Growth performance of herbal crops under three-tier agroforestry system

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ABSTRACT

Investigations were done to find out the performance of herbal crops under sapota-jatropha-based three-tier agroforestry system at the agronomy farm of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during rainy season 2011 and 2012. The experiment was laid out in randomized block design with six treatments and four replications. Three medicinal plants viz basil (*Ocimum sanctum* L), Kalmegh (*Andrographis paniculata* Well) and mint (*Mentha arvensis* L) were selected for the present study. The observations viz plant height, number of branches/plant, crown spread (E-W and N-S), fresh and dry weight per plant and survival percentage were recorded at the end of experiment after planting. Intercropping of basil, Kalmegh and mint recorded higher plant height; the sole crops of basil, Kalmegh and mint recorded maximum number of branches per plant, crown spread (E-W and N-S) and survival percentage. The maximum fresh and dry weight per plant was recorded in sole crops as compared to intercrops. The trend remained same during both the years.

Keywords: Agroforestry; herbal; intercropping; basil; Kalmegh; mint

INTRODUCTION

Forests are the primary source of medicinal plants. To meet the requirements of expanding regional and international markets and healthcare needs of growing populations increasing volumes of medicinal plants are harvested from forests and other natural sources. Loss of forest lands for agriculture and plantation, overgrazing, irregular exploitation of herbs in forest and other natural woodlands are contributing to extinction of many species and depletion of the supply of medicinal plants from forests. Over-exploitation and consequent depletion of medicinal plants not only affect their supply and loss of genetic diversity within these species but seriously affect the livelihood of indigenous people living in forest fringe (Patra 2012). Medicinal plants growing in forests require partial shade, moist soils rich in organic matter, high relative humidity and mild temperatures. Cultivation of such medicinal plants can be taken up in thinned forests, cleared forest patches and as intercrops in orchards and new forest plantations (Venugopal et al 2008). There are number of indigenous under-storey herbs and shrubs that can be produced as a part of forest farming or in new forest plantations to improve economic returns from the forests in India. Newly established forest plantations can be intercropped with medicinal plants similar to food crops until the trees cover the ground. The participation of the local people with the right to share benefits of the plantations especially ownership to crops has helped the government to establish plantations without conflict with the local people in many Asian countries. The same approach can be employed for the cultivation of medicinal plants in the new plantations. In the rehabilitation of degraded forest lands participating, planning and implementation with local communities and economic benefits from an early stage onwards will ensure commitment of the people. The intensity of shade experienced by the under-storey medicinal plants growing in forests and tree plantations affects their growth and chemical composition. In recent years attention has been focused on the diversified medicinal plant production system for maximizing utilization of resources as compared to the monoculture cropping systems. The improved use of resources results in greater total intercrop yields as compared to sole crops of the same species grown on the same area (Oraon et al 2005). This allows judicious use of

the internal spaces of the trees and crops promoting diversification, enhancing per capita land productivity and cultivation of the crops in demand (Willey 1979). Medicinal plants in the nature are now under great pressure due to their excessive collection and exploitation (Laloo et al 2006). Continuous exploitation of several medicinal plant species and substantial loss of their habitats have resulted in the population decline of many high value medicinal plant species over the years (Kala and Sajwan 2003). As such there is no sufficient work on agroforestry system of horticultural, silvicultural and medicinal crops in India. Therefore the study was conducted to develop the suitable agroforestry system for horti-silvicultural and medicinal crops.

MATERIAL and METHODS

An experiment was conducted under rainfed conditions during kharif season of 2011and 2012 at Navsari Agricultural University, Navsari, Gujarat. The climate of this area is humid and the mean relative humidity remains above 68.27 per cent throughout the year. The seven-year old plantation of sapota, *Manilkara acharas* (Mill) Fosberg at 10.0 x 10.0 m spacing inter-cropped with five-year old plantation of Jatropha, *Jatropha curcus* L at 2.5 x 2.5 m spacing was used for intercropping study. Three herbal medicinal plants viz basil, *Ocimum sanctum* L at 50 x 40 cm, Kalmegh, *Andrographis paniculata* Well at 50 x 40 cm and mint, *Mentha arvensis* L at 30 x 45 cm were selected for the present study. The experiment was laid out in randomized block design replicated four times with treatments T_1 (*M achras + J curcas + O sanctum*), T_2 (*M achras + J curcas + A paniculata*), T_3 (*M achras + J curcas + M arvensis*), T_4 (*O sanctum* sole), T_5 (*A paniculata* sole) and T_6 (*M arvensis* sole). Farmyard manure was applied @ 20 ton/ha to all the plots uniformly and was incorporated into the soil at the time of land preparation. NPK @ 40:15:15 kg/ha was applied for basil, @ 40:20:40 kg/ha for Kalmegh and @ 120:50:60 kg/ha for mint. All intercultural operations were done as per requirement. Fifteen plants were randomly selected from net plot area of each treatment per replication and were tagged. The selected plants were used for recording the observations viz plant height, number of branches/plant, crown spread (E-W and N-S), survival percentage and fresh and dry weight per plant at the end of experiment after planting.

