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RESEARCH ARTICLE

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Compatibility of soybean-safflower in sapota timber based agroforestry system

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ABSTRACT : An experiment was initiated from 2006 to 2016 to study the compatibility of Soybean – Safflower in Sapota Timber based Agroforestry System at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on medium black soils under rainfed conditions. Sapota was planted at 8 x 8 m and a timber tree is planted in between two sapota trees. Timber tree species *viz.*, *Pterocarpus marsupium*, *Tectona grandis*, *Terminalia paniculata*, *Lagerstroemia lanceolata* and *Terminalia alata*. Field crops *viz.*, Soybean and Safflower were grown in alleys of Sapota – Timber trees every year in both *Kharif* and *Rabi* season, respectively. Both crops growth was better with *Tectona grandis* + sapota and *Lagerstroemia lanceolata* + sapota and *Pterocarpus marsupium* + sapota as compared to other tree species. The grain yield reduction was increased as growth of trees advanced and was minimum in *Kharif* season than *Rabi*. Among the tree species, better growth was observed in *Tectona grandis* + sapota + field crop and *Lagerstroemia lanceolata* + sapota + field crop as compared to other tree species. The sapota grown and fruit yield were higher in *Tectona grandis* and *Lagerstroemia lanceolata* as compared to other tree species.

KEY WORDS : Grain yield reduction, Compatibility, Sapota, Timber trees

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INTRODUCTION

Agroforestry is the integration of woody plants with herbaceous and fruit plants to derive both economic and ecological benefits. Furthermore, intercropping of annuals in timber trees compared with sole tree woodlots may offer the advantages of reduced tree establishment costs, income generation during the unproductive phase of the trees and efficient use of natural and input resources. In this context, mixing of the components (fruits, vegetables and trees) is essential, profitable and additional income generation upto the productive phase of the tree. This kind of promotion of agroforestry will help in meeting the basic needs of the farmers on the sustainable basis besides halt the environmental degradation (Thapa *et al.*, 1989).

The system combines agricultural and tree crops of varying longevity, arranged either temporarily or spatially to maximize and sustain agricultural yield and minimize degradation of soil and water resources (Lal, 1990).

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Agroforestry, although not new in itself, requires new strategies and technologies as compared to traditional or modern agriculture and forestry (Dhyani *et al.*, 2009). The sustainability of agroforestry systems on acid soils has been an important issue worldwide. Uehara (1994) reported that sustainable land management relies on aspects of productivity, stability, resiliency and equitability. Lovenstein *et al*. (1991) suggested introducing annual crops between rows of trees in these fields, in order to exploit the soil moisture throughout the profile. Different crop species are grown together in the same field at the same time compete with each other for available resources. The maximum amount of attainable biomass for individual species depends primarily on the relative availability of the resources within a production situation.

Agroforestry, growing of multipurpose trees along with agricultural crops and rearing of animals, has been an important soil conservation practice. Agroforestry systems are believed to increase or atleast maintain the organic matter level of soils (Young, 1989) mainly through litter fall and improvement in soil physical environment following the loss of topsoil from an erosion event (Escobar *et al.*, 2002).

Hence, the present investigation is to know compatibility of soybean-safflower with different timber tree species sapota based agroforestry system.

EXPERIMENTAL METHODS

An experiment was initiated at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad under rainfed conditions. The experiment consisted of Sapota fruit tree species planted at 8 x 8 m spacing on medium black soil. One timber tree was planted in between two sapota trees. The timber tree species *viz.*, *Pterocarpus marsupium, Tectona grandis, Terminalia paniculata, Lagerstroemia lanceolata, Terminalia alata* of uniform rotation were selected for timber evaluations. Field crops *viz.*, Soybean and Safflower were sown in the inter space of Sapota + Timber alleys. The experiment was randomized block design with four replications.

The experiment site had medium black soil with pH 6.85 and available nitrogen 245 kg/ha, Phosphorus 19.6 kg/ha and Potassium 285 kg/ha. The mean annual rainfall was 779.4 mm received in 57 rainy days and average mean maximum temperature and minimum temperature were 34.7°C in April and 14.6°C in January, respectively with relative humidity of 50 to 85 %.

The recommended package of practices was followed for raising Soybean. Soybean variety JS-335 was sown in *Kharif*. Seeds were treated with Rhizobium culture, phosphorus solubilizing bacteria (PSB) and bavistin. Seeds 62.5 kg/ha were sown at 30 x 5 cm apart. Recommended fertilizer of 35 : 50 : 35 kg ha^{-1} $N:P_2O_5:K_2O$ was applied as basal dose. Suitable plant protection measures were taken upto control pest and disease. Safflower variety A-1 was grown in *Rabi*. Seeds were treated with bavistin and about 6 kg ha^{-1} seeds were sown in 45 cm x 5 cm apart. Recommended fertilizer application of 40: 40: 20 kg ha^{-1} $N:P_2O_5:K_2O$ was applied as basal dose. Suitable plant protection measures were taken to control pests and diseases.

