Diversification of Farming System by combining Commercial Tree Species with Medicinal Plants to boost Economy of Farmers under Rainfed Conditions

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Abstract

Four medicinal plant species namely, *Ocimum sanctum, Spilanthes acmella, Tagetes minuta* and *Withania somnifera* have been grown successfully as intercrops between the rows of *Populus* hybrid, a commercial timber tree species. The presence of tree canopies did not influence growth and yield of economically important organs of medicinal plant species although some adverse effect of tree species was evident in plants growing nearer to the tree rows. Growth parameters like plant height, branch number, leaf area and leaf area index; yield attributes namely herbage yield and production efficiency per unit area were slightly less when medicinal plant species were grown in combination with tree species in comparison to sole cropping. The standing tree biomass (timber wood) ensured additional income from the system (medicinal plants + trees). Physiological parameters of medicinal plants were affected only in plants up to 1m distance from tree rows. The presence of trees resulted in reduced light transmission to the plants nearer to the tree lines. Photosynthetic rate was comparatively less in plants of all the four medicinal plant species growing immediately beneath tree canopies, however, rate increased with the increase in distance from tree trunk. Out of the four tree spacings i.e. 8x3, 6x4, 5x5 and 4x6 m; *Populus* planted at 8x3 m and 6x4 m proved to be the best tree spacings for no or little adverse effect on the production efficiency of medicinal plant species. The total income from diversified system (medicinal plant species + *Populus*) was substantially higher than monocropping of medicinal plants.

Media summary

Diversification of farming system by growing medicinal plant species with commercial timber trees on the farmland is a viable option for increasing income of farmers.

Keywords

Net income, herbage yield, biological interactions, resource utilization, photosynthetically active radiation, and agroforestry

Introduction

Diversification of existing cropping patterns coupled with development of suitable technology packages are required to cope with the increasing demand for diversified agricultural systems. There is a wealth of information available on optimizing conventional agricultural and forestry systems This knowledge has undoubtedly, helped to maximize the productivity, but the rising population coupled with falling productivity, land degradation, soil erosion and loss and over-use of cultivable land are some of the major constraints for sustainable production. The existing land use systems with separate allocation to agriculture and forest are inadequate to meet these demands. Agroforestry (growing trees + crops) provides a viable option to these systems with opportunities to diversify as well as increase overall land productivity. It is necessary to develop viable, acceptable, diversified and sustainable cropping systems, which ensure enhanced crop production by maximizing utilization efficiency of resources available. The integration of trees on the farmland paves the way for the improvement and diversification of existing systems, but creates complex biological interactions (Lawson and Kang 1990; Ong et al. 1991; Khybri et al. 1992; Rao et al. 1998; Gillespie et al. 2000; Thakur and Singh 2002, 2004). Diversification and sustainability in production are the two main goals and there is an opportunity to explore the possibility of growing commercial tree species with high value cash crops (HVCP) such as medicinal plant species on

the farmland without compromising quality of either product. This study was an attempt to explore the prospects of successfully growing important medicinal herbs as intercrops with commercial timber tree species to boost the income of farmers, while improving the long-term sustainability of the system.

Methods

Site and climate

The study site is the sub-tropical region with an elevation of 470 m amsl, which falls under Shivalik Ranges of Indian Himalayas. The area receives an annual rainfall of 1950 mm, most of which is received during the months from July to September.

Medicinal plant species

Uniform and healthy nursery grown seedlings of four medicinal plant species namely*, Ocimum sanctum, Spilanthes acmella, Tagetes, minuta* and *Withania somnifera* were transplanted at the onset of rainy season in the first week of July. The field was ploughed thoroughly and recommended doses of NPK fertilizers were given as soil application. Seedlings of medicinal plant species were planted with 40 cm plant x plant and row x row spacings in the plots between the rows of *Populus* trees. All necessary agrotechniques were used for better maintenance of intercrops. Sole plots of medicinal plants without trees were maintained in the same field.

Tree species

Six-year-old timber tree species (*Populus* hybrid) with 5-6 years of rotation period was used as commercial timber tree species for diversification. *Populus* trees were planted in East-West direction with tree spacings of 8x3 m, 6x4 m, 5x5 m and 4x6 m. Height, diameter, canopy size and leaf area index of trees at each spacing was determined.

