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GROWTH, YIELD AND BIOLOGICAL INDICES OF MEDIUM DURATION PIGEONPEA (*CAJANUS CAJAN* L.) INFLUENCED BY INTERCROP AND DIFFERENT PLANT POPULATION

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ABSTRACT
The study was conducted to optimize the spacing for medium duration pigeonpea at different planting geometry and row proportions under intercropped situation, during *kharif,* 2011 at Millet Breeding Station of TNAU, Coimbatore, India.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). The results indicated that plant height (192.1 cm), stem girth (7.9 cm), number of branches (23.3), dry matter production (6342 kg ha^{-1}) and yield of pigeonpea (1741 kg ha^{-1}) were achieved higher in pigeonpea (120 x 30 cm) + greengram 1:3 row ratio. Similarly biological indices like equivalent yield (2397 kg ha^{-1}), land equivalent ratio (1.52), area time equivalent ratio (1.15) and income equivalent ratio (1.29) were higher in aforesaid treatment. This finding with optimum plant density along with appropriate row proportion will be affordable for the pulse growing farmers.

INTRODUCTION

The greatest challenge of the 21st century in many developing countries are to produce more and more basic necessities namely food, fodder, fuel and fibre for ever increasing human and animal population from the limited available land. The availability of land for agriculture is shrinking every day as it is increasingly utilized fornon-agricultural purposes. Under this situation, one of the important strategies to increase agricultural productivity and intensive land use is development of high intensity cropping systems including intercropping system.

Intercropping is being popular in tropics (Tsubo *et al.,* 2005) and rainfed areas of the world (Dhima *et al.,* 2007) due to its advantages for soil conservation (Anil *et al.,* 1998) and weed control (Banik *et al.,* 2006). Research has been made to identify suitable intercrop for pigeonpea.

Pigeonpea (*Cajanus cajan* L.) is one of the major grain legume crops of tropical and subtropical regions and it is grown predominantly under rainfed conditions. India accounts for 90 per cent of world's pigeonpea growing area and 85 per cent 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} (FAO STAT., 2010). Pigeonpea offers a good scope for intercropping with fast growing early maturing and shallow rooted crops (Ramamoorthy *et al.*, 2004).

Greengram (*Vigna radiata* L.) also one of the most important pulse crop in India and gaining more importance because of its adaptation to short growth duration, low water requirement, low soil fertility and is favoured for consumption due to its easy digestibility and low production of flatulence. As short duration crop, it fits well invarious multiple and intercropping systems.

Significant increase in growth characters *viz.,* plant height, number of branches and root weight of greengram was observed with the application of vermicompost along with recommended dose of fertilizer when intercropped with pigeonpea (Rajkhowa *et al.,* 2002). Intercropping of pigeonpea with greengram and blackgram significantly produced higher pigeonpea equivalents than in pure stands (Singh *et al.*, 1986). Optimum population levels should be maintained to exploit maximum natural resources such as nutrient, sunlight, soil moisture and to ensure satisfactory yield (Sharifi *et al.*, 2009) hence they are known to affect crop environment, which influence the yield and yield components..

However, intercropping in pigeonpea may not be possible with normal planting pattern of 90 × 60 cm which is followed in Tamil Nadu. So adoption of wider planting geometry by maintaining the optimum plant population of pigeonpea provides an opportunity to introduce an intercrop. Hence, the present investigation was carried out in pigeonpea to introduce greengram as an intercrop with different row ratio and plant population.

MATERIALS AND METHODS

Crop production

The field experiment was conducted at Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore in the field

No MBS 7 East during *kharif,* 2011 which is geographically located in the northwestern Agro climatic zone of Tamil Nadu at 11° North latitude and 77° East longitude at an altitude of 426.7 meters above Mean Sea Level (MSL).

