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Growth and Yield Response of Safflower Under Pongamia Based Agroforestry System

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ABSTRACT

A field investigation was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India. Eleven seed sources of *Pongamia pinnata* were selected from three provenances from Maharashtra, Tamil Nadu and Karnataka to identify suitable seed sources for inclusion in agroforestry condition and to study their effect on safflower productivity. Results revealed that pongamia source RAK-89 recorded highest growth attributes *viz.*, height (5.05 m), diameter at breast height (11.86 cm), crown area (4.98 m^2/tree) and number of branches (38.16) followed by MTP-II. Safflower under RAK-89 Pongamia source recorded significantly higher total dry matter when compared to other Pongamia sources. Leaf dry matter, stem dry weight and capitulum dry weight of safflower was maximum in sole safflower when compared to safflower under different Pongamia sources. Maximum safflower seed yield was obtained in DPS-4 + safflower (1.5m and 3m; 430.70 and 442.53 kg ha^{-1}) compared to MTP-I + safflower (1.5 m and 3 m; 277.40 and 284.53 kg ha^{-1}). Reduction in yield in safflower was maximum under MTP-II + safflower Pongamia source compared to DPS-4 + safflower Pongamia source.

Key Words:

Intercrops, Pongamia source, Safflower, Seed yield

INTRODUCTION

Pongamia pinnata belongs to the family Papilionaceace, is a medium sized evergreen tree with a spreading crown and a short bole. It is one of the few nitrogen fixing trees producing seeds containing 30-40% oil. Natural distribution is along coasts and riverbanks in lands and native to the Asian subcontinent. It is also cultivated along roadsides, canal banks and open farm lands. It is a preferred species for controlling soil erosion and binding sand dunes because of its dense network of lateral roots. Its root, bark, leaves, sap, and flowers have medicinal properties and traditionally used as a medicinal plants.

The seeds are largely exploited for extraction of non-edible oil commercially known as 'Karanja oil', which is well known for its medicinal properties. Pongamia seeds consist of 95% kernel and are reported to contain about 27-40% oil. The yield of oil is reported to be about 24 to 26.5 per cent, if mechanical expellers are used for the recovery of oil from the kernels.

Assessment of growth performance of trees in a given agro- climatic condition is necessary to select the suitable source to include in farmland. Selection of appropriate *P. pinnata* source for agroforestry system on vertisol soils is of utmost importance in optimizing the volume and biomass production per tree. There are numerous reports document favorable and harmful effects of trees on agricultural crops grown under their shade. The changes are more pronounced with increase in tree size and stand density (Harsh and Tewari 1993). Trees modify surrounding environment including soil depending on species (Panwar et al. 2013, Koul and Panwar 2012) and planting arrangement and these modification in environment cause changes in crop production (Chauhan 2000, Prajapati et al. 2018). Present investigation, therefore was planned to study the performance of safflower under different Pongamia seed sources.

MATERIALS AND METHODS

The experiment was carried out during *rabi* season of 2013-14 in "I" block, Agroforestry experimental field, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, located at 15° 26' N latitude, a longitude of 75° 0' E and altitude of 678 m above mean sea level. The study site is situated in transitional tract, representing Northern transitional agro climatic zone (Zone 8) of Karnataka. During the year 2013 mean maximum temperature recorded was 30.4 °C and was similar to the mean value of previous eight years (30.5 °C). The mean minimum temperature was observed exactly the same as that of average value and was 18.4°C. The highest mean maximum temperature was recorded in April (36.9°C) and the lowest mean minimum temperature was recorded in December (12.7°C). During the year 2013 total of 740.4 mm rainfall was recorded in 63 rainy days as against average value of 892 mm in 65 rainy days. Major proportion of the rainfall was received during the months of May, July and September during study period. Relative humidity was higher (82, 89, 85 & 81%) during June, July, August and September months and a similar trend was observed during previous eight years data.