RESULTS and DISCUSSION

Plant height

The mean data pertaining to variation in plant height under sapota-jatropha and sole herbal crops are presented in Table 1. The results were found significant during both the years. The plant height was maximum when herbal crops were grown under sapota-jatropha as compared to sole cropping. In 2011 significant differences in the plant height were observed in all the herbal medicinal plants grown under sapota-jatropha and as sole crops. The plant height of basil, T_1 (69.65 cm) under sapota-jatropha was at par with sole crop, T_4 (68.33 cm). Kalmegh, T_2 (63.40 cm) and mint, T_3 (35.13 cm) plant height under Sapota-Jatropha was statistically at par with kalmegh and mint sole crops, T_5 (61.70 cm) and T_6 (32.40 cm) respectively. The herbal crops (basil, Kalmegh and mint) in second year and pooled analysis showed the similar trends as first year. The increase in plant height during the first year was recorded maximum in mint (8.43%) which was followed by Kalmegh (2.76%) and Basil (1.93%). Similarly in second year and pooled data it showed the similar results as first year. This might be due to their ability to retain more soil moisture and better microclimate due to less light intensity under intercropping as compared to open condition. These results are in conformity with the findings of Arya et al (2011), Kumar et al (2010) in Safed Musli and Vanlalhluna and Sahoo (2010) in ginger.

Number of branches per plant

The data regarding number of branches per plant of different herbal crops are presented in Table 1. The number of branches per plant was maximum in sole cropping as compared to intercropping under sapota-jatropha. The sole basil treatment T_4 (19.03) noted maximum number of branches per plant. Sole Kalmegh, T_5 (15.05) and mint, T_6 (17.53) recorded maximum number of branches per plant. Second year and pooled analysis also showed the same trend except Kalmegh observing significantly higher number of branches per plant in sole Kalmegh, T_5 (15.98) followed by Kalmegh grown under sapota-jatropha, T_2 (13.93). Reduction in number of branches per plant during first year was recorded minimum in mint (5.13%) followed by basil (6.99%) and Kalmegh (11.63%). Second year and pooled data showed same trend as first year. The possible reason could be that the available light, space, water or nutrients in a pure cropping system resulted in

Table 1. Growth and survival performance of herbal crops as influenced by Sapota-Jatropha three-tier agroforestry system

Treatment	Plant height (cm)			Number of branches/plant			Survival percentage		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
T_1 (Basil intercrop)	69.65	71.98	70.82	17.70	19.35	18.53	91.35	92.68	92.01
	(1.93)	(2.71)	(2.33)	(6.99)	(6.07)	(6.46)	(2.38)	(1.51)	(1.95)
T_2 (Kalmegh intercrop)	63.40	61.45	62.43	13.30	14.55	13.93	91.63	92.05	91.84
	(2.76)	(3.02)	(2.88)	(11.63)	(13.91)	(12.83)	(0.89)	(1.23)	(1.07)
T_3 (Mint intercrop)	35.13	37.55	36.34	16.63	15.53	16.08	89.63	90.05	89.84
	(8.43)	(9.38)	(8.90)	(5.13)	(3.84)	(4.51)	(2.18)	(2.60)	(2.39)
T_4 (Basil sole)	68.33	70.08	69.21	19.03	20.60	19.81	93.58	94.10	93.84
T_5 (Kalmegh sole)	61.70	59.65	60.68	15.05	16.90	15.98	92.45	93.20	92.83
T_6 (Mint sole)	32.40	34.33	33.37	17.53	16.15	16.84	91.63	92.45	92.04
SEm±	2.246	2.708	1.759	1.040	0.922	0.695	3.262	2.838	2.162
$CD_{0.05}$	6.77	8.16	5.08	3.14	2.78	2.01	NS	NS	NS

Figures in parentheses indicate per cent increase over respective sole cropping

production of more number of branches. As light passes through the tree canopy in plantations changes perceived by the plants through the phytochemical system may induce marked morphogenetic changes in plant and inhibit branching. Similar results were corroborated by Rathod et al (2010) and Venugopal et al (2008).

Survival of plants

All the herbal intercrops in their sole stand recorded non-significant results in their respective intercropping systems during study (Table 1). The maximum survival was recorded in sole basil, Kalmegh and mint in both the years as well as in pooled data. This may due to their capability in establishing root system. It may also be due to the possibility of their beneficial compatibility, interaction and greater biological efficiency of crops grown in association.