Pigeonpea variety Co 6 was used as main crop and greengram COGG 973 was used an intercrop for this study. The seeds were dibbled manually at different spacings as per the treatment schedule. As an intercrop, greengram with a spacing of 30 x 10 cm was raised as per the treatments. 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 experiment was laid out in a randomised block design with three replications. Treatments consisted of four inter row spacing (90, 120, 150 and 180 cm), four inter row spacing (30, 45 and 60 cm) and four intercrop row proportions (1:2, 1:3, 1:4 and 1:5) under ridges and furrow method of land configuration. The soil of the experimental field was sandy clay loam and was low in available nitrogen high in phosphorus and potassium.

The crop was fertilized with recommended dose of nutrients (25: 50: 25 kg of NPK ha^{-1}) through Urea, SSP (single super phosphate) and MOP (muriate of potash) and incorporated at the time of sowing (CPG, 2012). The entire dose of NPK was applied as basal. The other management operations were done as per recommended package of practices for both main and intercrops.

Five plants in each treatment in the net plot area were selected at random and tagged for biometric observations. While taking observations, five plants from sampling rows were pulled off in each treatment plot for recording dry matter production. Biological indices like Land equivalent ratio (Willey, 1979), Area time equivalent ratio (Hiebsch and McCollum, 1987), equivalent yield and Income equivalent ratio have been worked for assessing the system advantage. The statistical analysis was done as per procedure suggested by Gomezand Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

The data on plant height and stem girth of pigeonpea showed significantly lower variations due to intercropping of pigeonpea with greengram in different row proportions at all the growth stages.significantly higher plant height (192.1 cm), number of branches (23.3) and stem girth (7.9 cm) was recorded in pigeonpea (120 x 30 cm) + greengram and 1:3 row ratio which was comparable with the spacing of 120 x 45 cm with 1:3 row ratio. Significantly lower plant height was recorded (170.7 cm) in pigeonpea (180 x 60 cm) + greengram in 1:5 row ratios.

The plant growth characters are largely genetically controlled, and also it can be altered agronomically by wangling the crop environment and management factors. An increasing trend was noticed in plant height from closer to wider geometry to certain level then it was decreased and higher plant height was observed in 1:3 row proportion. This may be due to the competition between inter and intra row plants for the resources and space which encouraged vertical growth rather than horizontal growth. Same outcome was reported by Darshan (2008) in pigeonpea + sesame @ 1:3 ratio. The shortest plants (1:5 row ratio) were due to depletion of nutrients from those plots over time because of competitive interaction, hence plants showed stunted growth owing to inadequate supply of nutrients. This finding was consonance with Thippeswamy and Alagundagi (2001) in sorghum + cowpea @ 2:1 row ratio.

Dry matter production was highly influenced by planting geometry. The same trend as like that of plant height was followed for DMP also (Table 1). The total dry matter production was mainly influenced by assimilatory surface area and its photosynthetic ability.Dry matter production increased steadily with advancing growth stages and reached maximum at harvest. DMP was found to be more in 1:3 row proportions with the wider spacing of 120 x 30 cm which could be attributed to optimum population and accumulation of nutrients unit $area^{-1}$ compared to other row ratios. Similar observations have been made in earlier studies of Sunil Kumar *et al.* (2005) in maize + cowpea @ 2:2 ratio. Similarly, this same 1:3 row proportion recordedsignificantly higher number of branches per plant compared to other intercropping treatments. The response of branch number to population density was linear.

Seed yield

Seed yield of pigeonpea was significantly affected by different planting geometry and row ratios. Among the intercropping treatments significantly higher seed yield (1741 kg ha^{-1}) was recorded with the planting geometry of pigeonpea (120 x 30 cm) + greengram in 1:3 row ratio (Table 2). Higher yield was recorded in 1:3 row ratio of pigeonpea + greengram intercropping system, this could be due to high number of pods, seed weight and lower competition, which is because of early maturity and senescence of greengram. And also it was attributed to better plant development resulting in more uniform distribution of plants over cropped area which was coupled with greater light interception, efficient utilization of moisture, nutrients and solar energy under lower degree of inter and intra plant competitions. These favourable conditions for growth caused significantly higher values of yield components under row spacing of 120 x 30 cm. This result is in accordance with the findings Mandal (2014) in maize intercropping and Darshan (2008). Significantly lower pigeonpea yield recorded in 1:5 row ratio was mainly due to better growth of greengram which leads to intra and inter specific competition for natural resources

Biological advantages

Intercropping of pigeonpea and greengram in different planting geometries and row proportions had a significant influence on biological indices (Table 3).