The present study was conducted in an ongoing Agroforestry experiment in which 11 seed sources of *Pongamia pinnata* were planted during the year 2006 at 6 m × 4 m spacing. The 11 seed sources of pongamia comprised of seven sources from Maharashtra (RAK-103, RAK-106, RAK-11, RAK-90, RAK-22, RAK-05 and RAK-89), three seed sources from Tamil Nadu (MTP-I, MTP-II and MTP-III) and one seed source from Karnataka (DPS-4). Safflower (A-1) was sown as intercrop under *P. pinnata* alleys (6 m alley). Growth performance viz., height, diameter, crown area and number of branches were recorded for different *P. pinnata* sources were under agroforestry system. Safflower yield and yield attributing characters were recorded at the time of harvest (2^{nd} week of January, 2014). Data obtained were analyzed for comparing the treatment using Randomised Block Design.

RESULTS AND DISCUSSION

Growth performance of any seed source depends on its age, phenological characteristics, availability of growth resources etc. The site had significant effect on growth performance of *P. pinnata* belonging to different sources. Among the eleven *P. pinnata* sources, RAK-89 source attained the higher height value of 5.05 m and least height (3.47 m) was observed in RAK-22 source. The above result indicated that RAK-89 and MTP-II were most suitable sources with respect to height. Similarly with respect to diameter at breast height (dbh), RAK-89 source recorded the highest dbh (11.86 cm) followed by MTP-II and the least was recorded by DPS-4. The result reveals that RAK-89 is best suited to the experimental site when compared to all other seed sources (Table 1).

Table 1. Growth parameters of *Pongamia pinnata* seed sources under agroforestry

Seed source	Height (m)	DBH (cm)	Crown area (m^2 $tree^{-1}$)	No. of branches ($tree^{-1}$)
RAK-103	3.67	10.51	4.66	31.16
RAK-106	3.84	9.78	4.50	28.36
RAK-11	4.66	9.79	4.30	16.80
RAK-90	3.76	8.30	3.86	13.96
RAK-22	3.47	9.64	4.86	20.20
RAK-05	4.04	7.59	4.30	24.13
RAK-89	5.05	11.86	4.98	38.16
MTP-I	4.49	8.86	3.89	21.60
MTP-II	4.84	11.61	4.74	12.26
MTP-III	3.98	9.44	4.14	20.63
DPS-4	3.93	8.26	4.27	21.33
Mean	4.16	9.60	4.41	22.60
SE(m) ±	0.138	0.511	0.308	0.494
CD 5%	0.410	1.519	NS	1.469

However, the study of Tagupa et al. (2010) revealed that *Gmelina arborea* and *Acacia mangium* recorded maximum height in their study site. The study of biomass productivity by Rawat et al. (2008) observed that *Dalbergia sissoo* attained highest height growth at plantation in Punjab. The growth estimation by Nwoboshi (1994) in Ghana observed that *Gmelina arborea* reached maximum height of 16.6 m within 4 years from the date of planting when compared to other species. The present study also revealed that RAK-89 source has grown very well in terms of height and dbh when compared to all other Pongamia sources, which may be due to high potential and wider adaptability of this Pongamia source in agroclimate zone 8. Devarnavadgi and Murthy (1999) also noticed significant higher plant height and dbh in Subabul when compared to other species studied at 8 years after planting. Similarly plant height growth in ten year old plantation was found to be minimum in *Anogeissus accuminata* when compared to other species tested at Jhansi (Rai et al. 2000).

There was significant differences among Pongamia sources with respect to crown area. Higher average crown area was observed in RAK-89 (4.98 m^2 $tree^{-1}$) than in other Pongamia sources. The crown area which forms photosynthetic structure helped in higher dry matter productivity. The higher value of growth attributes viz., height and dbh in RAK-89 Pongamia source may be attributed to higher crown area. The crown area was highest in RAK-89 and was significant at all stages when compared to other Pongamia sources. The increased crown area in RAK-89 Pongamia sources may be due to absorption of higher amount of solar radiation resulting in increased production of photosynthesis. Increased distribution of these photosynthates into main stem ultimately resulted in height, dbh and number of branches and crown area.

Growth analysis is the physiological probe in order to explain and account cause and effect relationship for yield differences. Dry matter accumulation of safflower recorded at different stages under different *P. pinnata* sources revealed that safflower under RAK-89 source recorded significantly higher total dry matter when compared to other Pongamia sources. Partitioning of dry matter into leaf, stem and capitulum also revealed significantly higher dry matter in safflower under RAK-89 when compared to other Pongamia source (Table 2).This increased total dry matter of safflower may be attributed to significantly higher growth parameters caused by higher soil moisture content and light transmission ratio.

