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Morphophenological Characters and Productivity of Pigeon Pea [*Cajanus cajan* (L.) Millsp.] as Influenced by Crop Geometry and Plant Growth Regulators

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ABSTRACT

Background: Intensive cultivation with suitable crop geometry for optimum utilization of resources is one of the possible ways for increasing productivity of pigeonpea. Plant growth regulators have the capacity to stimulate and inhibit physiological processes, which directly or indirectly might affect crop yield and quality. This investigation was planned to study the influence of crop geometry and foliar application of plant growth regulators on production potential of pigeonpea.

Methods: The field experiment was conducted at experimental farm of Agronomy Department, V.N.M.K.V., Parbhani, during *kharif* season of 2018 and 2019. The experiment was laid out in split plot design with four main plot treatments and five sub plot treatments. The main plot treatments comprised of four crop geometries while the sub plot treatments were five treatments on foliar application of plant growth regulatorsalongwith control.

Result: Various crop geometries shown remarkable effect on growth and developement of pigeonpea. The crop geometry of 60-120 cm × 20 cm and 90 cm × 20 cm recorded maximum plant height of pigeonpea as compared to other wider crop geometries. While in case of all the other growth attributes *viz.* number of functional leaves plant^{-1}, leaf area, number of branches plant^{-1} and dry matter accumulation plant^{-1} crop geometry of 120 cm × 20 cm and 75-150 cm × 20 cm were found superior as compared to othertreatments and were at par with each other. The yield per hectare was increased at closer crop geometry 60-120 cm × 20 cm as the lower per plant yield was compensated by higher plant population. The crop geometry 60-120 cm × 20 cm produced significantly higher seed yield (1661, 1982 and 1821 kg ha^{-1} during 2018, 2019 and pooled mean respectively) over crop geometry of 120 cm × 20 cm and crop geometry 75-150 cm × 20 cm, but it was found at par with crop geometry 90 cm × 20 cm. Among the foliar application of plant growth regulators, growth characters *viz.,* plant height, number of functional leaves, leaf area, number of branches and dry matter accumulation plant^{-1} as well as chlorophyll content were enhanced with the foliar application of Brassinosteroids @ 0.1 ppm and application of NAA @ 40 ppm during both the years of study. Foliar application of Brassinosteroids @ 0.1 ppm also recorded early flower initiation and significantly highest seed yield (1742, 2018 and 1880 kg ha^{-1} during 2018, 2019 and in pooled data, respectively), while it was at par with foliar application of NAA @ 40 ppm.

Key words: Crop geometry, Growth, Pigeon pea, Plant growth regulators, Productivity.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a versatile deep rooted legume crop, well known for its drought tolerance under *Kharif* rainfed upland ecosystem (Emefiene *et al.,* 2013). It is an important protein rich annual pulse crop, grown throughout the tropical and sub-tropical regions of the world.

Choice of a suitable geometry for a particular genotype is one of the important factors among the different agronomic techniques in deciding the yield of pigeon pea. Adaptation of proper planting geometry to a particular genotype will go a long way in making efficient use of limited growth resources and to stabilize yield. Pigeonpea being highly branching and having indeterminate growth habit responds very well to crop geometry. Hence to achieve potential yields, it is important to maintain optimum plant population which can effectively utilize available moisture, nutrients and solar radiation.

Microclimate coupled with physiological process may include internal hormonal imbalance and may result in abscission of flowers and immature pods and drastic reduction in yield of pigeon pea. Plant growth regulators have the capacity to stimulate and inhibit physiological processes, which directly or indirectly might affect crop yield and quality. The plant growth regulators are also known to

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enhance the source sink relationship and stimulate the translocation of photo assimilates, thereby increase the productivity. Brassinosteroids (BRs) are a group of steroidal plant hormones that play pivotal roles in a wide range of developmental phenomenon in plants including cell division and cell elongation in stems and roots, photomorphogenesis, reproductive development, leaf senescence and stress responses (Clouse and Sasse 1998). There is limited information on the influence of plant growth regulators on growth, development and productivity of pigeon pea.

