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Response of pigeonpea [*Cajanus cajan* (L.) Mill sp.] + soybean intercropping system on growth and yield attributes

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Abstract

Present investigation was carried out at College of Agriculture, Badnapur situated at 19° 52'00" North latitude and 75° 44'00" East longitudes at 498 m altitude above mean sea level on clayey soil. Soil was moderate in nitrogen, low in phosphorus and high in potassium. Rainfall received during experimental period was 437 mm with 20 rainy days (70% of normal rainfall) during *Kharif* 2018. The experiment was conducted in split plot design with two factors viz., intercropping systems (T₁- pigeonpea + soybean (2:4), T₁- pigeonpea + soybean (1:6), T₃- sole pigeonpea and T₄-sole soybean) and four irrigation stages (rainfed treatment (I₁), irrigation at bud initiation (I₂), irrigation at pod development (I₃), irrigation at bud initiation + pod development (I₄)) with 16 treatments combinations. Each experimental unit was repeated three times in various plot size in gross plot and in net plot with various spacing depending on intercropping system. Sowing was completed on 11th July 2018. The fertilizer dose of 30:60:30 NPK kg/ha was applied at time of sowing.

The significantly maximum number of pods/plant, weight of pod/plant and seed yield/plant were observed with Pigeonpea + soybean (1:6) ratio. The better performance of pigeonpea + soybean (1:6) may be attributed to its better vegetative growth over pigeonpea + soybean (2:4) and sole pigeonpea, respectively. Amongst intercropping system, pigeonpea + soybean (2:4) recorded maximum pigeonpea equivalent yield (2228 kg/ha), than sole pigeonpea and sole soybean, however, it was at par with pigeonpea + soybean (1:6) for pigeonpea equivalent yield. Amongst irrigation stages, two irrigations at bud initiation + pod development recorded significantly maximum pigeonpea equivalent yield (2412 kg/ha) followed by irrigation at pod development, irrigation at bud initiation and rainfed treatment, respectively. In general, significantly better growth and yield were observed with two irrigations at bud initiation + pod development was observed over rest of the irrigation stages and rainfed treatment.

Amongst interactions of intercropping systems and irrigation stages, interaction of pigeonpea + soybean (1:6) with two irrigations at bud initiation and pod development gave significantly maximum PEY (2412 kg/ha) than rest of the interactions.

Keywords: Pigeonpea, soybean, intercropping system, irrigated condition, growth, yield

Introduction

Pigeonpea also known as red gram, arhar and tur [*Cajanus cajan* (L.) Mill sp.] is the most important *Kharif* grain legume. It belongs to the family Leguminosae, sub-family papilionaceae, originated from the Africa. It has the lowest harvest index 19% but a rich source of protein and amino acids like lycine, tryocene, cysteine and arginine and can be cultivated in the wide range of pH *i.e* 5 to 8.

The crop is extensively grown in Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Andhra Pradesh and Gujarat etc. After gram, pigeon pea is the second most important pulse crop in the country. It accounts for about 11.8% of the total pulse area and 17% of the total pulse production of the country. Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Andhra Pradesh accounts for 87% area of the country and 83.8% of total production. Bihar has the highest productivity 1702 kg/ha (Anonymous, 2018) [1].

In India, the area under pigeon pea was 5.4 million hectares. Production and productivity were 4.78 million tones and 885 kg/ha respectively and in Maharashtra, the area under pigeon pea was 15.33 lakh hectares and production was 14.6 lakh tones and productivity is 951 kg/ha during the year 2017-18 (Anonymous, 2018) [1]. In Marathwada region area under pigeon pea was 5.95 lakh hecters. Production and productivity were 4.47 lakh ton and 759 kg/ha, respectively.