The significantly highest pigeonpea equivalent yield (2397 kg ha^{-1}), land equivalent ratio (1.52) area time equivalent ratio (1.15) and income equivalent ratio (1.29) were recorded in pigeonpea (120 x 30 cm) + greengram in 1:3 row proportion.

Crop equivalent yield is an important index in assessing the performance of different crops under a given circumstance. Based on the price structure, economic yield of component

Table 1: Effect of planting geometry and row proportions of pigeonpea + greengram intercropping system on plant height, stem girth, number of branches and drymatter production of pigeonpea

Treatments	Pl. ht (cm)	Stem girth (cm)	No. of branches	DMP(kg ha^{-1})
T_1- Pigeonpea (90 x 30 cm) + Greengram (1:2)	190.5	5.3	21.5	4160
T_2- Pigeonpea (90 x 45 cm) + Greengram (1:2)	191.4	5.9	21.6	4347
T_3- Pigeonpea (90 x 60 cm) + Greengram (1:2)	192.3	7.6	22.5	4788
T_4- Pigeonpea (120 x 30 cm) + Greengram (1:3)	192.1	7.9	23.3	6342
T_5- Pigeonpea (120 x 45 cm) + Greengram (1:3)	191.5	7.8	22.7	5078
T_6- Pigeonpea (120 x 60 cm) + Greengram (1:3)	185.3	7.4	21.5	3916
T_7- Pigeonpea (150 x 30 cm) + Greengram (1:4)	185.5	7.2	22.3	4211
T_8- Pigeonpea (150 x 45 cm) + Greengram (1:4)	181.3	7.4	21.7	3279
T_9- Pigeonpea (150 x 60 cm) + Greengram (1:4)	180.6	7.4	21.5	2295
T_{10}- Pigeonpea (180 x 30 cm) + Greengram (1:5)	183.5	6.7	22.1	3142
T_{11}- Pigeonpea (180 x 45 cm) + Greengram (1:5)	173.8	7.3	22.4	2492
T_{12}- Pigeonpea (180 x 60 cm) + Greengram (1:5)	170.7	7.5	22.6	1935
SEd	6.85	0.70	0.56	184.8
CD (P = 0.05)	14.30	1.45	1.16	383.3

Table 2: Effect of planting geometry and row proportions of pigeonpea + greengram intercropping system on grain of pigeonpea and greengram

Treatments	Pigeonpea yield (kg ha^{-1})	Greengramyield (kg ha^{-1})
T_1- Pigeonpea (90 x 30 cm) + Greengram (1:2)	1295	383
T_2- Pigeonpea (90 x 45 cm) + Greengram (1:2)	1312	395
T_3- Pigeonpea (90 x 60 cm) + Greengram (1:2)	1508	452
T_4- Pigeonpea (120 x 30 cm) + Greengram (1:3)	1741	468
T_5- Pigeonpea (120 x 45 cm) + Greengram (1:3)	1564	460
T_6- Pigeonpea (120 x 60 cm) + Greengram (1:3)	1391	437
T_7- Pigeonpea (150 x 30 cm) + Greengram (1:4)	1098	442
T_8- Pigeonpea (150 x 45 cm) + Greengram (1:4)	991	434
T_9- Pigeonpea (150 x 60 cm) + Greengram (1:4)	818	445
T_{10}- Pigeonpea (180 x 30 cm) + Greengram (1:5)	942	472
T_{11}- Pigeonpea (180 x 45 cm) + Greengram (1:5)	831	467
T_{12}- Pigeonpea (180 x 60 cm) + Greengram (1:5)	734	504
SEd	57.33	21.6
CD (P = 0.05)	118.9	44.7

Table 3: Effect of planting geometry and row proportions on pigeonpea equivalentyield, land equivalent ratio (LER), area time equivalent ratio (ATER) and income equivalent ratio(IER) of pigeonpea + greengram intercropping system