Table 2. Influence of seed sources of *Pongamia pinnata* on growth characters of Safflower under agroforestry

Seed source	Leaf dry weight (g plant-1)		Stem dry weight (g plant-1)		Capitulum dry weight (g plant-1)		Total dry weight (g plant-1)	
	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
RAK-103	1.85	1.98	2.34	2.51	9.33	12.50	13.52	18.09
RAK-106	1.54	1.75	0.89	1.10	8.82	12.03	11.26	15.69
RAK-11	1.54	1.89	0.96	1.18	7.74	11.73	10.24	14.83
RAK-90	0.32	0.57	0.63	0.77	4.63	8.51	5.59	9.86
RAK-22	1.34	1.67	1.31	1.47	7.24	11.20	9.90	14.35
RAK-05	1.92	2.08	1.51	1.68	6.35	10.69	9.79	14.45
RAK-89	2.51	2.89	3.13	3.39	8.48	12.45	14.13	18.80
MTP-I	1.14	1.57	0.45	0.66	5.35	9.22	6.95	11.46
MTP-II	2.06	2.36	2.81	3.01	8.16	12.24	13.03	17.62
MTP-III	1.25	1.56	0.38	0.59	5.56	9.75	7.21	11.90
DPS-4	1.55	1.89	1.84	2.08	10.80	12.56	14.20	18.54
Safflower (Sole)	2.44	2.44	3.96	3.96	12.72	12.72	19.13	19.13
Mean	1.62	1.88	1.68	1.87	7.93	11.30	11.24	15.39
For comparing means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Seed source (SS)	0.026	0.076	0.027	0.076	0.239	0.682	0.229	0.653
Distance (D)	0.011	0.031	0.011	0.031	0.097	0.278	0.093	0.267
Interaction (SS× D)	0.037	0.107	0.038	NS	0.338	0.964	0.324	0.924

D_1 = 1.5 m distance from Pongamia alleys; D_2 = 3.0 m distance from Pongamia alleys

Among the distances of safflower intercrop, 3 m distance from *P. pinnata* alley recorded higher dry matter production than at 1.5 m distance from Pongamia row because of less competition for light, water, nutrients and higher light transmission ratio. Similarly leaf dry matter, stem dry weight and capitulum dry weight of safflower was maximum in sole safflower when compared to safflower under different Pongamia sources, which may be due to higher light transmission ratio. Similar observations were made by Rao and Mittra (1988) and Singh (1997).

The highest seed yield of safflower was obtained in DPS-4 + safflower (1.5m and 3m; 430.70 and 442.53 kg ha-1) compared to MTP-I + safflower (1.5m and 3m; 277.40 and 284.53 kg ha-1). Increased yield of safflower was mainly due to more number of seeds per capitulum, number of capitulum per plant and test weight per plant. These yield attributes had positive correlation with Pongamia source DPS-4 which was significantly higher due to more dry matter accumulation at various stages (Table 3).

The lowest safflower yield was recorded in MTP-I + safflower (1.5m and 3m; 430.70 and 442.53 kg ha-1) and the extent of reduction of safflower yield was 46, 50, 54 and 63 per cent in MTP-II + safflower, MTP-III + safflower, RAK-05 + safflower and RAK-11 + safflower respectively compared to sole safflower (Table 4). Reduction in yield in safflower was maximum under MTP-II + safflower Pongamia source compared to DPS-4 + safflower Pongamia source. This may be due to narrow type of canopy and intermediate branching habit (between dense and profuse), higher contribution of leaf litter to the soil (1861 kg ha^{-1}) which in turn higher nutrient release to the soil. Pongamia sources belonging to Karnataka (DPS-4) and Maharashtra had higher number of defoliation days (101-225 days) and peak growing period of safflower overlapped with defoliation period (January-March) which helped in increased light interception through the crowns of Pongamia which in turn increased yields in safflower. Reduction of safflower under various Pongamia sources under study was attributed to low light interception which could be attributed to reduction in photosynthesis rate, transpiration rate and stomatal conduction. Different workers reported yield reduction of arable crops under agroforestry system to a greater extent after 4-5 year of planting (Singh and Korwar 1986 and Kulkarni et al. 1970).