Thus scientific manipulation by synchronizing plant growth through growth regulating chemicals in pigeonpea is needed, which can check the excessive vegetative growth, thereby creating proper balance between source and sink for enhanced crop yield and also to optimize the plant density to exploit yield potential. Keeping these views, the present investigation was carried out with an objectivesto enhance yield through proper planting geometry and foliar sprays of plant growth regulators, at experimental farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

MATERIALS AND METHODS

Present research experiment was conducted at research farm of Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) during *kharif* season of 2018 and 2019. The experiment was laid out in split plot design with the treatments consisted of twenty treatment combinations comprising four crop geometry in main plot and five foliar applications of plant growth regulators in sub plot and replicated thrice. The main plot treatments comprised of four crop geometries as 90 cm × 20 cm, 120 cm × 20 cm 60-120 cm × 20 cm and 75-150 cm × 20 cm whiles sub plot treatments were five treatments on foliar application of plant growth regulators *i.e.* NAA @ 40 ppm, Mepiquat chloride @ 50 g a.i ha^{-1}, Brassinosteroids @ 0.1 ppm, Chlormequat chloride @ 75 g a.i ha^{-1} and control.

The onset of monsoon started from 23^{rd} standard meteorological week and with total rainfall of 781.4 mmduring first year while during second year (2019) the total quantity of rainfall received was 928.9 mm. During first and second year of experimentation sowing was accomplished on 26^{th} June 2018 and 28^{th} June 2019 respectively. Periodical observations on growth and yield contributing characters of pigeonpea along with the yield data were recorded and statistically analyzed to evaluate the effect of different treatments. Data on seed yield and straw yield were further subjected to calculations on harvest index, economic analysis and rain water use efficiency.

RESULTS AND DISCUSSION

The data on morpho-phonologicalparameters *viz.* number of functional leaves $plant^{-1}$, leaf area, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$, along with the seed yield of pigeonpeaas influenced by crop geometry and foliar application of plant growth regulators during the course of investigation are critically interpreted and results are presented below.

Effect of crop geometry on growth, phenological parameters, yield and net returns of pigeonpea

Various crop geometries shown remarkable effect on growth of pigeonpea. The crop geometry of 60-120 cm × 20 cm and 90 cm × 20 cm recorded maximum plant height of pigeonpea as compared to other wider crop geometries (Table 1). While in case of all the other growth attributes *viz.* number of functional leaves $plant^{-1}$, leaf area andnumber of branches $plant^{-1}$ dry matter accumulation $plant^{-1}$, crop geometry of 120 cm × 20 cm and 75-150 cm × 20 cm were found superior as compared to other. The crop geometry of 120 cm × 20 cm and 75-150 cm × 20 cm were at par with each other, this might be due to better availability of growth factors like moisture, space *etc.* for enhanced development of individual plant. Similar results were obtained by Waghmare *et.al* (2016). Maximum mean dry matter production $plant^{-1}$ of pigeonpea was recorded with crop geometry of 120 cm × 20 cm (S_2), it was at par with crop geometry of 75-150 cm × 20 cm (S_4) and significantly superior over crop geometry of 90 cm × 20 cm (S_1) and 60-120 × 20 cm (S_3). The increased dry matter accumulation $plant^{-1}$ of pigeonpea plants at wider spacing may be attributed to less competition between plants and greater availability of growth resources for each plant which might have increased production and accumulation of photosynthates resulting in more dry matter accumulation. The above findings are in line with those reported by Pavan *et al.* (2011) and Sujatha *et al.* (2018). The mean duration for flower initiation and 50% flowering of pigeonpea was delayed during 2019 as compared to during 2018 (Table 3). The flower initiation and 50% flowering of pigeonpea were earlier in crop geometry 60-120 × 20 cm (S_3) and 90 cm × 20 cm (S_1) as compared to crop geometry of 120 cm × 20 cm (S_2). The data on mean chlorophyll content was not influenced significantly by different crop geometry during both the years of investigation.

