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Original Research Article

Effect of Different Plant Geometries and Irrigation Schedules on Growth and Yield Contributing Characters of Pigeon Pea

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Keywords

Pigeonpea, Plant geometry, Irrigation schedule, Paired row planting, Rainfed

A B S T R A C T

A field experiment was conducted at Agronomy Farm, College of Agriculture, Parbhani during *kharif* season of 2012-13 and 2013-14. The experiment was laid out in split plot design with three main plot treatments and four sub plot treatments. The main plot treatments were irrigation schedules as rainfed (no irrigation), two irrigations (at bud initiation and pod development stage) and three irrigations (at bud initiation, flowering and pod development stage). Sub plot treatments were four plant geometries i.e. 120 x 45 cm, 60-120 x 60 cm, 75-150 x 45 cm and 90-180 x 45 cm. All the growth, yield and yield attributes *viz*., plant height, number of functional leaves, leaf area, number of branches, dry matter production, number of pods plant^{-1}, seed yield (q ha^{-1}), straw yield (q ha^{-1}), gross monetary returns (Rs ha^{-1}), net monetary returns (Rs ha^{-1}) and benefit to cost ratio were significantly higher with application of three irrigation (I_2) treatment than two irrigation (I_1) and rainfed pigeonpea (I_0). The plant geometry of 90-180 x 45 cm recorded significantly higher number of functional leaves, leaf area, number of branches, dry matter, pods plant^{-1}, pod weight (g) and seed yield plant^{-1} during both the years but plant height, seed yield (q ha^{-1}), straw yield (q ha^{-1}), gross monetary returns (Rs ha^{-1}), net monetary returns (Rs ha^{-1})and benefit to cost ratio were higher with plant geometry of 75-150 x 45 cm than any other due to higher plant population ha^{-1}. Treatment combination of three irrigations (I_2) with 75-150 x 45 cm plant geometry recorded significantly higher seed yield (q ha^{-1}), net monetary returns (Rs ha^{-1})and benefit to cost ratio during both the years. Interaction effects of irrigation and plant geometries on different growth, yield and yield attributes were not visible during both the years of experimentation.

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp, 2n = 22) commonly known as redgram or arhar or tur in India originated in South Africa in the areas of Angola and Nile river. Pigeonpea is short day; often cross pollinated avenue crop belongs to family leguminosae. The ability of pigeonpea to produce economic yield in soil characterized by moisture deficit makes it an important crop of dryland agriculture.

India is producing 14.76 million tones of pulses from an area of 23.63 million hectare, which is one of the largest pulses producing countries in the world. However, about 2-3 million tons of pulses are imported annually to meet the domestic consumption requirement accounting 21.50 per cent of total food imports. Thus there is need to increase production and productivity of pulses in the country by more interventions (Anonymous, 2013).

In paired row planting system each third row is removed and crops are grown in paired row cropping system. It is suitable for dryland region and objective is to conserve soil moisture and account for higher yield. It is different from skip cropping where a line is left unsown in the regular row series of sowing. Hence, it is essential to standardize a paired row planting system at a particular spacing in pigeonpea.

Water is the most important inputs essential for the production of crops. Plants need it continuously during their life and in huge quantities. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients. Both its shortage and excess affects the growth and development of a plant directly. The rainfall of our country is dependent on the monsoons. In order to grow food crops and agricultural products in large quantities to feed the growing millions, intensive farming with extensive irrigation is essential. Lack of irrigation facilities and improper planting patterns are the major constraints attributing to lower productivity of pulses especially pigeonpea. As a long durational crop, its reproductive growth occurs on residual moisture and lack of moisture at reproductive and terminal stages affects the stability of the yield resulting in lower productivity. In view of the above facts the present investigation was undertaken to asses the interaction effect of paired row planting systems in increasing and stabilizing the yield of BSMR-736, a wilt and sterility resistant variety of pigeonpea released by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani under different irrigation schedules. The knowledge of row spacing in paired row planting under different irrigation schedules will help the farmers to enhance the productivity of pigeonpea by adopting appropriate combination.