Observations

The growth and yield parameters of medicinal plant species, grown with and without trees were determined at monthly intervals after transplanting by following standard methods. The plant height of 10 randomly selected plants per replication under each treatment was measured before harvesting. The leaf area was determined by using CI-203 (CID. USA) leaf area meter while LAI-2000 Plant Canopy Analyzer was used for leaf area index. Herbage yield was determined after harvesting the crop and expressed as t/ha. The production efficiency was calculated by dividing total biological yield with duration of crop. The values have been expressed as kg/ha/day. Photosynthetic rate (μ mol m^{-2} s^{-1}) was taken between 1100 to 1230 hours using pre-calibrated and pre-programmed LCA-4 Portable Photosynthesis System (ADC.UK). Records were taken on four randomly selected leaves per replication from each sampling plot. The transpiration rate of medicinal plant species was recorded using photosynthesis system and expressed as m mol m^{-2} s^{-1}. Light transmission was determined using PAR sensors by placing these sensors in the plots beneath canopies of trees just above medicinal plants within 1m, between 1-2m and between 2-3m away from the tree rows. Readings in the open were taken away from the trees but in the same field. Records were taken at 1000, 1200, 1400 and 1600 hours at 15 day intervals during the months from July to November. Data have been analysed by using technique of analysis of variance in randomized block design with three replications.

Results

The data in Table 1 shows the impact of tree canopies on herb yield of medicinal plant species during two consecutive experimental years. The data indicate comparatively higher yield reduction in comparison to sole crop plots (plots without trees) when grown nearer to the tree line (up to 1 m distance). The presence of poplar trees were not observed to adversely affect herb yield in all the four medicinal plant species between 1-2 m distance from the tree line, especially under tree spacings of 8x3 and 6x4 m. Herb yield

reduction in all the species under closer *Populus* spacings (5x5 and 4x6 m) varied between 33-46% of control up to 1 m distance from tree rows , while the reduction was 15-31% between 1-2 m distance from the tree rows. Wider tree spacings (8x3 and 6x4 m) were not found to have any adverse effect on the herb yield (Table 1).

Table 1. Total herb yield (t/ha) of intercrops as influenced by tree spacings. D_1 and D_2 distances from tree rows.

Tree Herb species spacings	Ocimum sanctum D_1	D_2	*Spilanthes acmella* D_1	D_2	*Tagetes minuta* D_1	D_2	*Withania somnifera* D_1	D_2
Year 2001								
8 x 3 m	5.78	7.38	4.03	4.94	1.87	2.46	0.116	0.117
6 x 4 m	5.70	7.09	3.74	4.72	1.78	2.27	0.117	0.166
5 x 5 m	5.34	6.77	3.55	4.44	1.63	2.06	0.112	0.157
4 x 6 m	4.89	6.53	3.29	4.19	1.54	1.92	0.108	0.152
Control (no trees)	8.09		5.43		2.86		0.195	
$CD_{0.05}$ to								
Compare spp	0.08							
Compare distances	0.03							
Year 2002								
8 x 3 m	7.13	9.07	4.69	5.88	2.24	2.81	0.147	0.194
6 x 4 m	6.81	8.85	4.54	5.64	2.03	2.70	0.144	0.178
5 x 5 m	6.65	8.70	4.19	5.29	1.87	2.43	0.142	0.166
4 x 6 m	6.34	8.28	3.78	4.99	1.81	2.31	0.129	0.156
Control (no trees)	10.58		6.24		3.37		0.203	
$CD_{0.05}$ to								
Compare spp	0.06							
Compare distances	0.05							

The production efficiency of different medicinal and aromatic plant species was significantly influenced at different poplar spacings and distances from tree trunk (Table 2). The intercrops under different tree spacings registered comparatively lower production efficiency (kg/ha/day) in comparison to open control (sole crop). *Populus* planted at 8x3m and 6x4m spacings had very little adverse effect on production efficiency, especially between 1-2 m distance from tree lines. Closer spacings of 5x5m and 4x6m reduced production efficiency to greater extent in comparison to wider row spacings (Table 2).