Different crop geometries had significant influence on the seed yield of pigeonpea. The crop geometry 60-120 cm × 20 cm (S_3) produced significantly higher seed yield (1661, 1982 and 1821 kg ha^{-1}) as well as net returns over crop geometry of 120 cm × 20 cm (S_2) and crop geometry 75-150 cm × 20 cm (S_4), but it was found at par with crop geometry 90 cm × 20 cm (S_1). The percent increase in seed yield of pigeonpea recorded with crop geometry 60-120 cm × 20 cm (S_3) over crop geometry of 120 cm × 20 cm (S_2) and crop geometry 75-150 cm × 20 cm (S_4) was 22.85 and 10.82 per cent, respectively on pooled basis. The probable reason behind this increase in the seed yield at closer crop geometry as compared to wider might be that, though the closer spacings showed lower values of attributes per plant like seed weight per plant, pods per plant as a result of intra row competition, the total yield was increased at closer spacing as the lower per plant yield was compensated by higher plant population per unit area. Also suitable planting geometry with crop geometry of 60-120 cm × 20 cm (S_3) helped in optimum and efficient utilization of the available resources and ultimately enhanced the yield.

Effect of foliar application of plant growth regulators on morpho-phenological parameters yield and net returns of pigeonpea

Foliar application of plant growth regulators showed a remarkable influence on various growth attributes of pigeonpea. (Table 1) Growth characters *viz.,* plant height, number of functional leaves, leaf area, number of branches and dry matter accumulation plant^{-1} were enhanced with the foliar application of Brassinosteroids @ 0.1 ppm and application of NAA @ 40 ppm during both the years and was significantly higher than control, foliar application of Mepiquat chloride @ 50 g a.i ha^{-1} (G_2) and Chlormequat chloride @ 75 g a.i ha^{-1} (G_4). Decrease in plant height of pigeonpea sprayed with Mepiqaut chloride might be due to the interference in gibberellic acid biosynthetic pathway as the reduced amount of gibberellins in the plant system affects the growth and decrease plant height. These results correlates with the findings of Kshirsagar *et al.* (2008) and Kashid *et al.* (2010) who reported decreac se in plant height with foliar application of mepiquat chloride and cycocel treated plants. Sumathi *et al* (2016) also reported that, use of Giberellic acid (GA3) and Brassinosteroid (BR) significantly increased plant height in pigeonpea.

Among the plant growth regulators, foliar application of Brassinosteroids @ 0.1 ppm and foliar application of NAA @ 40 ppm recorded numerically higher values of chlorophyll content over other treatments. The data presented in Table 2 indicated that the foliar application of Brassinosteroids @ 0.1 ppm (G3) recorded higher seed yield as well net returns (Table 2) and was at par with foliar application of NAA @ 40 ppm (G_1) and significantly superior over other treatments, during both the years of experimentation and in pooled analysis. The magnitude of increase in seed yield recorded under the foliar application of Brassinosteroids @ 0.1 ppm (G_3) over foliar application of Mepiquat chloride @ 50 g a.i ha^{-1} (G_2), Chlormequat chloride @ 75 g a.i ha^{-1} (G_4) and control (G_5) on pooled basis was 20.75 per cent, 25.70 per cent and 36 per cent respectively. The maximum yield recorded by Brassinosteroids might be due to better vegetative growth, enhanced pod number, pod clusters, pod weight and seed yield per plant. These results are in line with findings reported by Kashyap *et al.,* (2002), Ramesh and Ramprasad (2013), Sumathi *et al.* (2016).

Interaction effect

It was observed that interaction between crop geometry 60-120 cm × 20 cm (S_3) with foliar application of Brassinosteroids @ 0.1 ppm (G_3) recorded higher seed yield (Table 4) and net returns, (Table 5) it was at par with interaction between crop geometry 60-120 cm × 20 cm (S_3) with foliar application

Table 1: Mean plant height (cm), number of functional leaves plant^{-1}, leaf area plant^{-1} (dm^2), number of branches plant^{-1}, dry matter accumulation plant^{-1} (g) of pigeonpea as influenced by different treatments during 2018 and 2019.

