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Analysis of light transmission ratio and yield advantages of pigeonpea in relation to intercrop and different plant population

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A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore, during *kharif* 2011 to optimize the spacing for medium maturation pigeonpea at different planting geometry and row proportions under intercropped and irrigated situation. The experiment was laid out in Randomized block Design with 3 replications. Adjacent to the treatment plots, sole pigeonpea and greengram were also raised in dummy plots with same management practices to calculate the yield advantages. The treatments comprised of planting geometry (row spacing of 90, 120, 150 and 180 cm at varied level of plant to plant spacing with 30, 45, and 60 cm) and different row proportions of pigeonpea + greengram (1:2, 1:3, 1:4 and 1:5) Pigeonpea sown with different spacing's under sole as well as intercropped with greengram showed positive effect on various agronomic traits and yield parameters for different planting geometry. Sowing of pigeonpea at 120 x 30 cm with 1:3 row proportions recorded significantly higher LER (1.52), ATER (1.15) and IER (1.29) was recorded. The lowest light transmission ratio of 34.7% was recorded with the above said treatment.

Key words: Pigeonpea, planting geometry, light transmission ratio, land equivalent ratio, area time equivalent ratio and income equivalent ratio.

INTRODUCTION

Pigeonpea (*Cajanus cajan* L.) is one of the major grain legume crop of tropical and subtropical regions and it is grown predominantly under rainfed conditions. India accounts for 90% of world's pigeonpea growing area and 85% of world's production of pigeonpea. In India, it is grown in an area of 4.5 M ha with an annual production of 3.3 MT and productivity of 799 kg ha^{-1}. When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and low harvest index; therefore it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profit.

Pigeonpea is desirable for inter-cropping with different crops like cotton, sorghum, pearlmillet, greengram, blackgram, maize, soybean and groundnut for enhancing yield output and sustaining soil fertility. Greengram

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(*Vigna radiata* L.) also one of the most essential pulse crop in India because of its shorter growth duration, low water demand, low soil fertility and is privileged for consumption due to its soft digestibility and low yield of flatulence (Shil and Bandopadhyay, 2007).

Agronomic package like plant population is recognized to affect crop environment, which determine the yield components. Optimum population levels should be maintained to tap utmost natural resources such as nutrient, sunlight, soil moisture and to assure satisfactory yield (Sharifi et al., 2009). If plant population is lower than optimum, then per hectare production will be down and weeds will also be to a greater extent (Allard, 1999).

The low productivity of pigeonpea has been ascribed to the reality that large area is under rainfed situation raised in broader spacing. Under such situation, other leguminous crops such as greengram can be sprung up as an intercrop to heighten the productivity of the system. However, intercropping in pigeonpea may not be potential with conventional planting pattern of 90 × 30 cm. Thereby adoption of wider planting geometry pave a way for preserving the optimum plant population of pigeonpea and also it provides a chance for introducing an intercrop. Keeping above in perspective, a trial was carried out to study the effect of planting geometry on pigeonpea under intercropped and irrigated condition.

MATERIALS AND METHODS

Climate and soil

Field experiment was conducted during *kharif,* 2011, to optimize the spacing for medium maturation pigeonpea at different planting geometry and row proportions under intercropped and irrigated situation at Millet Breeding Station of TNAU, Coimbatore, Tamil Nadu (India) is situated at 11° North latitude and 77° East longitude at an altitude of 426.7 m above Mean Sea Level (MSL). The mean annual rainfall of Coimbatore is 657 mm distributed over 47 rainy days and the mean maximum and minimum temperatures were 31.5 and 21.4°C, respectively during the crop period.

The relative humidity ranged from 61 to 90% in the forenoon and 14 to 68% in the afternoon. The mean bright sunshine hours per day were 7.4 h with a mean solar radiation of 429 cal cm^{-2} day^{-1}. The meteorological data for the cropping season 2011 was recorded at the meteorological observatory of from Agro Meteorological Observatory at Tamil Nadu Agricultural University, Coimbatore. The sandy clay loam was alkaline (pH 8.32), medium in organic carbon (0.59%), available N (148 kg ha^{-1}), available P (26 kg ha^{-1}) and available K (307 kg ha^{-1}).

Treatment details

The treatments comprised of planting geometry (row spacing of 90, 120, 150 and 180 cm at varied level of plant to plant spacing with 30, 45, and 60 cm) and different row proportions of pigeonpea + greengram (1:2, 1:3, 1:4 and 1:5) were taken in randomized block design with three replications. The gross and net plot sizes were 18.0 x 8.4 m and 14.4 x 4.8 m respectively. Adjacent to the treatment plots, sole pigeonpea and greengram were also raised in dummy plots with same management practices to calculate the yield advantages. The pigeonpea variety CO 6 was chosen for the study. The COGG 973 of greengram was used as intercrop.

