9 in comparison to control (T_{10}) without manures. This was true for both the experimental years. A similar pattern was observed for *T. minuta,* where organic manure treated plants registered higher rate of photosynthesis than the plants without organic manures (Table 5).

The findings of the present investigation indicate that the use of organic manures benefited both the herb species by improving growth and economic yield and production efficiency even in the presence of hedgerows of perennials. This is desirable and essential. The reduction in growth and yield of plants, while growing at closer distance to *Morus* hedgerows, probably indicates intense competition for critical resources like water, nutrients, photosynthetically active radiation (PAR) etc, especially at tree-crop interface (Gillespie *et al* 2000, Thakur and Singh 2003, Thakur and Kumar 2006, Thakur and Dutt 2007, Thakur *et al* 2007). The hedgerows being stronger and dominant component of the system, certainly has greater and easy access to the available resources. This deprives the associated crops of their share of resources, resulting in resource crunch at the tree crop interface. Possible reasons for this could be that closer plant to plant spacing resulted in more competition for above ground as well as below ground resources thereby causing reduction in growth and production ability of intercrops at closer spacing. The crop growing adjacent to the hedgerows would suffer from the shading caused by the hedgerows. It is true

Table 4. Effect of *Morus* hedgerows and organic manures on estimated oil yield (L ha^{-1}) of *Ocimum basilicum* and *Tagetes minuta*. D_1 (0-1 m), D_2 (between 1-2 m) and D_3 (between 2-3 m) are growing areas of herb plants from *Morus* rows.

Treatments	*Ocimum basilicum*								*Tagetes minuta*							
	Year 2005				Year 2006				Year 2005				Year 2006			
	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean
T_1	9.03	12.96	19.72	13.91	9.13	12.87	21.18	14.46	6.49	8.90	11.71	9.03	6.74	10.05	11.96	9.58
T_2	9.95	14.33	20.73	15.00	10.32	14.61	21.73	15.55	6.74	10.05	12.22	9.67	7.38	11.58	12.73	10.56
T_3	10.68	15.25	22.19	16.04	10.96	15.34	22.19	16.16	7.12	10.69	12.85	10.22	7.50	11.96	12.73	10.73
T_4	9.40	13.33	21.18	14.64	9.67	12.69	22.28	14.88	6.36	9.41	11.84	9.20	6.74	10.44	13.11	10.10
T_5	10.59	14.43	21.82	15.61	10.77	14.88	23.28	16.31	7.12	10.94	12.73	10.27	8.08	10.82	13.74	10.86
T_6	11.78	16.25	22.46	16.83	11.78	16.62	23.28	17.23	7.89	12.85	13.24	11.33	8.65	12.98	13.87	11.84
T_7	9.03	12.78	19.72	13.85	8.94	12.23	21.36	14.18	5.72	8.52	10.82	8.35	6.23	9.67	10.94	8.95
T_8	9.49	13.51	20.82	14.61	9.67	13.33	21.18	14.73	6.61	9.67	11.33	9.20	6.74	10.82	11.20	9.58
T_9	10.32	14.33	21.46	15.37	10.41	14.79	21.46	15.55	7.25	10.05	11.58	9.63	7.12	10.05	12.09	9.57
T_{10}	12.14	12.14	12.14	12.14	12.96	12.96	12.96	12.96	9.80	9.80	9.80	9.80	10.56	10.56	10.56	10.56
Mean	10.24	13.93	20.22		10.48	14.03	21.09		7.11	10.09	11.81		7.57	10.89	12.29	
$CD_{0.05}$	T (1.24), D (0.68), TxD (2.14)				T (1.01), D (0.55), TxD (1.76)				T (0.83), D (0.45), Tx D (1.44)				T (0.97), D (0.53), Tx D (1.68)			

Table 5. Effect of *Morus* hedgerows and organic manures on photosynthetic rates (µ mol m^{-2} s^{-1}) of *Ocimum basilicum* and *Tagetes minuta*. D_1 (0-1 m), D_2 (between 1-2 m) and D_3 (between 2-3 m) are growing areas of herb plants from *Morus* rows.