Materials and Methods

The field experiments were conducted at the Research Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* seasons of 2012-13 and 2013-14. The experiment was laid out in split plot design with three main plot treatments and four sub plot treatments. The main plot treatments were irrigation schedules as rainfed (no irrigation), two irrigations (at bud initiation and pod development stage) and three irrigations (at bud initiation, flowering and pod development stage). Sub plot treatments were four plant geometries i.e. 120 x 45 cm, 60-120 x 60 cm, 75-150 x 45 cm and 90-180 x 45 cm. Seeds of pigeonpea variety (BSMR-736) released by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani were used for experimental purpose. The seeds were sown by dibbling as per treatments at 120 cm x 45 cm, 60-120 cm x 60 cm, 75-150 cm x 45 cm and 90-180 cm x 45 cm spacing during 2012-13 and 2013-14 respectively, under rainfed conditions. The fertilizers were applied as per standard dose of 25: 50 (N: P) kg ha^{-1}. As pigeonpea is a leguminous crop, full dose of fertilizer was applied as basal dose. The sources of nutrients were urea (46% N) and di-ammonium phosphate (18% N, 46% P_2O_5).

Sampling technique

Five plants were selected from each net plot randomly and those selected plants were numbered for recording biometric observations at various stages of crop growth. Observations on plant characters as indicators of crop growth *viz*., height of the plant (cm), number of branches plant^{-1}, number of functional leaves plant^{-1}, leaf area plant^{-1} (dm^2) and total dry matter plant^{-1} (g) were recorded at various growth stages

Irrigation

Irrigation was applied to specific plots as per treatment at critical growth stages that is at bud initiation, flowering and pod development stage. No irrigation was given to rainfed plots.

Statistical analysis and interpretation of data

The experimental data obtained on various selected variables were analyzed by the standard method of statistical analysis (Panse and Sukhatme, 1967) for split plot design. The mean values of different treatments were then worked out along with corresponding standard error of mean (SEm). The critical difference at 5 per cent level of significance was computed by the formula.

CD = SEm x √2 x t value at respective d.f.

Results obtained have been presented in the form of summary tables, providing SEm in each case and CD at 5 per cent level wherever significant. The values of CD have been taken into account for drawing conclusions.

Pooled analysis of yield data

The simple technique of analysis of variance may not be valid under two different seasonal conditions because of the error variances in the seasons, treatments and season interaction. Hence, pooled analysis of seed yield, gross monetary returns, net monetary returns and benefit cost ratio for two years were carried out as per the procedure outlined by Cochran and Cox (1957). The homogeneity of error variance was tested by applying the Bartlett's test. The pooled estimates of variance were computed as:

$$s^2 = \sum_{i=1}^{n} s_i^2 \quad \text{for} \quad i = 1$$

Where, s_i = error variance

Then the Chi-square test (χ^2) was applied to test the homogeneity of 'n' variance with equal degree of freedom as:

$$\chi^2 = \frac{f\left(n \log_e s^2 - \sum_{i=1}^{n} \log_e s^2\right)}{1 + \frac{n+1}{3nf}}$$

Where,

f = degrees of freedom

Results and Discussion

Irrigation

Three irrigations in pigeonpea improved significantly all the growth attributes viz., plant height, number of branches plant^{-1}, functional leaves, leaf area and dry matter production plant^{-1} as compared to two irrigations and rainfed treatment during both the years. The yield attributes viz., number of pods plant^{-1}, weight of pods plant^{-1} and seed yield plant^{-1} were improved significantly with three irrigations as compared to two irrigations and rainfed treatment during both the year. Choudhari *et al.,* (2004), Gajera and Ahlawat (2006), Reddy *et al.,* (2008) reported the similar results.

Table.1 Mean plant height, no. of branches and dry matter accumulation plant^{-1} as influenced by different treatments at harvest