Treatments/Land configuration	Plant height (cm)		Number of functional leaves plant^{-1}		Leaf area plant^{-1} (dm^2)		Mean number of branches plant^{-1}		Dry matter accumulation plant^{-1} (g)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Main plot: Crop geometry										
S_1: 90 cm × 20 cm	159.97	165.81	191.53	197.92	71.37	73.06	23.90	24.93	104.07	111.11
S_2 :120 cm × 20 cm	152.94	159.55	227.40	220.26	84.97	81.26	29.93	27.03	127.65	134.84
S_3: 60-120 cm × 20 cm	165.68	168.52	201.13	208.39	74.98	76.96	26.06	23.88	112.88	116.22
S_4: 75-150 cm × 20 cm	153.63	160.43	213.67	221.08	79.73	81.57	26.83	26.64	121.06	126.66
S.E.(m)±	1.45	1.67	6.37	3.18	2.53	1.15	0.31	0.38	4.02	4.37
C.D. at 5%	5.00	5.79	22.05	11.02	8.74	3.97	1.18	1.33	13.92	15.13
Sub plot (Growth regulators): (02 sprays at bud initiation and flowering)										
G_1: NAA @ 40 ppm	162.36	169.5	218.75	227.46	81.50	83.95	27.98	26.66	124.31	138.09
G_2: Mepiquat chloride @ 50 g a.i ha^{-1}	154.96	159.55	207.33	201.35	77.36	74.25	26.25	25.69	103.29	119.93
G_3: Brassinosteroids @ 0.1 ppm	159.52	165.48	234.08	223.75	87.36	82.59	29.05	26.72	123.04	138.84
G_4: Chlormequat chloride @ 75 g a.i ha^{-1}	154.67	159.67	200.42	203.66	74.83	75.18	25.05	25.07	102.35	112.74
G_5: Control	158.62	163.68	181.58	203.33	67.78	75.08	24.62	23.82	99.85	101.49
S.E.(m)±	1.15	1.33	9.82	3.21	3.65	1.20	0.55	0.52	2.23	2.97
C.D. at 5%	3.32	3.84	28.30	9.25	10.53	3.46	1.59	1.51	6.41	8.58
S × F interaction										
S.E.(m)±	2.30	2.65	19.64	8.60	7.31	2.40	1.11	1.04	4.45	5.95
C.D. at 5%	NS	NS	NS	NS	NS	6.92	NS	NS	12.82	NS
General mean	158.03	163.00	208.43	211.91	77.76	78.20	26.63	25.60	114.16	122.21

Table 2: Mean chlorophyll content (SPAD), seed yield (kg ha^{-1}), harvest index and net returns(Rs. ha^{-1}) of pigeonpea as influenced by different treatments during 2018, 2019 and pooled mean.

Treatments	Mean chlorophyll content (SPAD)		Seed yield (kg ha^{-1})			Harvest index			Net returns (Rs. ha^{-1})		
	2018	2019	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Mean
Main plot: Crop geometry											
S_1: 90 cm × 20 cm	45.34	42.28	1466	1782	1624	26.40	26.46	26.44	47744	73932	60838
S_2 :120 cm × 20 cm	46.58	45.45	1239	1572	1405	25.56	27.68	26.63	35158	60633	47895
S_3: 60-120 cm × 20 cm	46.69	41.75	1661	1982	1821	27.73	28.47	28.10	58502	85641	72072
S_4: 75-150 cm × 20 cm	47.05	41.13	1281	1361	1321	27.22	28.17	27.70	37237	47444	42341
S.E.(m)±	1.16	0.90	57.52	72.37	64.02	0.33	1.67		3230	4033	3414
C.D. at 5%	NS	NS	199.02	254.74	221.52	1.16	NS		11371	14196	12018
Sub plot (Plant growth regulators) (02 sprays at bud initiation and flowering)											
G_1: NAA @ 40 ppm	46.72	41.80	1630	1847	1739	25.56	27.16	26.36	57054	77403	67228
G_2: Mepiquat chloride @ 50 g a.i ha^{-1}	47.39	42.47	1384	1596	1490	27.57	26.43	27.00	41343	60784	51064
G_3: Brassinosteroids @ 0.1%	46.31	44.21	1742	2018	1880	27.42	26.91	27.17	63147	88406	75778
G_4: Chlormequat chloride @ 75 g a.i ha^{-1}	45.95	43.97	1212	1583	1397	27.13	29.52	28.33	32950	60416	46683
G_5: Control	45.58	39.82	1089	1328	1208	26.06	28.43	27.25	28806	47553	38180
S.E.(m)±	0.75	0.97	34.97	79.55	59.62	0.40	1.54		1965	4514	2799
C.D. at 5%	NS	2.80	96.78	220.18	152.03	1.17	NS		5438	12494	7749
S × F interaction											
S.E.(m)±	1.49	1.98	69.94	159.12	112.44	0.81	3.09		3930	9029	5599
C.D. at 5%	NS	NS	193.56	440.36	309.21	NS	NS		10877	24989	15498
General mean	46.39	42.73	1412	1674	1543	26.75	27.69		44660	66913	55786

