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Growth and productivity of soybean (*Glycine max*) and safflower (*Carthamus tinctorius*) under different tree species

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ABSTRACT

A field experiment was conducted during 1990–2005 to know the productivity of soybean (*Glycine max* L. Merr) – safflower (*Carthamus tinctorius* L.) crop sequence in different multipurpose trees in black clayey soils under rainfed conditions at Dharwad. The experiment consisted of 10 different tree species, viz neem (*Azadirachta indica* L. Juss), rose wood (*Dalbergia latifolia* Roxb), Khejri (*Prosopis cineraria* L.), Babool (*Acacia nilotica* L.), Casuarina (*Casuarina equisetifolia* J R & G), Silk Cotton tree (*Ceiba pentandra* L.), Nilgiri (*Eucalyptus tereticornis* L.), Bahera (*Terminalia bellerica* Gaertn, Roxb), Tamarind (*Tamarindus indica* L.) and Mango (*Mangifera indica* L.) were planted at 10 m ×10 m. Field crops were grown in alley of trees in sequence. Yield reduction of field crop decreased with increase in growth of trees species. It was heigher in safflower compared to soybean. Soybean yields were significantly higher with *P. cineraria* compared with the other tree species. Grain yield reduction was higher in *Ceiba pentandra, Dalbergia latifolia, T. bellerica, T. indica*. Similar trends were observed in *rabi* yield of safflower. The growth of tree species was higher in *T. bellerica, C. pentandra, E. tereticornis* and *C. equisetifolia* compared with the other tree species. Economic analysis indicated that benefit : cost ratio, net returns and internal rate of returns were higher in field crop + *P. cineraria* compared to other tree species.

Key words: Agroforestry system, Benefit : cost ratio, Internal rate of returns, Multipurpose trees

Agroforestry is a sustainable land use practice in different parts of India. Many kinds of agroforestry practices have been recognized in India (Puri and Nair 2004). It provides fuel, wood, fodder, timber and act as insurance against failure of crops. It has several benefits like enriching the soil and carbon sequestering. The effects of trees on crop are not consistent and these effects may be complimentary or competitive depending upon the level of competition for growth resources between trees and crops and also site conditions which result in increase or reduction of yield of agricultural crops. Soybean (*Glycine max* L. Merr.) is a valuable crop now gaining importance due its industrial value. While safflower (*Carthamus tinctorius* L.) is an important oilseed crop of the tract grown under residual soil moisture conditions in winter (*rabi*) season. The present study was initiated to find out the ideal tree-crop combinations with trees planted individually at random, as a common practice seen in farmers' field under rainfed conditions in northern Karnataka.

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MATERIALS AND METHODS

The experiment was conducted at Main Agricultural Research Station, Dharwad, Karnataka under rainfed conditions from 1990 to 2005. The soil is black soil and having *p*H 6.9, organic carbon 0.93%, available P and K were 23.8 and 310 kg/ha, respectively. The experiment consisted of 10 tree species, viz *Neem* (*Azadirachta indica* Juss), Rose wood (*Dalbergia latifolia* Roxb), *Khejri* (*Prosopis cineraria* L.), Babool (*Acacia nilotica* L.), Casuarina (*Casuarina equisetifolia* JR & G.), Silk cotton tree (*Ceiba pentandra* L.), Nilgiri (*Eucalyptus tereticornis* L.), *Bahera* (*Terminalia bellerica* Gaertn, Roxb), Tamarind (*Tamarindus indica* L.) and Mango (*Mangifera indica* L.). Five seedlings of each tree were planted at 10 m×10 m spacing. Gross plot size was 500 m^2 and net plot size was 300 m^2. The experiment was laid out in randomized block design with 3 replications. Field crops, viz soybean (*Glycine max* L. Merr) and safflower (*Carthamus tinctorius* L.) were grown sequentially in these tree species and also sole crop during rainy (*kharif*) and winter (*rabi*) season, respectively in between tree row from 1992 to 2005. The location transitional tract on the eastern side of western Ghats and receive mean annual rainfall 1069 mm