Treatments	Height		No. of branches		Dry matter plant^{-1}	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Irrigation						
I_0- Rainfed	188.50	205.50	15.08	16.25	148.42	162.83
I_1-Two irrigations	212.75	226.00	19.33	20.41	197.58	217.75
I_2- Three irrigations	226.58	243.25	21.25	22.00	222.67	243.17
S.Em. $\pm$	2.10	3.24	0.49	0.24	2.01	1.34
CD @ 5 %	6.24	9.63	1.46	0.71	5.96	4.00
Plant geometry (cm^2)						
S_1 - (120 X 45)	202.56	220.22	17.88	18.88	187.00	204.56
S_2 - (60-120 X 60)	194.44	211.22	16.77	17.33	179.56	199.00
S_3 - (75-150 X 45)	223.44	237.44	19.11	20.33	193.00	210.78
S_4 - (90-180 X 45)	216.67	230.78	20.44	21.66	198.67	217.33
S.Em. $\pm$	4.46	5.34	0.55	0.51	3.48	3.25
CD @ 5 %	13.23	15.85	1.65	1.51	10.33	9.80
Interaction (I X S)						
S.Em. $\pm$	7.72	9.25	0.96	0.88	6.03	5.63
CD @ 5 %	NS	NS	NS	NS	NS	NS
General mean	209.28	224.92	18.55	19.55	189.56	207.92

Table.2 Mean weight of pods plant^{-1} (g), seed yield plant^{-1} (g) and test weight (g) of seeds of pigeonpea as influenced by different treatments

Treatments	2012-13			2013-14		
	Weight of pods plant^{-1} (g)	Seeds yield plant^{-1} (g)	Test weight (g)	Weight of pods plant^{-1} (g)	Seeds yield plant^{-1} (g)	Test weight (g)
Irrigation (I)						
I_0- Rainfed	87.75	55.71	102.19	105.04	66.68	103.68
I_1- Two irrigations	135.89	84.93	103.68	150.30	93.93	104.93
I_2- Three irrigations	168.40	104.05	104.67	180.68	111.90	105.78
S.Em. $\pm$	1.27	1.37	0.91	1.45	1.95	2.84
CD @ 5 %	3.79	4.08	NS	4.31	5.81	NS
Plant geometries (S)						
S_1 - (120 X 45)	125.55	78.43	103.51	139.54	87.20	104.98
S_2 - (60-120 X 60)	115.01	71.50	103.49	128.10	80.04	104.71
S_3 - (75-150 X 45)	135.77	84.83	103.52	150.85	94.28	104.92
S_4 - (90-180 X 45)	146.39	91.48	103.53	162.87	101.82	104.59
S.Em. $\pm$	4.94	2.94	3.47	5.60	3.66	2.55
CD @ 5 %	14.68	8.73	NS	16.62	10.87	NS
Interaction (I x S)						
S.Em. $\pm$	8.57	5.09	6.01	9.70	6.34	4.41
CD @ 5 %	NS	NS	NS	NS	NS	NS
General mean	**130.68**	**81.56**	**103.51**	**145.34**	**90.84**	**104.80**

Table.3 Mean seed yield (q ha^{-1}) of pigeonpea as influenced by different treatments

Treatments	Seed yield (q ha^{-1})		
	2012-13	**2013-14**	**Pooled analysis**
Irrigation (I)			
I_0- Rainfed	9.44	11.52	10.48
I_1- Two irrigations	14.79	16.52	15.66
I_2- Three irrigations	18.34	19.81	19.07
S.Em. $\pm$	0.30	0.34	0.15
CD @ 5 %	0.91	1.03	0.47
Plant geometries (S)			
S_1 - (120 X 45) cm	13.80	15.51	14.66
S_2 - (60-120 X 60) cm	12.58	14.19	13.38
S_3 - (75-150 X 45) cm	16.04	17.98	17.01
S_4 - (90-180 X 45) cm	14.34	16.12	15.23
S.Em. $\pm$	0.52	0.60	0.45
CD @ 5 %	1.54	1.79	1.41
Interaction (I x S)			
S.Em. $\pm$	0.90	1.04	0.78
CD @ 5 %	NS	NS	NS
General mean	**14.19**	**15.95**	**15.07**

Table.4 Mean straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index of pigeonpea as influenced by different treatments

