Indian J. Dryland Agric. Res. & Dev. 2015 30(2) : 100-104 DOI 10.5958/2231-6701.2015.00032.9

Identification of Pongamia *(Pongamia pinnata L.)* Based Suitable Intercropping Practices for Sustainable Production of Biofuel and Nutritional Security in Semi-Arid India

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ABSTRACT: A field experiment was conducted for two consecutive cropping years to investigate the effective intercropping practices, keeping pongamia as the main crop with redgram, horsegram, castor and blackgram as an intercrop. The trials were conducted in factorial RBD with three spacing of pongamia viz. 6 × 6m, 6 × 4m and 6 × 8m, while recommended spacing of pongamia was 6 × 6m. All intercrops were sown as per the recommended package of practices. The study revealed highly significant differences in performance due to spacing, intercrops and their interaction in both the years of evaluation. Based on two year's study, cultivation of redgram as intercrop with pongamia was found to be the best practice with spacing of 8×6m followed by 6×6m for maximizing the returns and utilizing the space available between rows of pongamia.

Key words: Biofuel, pongamia, intercropping, semi-arid

Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time, is an age old and commonly used cropping practice which aims at matching crop demand to the available growth resources and labor (Lithourgidis *et al*. 2011). With increasing pressures on agricultural land arisen out of population growth, farmers have no option but to explore new ways to intensify production per unit area of land (Usmanikhail *et al*. 2012). Intercropping systems impart yield stability, allowing consistent yields (Willey, 1979; Horwith, 1985; Fukai and Trenbath, 1993) efficient use of the resources and cost reductionon use of inputs (Keatings and Carberry, 1993; Morris and Garrity, 1993). Intercropping usually gives higher income per unit area than sole cropping by utilizing space available between two rows of main crop. It acts as an insurance against failure of main crop in abnormal year and also maintain soil fertility especially when legumes are used as intercrops. Legume as intercrops are among the most frequently used and highly productive (Ofori and Stern, 1987). While, the importance of biofuels as renewable source of energy is gaining importance worldwide including India, primarily due to its positive contribution to climate change which, otherwise is impacting negatively on human, animal and soil health along with air and water pollution. Improving the production and productivity of these biofuels including pongamia is a very pertinent issue in the semi-arid and arid tropics of the world. These biofuels are recommended for wastelands or unproductive lands with low water holding capacity while fertile lands are meant for food crops to meet the energy and food security of the country.

The annual production of pongamia in India is eight thousand tonnes, although the potential is around 200 thousand tonnes (Khare and Ahmed, 2003). The pongamia oil known as *Karanja* oil also has medicinal properties as well as it has value of commercial non-edible oil. The pongamia oil is also useful as fuel for cooking lamps, lubricant, water-paint binder, pesticide, soap making and tanning industries while leaves are readily consumed by goats and cattle (Troup 1983). Incorporation of leaves and the press cake in soils improves fertility, while dried leaves are used as an insect repellent in stored grains. Pongamia is drought resistant, nitrogen fixing leguminous tree and often planted in homesteads as a shade or ornamental tree. Its root, bark, leaf, sap, and flower also have medicinal properties. Pongamia is widely used as an intercrop particularly with legumes and pulses (Chaukiyal *et al.,* 2000). The dwarf and short duration oilseed and pulse crops such as mustard, groundnut, chickpea, cowpea, horsegram, and millets like bajra, etc., can be grown successfully as intercrops without affecting the growth of pongamia plants (Kesari and Rangan, 2010). Intercropping increases the economic feasibility of pongamia plantation and generates revenues during gestation period from the same land (Pokhriyal *et al.,* 1996). The intercrops selected by various institutions in India for agri-silvicultural trial in pongamia suggests that there are no significant differences between sole cropping and intercropping on plant height, collar diameter, number of branches, and grain yield.

The objective of the present study was to determine the effect of intercropping and planting geometry on the performance of pongamia along with intercrops and to identify the best intercrop for better utilization of unproductive land in semi-arid regions in India.

Materials and Methods

Study Site

The experiment was conducted for two years at the Hayatnagar Research Farm (HRF) of Central Research Institute for Dryland Agriculture (17°27'N latitude and 78°35'E longitude and about 515 m above sea mean level), Hyderabad, India. The climate is semi-arid with hot summers and mild winters. The mean maximum air temperature during summer (March, April and May) ranges from 35.6 to 38.6°C, where as in winter (December, January and February) ranges from 13.5

to 16.8 °C. Annual long-term average rainfall for the site is about 750 mm received predominantly from June to October. The soils are medium-textured, red soil with shallow depth (Typic Haplustalf as per USDA soil classification). The weather data of the experimental site for first (2007) and second (2008) year are presented in Figure 1.