Silvicultural operation for timber trees *viz.*, pruning the branches in bottom 2/3rd height and soil working were done every year before on set of monsoon. Pruning of branches of trees and climber control were done at later stages. Root pruning was made by deep ploughing every year along the tree rows. Observations like height, spread, dbh and clear bole height were recorded. Grain and haulm yield of field crops were recorded every year.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Growth and productivity of soybean:

Field crop yield differed significantly when grown in agroforestry system. Both crops soybean and safflower were recorded significantly higher when they are grown solely as compared to agroforestry systems. Soybean grain yield (Table 1) was significantly reduced in sapota timber based agroforestry system as compared to sole field crops. Plant height, leaf area, number of leaves, total dry matter production, seed yield per plant tests were higher with *Pterocarpus marsupium, Tectona grandis* and *Lagerstroemia lanceolata* as compared to *Terminalia alata and Terminalia paniculata* with sapota based agroforestry system. The yield reduction increased as age of tree advance and also rainfall pattern of site. The mean reduction yield was 29 % in *Terminalia paniculata* + sapota, 26.2 % in *Pterocarpus marsupium*

+ sapota, and 27 % in *Terminalia alata* as compared to sole soybean. Among the timber trees, the minimum reduction was recorded in *Tectona grandis* + sapota (26 %) and *Lagerstroemia lanceolata* + sapota (23.2 %) as compared to the other timber tree species. This may be due to better penetration of light / solar radiation and moisture status of soil and also its negative effects of trees on field crops. Field crop yield reduction was in order of *Terminalia alata, Terminalia paniculata, Pterocarpus marsupium, Lagerstroemia lanceolata,* sole sapota in both the seasons. Hence, soybean is more compatible with *Tectona grandis* and *Lagerstroemia lanceolata* as compared to other tree species.

This may be due to the lower leaf area, total dry matter production and grain yield. Similar reports were reported by Mishra *et al.* (2004). The decrease was minimum in barseem and maximum in wheat as reported by Nandal and Hooda (2005) in popular based agroforestry system. Swamy and Puri (2005) also reported significant variation in grain and straw yield of wheat due to *Gmelina arborea* tree spacing.

Growth and productivity of safflower:

Grain yield of safflower was higher in sole safflower followed by safflower with sapota. Grain yield of safflower reduced with timber tree species (Table 2). The yield reduction of safflower with tree species was higher as compared to *Kharif* (Soybean) crops. The reduction yield was increased with age of tree advanced. Among tree species both sapota with *Tectona grandis, Lagerstroemia lanceolata* has lower reduction of yield as compared to *Pterocarpus marsupium, Terminalia paniculata* and *Terminalia alata*. The poor growth of safflower may be due to higher tree crop interaction for moisture / nutrients as moisture is limiting factors in rabi season.

Similar reduction in yield of intercrops under trees than sole cropping was obtained by Ravi *et al*. (2009) under *Ailanthus excelsa* based agroforestry system and by Rishi *et al.* (2011) under *Populus deltoids* and *Melia composita* based agroforestry systems. Similar findings were also observed in babul (*Acacia nilotica*) planted with intercrops than sole trees (Gill, 2005) and by Khistaria *et al.* (1998) in *Bambusa vulgaris* and also in wild cherry and hybrid walnut (Chifflot *et al.*, 2010).

Growth of Sapota:

Sapota growth was higher when grown alone (Table

Table 1 : Soybean grain yield (kg/ha) as influenced by sapota timber based agroforestry system

Sr. No.	Agroforestry systems	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average yield
1.	Sapota + *Pterocarpus marsupium* + FC	1360.0	1185.0	767.5	625.5	584.6	597.2	636.3	568.8	475.6	755.6
2.	Sapota + *Tectona grandis* + FC	1325.0	1237.0	789.2	635.6	563.8	530.1	623.8	581.3	460.4	749.6
3.	Sapota + *Terminalia paniculata* + FC	1331.0	1250.0	762.5	639.4	538.6	513.4	575.0	506.3	425.0	726.8
4.	Sapota + *Lagerstroemia lanceolata*+FC	1381.2	1275.0	770.5	642.4	548.6	605.4	633.3	625.0	495.6	775.2
5.	Sapota + *Terminalia alata* + FC	1387.5	1281.5	738.7	631.5	538.6	505.4	558.8	581.3	415.0	737.6
6.	Sapota + FC	1425.0	1369.0	759.2	682.5	590.2	667.3	677.3	696.9	575.5	827.0
7.	Field crops (FC)	1466.2	1437.5	1085.0	885.6	785.6	962.3	827.3	916.3	652.4	1002.0
	S.E.±	96.5	30.6	30.3	32.6	30.4	38.5	11.6	15.6	13.4	-
	C.D. (P=0.05)	286.5	90.8	90.0	96.8	89.9	114.5	34.5	46.4	39.8	-

Table 2 : Safflower grain yield (kg/ha) as influenced by sapota timber based agroforestry system