Material and Methods

The present field experiment was conducted during *kharif* season of 2018-19 at the Experimental Farm of Agronomy at Agriculture Research Station, Badnapur, Jalna

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(Maharashtra), Vasantrao Naik Marathawada Krishi Vidyapeeth Parbhani. The initial soil sample analysis the experimental plot was clayey in texture, low in available nitrogen (160 kg ha⁻¹), moderate in available phosphorus (10.2 kg ha⁻¹), high in available potassium (590 kg ha⁻¹). The soil was slightly alkaline in reaction (7.8 pH). The experiment was laid out in Split plot design with three replications. The treatments were Main plot: Intercropping: T₁: Pigeonpea + soybean (2:4) for soybean at 30 cm row spacing - (150 + 30 x 20 cm²), T₂: Pigeonpea + soybean (1:6) for soybean at 30 cm row spacing - (210 x 20 cm²), T₃: sole crop of pigeon pea - (90 x 20cm²), T₄: sole crop of soybean- (45 x 5 cm²) and Sub plot : Irrigation scheduling for pigeonpea as per critical stages I₁: Rain fed (Control), I₂: Irrigation at bud initiation, I₃: Irrigation at pod development, I₄: Irrigation at bud initiation and pod development. Sowing was done by dibbling by using seed rate of 12 kg/ha. The total rainfall received during growth period of pigeonpea was 437.5 mm with 20 rainy days. The recommended dose of fertilizer was 30:60:30 kg NPK/ha applied as per treatments through urea, SSP and MOP. Other cultural practices were done as per treatments. Statistical analysis of the data was carried out by using standard analysis of variance (Panse and Sukhatme 1967)^[6].

Result and Discussion

Effect of different treatments on growth characteristics of pigeonpea as influenced by different intercropping systems and irrigation stages

The results regarding plant height, number of functional leaves/plant, number of branches/plant and total dry matter production/plant of pigeonpea are presented in table 1.

Significantly maximum dry matter per plant (125.68 g) and branches per plant (16.36) at harvest were recorded in Pigeonpea + Soybean (1:6) than rest of the treatments. The better performance of pigeonpea + soybean (1: 6) may be attributed to its better vegetative growth over pigeonpea + soybean (2: 4) and sole pigeonpea, respectively. These findings were in conformity with Srichandan *et al.* (2015)^[9].

Sole pigeonpea recorded significantly lowest mean total dry matter and number of branches. It was comparable with pigeonpea + soybean (2: 4) at all stages. Magdum (1982)^[4] reported significant influence of intercropping system on growth attributes. Although number of leaves, plant height showed non significant values at harvest due to intercropping it's impact might have given statistically significant effect on dry matter/plant and number of branches.

Irrigation stages significantly influenced all the growth attributes *viz.*, plant height, number of functional leaves, mean number of branches and mean total dry matter per plant. In general, significantly better performance of two irrigations at bud initiation + pod development was observed over rest of the irrigation stages and rainfed treatment except number of leaves per plant, where it was at par with irrigation at bud initiation. Significant effect of irrigation on growth attributes was also reported by Bhan and Khan (1979)^[2]. Which might be attributed to better moisture availability under irrigated conditions.

The lowest values of growth attributes due to rainfed treatment might be attributed to terminal drought (after 36 MW) as well as dry spell during the monsoon. Bhowmik *et al.* (1983)^[3] also noted lowest growth attributes due to rainfed treatment compared to irrigation treatments.

Table 1: Effect of different treatments on growth characteristics of pigeonpea as influenced by different intercropping systems and irrigation stages

Treatment		Height/plant	Leaves/plant	Branches/plant	dry matter/plant(g)
I) Intercropping system Pigeonpea (BDN-716) + Soybean (MAUS-71)					
C ₁	Pigeonpea + soybean (2:4)	125.15	72.24	14.10	110.42
C ₂	Pigeonpea + Soybean (1:6)	132.12	78.52	16.36	125.68
C ₃	Sole pigeonpea	126.57	72.07	13.98	103.28
C ₄	Sole Soybean	.....	.....	.....	.....
SE ±		1.84	2.71	0.29	2.17
CD at 5 %		NS	NS	1.12	8.51
Irrigations stages					
I ₁	Rainfed (Control)	120.12	54.01	12.37	87.60
I ₂	Bud initiation	128.16	66.51	15.02	109.36
I ₃	Pod development	126.93	86.42	14.79	114.58
I ₄	Bud initiation and Pod development	136.42	90.16	17.07	140.88
SE ±		2.65	1.71	0.55	3.50
CD at 5 %		7.87	5.08	1.64	10.40
Interaction (C x I)					
SE ±		4.58	2.96	0.96	6.06
CD at 5 %		NS	8.80	NS	NS
General Mean		127.90	74.73	14.81	113.10

*A.H- At harvest

Table 2: Interaction effect of intercropping system and irrigation stages on mean number of functional leaves/plant at harvest.