Treatments	2012-13			2013-14		
	Straw yield (q ha^{-1})	**Biological yield (q ha^{-1})**	**Harvest index**	**Straw yield (q ha^{-1})**	**Biological yield (q ha^{-1})**	**Harvest index**
Irrigation (I)						
I_0- Rainfed	29.17	38.61	24.42	35.94	47.46	24.24
I_1- Two irrigations	41.13	55.93	26.42	46.43	62.96	26.21
I_2- Three irrigations	48.62	66.96	27.36	53.10	72.92	27.14
S.E. $\pm$	0.83	1.14	0.68	0.98	1.33	0.51
C.D. at 5 %	2.48	3.40	2.02	2.93	3.96	1.52
Plant geometries (S)						
S_1 - (120 X 45)	38.93	52.74	25.89	44.33	59.85	25.69
S_2 - (60-120 X 60)	36.10	48.69	25.56	41.24	55.43	25.36
S_3 - (75-150 X 45)	43.70	59.74	26.58	49.66	67.65	26.37
S_4 - (90-180 X 45)	39.83	54.18	26.23	45.40	61.52	26.03
S.E. $\pm$	1.24	1.64	0.10	1.37	1.97	0.09
C.D. at 5 %	3.76	4.96	0.32	4.12	5.94	0.28
Interaction (I x S)						
S.E. $\pm$	2.16	2.85	0.18	2.37	3.41	0.16
C.D. at 5 %	NS	NS	NS	NS	NS	NS
General mean	**39.64**	**53.84**	**26.07**	**45.16**	**61.11**	**25.86**

Similarly, the improvement in yield attributes were also reflected in seed yield (q ha^{-1}) wherein three irrigations produced significantly higher seed yield of 18.34, 19.81 and 19.07 q ha^{-1} during 2012-13, 2013-14 and in pooled analysis, respectively compared to two irrigations and rainfed treatment. The increasing trend in straw yield due to irrigation in pigeonpea was also observed and it was significantly higher than rainfed during both the year. Similar findings are related with Mula *et al.*, (2010), Zaman *et al.*, (2009) and Suresh *et al.*, (2013)

The harvest index values were maximum in irrigated (I_1 and I_2 both) pigeonpea as compared to rainfed during both the years of experimentation. The test weight and quality parameter like protein content (%) were not influenced significantly due to irrigation treatments during both the year.

Three irrigations given to pigeonpea were found economically viable and recorded significantly higher gross monetary returns, net monetary returns and benefit cost ratio compared to two irrigations and rainfed pigeonpea.

Plant geometries

The growth characters viz., plant height (cm), number of functional leaves $plant^{-1}$, leaf area (dm^2), number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$ (g) were substantially influenced by plant geometries.

The plant geometry of 75-150 x 45 cm recorded significantly higher plant height followed by plant geometry of 90-180 x 45 cm than any other plant geometry. The number of functional leaves, leaf area, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$ was influenced significantly with plant geometry of 90-180 x 45 cm as compared to other plant geometries except 75-150 x 45 cm plant geometry, which was found at par with it during both the year. Similar findings are related with Sarita *et al.*, (2012), Zote *et al.*, (2011), Mula *et al.*, (2010).

All the growth attributing characters except plant height were improved with increase in inter and intra row plant spacing. The plant height was increased with decrease in inter and intra row spacing.

The plant geometry of 90-180 x 45 cm recorded significantly higher number of pods $plant^{-1}$, pod weight, seed yield $plant^{-1}$ as compared to other plant geometries except 75-150 x 45 cm plant geometry which was found at par with it. Although, seed yield $plant^{-1}$ was higher in 90-180 x 45 cm plant geometry, seed yield (q ha^{-1}) was found significantly higher in 75-150 x 45 cm plant geometry due to higher plant population ha^{-1} than 90-180 x 45 cm plant geometry. Similarly, straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index were also significantly more with plant geometry of 75-150 x 45 cm than any other plant geometry during both the year. Different plant geometries did not show any significant impact on protein content (%) and test weight (g) during both the years of study. Pavan *et al.*, (2011), Meena *et al.*, (2013) and Ravikumar *et al.*, (2013) are similar results.

The gross monetary returns, net monetary returns and benefit cost ratio were significantly influenced by different plant geometries in individual years and in pooled data. The plant geometry of 75-150 x 45 cm was found economically viable and recorded significantly higher gross monetary returns, net monetary returns and benefit to cost ratio than 90-180 x 45, 120 x 45 and 60-120 x 60 cm plant geometries.

Interaction

During both the years, the interaction between irrigation schedules and plant geometries were found to be non-significant for all the growth, yield attributing, yield, quality and economical characters at all the stages of crop growth.

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