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Influence of pigeonpea varieties and plant geometries on yield and economics in coconut plantation under island ecosystem

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Abstract
Field experiments were conducted during 2013-2015 under coconut plantation at Sipighat Research farm, ICAR-Central Island Agricultural Research Institute, Port Blair. The experimental design was factorial RBD with two factors *viz.,* varieties/genotypes and plant geometries. Four red gram varieties/genotypes (Co-6, Bahar, ANP-11-21 and ANP-12-02) were tested with six different plant geometries (60 x30 cm, 60 x 45 cm, 75 x 30 cm, 75 x 45, 90 x 30 cm and 90 x 45 cm) under coconut garden. It was observed that light intensity in the interspaces of coconut (74530 to 7380 lux) was just enough to drive the photosynthesis and other vital physiological process under coconut. Among the varieties/ genotypes, ANP-12-02 recorded higher seed yield (610 kg/ha), stover yield (1720 kg/ha), net return (₹17963) and B: C ratio (2.17) which was at par with Co-6 as compared to all other varieties. Though 90 x 45 cm spacing recorded better growth and yield attributes, the maximum seed yield (606 kg/ha), stover yield (1628 kg/ha), net return (₹18822) and B: C ratio (2.35) were recorded by 75 x 45 cm due to higher plant population per unit area and at par with 90 x 30 cm and 90 x 45 cm spacing. The results showed that pigeon pea (ANP-12-02) can be grown as intercrop in coconut garden with 75 X45 cm spacing which can give yield upto 70 -80% of pure stand yield. This provided scope for increasing the pigeon pea production under existing coconut plantation besides enriching the soil.

Keywords: Variety, plant geometry, pigeon pea and coconut plantation

Introduction
The agricultural land use in the islands is dominated by plantation crops of coconut and arecanut. Coconut is cultivated on an area of 16268 ha and grown either as monocrop or as a component crop of multistorey cropping system. These plantations are tall and old. In respect of space and light penetration, the plantations provide scope for crop intensification and diversification. The intensification of coconut plantations with pulse by intercropping is expected to enhance farm income and soil fertility under island condition. It may also allow the farm families to overcome food scarcity and create more employment opportunities. Studies have indicated that in coconut plantation only about 20-30 per cent of the soil and light are utilized. The soil fertility in most of these old coconut plantations is on decline due to inadequate application of manures and fertilizers. Thus, the interspaces of coconut form an excellent avenue for pulse intercropping, as they enrich soil through N fixation. At present, only 177 tonnes of pulses are produced per annum (DES, 2018) [1] as against the requirement of 6200 t/year. The level of technology use and improved varieties are very minimal. Hence to fulfil this huge demand and supply gap of pulses, intercropping in coconut with suitable production technologies is contemplated. Coconut plantations provide very good scope for intercropping of Pigeon pea. Pigeon pea is one of the important tropical pulse crops of India and ranks seconds after chickpea in area and production. It is commonly known as red gram or Arhar and grown in *kharif* as well as in *Rabi* season. Food value of pigeon pea is protein (22.3%), fat (1.7%), minerals (3.5%), fiber (1.5%) and carbohydrates (57.6%). It is mainly eaten in the form of split pulse as dal': Seed of arhar are also rich in iron and iodine. They are rich in essential amino acids like lycine, tyrocene, cystine and arginine. The outer covering of seed provides a valuable feed for milch cattle. The husk of pods and leaves obtained during threshing constitute a valuable cattle feed. Woody parts of the plant are used for fuel. It is a legume crop and hence possesses valuable properties as restorer of nitrogen to the soil (Anon, 2016) [2]. Some of the studies suggested that the enhanced domestic production of pulses under coconut not only meets current demands but also increase consumption of pulses which is considered to be an excellent human food (Nair *et al*., 2013) [3]. However, comprehensive information on the performance of red gram as intercrops in coconut garden is lacking. Identification of suitable crop geometry, varieties and characterization of the growing

conditions are very essential before large scale introduction of red gram under coconut plantations. In view of the above, the present study was undertaken to evaluate suitable varieties of red gram, investigate the appropriate crop geometry for enhancing pigeonpea production besides characterizing the growing condition under coconut plantations.

Materials and Methods

A field experiment was undertaken for two years (2013-2015) under 36 years old coconut (Andaman tall) plantation with 7.5 m x7.5 m spacing in undulated terrain at Sippighat Research farm, ICAR-Central Island Agricultural Research Institute, Port Blair (11° 36’27.49” N Latitude and 92° 40’39.99” E Longitude). The experimental design was factorial RBD with two factors *viz.*, varieties/genotypes and plant geometries. Four red gram varieties/genotypes (Co-6, Bahar, ANP-11-21 and ANP-12-02) were tested with six different plant geometries (60 x30 cm, 60 x 45 cm, 75 x 30 cm, 75 x 45, 90 x 30 cm and 90 x 45 cm) under coconut garden. The treatments were replicated twice. The recommended dose of NPK (12.5, 25 and 12.5 kg/ha) was applied through urea, DAP and MOP. The seeds were dippled at 2 to 3 cm depth after field preparation. Sowing was carried out on 13th August 2013 and harvested in 27th February 2014 for the first crop. For the second crop, sowing was carried out on 16th August 2014 and harvested on 5th March 2015. All the recommended cultural and plant protection measures for rainfed conditions were followed during the experiment. The crops were harvested when 90 per cent pods were matured and sun dried before threshing. Soil samples were collected from the experimental site and necessary parameters were determined. The data collected on growth and yield attributes were analysed statistically by using analysis of variance technique appropriate to randomized block design and valid conclusion were drawn as suggested by Panse and Sukhatme (1978) [4]. The data pertaining to growth and yield parameters along with their statistical interpretations are presented and discussed.

