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RESEARCH PAPER

Correlation study in growth parameters of Pongamia (*Pongamia pinnata*) and physiological parameters of black gram (*Vigna mungo* (L.) Hepper) in agroforestry system

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Abstract: The present investigation was conducted to study the tree crop interaction considering the Pongamia (*Pongamia pinnata)* tree morphological characteristics and physiological parameters of black gram (*Vigna mungo* (L.) Hepper) in agroforestry system. The experiment was conducted during *kharif* 2019-20 and 2020-21 in "T" block, Agroforestry experimental fields of University of Agricultural Sciences, Dharwad campus which is located at 15° 26' North latitude and 75° 0' East longitude, with an elevation (altitude) of 678 m above mean sea level. *Pongamia pinnata* provenance's growth and volume observations were recorded. They included tree height, tree girth, canopy cover and number of branches *etc.* Two years pooled data recorded maximum values in treatment (T1) RAK-1 (Rahuri Karanja-1) + black gram followed by (T9) RAK-9 + black gram which is on par with (T6) RAK-7 + black gram. Lowest values recorded in (T8) RAK-9 + black gram which is on par with (T4) RAK-4 + black gram. Whereas the growth parameters of black gram like leaf area duration (LAD), absolute growth rate (AGR), crop growth rate (CGR) and dry matter accumulation recorded under Pongamia provenances which showed opposite trend because of the fluctuations of light and mutual shading of the crops within or in between rows, frequent overcast due to clouds as a common phenomenon during tropical and sub-tropical monsoons causing regular fluctuation of sunlight. The treatment (T11) sole crop showed the maximum value, followed by (T8) RAK-9 + black gram and (T4) RAK4 + black gram and lowest value was recorded at (T1) RAK-1 + black gram treatment. Sole legumes recorded maximum AGR. CGR, LAD and dry matter accumulation were also found to have highest significant positive correlation with seed yield.

Introduction

Pongamia pinnata L. known as pongamia or kerung, belongs to family Fabaceae which is medium size, an evergreen tree having short trunk and dispersing crown. The trees are planted for shade purposes and grown as an ornamental tree. It is also a nitrogen fixing tree which produces seeds containing 30-40% oil. It is a high-speed growing; deciduous, glabrous, trunk of diameter up to 60 cm, bark is smooth, grey in colour. Its leaves are imparipinnate , sometimes shiny, young, pinkish red, glossy and deep green when mature. Its many parts are used for timber, fuel production, medicinal and industrial purposes (Alam *et al.,* 2004). The annual production of *Pongamia* in India is 8000 tonnes, although the potential is around 200 thousand tonnes (Khare and Ahmed, 2003). *Pongamia* oil, known as Karanja oil, also has medicinal properties and the value of non-edible commercial oil. *Pongamia* oil is also beneficial as fuel for cooking lamps, lubricant, water-paint binder, pesticide, soap-making and tanning industries, while leaves are readily consumed by goats and cattle. Incorporating leaves and press cake in soils improves fertility, while dried leaves are used as insect repellent in stored grains.

Black gram (*Vigna mungo* (L.) Hepper) is a fast-growing erect, herbaceous annual legume reaching 30-100 cm height with a well-developed taproot, and its stems are diffusely branched from the base. Black gram differs from green gram (*Vigna radiata* (L.) R. Wilczek) with a distinct bright yellow corolla, while green gram is pale yellow. Black gram pods are erect, whereas pods are pendulous for green gram. A black gram is more pubescent than a green gram, and a white hilum is visible in the seed. Heavy soil is preferred for black gram over lighter soils for green gram (Göhl, 1982).

In an agroforestry system, low incident light or reduced solar radiation affects the survival and productivity of crops grown under the trees. Some other significant reasons being also responsible for fluctuations of light are mutual shading of the crops within or in between rows, frequent overcast due to clouds as a common phenomenon during tropical and sub-tropical monsoons causing regular fluctuation of sunlight (Alam *et al.,* 2018).