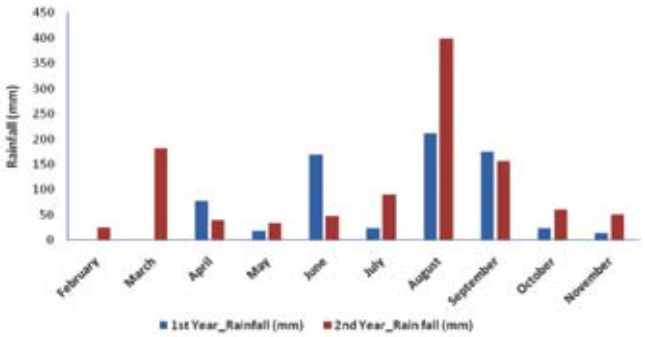

Fig. 1 : Weather parameter of both year of experiment

Methods

Plantation of pongamia at experimental site

During July 2003, 4 months old seedlings of pongamia were planted in the pits of 45 cm × 45 cm × 45 cm size. The pit mixture contained dugout soil + 2 kg compost + N, P and K at 42g, 168g and 42g, respectively. The experiment was laid out in factorial randomized block design (RBD) with pongamia as the main crop having 3 spacing of 6 × 4m, 6 × 6m and 8 × 6m with 3 replications. The recommended spacing of cultivation for pongamia is 6 × 6m. Total plot area in each spacing was 600 square meters (30m × 20m). The fertilizer was applied (Table 1) to pongamia plantation once every year (from 2003 to 2008) at the onset of monsoon during the month of June/July.

Table 1 : Year wise fertilizer doses for pongamia plantation per tree during 2003 to 2008

Year	Urea (g/ plant)	SSP (g/ plant)	MoP (g/ plant)
1st Year (2003) (At the time of plantation)	42	168	42
2nd Year (2004)	84	336	84
3rd Year (2005)	126	504	126
4th Year (2006)	168	672	168
5th Year (2007)	210	840	210
6th Year (2008)	252	1008	252

Intercropping (red gram, horse gram, black gram and castor)

Intercropping of red gram, horse gram, black gram and castor in between pongamia plantation was done following recommended spacing and package of practices for individual intercrop during first and second year of experiment, having three replication for each intercrop. The plot size was 600 square meter for each intercrop under three different spacing of main crop (Figure 2). The varieties ICPL-85063 (Lakshmi), CRIDA-18R, LBG-462 and DCS-9 of redgram, horsegram, blackgram and castor respectively, were used in the experiment. The sowing of intercrop was done on 14th July in both the years with spacing of 90 × 40 cm, 30 x 10 cm 30 × 10 cm and 90 × 45 cm for redgram, horsegram, blackgram and castor, respectively. A uniform basal dose of 40 kg N and 50 kg P_20_5 per hectare were applied at the time of sowing of intercrops.

Fig. 2 : Pongamia intercrop with redgram and horsegram and as sole crop

Data analysis

There were two factors in the study namely spacing (three levels) and intercrops (four inter crops + control = five levels). The experimental design was mixed factorial with three levels of spacing as one factor and five levels of intercrop as another factor. The experiment was laid out in randomized complete block design. The objective was to compare the main and interaction effects of spacing and intercrop on returns/yield. Since, the yield of intercrop cannot be compared or added to pongamia yield directly, yield obtained with each intercrop was converted into pongamia equivalent yield using farm harvest prices (FHP). The FHP for pongamia (₹ 1350/-), redgram (₹ 4350/-), blackgram (₹ 4350/-), castor (₹ 3650/-) and horsegram (₹ 3500/-) per quintal was calculated as per the prevailing market prices. Accordingly, FHP factor derived as 3.22 (for redgram and blackgram), 2.70 for castor and 2.59 for horsegram. The intercrop yields (per ha) were multiplied with respective FHP factors and then added to pongamia yield. As experiment was conducted for two years (2006-07 and 2007-08), pooled analysis of variance was made considering year effect as random variable. The statistical analysis was done using proc glm of SAS software version 9.2. All the terms involving year effect was considered as random in the ANOVA model. Tukey's studentized range test (HSD) was employed to offer corrections to p-values while doing multiple comparisons. P value less than 0.05 was used as the criteria for rejecting the null hypothesis of equality of means for spacing, intercrops and interactions between them separately.