Results and Discussion

Growing condition

The results showed that the experimental soil was sandy loam, acidic pH (5.2± 0.3) medium in organic carbon (0.6%) with low salinity (0.3 dS m^{-1}) and thus necessitated manurial application (5 t/ha) during the experiment. The soil was low in available N (205 kg ha^{-1}), P (4.5 kg ha^{-1}) and K (95 kg ha^{-1}) at the start of the experiment. A total of 1330 mm and 1650 mm rainfall was received during crop growth during 2013-14 and 2014-15, respectively. In general, the pulses have a temperature optimum of 25-30 °C and their light saturation occurs around 50000 lux (Bhattacharya and Vijaylaxmi, 2010) [5]. The mean minimum and maximum temperature ranged between 24 to 32°C. Another important factor affecting crop production is light intensity. It strongly influences the duration and progress rate of physiological processes and plant growth. Pulse crop requires light intensity of 50000 lux for 7 – 9 hours duration in the day time. The average observed light intensity (lux) in coconut garden during flowering to harvest period of red gram ranged from 74530 to 7380 in-between trees and 22060 to 2572 under shade in the coconut garden. The light intensity was sufficient for pulse crops with 5-6 hours duration in-between coconut trees (75-80% area).

Effect of varieties/genotypes

The data on growth and yield performance of red gram as influenced by different varieties/genotypes is presented in table 1 and 2. It revealed that the growth and yield attributes of red gram were significantly influenced by the different varieties/genotypes. Among the varieties/genotypes, ANP-12-02 registered significantly maximum plant height (164 cm) and number of branches/plant (11.0) and at par with Co-6. The varieties/genotypes *viz.,* Bahar and ANP-11-21 recorded comparatively minimum number of branches/plant. Similarly, ANP-12-02 recorded more number of pods/plant (90.6) which was at par with Co-6 as compared to Bahar and ANP-11-21. ANP-12-02 registered more number of seeds/pod (3.9) which was at par with Co-6. The higher 1000 seed weight (75.2) was recorded for ANP-12-02 which was at par with Co-6. The other varieties *viz*., Bahar and ANP-11-21 recorded comparatively lesser yield attributes. Under coconut plantation, pigeon pea recorded a mean seed yield of 544 kg/ha. Among the varieties/ genotypes, ANP-12-02 recorded higher yield (610 kg/ha) and at par with Co-6 as compared to all other varieties under test. The higher seed yield resulted was mainly due to more number of pods per plant as it is one of the important yields attributing character. The productivity of remaining varieties *viz.*, Bahar and ANP-11-21 was in the intermediate range. This could be attributed to the combined effect of varietal difference and their environmental adaptability. These results were in confirmatory with the findings of Singh *et al*. (2014) [6] who also reported higher seed yield per plant for ANP-12-02 over best check. The stover yield varied significantly among the pigeon pea varieties under test. Among the varieties/genotypes, ANP-12-02 produced significantly maximum stover yield (1720 kg/ha) which was followed by Co-6. Besides higher seed yield, increase in stover production can serve as a potential fodder to livestock in the islands. The analysis showed that higher seed yield of ANP-12-02 has resulted in higher net return (₹17963) and B: C ratio (2.17) followed by Co-6. Such variations in yield and yield attributes among the pigeon pea varieties have also been observed by several research workers (Sudha Rani (2015) [7], Ramanjaneyulu *et al*. (2017) [8], Birendra Tigga *et al*. (2017) [9] and Dhanalakshmi *et al*. (2017) [10].