Mean Interaction Table					
Pigeonpea Functional leaves at harvest					
	I ₁	I ₂	I ₃	I ₄	Mean
C ₁	49	74	81	86	72
C ₂	57	63	96	98	79
C ₃	56	62	83	87	72
Mean	54	67	86	90	
SE ±				2.96	
CD at 5 %				8.80	
General Mean				74	

The significantly highest mean number of functional leaves/plant were observed in pigeonpea + soybean (1: 6) intercropping system due to interaction effect of two irrigations at harvest.

Effect of different treatments on yield and yield attributing characters of pigeonpea as influenced by different intercropping systems and irrigation stages

Various yield attributes viz., number of pods per plant, weight of pods per plant and seed yield per plant were significantly influenced due to intercropping systems under study. The significantly maximum number of pods/plant, weight of pod/plant and seed yield/plant were observed with Pigeonpea + soybean (1: 6) ratio followed by pigeonpea + soybean (2: 4) and sole pigeonpea, respectively. Sole pigeonpea observed the significantly lowest number of pods/plant, weight of pod/plant and seed yield/plant.

Better yield attributes in case of pigeonpea + soybean (1: 6) intercropping systems might be attributed to better growth attributes particularly number of branches/plant and dry matter/plant which reflected into better source-sink relationship as compared to pigeonpea + soybean (2: 4) and sole pigeonpea, respectively. Which might be due to less competition for moisture and space amongst pigeonpea plants under wider spacing of pigeonpea (1: 6) compared to (2: 4) ratio and sole cropping particularly after the harvest of soybean crop.

Amongst irrigation stages, two irrigations at bud initiation + pod development produced significantly maximum number of pods/plant, weight of pods/plant, seed yield/plant and 100 seed weight than rest of irrigation stages. Superior performance of two irrigations at bud initiation + pod development over irrigation at bud initiation as well as irrigation at pod development and rainfed treatment might be attributed to better growth attributes and moisture availability during reproductive stage which might have helped in better source-sink relationship. Similar findings were reported by Pramod *et al.* (2010)^[7].

Interaction effect due to intercropping systems and irrigation stages were found significant to the number of pods/plant and weight of pod/plant (g). The highest number of pod/plant and weight of pod plant (g) was recorded with pigeonpea + soybean (1: 6) at two irrigation stages irrigation at bud initiation and pod development. The lowest number of pod/plant and weight of pod/plant (g) was recorded with sole pigeonpea under rainfed treatment and was at par with pigeonpea + soybean (2: 4) under rainfed situation. Seed yield/plant and seed index were not significantly influenced due to interaction of intercropping systems and irrigation treatments.

Various growth and yield attributes were influenced due to different row spacings and planting geometries which ultimately resulted into significant variation in pigeonpea yield per hectare.

Sole pigeonpea gave significantly maximum seed yield, straw yield and biological yield than pigeonpea + soybean (2: 4), moreover, pigeonpea + soybean (2: 4) was comparable with pigeonpea + soybean (1: 6) for seed yield, straw yield and biological yield. Lowest seed yield, straw yield and biological yield was observed with pigeonpea + soybean (1: 6) which was at par with pigeonpea + soybean (2: 4) for seed yield, straw yield and biological yield. Similar reports were noted by Niranjana *et al.* (2013)^[5].

Sole soybean gave significantly maximum seed yield (2478 kg/ha), straw yield (3965 kg/ha) and biological yield (6444 kg/ha), respectively. Lowest seed yield, straw yield and biological yield was observed with pigeonpea + soybean (2: 4) which was at par with pigeonpea + soybean (1: 6) for straw yield and biological yield. Similar findings were also reported by Sonawane *et al.* (2011).

The highest pigeonpea equivalent yield (PEY) of pigeonpea + soybean (2: 4) is due to better yield of both intercropping and better prices of pigeonpea over soybean crop and was at par with pigeonpea + soybean (1: 6) intercropping system. The lowest PEY under sole soybean was recorded and was at par with sole pigeonpea.