Besides the potential benefits of tree-based intercropping systems, interactions within agroforestry systems can be beneficial, neutral, or unfavourable (Ong, 1996). Competitive interactions should be avoided to properly design and manage intercropping systems and maximize tree-based systems' potential benefits (Thevathasan *et al.,* 2004). The studies of interactions in agroforestry systems necessitate the evaluation of several complex processes, including plant competition (*i.e.*, for light, water, and nutrients), those related to soil conservation, soil fertility, allelopathy, pests and diseases, and microclimatic modifications (Rao *et al*., 1998). In recent days Pongamia tree is popular for various benefits and the objective of the present study is to explore the influence of ten Pongamia provenances on growth and productivity of black gram since farmers are

Table 1. Tree height (m), tree girth (cm), canopy cover (m^2), number of branches of different *Pongamia pinnata* provenances at *kharif* 2019 and 2020 (4th and 5th years old tree)

Treatments	Pooled data for 2019 and 2020			
	Tree height (cm.)	Tree girth (cm)	Tree cover (m^2)	Number of branches
T_1 – RAK-1 + Black gram	3.66	18.85	3.03	29.85
T_2 – RAK-2 + Black gram	2.92	16.40	2.62	23.30
T_3– RAK-3 + Black gram	2.94	15.70	2.56	23.80
T_4 – RAK-4 + Black gram	2.23	12.45	1.91	18.50
T_5 – RAK-6 + Black gram	2.68	15.20	2.32	20.65
T_6 – RAK-7 + Black gram	3.28	17.55	2.83	25.20
T_7 – RAK-8 + Black gram	2.66	15.95	2.37	21.40
T_8 – RAK-9 + Black gram	2.25	12.4	1.95	18.30
T_9 – RAK-10 + Black gram	3.26	17.8	2.81	25.75
T_{10} – DPS-1 + Black gram	2.67	14.8	2.35	21.20
S. Em (±)	0.32	0.57	0.31	0.90
C. D. (5%)	0.93	1.67	0.92	2.60

growing black gram that to DU-1 which is high yielding and drought resistant and Pongamia for bio diesel, fodder, fuel and shade for animals in marginal lands under agro forestry system in northern transitional zone of Karnataka.

Material and methods

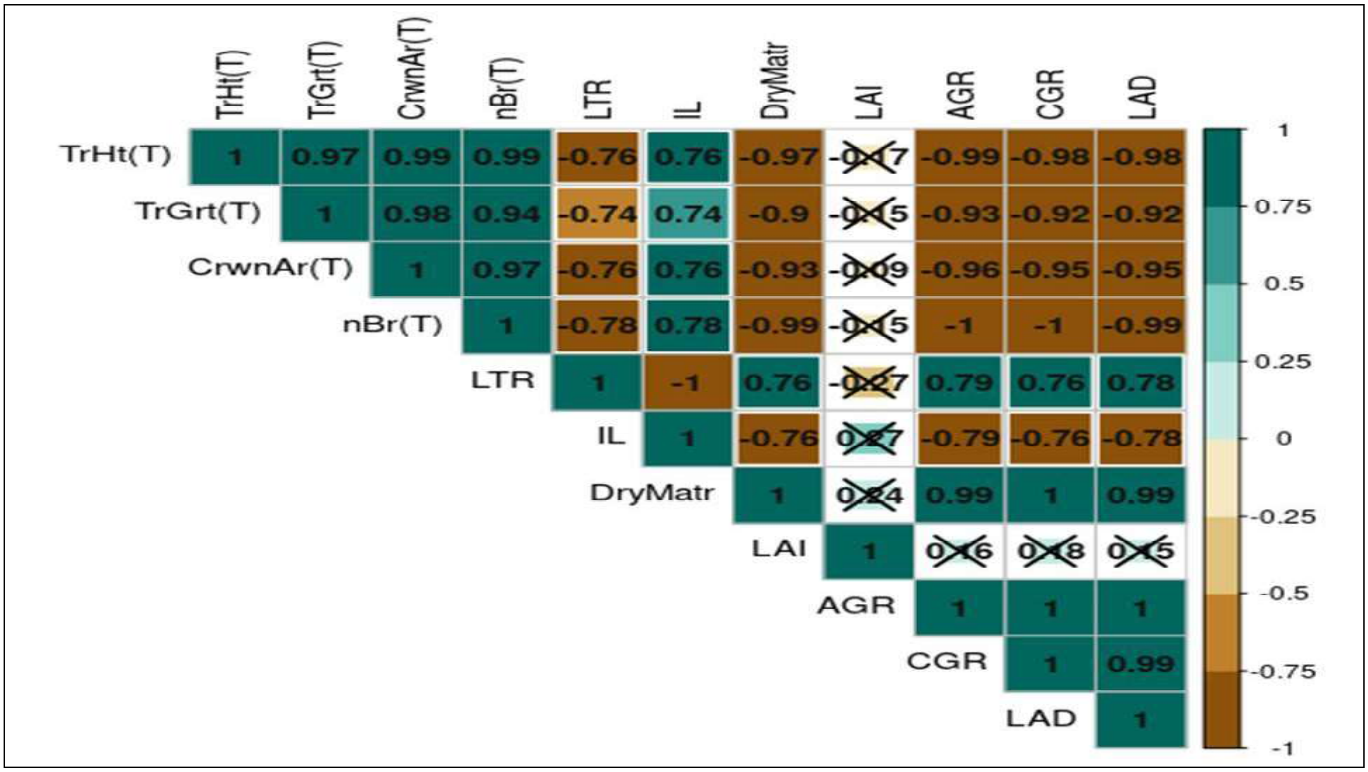
After 35 days of black gram sowing, various observations on *Pongamia* were recorded. Tree height (m.) was measured with ravi multi meter and observations were recorded in meter. Tree girth (cm.) was measured at breast height with tree calliper. Further crown area, tree volume and number of tree branches were also recorded. The morphological characters of black gram were recorded at 35, 55 days after sowing and at harvest. Five plants were uprooted at random in each treatment and partitioned into their component parts *viz.,* stem, leaf and reproductive parts and were air dried and then transferred to hot air oven at 80°C until a constant weight was obtained and their dry weight at 35 and 55 DAS were recorded. Leaf area index (LAI) was worked out by dividing the leaf area per plant by land area occupied by the plant at 35 and 55 DAS and AGR, CGR and LAD were recorded using data at 35-55DAS and at harvest.