with 74 rainy days. Mean monthly maximum temperature varies from 25.5 to 35°C and mean minimum temperature varies from 14.6 to 22.8°C. Relative humidity is generally higher in July and August and minimum in May. Silvicultural practices, viz pruning the branches in bottom 2/3 of the total height and soil working were done before the onset of monsoon. Root pruning was made by deep ploughing every year for tree rows. Recommended package of practices were followed for soybean and safflower. 'JS 335' soybean was sown in *kharif* with seed @ 62.5 kg/ha at 30 cm × 5 cm apart. Seeds were treated with *Rhizobium* culture @ 50 g/kg seeds before sowing of crop. NPK was applied @ 30, 50, 35 kg/ha, respectively as basal dose. Suitable plant protection measures were taken up. In *rabi* season 'A 1' safflower was sown @ 6 kg/ha at 45 × 20 cm. A fertilizer dose of 40 : 50 : 25 kg/ha NPK was applied as basal dose. The growth parameters, viz dbh, height and crown spread were recorded every year for trees. Trees, viz *E. tereticornis C. equisetifolia* and *A. nilotica* were felled during 1998–99 as they attained their rotation age. Coppices growth was allowed in *E. tereticornis*. while *C. equisetifolia* was replanted and *A. nilotica* was replaced by *Pterocarpus marsupium*. At the end of experimentation the biomass of trees was assessed. The income from field crops were worked out based on prevailing market rates. The economic analysis was made by the income generated from field crops, trees, lint yield of silk cotton, fruit yields of mango and tamarind.

RESULTS AND DISCUSSION

Growth of tree species

During 1997–98, among the tree species *E. tereticornis* recorded higher plant height (14.16 m), followed by *C. equisetifolia* (11.69 m), *C. pentandra* (7.13 m) and *T. bellerica* (5.51 m). Plant height was at par with each other in case of *A. indica*, *D. latifolia* and *T. indica*. The lowest height was noticed in *M. indica* (2.60 m) and *P. cineraria* (3.00 m) (Table 1). Significantly higher diameter at breast height (dbh) was recorded in *C. pentandra* (25.70 cm) and was followed by *E. tereticornis* (25.54 cm), *C. equisetifolia* (16.90 cm) and *A. nilotica* (16.24 cm). dbh was lowest in *M. indica* (5.60 cm) and *P. cineraria* (6.24 cm).

E. tereticornis, C. equlitifolia and *A. nilotica* were completed their rotation age and were harvested during 1998–99 and replanted in *kharif* 1999 for comparing with long rotation tree species. Estimated timber volume of the harvested tree species revealed that the marketable timber was higher in *E. tereticornis* (0.559 m^3/tree), followed by in *C. equisetifolia* (0.217 m^3/tree) and was lowest in *A. nilotica* (0.167 m^3/tree.).

During 2004–05, among the retained trees, plant height was significantly higher in *T. bellerica* (10.23 m) and *C. pentandra* (8.96 m), followed by *D. latifolia* (7.93 m) and *A. indica* (7.90 m). The lowest plant height was observed in *M. indica* (6.40 m) and *T. indica* (6.84 m) (Table 1). Diameter at breast height was significantly higher (44.61 cm) in *C. pentandra*, followed by *T. bellerica* (33.07 cm) and was lowest in *M. indica* (18.89 cm).

Crown area was significantly higher in *C. pentandra* (89.23 m^2/plant), followed by *T. bellerica* (86.08 m^2/plant) and lowest in *P. cineraria* (10.07 m^2/plant). During 2005–06 estimated volume was significantly higher in *C. pentandra* (1.40 m^3/plant) and *T. bellerica* (0.875 m^3/plant) as compared to *M. indica* (0.178 m^3/plant). Coppice growth was better in *E. tereticornis*, followed by *C. equisetifolia* and the lowest growth was noticed in *P. marsupium* among the replanted tree species (Table 1). The total volume was higher in *C. pentandra E. tereticornis*, *T. bellerica*, *A. indica* and *D. latifolia* (Table 1). Looking to the timber quality, values