Agronomic packages

The crop was sown under irrigated condition. Hence to meet out the basic agronomic package the crop was fertilized with recommended dose of nutrients (25: 50: 25 kg of NPK ha^{-1}) through Urea, single super phosphate (SSP) and muriate of potash (MOP) and incorporated at the time of sowing. Urea is the cheapest source of nitrogen as far as farmer's point of view. The entire dose of NPK was applied as basal.

Growth and yield components were recorded in the five randomly selected plants. Net returns were calculated by deducing cost of cultivation from gross returns. The B:C ratio was worked out as a ratio of gross returns to cost of cultivation. Competitive indices, nutrient uptake and soil fertility status were also taken by following standard procedures. The crops were sown on 19th of August 2011 as per the treatments. Thinning was done at 20 DAS leaving one healthy seedling per hill. Pre-emergence herbicide of Pendimethalin 30% EC at 1.0 kg ha^{-1} was sprayed as on 3 DAS through the battery operated knapsack sprayer. Weeding was done in all the treatment plots on 35 DAS by hand hoe with the help of manual labour.

Sampling and measurements

Plants are harvested separately from the net plot area of each treatment and pods are separated, threshed, weighed and recorded as grain yield (kg ha^{-1}). The grain yield was recorded at 12% moisture level.

Computations for light transmission ratio and yield advantages

The yield differences among the treatments and sole plots were used to estimate the yield advantages due to different plant geometry. The light transmission ratio and yield advantages were calculated as proposed by Yoshida et al. (1972), Willey (1979) and Hiebsch and McCollum (1987).

$$\text{Light transmission ratio LTR (\%)} = \frac{Ii}{Io} \times 100$$

Where, Ii = Light intensity received at the ground level, Io = Light intensity received above the canopy of the corp.

$$\text{Land equivalent ratio (LER)} = LA + LB = \frac{YA}{SA} + \frac{YB}{SB}$$

Where, LA and LB are the LER for individual crops, YA and YB are the individual crop yield in intercropping, SA and SB are their sole crop yields.

$$\text{Area time equivalent ratio (ATER)} = \frac{(Ryc \times tc) + (Ryp \times tp)}{T}$$

Where, Ry = Relative yield of species c (main crop) and p (intercrop).

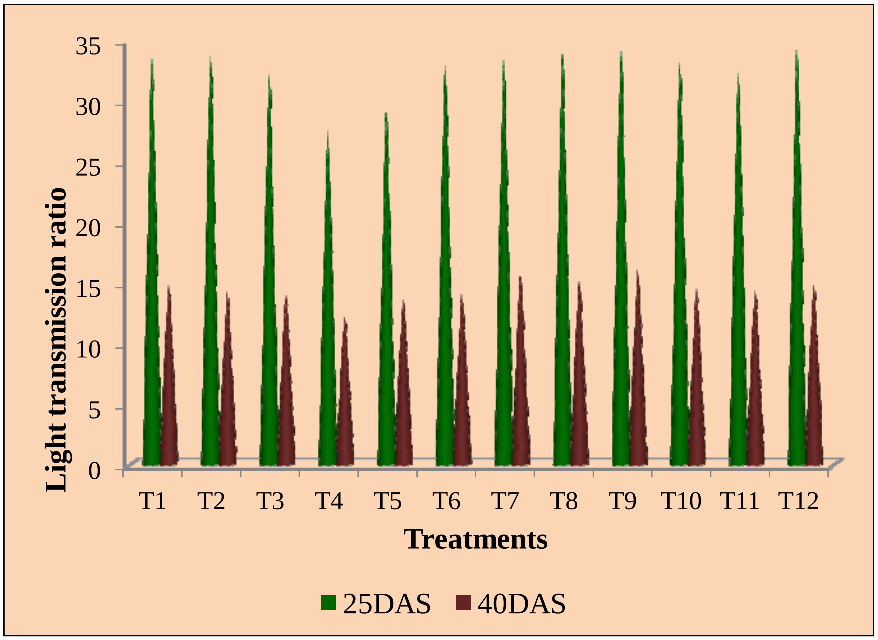

Figure 1. Effect of planting geometry and row proportions on light transmission ratio (LTR) of pigeonpea + greengram intercropping system.

$$Ry = \frac{\text{Yield of intercrop per hectare}}{\text{Yield of monocrop per hectare}}$$

t = duration (days) for species C and P, T = duration (days) for the intercropped system.

$$\text{Income equivalent ratio (IER)} = \frac{Iab}{Iaa} + \frac{Iba}{Ibb}$$

Where, Iaa : Gross income of component 'a' in pure stand, Ibb : Gross income of component 'b' in pure stand, Iab: Gross income of component 'a' in mixed stand with 'b', Iba: Gross income of component 'a' in mixed stand with 'b'.