Crown spread (cm)

The observations on the crown spread (East-West) of sole crop and herbal crops grown under sapota-jatropha are furnished in Table 2. It is revealed from the data that in the first year sole basil, T_4 (78.70 cm), Kalmegh, T_5 (28.88 cm) and mint, T_6 (56.38 cm) recorded maximum crown spread (East-West) grown under sapota-jatropha. During 2012 and in pooled data similar trend was observed. The reduction in crown spread (East-West) was noted minimum in basil (1.39%) followed by Kalmegh (7.55%) and mint (11.49 %). Similar trend was observed in second year and pooled data. The crown spread (North-South) between intercrops and sole crops was maximum in sole basil, T_4 (75.20 cm). However reduction in crown spread (North-South) was observed minimum in basil (0.40%) followed by mint (3.79%) and Kalmegh (15.40%). The same trend was recorded in second year and in pooled data. The crown spread of East-West and North-South in Basil, Kalmegh and Mint was found to be significantly higher in open condition as compared to intercropped which may be due to more branching and sidewise growth of plants resulting from their profuse growth under open conditions. The primary reason for the decrease in the spread of plants under shade may be the reduction in the number of branches under sapota-jatropha shaded conditions. Similar results were corroborated by Rathod et al (2010) and Venugopal et al (2008).

Fresh weight per plant

Maximum fresh weight per plant of all the herbal crops was observed in sole cropping as compared to crops grown under sapota-jatropha (Table 2). The fresh weight per plant was noted higher in sole crops of basil, T_4 (168.43 g), Kalmegh, T_5 (68.43 g) and mint, T_6 (74.13 g). In the second year as well as in pooled data the similar trend was experienced. The reduction in fresh weight per plant in the first year was recorded minimum in basil (5.30%) followed by mint (16.84%) and Kalmegh (18.02%).Similar trend was recorded in second year and pooled data. It might be due to the uninterrupted and adequate amount of incident sunlight besides zero tree-crop competition. Similar results were found by Vanlalhluna and Sahoo (2010), Venugopal et al (2008) and Parekh et al (2005).

Table 2. Crown spread and fresh and dry weight of herbal crops as influenced by sapota-jatropha three-tier agroforestry system

Treatment	Crown spread (E-W) (cm)			Crown spread (N-S) (cm)			Fresh weight per plant (g)			Dry weight per plant (g)		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
T_1 (Basil intercrop)	77.61	81.53	79.57	74.90	79.85	77.38	159.50	160.53	160.01	52.38	54.33	53.35
	(1.39)	(1.39)	(1.39)	(0.40)	(0.37)	(0.39)	(5.30)	(5.65)	(5.48)	(3.16)	(1.24)	(2.20)
T_2 (Kalmegh intercrop)	26.70	22.23	24.46	20.88	26.55	23.72	56.10	56.91	56.51	21.18	21.91	21.54
	(7.55)	(10.18)	(8.77)	(15.40)	(10.91)	(12.92)	(18.02)	(17.41)	(17.71)	(20.35)	(19.24)	(19.81)
T_3 (Mint intercrop)	49.90	46.80	48.35	40.92	46.03	43.47	61.65	63.73	62.69	25.10	25.82	25.46
	(11.49)	(9.57)	(10.56)	(3.79)	(2.02)	(2.86)	(16.84)	(15.29)	(16.06)	(20.01)	(19.11)	(19.56)
T_4 (Basil sole)	78.70	82.68	80.69	75.20	80.15	77.68	168.43	170.15	169.29	54.09	55.01	54.55
T_5 (Kalmegh sole)	28.88	24.75	26.81	24.68	29.80	27.24	68.43	68.91	68.67	26.59	27.13	26.86
T_6 (Mint sole)	56.38	51.75	54.06	42.53	46.98	44.75	74.13	75.23	74.68	31.38	31.92	31.65
SEm±	2.707	2.858	1.968	2.129	2.034	1.472	4.517	5.469	3.547	1.560	1.753	1.173
$CD_{0.05}$	8.16	8.61	5.68	6.41	6.13	4.25	13.61	16.48	10.24	4.70	5.28	3.39

Figures in parentheses indicate per cent increase over respective sole cropping

Dry weight per plant

The maximum dry weight per plant was recorded in sole crops as compared to intercropping under sapota-jatropha (Table 2). In the first year sole crop of basil, T_4 (54.09 g), Kalmegh, T_5 (26.59 g) and mint, T_6 (31.38 g) recorded significantly higher dry weight per plant which was followed by Kalmegh and mint grown under sapota-jatropha, T_2 (21.18 g) and T_3 (25.10 g). During second year and in pooled data the trend remained same. The reduction in dry weight per plant during first year was minimum in basil (3.16%) followed by mint (20.01%) and Kalmegh (20.35%). Similar trend was obtained in second year and pooled data. It may be due to less competition for light, nutrients and moisture in open conditions for synthesizing food material. Similar results were reported by Vanlalhluna and Sahoo (2010), Venugopal et al (2008), Shinde (2001) and Singh et al (1997).

CONCLUSION

Intercropping of basil, Kalmegh and mint under sapota-jatropha recorded higher plant height as compared to their sole cropping during both the years and pooled analysis. The sole crops of basil, Kalmegh and mint recorded maximum number of branches per plant, crown spread (East-West), crown spread (North-South) and survival as compared to intercrops under sapota-jatropha in both the years and pooled analysis. Significantly maximum fresh and dry weight per plant was recorded in sole crop as compared to intercrops.

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