Table 1 Growth parameters of different tree species in agroforestry system

Tree species	Height (m)			Dbh (cm)			Crown area (m^2/plant)	Volume (m^3/plant)
	1st year	5th year	12th year	1st year	5th year	12th year	12th year	12th year
A. indica	1.68	4.15	7.90	1.55	7.68	25.35	58.31	0.388
D. latifolia	1.36	4.16	7.93	1.53	9.08	23.03	32.98	0.340
P. cineraria	0.52	3.00	7.14		6.24	20.61	11.07	0.238
C. pentandra	2.21	7.13	8.96	3.30	25.7	44.61	89.23	1.400
**C. equisetifolia*	3.79	11.69	6.43	3.72	16.90	6.64	14.35	0.239
**E. tereticornis*	5.32	14.50	13.61	5.11	25.54	18.84	18.88	0.937
T. bellerica	0.66	5.51	10.23		13.30	33.07	86.08	1.875
**A.nilotica–P. marsupium*	2.55	8.99	3.12	3.67	16.24	3.22	3.63	0.170
M. indica	0.55	2.60	6.40		5.60	18.89	35.56	0.178
T. indica	1.47	3.67	6.84	1.15	10.55	25.86	52.00	0.335
CD (*P*=0.05)	1.38	3.20	2.49		5.22		19.87	0.300

*Felled during 1998–99 and replanted during *kharif* 1999

*Coppices were allowed in eucalyptus; *Casuriana replanted with casuriana; **A. nilotica* replanted with *Pterocarpus marsupium*

Table 2 Reduction in soybean yield (%) as influenced by different tree species (*kharif*) in agroforestry system

Tree species	92–93	93–94	94–95	95–96	96–97	97–98	98–99	99–00	00–01	01–02	02–03	03–04	04–05
A. indica + SB	100	22.87	22.94	33.40	39.31	38.92	41.32	40.53	39.81	40.14	55.00	56.16	54.89
D. latifolia + SB	100	11.12	18.24	25.92	38.36	34.21	41.24	50.27	55.81	54.39	57.09	57.44	58.18
P. cineraria + SB	100	11.35	15.98	20.32	23.16	27.02	27.68	28.44	23.93	23.87	24.18	25.64	28.21
C. pentandra + SB	100	26.00	33.86	44.29	51.11	52.41	54.99	67.07	70.45	73.57	78.54	65.60	66.04
C. equisetifolia + SB	100	18.35	32.66	42.13	47.40	50.97	52.78	5.40	11.50	11.47	12.44	13.92	28.84
E. tereticornis + SB	100	30.80	34.71	54.80	58.00	60.74	60.69	10.19	18.09	19.52	29.26	24.48	34.25
T. bellerica + SB	100	23.86	30.73	32.71	43.43	45.32	42.39	54.41	68.69	69.81	76.29	63.76	69.33
A.nilotica-P. marsupium + SB	100	28.31	31.59	48.02	53.64	59.08	61.43	8.06	8.69	10.03	12.98	10.24	26.39
M. indica + SB	100	22.27	30.68	29.31	35.89	38.02	38.69	32.05	36.40	48.09	55.80	48.88	53.12
T. indica+SB	100	12.71	25.21	41.06	47.38	49.62	38.71	49.70	44.85	47.99	64.27	58.16	60.56
Soybean (SB)	100	30.13	9.94	33.78	32.04	38.59	21.75	26.30	26.70	24.84	20.88	12.50	14.25
CD (*P*=0.05)	NS	NS	11.54	18.51	11.05	13.18	13.82	14.92	14.37	14.90	14.48	13.39	12.95

SB, Soybean

Table 3 Reduction in safflower yield (%) as influenced by different tree species (*rabi*) agroforestry system

Tree species	91–92	92–93	93–94	94–95	95–96	96–97	97–98	98–99	99–00	00–01
A. indica + SF	5.56	21.75	39.13	42.24	41.43	43.17	39.03	40.39	49.12	23.15
D. latifolia + SF	18.06	28.70	34.93	42.17	48.29	48.04	54.55	45.15	55.75	52.59
P. cineraria + SF	8.33	10.00	14.49	26.93	32.91	36.61	38.47	35.71	34.51	34.51
C. pentandra + SF	22.22	29.78	39.13	46.27	62.59	68.68	69.46	70.97	80.80	84.57
C. equisetifolia + SF	11.11	20.00	30.43	50.62	55.66	60.95	51.91	57.91	8.85	14.32
E. tereticornis + SF	22.22	28.60	37.68	47.76	53.63	63.17	74.19	74.00	20.35	30.77
T. bellerica + SF	11.11	20.70	38.99	53.42	49.31	56.72	61.87	67.62	65.04	62.35
A.nilotica – P. marsupium + SF	29.17	25.00	36.09	42.11	57.46	64.66	75.92	73.00	18.01	26.10
M. indica + SF	13.89	15.70	21.59	31.68	36.63	40.95	35.65	40.56	45.49	47.81
T. indica + SF	15.56	20.60	30.14	39.75	41.50	48.89	49.00	44.05	52.21	58.27
Safflower (SF)	100	100	100	100	100	100	100	100	100	100
CD (*P*=0.05)	12.31	14.82	11.82	11.62	13.18	11.22	12.03	11.65	13.17	11.14

SF, Safflower

Poor yields/crop failures in field crop due to shortage of soil moisture

of timbers of *D. latifolia* and *A. indica* were higher as compared to other tree species.