Results and Discussion

The year wise and pooled analysis of variance (ANOVA) for pongamia grain equivalent yield under intercrops of trials in given in Table 2 and Table 3, respectively. The ANOVA revealed significant variances due to spacing, intercrop and their interaction for both the years, while

variance due to replication was non-significant. The pooled analysis of variance treating year as random, showed highly significant variances due to spacing, intercrop and interaction components spacing × intercrop and year × intercrop, while it was non-significant for year, replication (year), year × spacing and year × spacing × intercrop. The significant variation due to spacing, intercrop, spacing × intercrop and year × intercrop interaction for seed yield indicated influence of spacing, intercrop and their interaction in the performance pongamia and intercrops.

Table 2 : Analysis of variance of grain yield for the year 2007 and 2008

Source	df	Mean Sum of Square	
		1st year (2007)	2nd year (2008)
Rep	2	1.30	0.52
Spacing	2	23.25**	6.30*
Intercrop	4	356.67**	335.94**
Spacing × Intercrop	8	11.09**	15.54**
Error	28	1.52	1.13

Table 3 : Combined ANOVA of grain yield of intercropping of pongamia

Source	df	Mean Sum of Square	F_{cal}	Pr > F
Year	1	0.53	0.40	0.53
Rep(year)	4	0.91	0.69	0.60
Spacing	2	26.86**	20.21	<0.0001
Intercrop	4	686.65**	516.64	<0.0001
Spacing × Intercrop	8	25.56**	19.23	<0.0001
Year × Spacing	2	2.68	2.02	0.142
Year × Intercrop	4	5.96**	4.48	0.003
Year × Spacing* Intercrop	8	1.06	0.8	0.60
Error	56	1.33		

The mean yield under different spacing is given in Table 4. The results showed that pongamia grown with spacing of 8 × 6m as an intercrop gave highest yield as compared to 6 × 6m and 6 × 4m in both the years of evaluation. The mean intercrop yield of redgram was significantly superior as compared to others in both the years of evaluation (Table 5). The mean performance of sole pongamia and as intercrop under different spacing is given Table 6. The results revealed that, redgram yield with spacing of 8 × 6m and 6 × 6m was significantly superior to all other combination of spacing × intercrops indicating redgram is the most profitable intercrop with pongamia. The redgram yield during 2007 was statistically at par with 8 × 6m and 6 × 6m spacing, while in 2008, 8 × 6m was better than 6 × 6m. This indicated that redgram is best choice as intercrop with pongamia for utilization of space in between pongamia trees. These results indicated the impact of intercropping under different spacing for enhanced profitability in pongamia plantation.

Redgram, blackgram, castor and horsegram were studied to know the yield patterns in these crops in varied spacing of pongamia under rainfed condition. All these intercrops are considered as a very good contingent crop under rainfed situation in semi-arid region in India. Redgram, blackgram and horsegram being leguminous have the added benefits of nitrogen fixation and ability to improve soil health. The present study deals with a tree legume and a crop legume, which would be very beneficial in drylands and their mixing will enrich the soil fertility in the long run. To strike a

Table 4 : Mean grain yield in different spacing for two year

Spacing	Pongamia equivalent yield (q/ha)	
	1st year (2007)	2nd year (2008)
8 × 6	10.54[a]	10.21[a]
6 × 6	9.80[a]	9.77[a]
6 × 4	8.11[b]	8.93[b]
GM	9.49	9.64
CV	13.00	11.04
LSD	0.92	0.79

Table 5 : Intercrop yield with pongamia during two years

Intercrop	Pongamia equivalent yield (q/ha)	
	1st year (2007)	2nd year (2008)
Redgram	19.06[a]	19.28[a]
Horsegram	9.92[b]	9.95[b]
Blackgram	8.63[c]	9.40[b]
Castor	8.38[c]	6.93[c]
Sole Pongamia (Control)	1.45[d]	2.64[d]
GM	9.49	9.64
LSD	1.19	1.02