Sr. No.	Agroforestry systems	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average yield
1.	Sapota + *Pterocarpus marsupium* + FC	1193.7	1050.0	697.5	512.5	432.5	385.4	482.5	0.0	120.6	541.6
2.	Sapota + *Tectona grandis* + FC	1100.0	1105.0	769.7	578.0	478.2	298.6	466.3	0.0	135.2	547.9
3.	Sapota + *Terminalia paniculata* + FC	1037.5	1000.0	717.5	527.6	427.6	276.2	388.8	0.0	146.4	502.4
4.	Sapota + *Lagerstroemia lanceolata* + FC	1125.0	1077.5	700.0	532.2	432.2	364.8	456.8	0.0	158.2	538.5
5.	Sapota + *Terminalia alata* + FC	1025.0	1055.6	712.5	546.6	446.6	314.4	383.8	0.0	174.4	517.7
6.	Sapota + FC	1268.7	1210.0	720.0	530.0	430.4	390.8	506.3	0.0	220.6	586.3
7.	Field crops (FC)	1562.5	1405.0	870.0	682.4	536.2	494.2	603.8	0.0	328.5	720.3
	S.E.±	45.0	35.01	27.9	29.8	26.8	25.6	8.7	-	10.6	-
	C.D. (P=0.05)	133.7	103.9	83.1	88.5	79.3	76.1	26.1	-	31.4	-

Table 3 : Growth and yield parameters of soybean as influenced by sapota timber based agroforestry system

Sr. No.	Agroforestry systems	Plant height (cm)	No. of leaves	Leaf area (dm^2/plant)	Total dry matter (g/plant)	Seed yield (g/plant)	Test weight (g)
1.	Sapota + *Pterocarpus marsupium* + FC	28.3	26.5	8.04	23.80	20.8	11.21
2.	Sapota + *Tectona grandis* + FC	26.4	23.6	7.23	22.0	21.6	12.31
3.	Sapota + *Terminalia paniculata* + FC	22.1	17.8	6.38	16.03	18.1	7.92
4.	Sapota + *Lagerstroemia lanceolata* + FC	28.6	28.5	8.26	26.15	24.8	12.3
5.	Sapota + *Terminalia alata* + FC	21.2	21.5	6.43	18.86	13.4	6.90
6.	Sapota + FC	30.5	29.4	9.24	33.48	22.6	13.40
7.	Field crops (FC)	36.6	31.9	11.99	32.77	23.8	13.60
	S.E.±	0.38	0.36	0.19	0.89	1.13	0.41
	C.D. (P=0.05)	1.38	1.03	0.55	2.56	3.32	1.20

Table 4 : Growth of tree species and sapota and fruit yield of sapota in different agroforestry systems (2015-16)

Sr. No.	Agroforestry systems	Tree species			Sapota			
		Height (m)	DBH (cm)	Crown area (m^2/pl)	Height (m)	Collar diameter (cm)	Crown area (m^2/pl)	Fruit yield (kg/pl)
1.	S + *P. marsupium* + FC	9.25	25.08	23.10	4.24	12.55	12.92	1135.0
2.	S + *T. grandis* + FC	8.97	23.61	28.30	4.14	11.53	10.00	1106.3
3.	S + *T. paniculata* + FC	8.63	21.29	31.39	4.15	11.74	10.19	647.5
4.	S + *L. lanceolata* + FC	8.25	19.42	21.90	4.42	12.22	11.37	1097.5
5.	S + *T. alata* + FC	8.54	20.02	32.70	4.19	12.46	10.18	712.5
6.	Sapota + FC	-	-	-	4.75	13.75	15.24	1578.8
7.	Field crops (FC)	-	-	-	-	-	-	-
	S.E.±	0.31	1.33	1.45	0.16	0.46	0.72	8.1
	C.D. (P=0.05)	0.95	4.11	6.02	0.48	1.38	2.16	24.4

Field crops (FC): Soybean - Safflower

3). Height of Sapota was significantly higher in association with Sapota + *Lagerstroemia lanceolata* (4.42 m) followed by Sapota + *Pterocarpus marsupium* (4.24 m). Collar diameter and crown area of sapota was significantly higher in association with Sapota + *Pterocarpus marsupium* (12.55 cm and 12.92 m^2/plant, respectively) as compared to sapota with other tree species. Fruit yield of sapota was significantly higher when sapota grown alone (1578 kg/ha) followed by Sapota + *Pterocarpus marsupium* (1135 kg/ha) and Sapota + *Tectona grandis* (1106 kg/ha) and lowest in Sapota + *Terminalia alata* 712 kg/ha).

Growth of Timber Trees:

The height and DBH of trees (Table 4) were significantly higher in the *Pterocarpus marsupium* (9.25 m and 25.08 cm) with sapota + FC and lowest in the *Lagerstroemia lanceolata* (8.25 m and 19.42 cm) with sapota + FC when compared to other tree species. Whereas maximum crown area was recorded in the *Terminalia alata* (32.70 m^2/plant) with sapota + FC followed by *Terminalia paniculata* (31.39 m^2/plant) with sapota + FC as compared to other tree species. Both crops were more suitable with *Pterocarpus marsupium*, *Tectona grandis* and *Lagerstroemia lanceolata* as compared to *Terminalia alata* and *Terminalia paniculata*.

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