Effect of tree species on crops

The productivity of both crops decreased under tree species as compared to their sole crops. The crop yields decreased as the age of the trees advanced. It depend on growing habit of tree species and effects of trees. The reduction in crop yields was slightly higher in *rabi* than *kharif* season.

Grain yield of soybean

Soybean yield decreased significantly among different tree species during all the years (Table 2). There was no difference in the yield of soybean with different tree species. After the completion of second year, grain yield of soybean was significantly higher in sole soybean as compared to agroforestry system. Among tree species, soybean yield was significantly reduced in *E. tereticornis* and *C. equisetifolia* at early stages as compared with *T.bellerica, D. latifolia,* and *C. pentandra*. During 1997–1998, the maximum yield reduction were observed in *E. tereticornis, C. equisetifolia, A. nilotica* and *C. pentandra*.

The tree species, viz *E. tereticornis, C. equisetifolia* and *A. nilotica* were felled during 1997–98 and further yield levels were increased in these tree species. On the contrary, in retained trees, yield reduction increased as age advances in *T. bellerica, D. latifolia* and *C. pentandra*. Similar results were indicated by Shankaran *et al.* (1987) in greengram (*Vigna radiata* L. Wilzek) with *Acacia albida*.

Among all tree species, yield reduction of soybean was less in *P. cineraria*. This may be due to its small leaf size and sparse canopy of *P. cineraria* which permitted more light interception to field crops and less competition for soil

Table 4 Economic evaluation of agroforestry system at the end of 15 years

Agroforestry system	Av. cost (Rs/ha/yr)	Av. gross returns (Rs/ha/yr)	Av. net returns (Rs/ha/yr)	Discounted @ 12% interest			Benefit: cost ratio	IRR (%)
				Average cost (Rs/ha/yr)	Average gross returns (Rs/ha/yr)	Average net returns (Rs/ha/yr)		
A. indica + FC	10 783	19 192	8 409	3 961	6 788	2 827	1.71	81
D. latifolia + FC	10 783	21 653	10 870	3 961	6 997	3 036	1.77	72
P. cineraria + FC	10 783	24 499	13 716	3 961	9 002	5 041	2.27	124
C. pentandra + FC	10 783	13 606	2 823	3 961	4 748	787	1.20	51
C. equisetifolia + FC	10 783	21 753	10 969	3 961	7 531	3 570	1.90	78
E. tereticornis + FC	10 783	23 724	12 940	3 961	7 665	3 703	1.94	69
T. bellerica + FC	10 783	16 722	5 939	3 961	5 641	1 680	1.42	66
P. marsupium + FC	10 783	19 004	8 220	3 961	6 360	2 399	1.61	58
M. indica + FC	10 783	19 032	8 249	3 961	6 869	2 908	1.73	76
T. indica + FC	10 783	18 918	8 135	3 961	6 732	2 770	1.70	75
Field crop	10 497	20 783	10 286	3 836	7 228	3 392	1.88	90

FC, Field crop; IRR, internal rate of returns
Prices of major products: Silk cotton lint – ₹ 20/kg; tamarind fruit – ₹ 8/kg; mango fruit– ₹ 35/kg; soybean seed– ₹ 12/kg
safflower seed – ₹ 8/kg

moisture and nutrients due to deep rooting system of *P. cineraria*. Similar results were reported by Mishra *et al.* (2004) in soybean under different clones of *Populous deltoids*. Lower reduction in grain yield of mustard in association with *P. cineraria* and *Acacia.leucocephala* as compared with *Dalbergia sissoo* and *A. nilotica* due to differential canopy size as reported by Yadav *et al.* (2005).