Table 3: Effect of different treatments on yield and yield attributing characters of pigeonpea as influenced by different intercropping systems and irrigation stages

Treatment	No. of pod /plant	Weight of pod plant/ (g)	Seed yield plant/ (g)	Number of seeds/pod	100 seed weight (g)	Pigeonpea Seed yield (kg /ha)	Soybean Seed yield (kg /ha)	PEY Seed yield (kg /ha)	
I) Intercropping system Pigeonpea (BDN-716) + Soybean (MAUS-71)									
C ₁	Pigeonpea + Soybean (2:4)	92	43	27	3.46	11.28	1233	1483	2227.69
C ₂	Pigeonpea + Soybean (1:6)	114	56	36	3.50	11.41	1033	1696	2170
C ₃	Sole pigeonpea	83	37	24	3.37	11.22	1702	.....	1702.44
C ₄	Sole Soybean	...	.....	.....	.....	.....	.....	2478	1662.16
	SE ±	1.78	2.06	0.77	0.08	0.32	60.10	52.57	59.35
	CD at 5 %	6.97	8.09	3.02	NS	NS	235.96	206.38	209.39
Irrigations stages									
I ₁	Rainfed (Control)	71	33	21	3.03	9.94	880	1882	1606.41
I ₂	Bud initiation	85	41	27	3.38	10.96	1137	1893	1805.24
I ₃	Pod development	102	46	31	3.53	11.80	1331	1871	1939.01
I ₄	Bud initiation and Pod development	127	61	38	3.82	12.51	1944	1896	2411.70
	SE ±	2.49	0.99	1.19	0.08	0.15	33.16	62.62	34.66
	CD at 5 %	7.40	2.94	3.53	0.22	0.44	98.53	NS	101.77
Interaction (C x I)									
	SE ±	4.31	1.71	2.09	0.13	0.25	57.43	108.45	118.71
	CD at 5 %	12.82	5.09	NS	NS	NS	170.65	NS	223.82
	General Mean	96	45	29	3.44	11.30	1323	1886	1940.59

Table 4: Interaction effect of intercropping system and irrigation stages on pigeonpea mean number of pods/plant.

Mean Interaction Table					
Pigeonpea number of pods plant ⁻¹					
	I ₁	I ₂	I ₃	I ₄	Mean
C ₁	64	101	79	123	92
C ₂	93	109	98	155	114
C ₃	56	95	78	102	83
Mean	71	102	85	127	
SE ±			4.32		
CD at 5 %			12.82		
General Mean			96		

Table 5: Interaction effect of intercropping system and irrigation stages on pigeonpea weight of pod/plant (gm).

Mean Interaction Table					
Pigeonpea weight of pod/plant (gm)					
	I ₁	I ₂	I ₃	I ₄	Mean
C ₁	31	39	45	59	43
C ₂	43	49	55	76	56
C ₃	26	35	38	49	37
Mean	33	41	46	61	
SE ±			1.713		
CD at 5 %			5.09		
General Mean			45		

Table 6: Interaction effect of intercropping system and irrigation stages on pigeonpea seed yield (kg/ha).

Mean Interaction Table					
Pigeonpea seed yield (kg/ha)					
	I ₁	I ₂	I ₃	I ₄	Mean
C ₁	839	1106	1409	1580	1233
C ₂	722	803	864	1742	1033
C ₃	1078	1503	1719	2509	1702
Mean	880	1137	1331	1944	
SE ±			57.43		
CD at 5 %			170.65		
General Mean			1323		

Table 7: Interaction effect of intercropping system and irrigation stages on pigeonpea equivalent yield (PEY)

Mean Interaction Table					
Pigeonpea equivalent yield (PEY)					
	I ₁	I ₂	I ₃	I ₄	Mean
C ₁	1,846	2,082	2,414	2,570	2,228
C ₂	1,874	1,950	2,007	2,848	2,170
C ₃	1,078	1,503	1,719	2,509	1,702
C ₄	1,627	1,687	1,616	1,719	1,662
Mean	1,606	1,805	1,939	2,412	
SE ±			118.71		
CD at 5 %			223.82		
General Mean			1941		

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