Table 6 : Mean yield of pongamia and intercrop at different spacing

Treatment no.	Spacing	Intercrop	Pongamia equivalent yield (q/ha)	
			1st year (2007)	2nd year (2008)
1	6 × 4	Blackgram	8.69	8.48
2	6 × 4	Castor	6.20	7.16
3	6 × 4	Horsegram	9.02	9.30
4	6 × 4	Redgram	14.71	14.80
5	6 × 4	Sole Pongamia (Control)	1.97	2.92
6	6 × 6	Blackgram	8.75	7.62
7	6 × 6	Castor	8.77	9.48
8	6 × 6	Horsegram	8.58	8.56
9	6 × 6	Redgram	21.36	20.97
10	6 × 6	Sole Pongamia (Control)	1.55	2.32
11	8 × 6	Blackgram	8.45	7.25
12	8 × 6	Castor	10.18	10.04
13	8 × 6	Horsegram	12.17	11.96
14	8 × 6	Redgram	21.12	21.75
15	8 × 6	Sole Pongamia (Control)	0.81	0.90

balance between the food crops and biofuels, the best option would be intercropping for sustaining the nutrition security of the human along with the biofuel in a given area. This intercropping system would serve as a risk eversion strategy and provide nutritional security during the early stages of tree growth. Similar studies on efficient utilization of land by intercropping of pongamia with legumes were reported earlier (Pokhriyal *et al.,* 1996; Chaukiyal *et al.,* 2000; Kesari and Rangan, 2010). The present investigation revealed that intercropping of pongamia and grain legume may be recommended in arid and semi-arid drought prone areas, and wastelands for sustainable realization of the renewable source of energy through perennial oil yielding trees along with the annual grain legumes specially redgram followed by horsegram for sustaining the nutritional security of humans and livestock.

Conclusions

The above results on intercropping with leguminous biofuel tree and annual grain legume may be recommended in arid and semi-arid drought prone areas and wastelands at 8 x 6m, spacing of trees. Redgram and horsegram were found to be suitable intercrops. An intercropping of pongamia and leguminous crops is suggested as a win-win situation for degraded drylands and to mitigate climate change.

Acknowledgement

The authors acknowledge the externally funded project "National Network on Integrated development of Jatropha & Pongamia" by NOVODB.

References

Chaukiyal SP, Sheel SK and Pokhriyal TC. 2000. Effects of seasonal variation and nitrogen treatments on nodulation and nitrogen fixation behaviour in *Pongamia pinnata*. Journal of Tropical Forest Science. 12: 357-368.

Fukai S and Trenbath BR. 1993. Processes determining intercrop productivity and yields of component crops. Field Crops Research. 34: 247–271.

Horwith B. 1985. Arole for intercropping in modern agriculture. Bio Science. 35: 286-291.

Keating BA and Carberry PS. 1993. Resource capture and use in intercropping: solar radiation. Field Crops Res., 34: 273-301.

Kesari V and Rangan L. 2010. Development of *Pongamia pinnata* as an Alternative Biofuel. Journal Crop Science and Biotechnology. 13 (3): 127 - 137.

Khare VR, Shabaz Ahmed. 2003. Tree Borne Oil seeds-Initiatives and scope in MP. Tree borne oil seeds as a source of energy

for decentralized planning, Ministry of Non-Conventional Energy Sources 2003; 205-209.

Lithourgidis AS, Dordas CA, Damalas CA and Vlachostergios DN. 2011. Annual Intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Science. 5(4):396-410.

Morris RA, Garrity DP. 1993. Resource capture and utilization in intercropping: water. Field Crops Research. 34, 303-317.

Ofori F, Stern WR. 1987. Cereal–legume intercropping systems. Advances in Agronomy. 41: 41–86.

Pokhriyal TC, Chaukiyal SP and Singh KCH. 1996. Nitrogen fixation and nodulation behaviour in relation to seasonal changes in six multipurpose tree species. Indian Forest. 122: 718-726.

Troup. The Silviculture of Indian Trees. Vol-IV, Leguminosae, Government of India Press, Nasik, India. 1983; 345 p.

Usmanikhail MU, Tuno SD, Jamro GH, Oad FC, Hassan, SW, Chachar QD, Zada, AK and Gandahi AW. 2012. Agronomic and economic effect of intercropping sugarbeet with oilseeds and lentil. Pakistan Journal of Botany. 44(6):1983-1988.

Willey RW. 1979. Intercropping - its importance and research needs. Part 1.Competition and yield advantages. Field Crop Abstract, 32: 1–10.

Received: February 2015; Accepted: November 2015