Statistical analysis

The data were analyzed statistically following the procedure given by Gomez and Gomez (1984). Critical differences were worked out at five per cent probability level wherever the treatments were significant. The treatment differences that were non-significant were denoted as NS.

RESULTS

Light transmission ratio (LTR)

The light transmission ratio of intercropping system differed significantly due to planting geometries adopted for pigeonpea and row ratios of pigeonpea + greengram cultivars. During 25 DAS and 40 DAS among intercropped treatments, higher LTR of 34.7 and 16.2 was recorded in pigeonpea (150 x 60 cm) + greengram in 1:4 row proportion (T_9) followed by T_{12} (34.4) with 1:5 row proportion at 25 DAS. The lower LTR of 27.9 and 12.2 was recorded in intercropped pigeonpea (120 x 30 cm) with greengram 1:3 row proportion (T_4) at two stages (Figure 1).

Land equivalent ratio (LER)

The data obtained shows significant variations in land equivalent ratio due to cropping systems, planting geometry of pigeonpea and row proportions of pigeonpea and greengram (Figure 2). Among the intercropping treatments, comparatively highest LER (1.52) was recorded in pigeonpea (120 x 30 cm) + greengram in 1:3 row proportion (T_4). However, (T_{10}) pigeonpea (180 x 30 cm) + greengram in 1:5 (1.50), (T3) pigeonpea spacing (90 x 60 cm) (1.47) and pigeonpea (120 x 45 cm) + greengram 1:3 (T_5) remained on par with each other. Pigeonpea (90 x 30 cm) + greengram in 1:2 row proportion (T_1) recorded lower LER values (1.28).

Area time equivalent ratio (ATER)

Area time equivalent ratio showed significant variations due to cropping systems, row ratios of pigeonpea and greengram. Among the intercropped treatments, pigeonpea

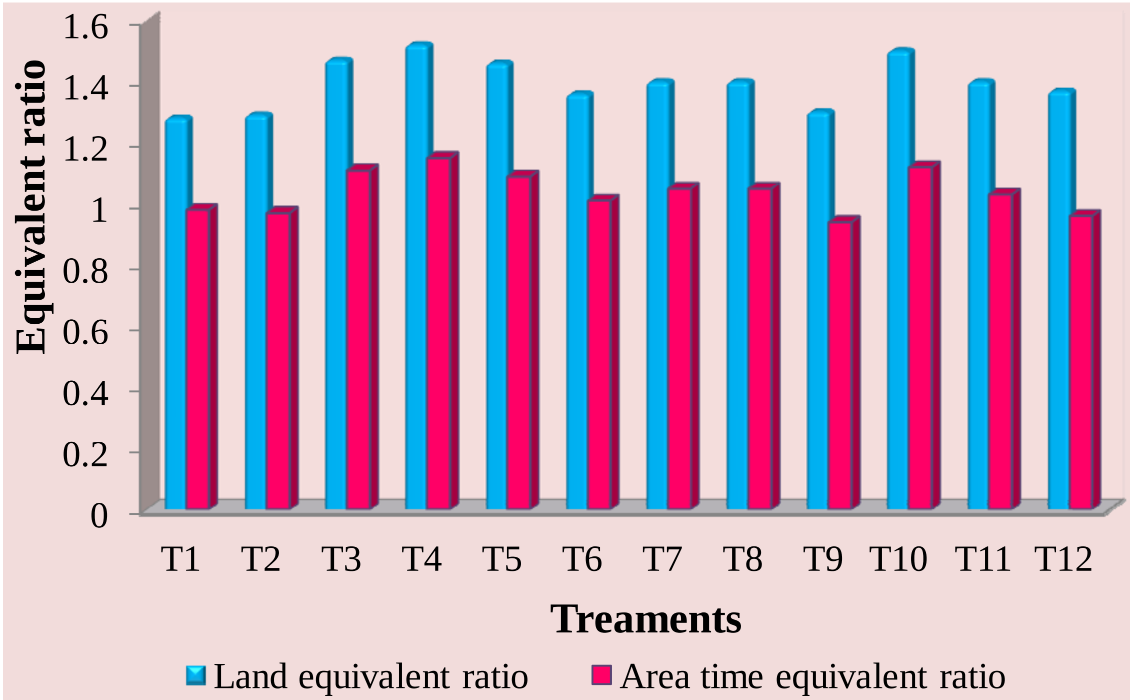

Figure 2. Effect of planting geometry and row proportions on land equivalent ratio (LER) and area time equivalent ratio (ATER) of pigeonpea + greengram intercropping system.

(120 x 30 cm) + greengram in different row ratios recorded significantly higher ATER (1.15) than all other intercropping treatments which was statistically on par with T_{10}, T_3 and T_5 treatments. Pigeonpea (150 x 60 cm) + greengram in 1:4 row ratio (T_9) recorded lower ATER (0.94).