The extent of reduction in seed yield of safflower was 1.6 per cent in 1.5 m distance compared to 3 m distances from *P. pinnata* alley. This decreased yield due to closer distance was attributed to greater competition between trees and safflower intercrop as evidenced by lower soil moisture and nutrient depletion.

Low light transmission affected all the biophysical and growth indices, which in turn affected dry matter accumulation.

The interaction effects of Pongamia sources and distances were significant except for haulm yield. Seed yield decreased nearer to Pongamia row in all sources except in sole soybean treatment. The probable reasons for differences in soil moisture content and light transmission ratio at various distances are tree crown size and root spread which in turn affected the total dry matter production, pod weight and number of pods per plant; which was similar to observations made by Nadagoud (1990) and Venkat Rao et al. (2006).

Table 3. Influence of seed sources of *Pongamia pinnata* on yield characters in Safflower under agroforestry

Seed source	Number of Capitula plant^{-1}		Number of seeds capitulum^{-1}		Seed weight plant^{-1} (g)		100 seed weight (g)	
	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
RAK-103	8.77	10.68	13.47	14.56	6.47	6.58	3.35	3.46
RAK-106	10.84	12.80	16.97	17.98	7.04	7.17	3.79	3.94
RAK-11	8.33	10.28	12.57	13.59	6.24	6.34	3.24	3.37
RAK-90	11.73	12.79	21.92	22.84	7.52	7.64	4.25	4.35
RAK-22	10.36	12.14	15.08	16.31	6.87	7.04	3.56	3.65
RAK-05	8.18	10.20	10.56	11.56	6.03	6.25	3.06	3.16
RAK-89	11.28	13.26	18.98	19.63	7.31	7.54	3.98	4.15
MTP-I	6.63	8.52	8.51	10.27	5.05	5.25	2.56	2.63
MTP-II	7.74	9.78	9.61	10.86	5.87	6.04	2.86	2.98
MTP-III	7.30	9.22	7.58	8.33	5.43	5.63	2.64	2.77
DPS-4	12.96	14.86	24.51	25.41	7.90	8.03	4.47	4.56
Safflower (Sole)	15.63	15.63	29.29	29.29	8.35	8.35	4.66	4.66
Mean	9.98	11.68	15.75	16.72	6.67	6.82	3.54	3.64
For comparing means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Seed source(SS)	0.069	0.196	0.225	0.642	0.022	0.063	0.014	0.040
Distance (D)	0.028	0.080	0.092	0.262	0.009	0.026	0.006	0.017
Interaction (SS× D)	0.097	0.277	0.318	NS	0.031	0.089	0.020	NS

D_1 = 1.5 m distance from Pongamia alleys; D_2 = 3.0 m distance from Pongamia alleys

Table 4. Influence of seed sources of *Pongamia pinnata* on seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index in Safflower under agroforestry

Seed source	Seed yield (kg ha^{-1})		Haulm yield (kg ha^{-1})		Harvest index	
	D_1	D_2	D_1	D_2	D_1	D_2
RAK-103	380.53	384.40	9023	9032	0.0405	0.0408
RAK-106	410.43	415.20	10050	10150	0.0392	0.0393
RAK-11	374.20	380.40	9002	9012	0.0399	0.0405
RAK-90	415.60	421.66	10850	10950	0.0369	0.0371
RAK-22	410.30	416.60	9078	9088	0.0432	0.0438
RAK-05	317.80	324.33	8068	8081	0.0379	0.0386
RAK-89	410.60	416.53	10380	10490	0.0381	0.0382
MTP-I	277.40	284.53	7089	7399	0.0377	0.0370
MTP-II	310.47	320.70	8014	8025	0.0373	0.0384
MTP-III	290.60	298.57	7065	7075	0.0395	0.0405
DPS-4	430.70	442.53	11080	11190	0.0374	0.0380
Safflower (Sole)	592.40	592.40	11550	11550	0.0488	0.0488
Mean	385.07	391.49	9270.75	9336.83	0.0397	0.0401
For comparing means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Seed source (SS)	0.375	1.071	43.833	125.180	0.0012	0.0036
Distance (D)	0.153	0.437	17.895	NS	0.0006	0.0018
Interaction (SS × D)	0.530	1.514	61.989	NS	0.0030	0.0091

D_1 = 1.5 m distance from Pongamia alleys; D_2 = 3.0 m distance from Pongamia alleys

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