Effect of plant geometries

The data on growth and yield performance of red gram as influenced by plant geometries is presented in table 1 and 2. The plant height of pigeon pea was not significantly influenced by the different spacing adopted (60 x30 cm, 60 x 45 cm, 75 x 30 cm, 75 x 45, 90 x 30 cm and 90 x 45 cm). However, the wider spacing *viz*., 90 x 45 and 75 x 45 cm recorded maximum number of branches (12.6 and 11.6). It was observed that pigeon pea grown at closer spacing recorded lower growth attributes. The more number of branches/plant in wider spacing might be due to better growth of plant because of optimum resources available to individual plant and their maximum utilization throughout the growth periods. The optimum plant density plays the key role to increase the growth and yield attributes of pigeonpea. The higher number of pods plant $^{-1}$(102.3) was registered in wider spacing (90 x 45 cm) and at par with 75 x 45 cm. In contrast, lower values of pods/plant were observed from closer spacing. The better availability of growth resources like water, nutrients, air and better cultural practices in wider plant geometry helped the plants to exhibit their full potential and produced higher yield attributes than closely spaced plants. The number of seeds/pod and 1000 seed weight were not altered by different plant geometries. Though 90 x 45 cm spacing recorded better growth and yield attributes, the maximum seed yield of 606 kg ha^{-1} was recorded by 75 x 45 cm due to higher plant population per unit area and at par with 90 x 30 cm and 90 x 45 cm spacing. Similar results were also reported by Waghmare *et al*., (2018) [11] who reported higher seed yield of pigeon pea in 75 x 45 cm plant geometry due to higher plant population. Similarly, higher stover yield of 1628 kg ha^{-1} was recorded by 75 x 45 cm and at par with 90 x 30 cm and 90 x 45 cm spacing. Whereas, the lower seed and stover yield were recorded by 60 x 30 cm, 60 x 45 cm and 75 x 30 cm spacing. Consequently 75 x 45 cm spacing registered higher net income (₹18822) and B: C ratio (2.35) as compared to the other plant geometries. The higher number of pods with optimum plant population at 75 x 45 cm spacing was responsible for the higher grain yield of pigeon pea intercropped in coconut plantation. The plant geometry of 75 x 45 cm was found economically viable and recorded significantly higher gross returns, net returns and benefit: cost ratio. Superiority of wider plant geometries for pigeon pea was also reported by Sujatha and Babalad (2018) [12], Ashok Sajjan (2018) [13] and Sheela Barla *et al*. (2018) [14].

Table 1: Growth and yield attributes of pigeon pea intercropped in coconut plantation as influenced by varieties and plant geometries (pooled data of 2013-14 and 2014-15).

Treatments	Plant height (cm)	No. of branches/plant	Pods/plant	Seeds/pod	1000 seed weight
Varieties					
V_1- Co-6	159	10.4	87.6	3.8	75.0
V_2- Bahar	143	9.3	77.7	3.7	72.3
V_3-ANP-11-21	146	9.9	76.1	3.6	69.2
V_4-ANP-12-02	164	11.0	90.6	3.9	75.2
SEm±	6.4	0.5	4.0	0.05	0.7
CD (0.05)	13.3	1.0	8.3	0.10	1.5
Plant geometries					
S_1- 60 x 30 cm	140	8.3	66.3	3.7	72.1
S_2- 60 x 45 cm	146	8.6	69.4	3.7	72.0
S_3-75 x 30 cm	154	9.6	71.9	3.8	73.3
S_4-75 x 45 cm	159	11.6	98.5	3.9	73.5
S_5-90 x 30 cm	156	10.1	89.5	3.7	73.0
S_6-90 x 45 cm	163	12.6	102.3	3.8	73.6
SEm±	5.6	0.4	3.5	0.04	0.6
CD (0.05)	NS	1.2	10.2	NS	NS
Interaction (V x S)					
SEm±	11.1	0.8	7.0	0.08	1.27
CD (0.05)	NS	NS	NS	NS	NS

Table 2: Yield and economics of pigeon pea intercropped in coconut plantation as influenced by varieties and plant geometries (pooled data of 2013-14 and 2014-15).

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio
Varieties					
V_1- Co-6	588	1540	31591	16291	2.06
V_2- Bahar	491	1452	27044	11744	1.77
V_3-ANP-11-21	487	1305	26283	10983	1.72
V_4-ANP-12-02	610	1720	33263	17963	2.17
SEm±	16.3	36.5	-	-	-
CD (0.05)	33.8	75.4	-	-	-
Plant geometries					
S_1- 60 x 30 cm	480	1312	26008	10308	1.66
S_2- 60 x 45 cm	518	1391	27968	13468	1.93
S_3-75 x 30 cm	513	1485	28127	13027	1.86
S_4-75 x 45 cm	606	1628	32722	18822	2.35
S_5-90 x 30 cm	578	1596	31383	16883	2.16
S_6-90 x 45 cm	569	1615	31069	17569	2.30
SEm±	14.2	31.6	-	-	-
CD (0.05)	41.3	92.4	-	-	-
Interaction (V x S)					
SEm±	28.3	63.2	-	-	-
CD (0.05)	NS	NS	-	-	-

Conclusions

It was observed that light intensity in the interspaces of coconut was sufficient to drive the photosynthesis and other vital physiological process under coconut plantation. However, the growth and yield performance of different varieties of pigeon pea significantly varied. From the experiment it is concluded that pigeon pea (ANP-12-02) can be grown as intercrop in the coconut plantation. The crop geometry should be preferably at 75 x 45 cm to provide sufficient space for exploitation of light and soil. Yield equivalent to 70-80% of pure stand under open condition can be realized using suitable variety with wider spacing. This provided scope for increasing the pulse production under existing coconut plantation besides enriching the soil. The best genotype and plant geometry also resulted in significantly higher stover yield which could be used as feed for starved animals of this island.

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