Income equivalent ratio (IER)

Income equivalent ratio was higher (1.29) with a crop geometry of pigeonpea (120 x 30 cm) + greengram under 1:3 row proportion (T_4), followed by pigeonpea spacing of 90 x 60 cm with 1:2 row ratio (T_3) . The lowest IER (1.04) was recorded in 1:4 row ratio of pigeonpea (150 x 60 cm) + greengram (T_9).

DISCUSSION

Light transmission ratio (LTR)

The better use of resources can be supported by observations on LTR, which showed significant difference due to intercropping systems. The higher light interception in intercropping/mixed cropping was due to quick growth and good vegetative cover, which helped in better interception of light. The lower LTR values was observed in 1:3 row ratio with pigeonpea spacing of 120 x 30 cm which implies the highest light utilization efficiency as compared to other row proportions (Figure 1). This was due to better spatial use of light by leaf canopy or root system might have made better spatial use of nutrients and water. It is also clear from the investigation that, the yield advantage in intercropping/mixed cropping was due to better overall use of resources than when crops grown separately.

These factors hold well in present investigation in which pigeonpea has deep root system while greengram have shallow root system. This is in conformity with Rathod (2002) in pigeonpea + cowpea, Biru et al. (2004) in sorghum + legume and Mohan (2003) in maize intercropped with legumes in 1:2 row proportion.

Land equivalent ratio (LER)

Advantage of intercropping over sole cropping system is measured through LER varied from 1.28 to 1.52 due to different planting geometry and row proportion (Figure 2). Thus, biological efficiency of land under intercropping was higher as compared to sole greengram/pigeonpea and different planting geometries of pigeonpea intercropped with greengram. The higher LER under intercropping systems may be due to better planting geometry and spatial arrangements which might have avoided the coincidence of the peak period of growth of component crops. Intercropping of pigeonpea and greengram in 1:3 row ratio recorded higher yield LER of

Table 1. Effect of planting geometry and intercropping on income equivalent ratio of pigeonpea + greengram intercropping system.

Treatments	IER
T_1- Pigeonpea (90 x 30 cm) + Greengram (1:2)	1.13
T_2- Pigeonpea (90 x 45 cm) + Greengram (1:2)	1.11
T_3- Pigeonpea (90 x 60 cm) + Greengram (1:2)	1.27
T_4- Pigeonpea (120 x 30 cm) + Greengram (1:3)	1.29
T_5- Pigeonpea (120 x 45 cm) + Greengram (1:3)	1.21
T_6- Pigeonpea (120 x 60 cm) + Greengram (1:3)	1.13
T_7- Pigeonpea (150 x 30 cm) + Greengram (1:4)	1.16
T_8- Pigeonpea (150 x 45 cm) + Greengram (1:4)	1.14
T_9- Pigeonpea (150 x 60 cm) + Greengram (1:4)	1.04
T_{10}- Pigeonpea (180 x 30 cm) + Greengram (1:5)	1.20
T_{11}- Pigeonpea (180 x 45 cm) + Greengram (1:5)	1.11
T_{12}- Pigeonpea (180 x 60 cm) + Greengram (1:5)	1.05
SEd	0.05
CD (P=0.05)	0.10

Means are compared as per CD/LSD. Model used is Agress software.

1.52 over other system and the lowest one with 1:2 row proportion. It was concluded that, for producing the same amount of yield, 52% more area is required under sole crop system. This is in accordance with the findings of Prakash and Bhushan (2000) in pigeonpea/castor + greengram.

Area time equivalent ratio (ATER)

In the present investigation, ATER realized from intercropping systems of pigeonpea and greengram was significantly higher than that obtained from either sole crop of pigeonpea or greengram. Higher ATER (1.15) under intercropping of pigeonpea and greengram indicate that not only the efficient use of land, but efficient use of time. The extent of time utilization ranges from 9.5 per cent in 1:4 row proportions to 15 per cent in 1:3 row ratios (Figure 2). The observations in the present experiment are in agreement with the criteria set out earlier by Patil (2003) in little millet + pigeonpea.

Income equivalent ratio (IER)

IER values are higher in 120 x 30 cm spacing with 1:3 row proportion, due to high resource use efficiency and equivalent yield. This system gives 29% higher economic advantage over growing crops in pure stands (Table 1). The similar result was reported by Billore et al. (2009) in soybean + pigeonpea cropping system. Thus, it can be inferred from the above results, on the basis of agronomic as well as economic performance, sowing of pigeonpea (120 x 30 cm) + greengram intercropping in 1:3 row proportion under ridges and furrows land configuration proved to be more productive and remunerative and this salient finding will be useful for pigeonpea growers to enhance income under irrigated conditions of Tamil Nadu.

Conflict of Interest

The authors have not declared any conflict of interest.

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