Treatments	Equivalent yield (kg ha^{-1})	Land equivalent ratio	Area time equivalent ratio	Income equivalent ratio
T_1- Pigeonpea (90 x 30 cm) + Greengram (1:2)	1831	1.28	0.98	1.13
T_2- Pigeonpea (90 x 45 cm) + Greengram (1:2)	1865	1.29	0.97	1.11
T_3- Pigeonpea (90 x 60 cm) + Greengram (1:2)	2142	1.47	1.11	1.27
T_4- Pigeonpea (120 x 30 cm) + Greengram (1:3)	2397	1.52	1.15	1.29
T_5- Pigeonpea (120 x 45 cm) + Greengram (1:3)	2209	1.46	1.09	1.21
T_6- Pigeonpea (120 x 60 cm) + Greengram (1:3)	2004	1.36	1.01	1.13
T_7- Pigeonpea (150 x 30 cm) + Greengram (1:4)	1717	1.40	1.05	1.16
T_8- Pigeonpea (150 x 45 cm) + Greengram (1:4)	1598	1.40	1.05	1.14
T_9- Pigeonpea (150 x 60 cm) + Greengram (1:4)	1441	1.30	0.94	1.04
T_{10}- Pigeonpea (180 x 30 cm) + Greengram (1:5)	1602	1.50	1.12	1.20
T_{11}- Pigeonpea (180 x 45 cm) + Greengram (1:5)	1484	1.40	1.03	1.11
T_{12}- Pigeonpea (180 x 60 cm) + Greengram (1:5)	1440	1.37	0.96	1.05
SEd	60.77	0.05	0.04	0.05
CD (P = 0.05)	126.02	0.10	0.08	0.10

crops is converted into base crop yield *i.e.,* pigeonpea equivalent yield. The pigeonpea equivalent yield obtained in 1:3 rows under intercropping system was attributed to better performance and yields of both the component crops under intercropping system. Similar results were reported by Subbian and Selvaraju (2000) found higher sorghum equivalent yield when soybean was intercropped with sorghum in 3:6 row proportion and Kantwa *et al.* (2006) in pigeonpea + blackgram.

Land equivalent ratio reflects the advantage of intercropping over sole cropping system. Intercropping of pigeonpea and greengram in 1:3 row ratio recorded higher yield advantage

of 52 per cent (LER 1.52) over other systems. The higher LER under intercropping systems may be due to better plantinggeometry and spatial arrangements which might have avoided the coincidence of the peakperiod of growth of component crops. This is in accordance with the findings of Padhi *et al*. (2010) in pigeonpea + finger millet. Pigeonpea being long duration crop with slow initial growth and deep root system did not pose any severe competition for natural resources with greengram under different row proportions and also it adds organic matter through leaf litter production and biologically fixed nitrogen for the benefit of the intercropping systems.

On the other hand, greengram being fast growing shallow rooted crop, utilized the resources from top layer (0-30 cm) of the soil and serving as cover crop conserved soil moisture reduced soil temperature and added organic matter to the soil. This is in accordance with the findings of Bhatti *et al*. (2006) in sesame + legume, Pramod *et al*. (2006) in pigeonpea + soybean and Padhi *et al*. (2010) in pigeonpea + finger millet.

In the present investigation, Area Time Equivalent Ratio (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 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. The observation in the present experiment are in agreement with the criteria set out earlier by Egbe and Adeyemo (2007) in maize + pigeonpea, Arjun Sharma and Guled (2012) in pigeonpea + greengram.

IER values are higher in 1:3 row proportion, due to high resource use efficiency and equivalent yield. This system gives 29 per cent higher economic advantage over growing crops in pure stands. The similar result was reported by Billore *et al*. (2009) in soybean + pigeonpea cropping system.

Experimental findings obtained from the field investigation, revealed that pigeonpea

(120 x 30 cm) + greengram 1:3 row ratio acquired better yield characters and yield besides being economically competitive and fruitfuland this salient finding will be useful for pigeonpeagrowers to enhance incomeunder irrigated conditions.

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