Grain yield of safflower

In *rabi* season, safflower yield was higher in sole crop as compared to tree species. Among the tree species studied grain yield were higher with *P. cineraria*; *A. indica* and *M.indica* as compared to *E.tereticornis, C.pentandra, A.nilotica* and *C.equsetifolia* (Table 3). Significantly higher reduction in safflower yield was noticed in fast growing tree species, viz *C. equesitifolia* and *E. tereticornis*. On the contrary less reduction of safflower yield was noticed in early stages of slow growing tree species, viz *C. pentandra, T. bellerica, D.lalifalia.* Yield reduction in safflower was minimum with *P. cineraria*; *A. indica* and *M. indica*. Later stages of experiment, safflower yield reduction was higher in *T.bellerica, D. latifolia* and *C. pentandra.* The reduction in yield in different tree species is based on growth of trees (Dhillon 1993). Roots of *A. nilotica* in the upper surface layer of soil might have also caused higher reduction in wheat yield as reported by Sharma (1992) and Yadav *et al.* (1993).

Crop yields of soybean and safflower were higher in *P. cineraria* and *A. indica* as compared to the other tree species. This may be due to the deep rooting system, sparse canopy and low moisture demand. Deep root system of *P. cineraria* might have avoided higher reduction of wheat yield (Arya and Goyal 1981). The results are also in agreement with Kattak *et al.* (1980) who observed lesser reduction in agricultural crop yields under tree cover. Hence, these tree species can be grown in field without much reduction in yield of soybean and safflower.

Economics of the system

The trees, viz *E. tereticornis, C. equisetifolia* and *A. nilotica* were harvested during 1998–99 and coppices were allowed to grow in *E. tereticornis*. *C. equisetifolia* was replanted and *A. nilotica* was replanted by *P. marsupium*. The estimated valuing and biomass worked. Based on income from field crop, the economic analysis was made.

Net returns (discounted at 12% interest) was higher in *P. cineraria* + field crops, followed by *C. equisetifolia* and *E. tereticornis* with field crops as compared to field crop alone and field crop with tree combinations. Benefit : cost ratio was higher in *P. cineraria* + field crops (2.27), followed by *E. tereticornis* (1.94) and *C. equisetifolia* (1.90) with field crops. Hence, these trees can be grown in the field without affecting the yield of field crops. Internal rate of returns was higher with the inclusion of tree species with field crops (Table 4). Growing of crops in the interspaces in poplar is reported to be more economical and assure regular income from agroforestry system (Chauhan 2000). Hence, growing field crops with *C. equiselifolia, D. latilfolia, P. cineraria* is sustainable farming system.

REFERENCES

Arya H C and Goyal. 1981. Khejri: a multipurpose legume of Indian Desert. *Science Reporter* **1**: 34–6.

Chauhan H S. 2000. Medicinal and aromatic plants for agroforestry. *Indian Farmers Digest* **32**: 17–8.

Dillon M S. 1993. 'Quantification and Mitigation of yield losses in wheat due to boundary plantation of eucalyptus'. Ph D thesis. Punjab Agricultural University. Ludhiana.

Khattak G M, Sheik M I and Khalia A. 1980. Growing of trees with agricultural crops. *Pakistan Journal of Forestry* **31**: 95–7.

Mishra A, Swamy S L and Puri Sunil. 2004. Growth and productivity of soybean under five promising clones of *Populus deltoids* in agri-silviculture system. *Indian Journal of Agroforestry* **8** (2) 9–13.

Puri S and Nair P K R. 2004. Agroforestry research for development of India: 25 years of experiences of National Programme. *Agroforestry System* **61–62** (1–3): 437–2.

Shankaran K A, Harsh L N and Katjus. 1987. Agroforestry in Arid regions of India. *Agroforestry systems* **5**: 59–88.

Sharma KK. 1992. Wheat cultivation in association with *Acacia nilotica* (L) Wild ex Del. Field bund plantation—a case study. *Agroforestry Systems* **17**: 43–51.

Yadav J P, Sharma K K and Khanna P. 1993. Effect of *Acacia nilotica* on mustard crop. *Agroforestry Systems* **21**: 91–8.

Yadav R S, Yadav B L, Chhippa B R, Keshwar G L. 2005. Nutrient Removal and yield wheat (*Triticum aestivum* linn) as influenced by different Tree species in agroforestry under semi-arid condition of Rajasthan. *Indian Journal of Agroforestry* **7** (1): 21–4.