Results and discussion

Pongamia provenaces (Rahuri Karanja1 to 9) and (DPS-1 Dharwad Pongamia Selection-1) growth and volume observations were recorded on tree height, tree girth, canopy cover and number of branches for two years. Pooled data recorded maximum values in treatment (T_1) RAK-1 + black gram followed by (T_9) RAK-9 + black gram which is on par with (T_6) RAK-7 + black gram. Lowest values recorded in (T_8) RAK-9 + black gram which is on par with (T_4) RAK-4 + black gram. Where as in case of Leaf area index, Leaf area duration, Absolute growth rate, Crop growth rate, dry matter accumulation these growth parameters of black gram under beneath of *Pongamia* provenances showed reverse trend. The treatment sole crop (T_{11}) showed maximum value, followed by (T_8) RAK-9 + Black gram and (T_4) RAK4 + black gram and lowest value were recorded at (T_1) RAK-1 + black gram treatment. Sole legumes recorded maximum AGR. CGR, LAD and dry matter accumulation

Table 2.Influence of *Pongamia pinnata* provenances on leaf area index, absolute growth rate (AGR, g day^{-1}), crop growth index ($gdm^{-2}day^{-1}$), leaf area duration ($gdm^{-2}day^{-1}$) and total dry matter (g day-1) at various growth stages in blackgram.

Treatments	Pooled data for the year 2019 and 2020									
	Leaf area index		Absolute growth rate		Crop growth index		Leaf area duration		Total dry matter	
	35 DAS	55 DAS	35-55 DAS	55DAS-Harvest	35-55 DAS	55 DAS-Harvest	35-55 DAS	55 DAS-Harvest	35 DAS	55 DAS
T_1 – RAK-1 + Black gram	0.725	0.936	0.103	0.190	0.307	0.596	16.2	12.1	2.24	4.16
T_2 – RAK-2 + Black gram	0.855	1.330	0.230	0.374	0.689	1.162	21.5	16.6	2.91	7.47
T_3– RAK-3 + Black gram	0.868	1.311	0.229	0.360	0.691	1.110	21.6	16.7	2.90	7.50
T_4 – RAK-4 + Black gram	1.022	1.557	0.257	0.483	0.768	1.475	25.0	19.6	3.51	8.66
T_5 – RAK-6 + Black gram	0.943	1.456	0.241	0.443	0.730	1.364	23.5	18.5	3.27	8.07
T_6 – RAK-7 + Black gram	0.807	1.185	0.210	0.320	0.635	0.961	19.7	15.1	2.56	6.77
T_7 – RAK-8 + Black gram	0.935	1.461	0.243	0.451	0.732	1.318	24.2	18.6	3.23	8.08
T_8 – RAK-9 + Black gram	1.023	1.593	0.259	0.508	0.778	1.496	26.0	20.2	3.57	8.58
T_9 – RAK-10 + Black gram	0.793	1.138	0.215	0.296	0.636	0.960	19.6	15.4	2.58	6.87
T_{10} – DPS-1 + Black gram	0.947	1.462	0.242	0.452	0.730	1.319	23.5	18.8	3.28	8.13
S. Em (±)	1.170	1.736	0.289	0.555	0.863	1.694	28.2	22.9	3.86	9.60
C. D. (5%)	0.03	0.04	0.01	0.01	0.02	0.04	0.76	0.60	0.10	0.26