Treatments	*Ocimum basilicum*								*Tagetes minuta*							
	Year 2005				Year 2006				Year 2005				Year 2006			
	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean	D_1 (0-1m)	D_2 (1-2m)	D_3 (2-3m)	Mean
T_1	3.94	4.15	3.28	3.79	3.25	3.11	3.51	3.29	5.21	4.68	4.89	4.93	4.02	4.48	4.25	4.25
T_2	3.90	3.56	4.47	3.98	3.60	2.81	3.11	3.17	4.99	5.05	4.79	4.94	4.32	3.47	5.55	4.45
T_3	3.76	4.63	3.87	4.09	3.35	4.28	2.98	3.54	5.79	4.41	4.81	5.00	4.70	4.86	4.17	4.58
T_4	3.40	3.31	2.90	3.20	3.66	3.38	3.28	3.44	4.58	4.31	4.79	4.56	4.11	4.91	4.93	4.65
T_5	3.08	3.46	3.51	3.35	4.46	3.45	2.39	3.43	4.61	5.42	4.48	4.84	4.17	3.54	5.07	4.26
T_6	4.17	3.22	3.32	3.57	3.29	3.47	2.92	3.23	4.86	5.24	4.71	4.94	3.92	4.23	4.55	4.24
T_7	3.14	3.57	4.51	3.74	3.21	2.82	4.43	3.49	4.24	4.47	4.45	4.39	4.29	3.58	4.90	4.26
T_8	3.59	3.84	2.99	3.47	3.58	2.73	2.87	3.06	4.69	4.69	4.38	4.58	4.32	4.15	4.35	4.27
T_9	3.55	3.38	3.17	3.36	3.38	3.36	3.02	3.25	4.38	4.13	4.40	4.30	4.37	3.85	4.26	4.16
T_{10}	2.65	2.65	2.65	2.65	2.76	2.76	2.76	2.76	3.36	3.36	3.36	3.36	3.70	3.70	3.70	3.70
Mean	3.51	3.57	3.46		3.45	3.21	3.12		4.66	4.57	4.47		4.19	4.07	4.57	
$CD_{0.05}$	T (NS), D (NS), TxD (NS)				T (NS), D (NS), TxD (NS)				T NS), D (NS), Tx D (NS)				T (NS), D (NS), Tx D (NS)			

that the growing of hedgerows with medicinal and aromatic herbs paves the way for diversification but nevertheless creates complex biological interactions. The results of the present study also hint at the stronger competition between the system components but only at closer plant spacing and distance to the hedgerows. As mentioned earlier that the application of organic manures namely vermicompost, enriched manure and farm yard manure was found very useful because the applied doses substantially bettered growth and performance of both *O. basilicum* and *T. minuta* even when growing as intercrop with hedgerows of *Morus alba*. Greater response was observed in *O. basilicum* in comparison to that in *T. minuta*,. This behaviour in *T. minuta* where lesser response to the applied organic manure was observed remains unexplained. Numerous previous reports describe positive and/or negative impacts of the tree canopies on the performance of associated crops (Kang *et al*., 1981; Rao *et al.,* 1998; Chauhan, 2000; Thakur and Dutt, 2004, Thakur *et al.,* 2007). In this study the presence of hedgerows of *Morus* at different spacing caused reduction in total herb yield (yield of economic organs viz. leaf and inflorescence) and production efficiency during both the consecutive experimental years only at closer within hedgerows spacing and distances. The herb and oil yield was greater in intercrops grown with organic manures even in the presence of perennials. The role of organic manures appears to minimize competition for critical resources, thus favoring better growth and production potential of herb species. The improvement in photosynthetic rates by the application of organic manures is one indication.

Based on the findings of the present investigation it can be concluded that *O. basilicum* and *T. minuta*, important medicinal and aromatic herbs, can be grown successfully as intercrops and their growth and production ability can be improved substantially by the use of organic manures even when grown as intercrops with hedgerows of *Morus alba* under agroforestry systems. The standing hedgerow biomass ensures additional benefit from the system (medicinal herbs + hedgerows).

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