Table 2. Impact of tree spacings on production efficiency (kg/ha/day) of medicinal herbs.

Tree Herb species spacings	Ocimum sanctum D_1	D_2	*Spilanthes acmella* D_1	D_2	*Tagetes minuta* D_1	D_2	*Withania somnifera* D_1	D_2
Year 2001								
8 x 3 m	51.6	65.5	35.7	44.1	16.7	21.9	0.92	1.41
6 x 4 m	50.9	63.3	33.4	42.2	15.9	20.2	0.93	1.32
5 x 5 m	47.7	60.4	31.7	39.6	14.5	18.4	0.89	1.24
4 x 6 m	43.7	58.3	29.3	37.4	13.7	17.0	0.86	1.20
Control (no trees)	72.2		48.4		25.5		1.55	
$CD_{0.05}$ to								
Compare spp	0.09							
Compare distances	0.06							
Year 2002								
8 x 3 m	63.6	80.9	41.8	52.5	20.0	25.1	1.16	1.54
6 x 4 m	60.8	79.0	40.5	50.4	18.1	24.1	1.14	1.41
5 x 5 m	59.4	77.7	37.4	47.2	16.7	21.7	1.13	1.32
4 x 6 m	56.6	73.9	33.7	44.5	16.2	20.6	1.02	1.24
Control (no trees)	94.4		55.7		30.1		1.61	
$CD_{0.05}$ to								
Compare spp	0.01							
Compare distances	0.06							

The presence of *Populus* affected photosynthetic rate (μ mol m^{-2} s^{-1}) of all the four crops at pre-bloom stage (Table 3). The photosynthetic rate differed significantly between crops and within a crop grown during first and second year of experimentation. Photosynthetic rate was higher and closer to sole crop in plants growing with poplar at higher row x row spacings (Table 3). Negative effect of tree canopies on photosynthesis was visible only at closer spacings and distance from tree rows, Out of the four crops; *Withania somnifera* recorded highest rate of photosynthesis during both the study years. So, shade caused by the tree canopies, reduced rate of photosynthesis only in plants growing immediately beneath tree canopies.

Table 3. Photosynthetic rate (μ mol m^{-2} s^{-1}) of medicinal herbs at pre-bloom stage growing with and without trees.

Tree Herb species spacings	Ocimum sanctum D_1	D_2	*Spilanthes acmella* D_1	D_2	*Tagetes minuta* D_1	D_2	*Withania somnifera* D_1	D_2
Year 2001								
8 x 3 m	6.87	9.72	6.50	8.92	5.88	7.33	11.40	11.05
6 x 4 m	6.88	8.90	6.32	7.57	5.20	7.63	8.33	10.36
5 x 5 m	5.37	7.57	5.32	7.35	5.37	7.28	7.90	11.00
4 x 6 m	4.95	7.55	5.63	7.10	5.18	6.62	7.70	10.30
Control (no trees)	10.67		9.37		7.93		12.00	
$CD_{0.05}$ to								
Compare spp	1.12							
Compare distances	1.03							
Year 2002								
8 x 3 m	9.90	11.99	7.95	10.60	5.90	7.92	11.13	11.17
6 x 4 m	9.07	11.60	8.05	9.60	4.92	7.07	11.60	11.40
5 x 5 m	7.92	11.30	6.77	9.22	5.22	6.45	9.43	12.00
4 x 6 m	7.80	9.33	7.27	8.40	4.85	5.87	8.20	10.80
Control (no trees)	11.57		11.50		8.50		11.80	
$CD_{0.05}$ to								
Compare spp	0.89							
Compare distances	0.81							

Conclusions

The combination of medicinal plants with commercial timber tree species on the same farmland ensures higher profit to the farmers. All the four high value medicinal plant species namely, *Ocimum sanctum*, *Spilanthes acmella, Tagetes minuta* and *Withania somnifera* can be grown successfully as intercrops. Poplar trees planted at 8x3m and 6x4m spacings may be adopted as suitable tree spacings to cultivate medicinal plant species for diversification and boosting economy of farmers under rainfed conditions.

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