were also found to have high significant positive correlation with seed yield. These parameters were lower at early stage of the crop growth and increased with advancement in crop growth thereby, indicating an increase in the accumulation of dry matter. Sole crop of Pongamia showed maximum Leaf area index, Leaf area duration, Absolute growth rate, Crop growth rate and other parameters since this treatment is without tree cover. However similar results were carried out by Kaushik *et al.* (2017), studied agri–silvi–horti systems among four silvi–horti systems, growth of shisham and khejri was significantly higher under agroforestry (agri–silvi–horti) systems than sole plantation. GBH (1.00 m) was recorded for shisham with aonla + wheat. Khejri performed better with wheat irrespective of fruit tree species. Further (Ashalatha *et al.,* 2015) reported as a whole, the morphology of the tree has caused the down regulation of the light transmission ratio, dry matter accumulation, absolute growth rate, crop growth rate and the leaf area duration of black gram. The growth and yield of annual crops were found to be less in intercrop compared to sole crop, while the volume of trees and growth rate improved when planted along with intercropping of pluses. The experiment conducted by Kesseler (1992), at Netherlands reveals that, the sorghum grown under shea butter tree *(Vitellaria paradox)* and locust bean tree *Parkia biglobosa* due to reduced light intensity under tree canopy spread Sorghum grain yields under shea butter tree and locust bean tree lower up to 35-90% and 15-65% lower than open field.

Karthikeyan *et al.* (2018), reported the tree height varied from 5.10 m to 6.18 m and 6.28 m to 7.82 m before sowing and after harvesting of the intercrops respectively and also exhibited significant difference in height increment. Among the different tree - crop combinations, maximum height increment in the tree component was recorded under *Melia* + Hedge Lucerne (1.75 m) and the lowest was reported under *Melia* + Guinea grass CO (GG) 3 (1.17m) when compared to control (*Melia* alone (1.22 m). Diameter at breast height ranged between 6.06 cm and 7.31 cm before sowing and 15.66 cm to 16.79 cm after harvesting the intercrops. Among the different tree-crop combinations studied, *Melia* + Lucerne (10.15 cm) recorded the maximum diameter increment and *Melia* + Hedge Lucerne (9.28 cm) was reported lowest diameter compared to control (*Melia* alone (9.30 cm)). Lin *et al.* (1998), reported that, the canopy cover play major role as above ground dry weight yield per pot was reduced in all warm-season grasses (C4 species) as the levels of shade increased.

Alam *et al.* (2018) assessed microclimate dynamics through ecophysiological and spectral traits in agroforestry system on cowpea (*Vigna unguiculata*) as influenced by different genotypes of *Dalbergia sissoo* trees, recorded a mean LAI values for PT-2, PT-6 and local genotypes as 2.26, 1.91 and 1.55, respectively in the agroforestry field. The results clearly demonstrated that the difference in light interception among the different genotypes was due to their difference in canopy LAI.

Among the two intercropping systems (Lata *et al.,* 2014), Ashwagandha in Terminalia showed significantly less dry matter over at all stages during both years compared to Ashwagandha intercropping in amla. Maximum dry matter of (776.4 g m^{-2}) during 2008 and (755.9 g m^{-2}) in 2009 were recorded in the sole cropping of Ashwamedha.

Correlation study indicates that pongamia tree parameters are showing neither positive nor negative correlation with the leaf area index of the intercropped black gram. All the growth parameters of the intercropped black gram are inversely related to the tree morphological characteristics except for intercepted light in blackgram. These inverse relationships are explained with the dependence of the parameters among themselves. The greater crown area of the tree has affected the leaf area duration of the intercropped black gram negatively which means to increase the leaf area duration of the intercropped black gram, the crown area had to be reduced. The higher crown area of the tree has also caused the reduction in the light transmission ratio to the intercropped black gram.

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