Table 3: Days to flower initiation and days to 50% flowering of pigeonpea as influenced by different treatments during 2018 and 2019.

Treatments	2018		2019	
	Days to flower initiation	Days to 50% flowering	Days to flower initiation	Days to 50% flowering
Main plot: Crop geometry				
S_1: 90 cm × 20 cm	96.06	114.07	102.87	124.67
S_2 :120 cm × 20 cm	96.66	115.60	104.87	126.87
S_3: 60-120 cm × 20 cm	95.23	114.66	103.00	125.00
S_4: 75-150 cm × 20 cm	96.20	115.07	105.60	127.60
S.E.(m)±	0.27	0.55	0.63	0.74
C.D. at 5%	0.87	NS	NS	NS
Sub plot (Plant growth regulators) (02 sprays at bud initiation and flowering)				
G_1: NAA @ 40 ppm	95.03	114.33	103.25	125.08
G_2: Mepiquat chloride @ 50 g a.i ha^{-1}	96.36	115.25	104.04	125.96
G_3: Brassinosteroids @ 0.1%	95.33	115.00	103.58	125.58
G_4: Chlormequat chloride @ 75 g a.i ha^{-1}	96.50	115.83	105.17	127.17
G_5: Control	97.92	115.33	104.38	126.38
S.E.(m)±	0.30	0.58	0.49	0.62
C.D. at 5%	0.85	NS	NS	NS
S × F interaction				
S.E.(m)±	0.59	1.15	0.98	1.24
C.D. at 5%	NS	NS	NS	NS
General mean	96.04	115.12	104.08	126.03

Table 4: Interaction effect of crop geometry and plant growth regulators on seed yield (kg ha^{-1}) of pigeonpea in pooled analysis.

Crop geometry	Growth regulators				
	G_1	G_2	G_3	G_4	G_5
S_1: 90 cm × 20 cm	1842	1561	1977	1461	1279
S_2: 120 cm × 20 cm	1692	1447	1698	1216	1074
S_3 : 60-120 cm × 20 cm	2070	1830	2154	1609	1441
S4: 75-150 cm × 20 cm	1450	1123	1690	1303	1040
S.E.(m)±			112.44		
C.D. at 5%			309.21		

Table 5: Interaction effect of crop geometry and plant growth regulators on net returns of pigeonpea in pooled analysis.

Crop geometry	Growth regulators				
	G_1	G_2	G_3	G_4	G_5
S_1: 90 cm × 20 cm	73764	55321	82078	50562	42466
S_2 :120 cm × 20 cm	58762	48287	65430	36252	30746
S_3: 60-120 cm × 20 cm	86575	71372	91948	58920	51542
$S_{4:}$ 75-150 cm × 20 cm	49812	29274	63654	40499	27964
S.E.(m)±			5599		
C.D. at 5%			15498		

of NAA @ 40 ppm (G_1) and interaction between crop geometry 90 cm × 20 cm (S_1) with foliar application of Brassinosteroids @ 0.1 ppm (G_3).

CONCLUSION

Based on the two years findings of present investigation, it can be concluded that, crop geometry of 60-120 cm × 20 cm and 90 cm × 20 cm for pigeonpea were found to be productive and remunerative, as compared to other crop geometries. While among the different plant growth regulators, foliar application of Brassinosteroids @ 0.1 ppm or foliar application of NAA @ 40 ppm (02 sprays at bud initiation and flowering) was found to be beneficial in improving morpho-phenological pa rameters along with chlorophyll content, early flower initiation, seed yield and net returns of pigeonpea, as compared to other plant growth regulators.

Conflict of interest: None.

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