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Integrated Effect of Planting Geometry and Growth Retardants on Yield and Economics of Pigeonpea under Rainfed

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ABSTRACT: The goal of research was to found the "integrated effect of planting geometry and growth retardants on yield and economics of pigeonpea under rainfed" during kharif season 2019-20 and 2020-21. A field trial was conducted at experimental farm of Department of Agronomy VNMKV, Parbhani. Planting geometry and growth retardants are important factor for improving yield and economics. In this study, the main plot consisted four planting geometry P_1- 60 cm × 20 cm, P_2- 90 cm × 20 cm P_3- 90 cm × 30cm (P_4- 120 cm × 20 cm and in sub plot consisted four growth retardant application (30 and 60 DAS) *viz.* G_1- Control, G_2-CCC @ 60 ppm, G_3-Paclobutrazol @ 100 ppm, G_4-Paclobutrazol @ 125 ppm. The experiment was conducted into split plot design with sixteen treatment combination. The result revealed that, significantly higher seed yield (kg ha^{-1}) was recorded with plating geometry 120 cm × 20 cm. Among all treatments, foliar application of Paclobutrazol @ 125 ppm was recorded higher seed yield, straw yield (kg ha^{-1}) during both years of investigation and in pooled analysis. Thus, the result of present study concluded that treatment combination of planting geometry with foliar application of Paclobutrazol @ 125 ppm was increase the yield and economics of pigeonpea.

Keywords: Chlormequate Chloride, growth retardants, Paclobutrazol, pigeonpea, planting geometry.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Mill sp.] also known as arhar or tur or redgram, is the second most significant pulse crop of India after Bengalgram. However, In Punjab pigeonpea was grown on an area of 2.6 thousand hectares and the total production was 2.63 thousand tonnes with average yield of 10.13 q ha^{-1}. In Marathwada region of Maharashtra, the area under pigeonpea was 5.95 lakh hectares with the production and productivity of 9.14 lakh tonnes and 1373 kg ha^{-1}, respectively (Anonymous, 2017).

Among all management practices, one of the important method of enhancing its production is to cultivate it intensively with the proper planting geometry (inter and intra row spacing). However, Pigeonpea reacts well to planting geometry because to its strong branching and unpredictable growth behaviour. As a result, both inter and intra row spacing have a significant impact on pigeonpea production. As a result, maintaining an optimal plant population that can efficiently utilise available moisture, nutrients, and solar radiation is critical for achieving potential yields.

Plant populations and single plant yield work together to produce grain yield. Maximum production in a certain cultivar and environment can be attained at a density where plant competition is minimal. This will be achieved at an optimal plant density, which not only makes better use of light, moisture, and nutrients, but also minimises overcrowding among the plants. The seeds, pods and leaves are used by human and livestock being rich in nutrition. Pigeonpea crop generally enhances soil fertility through leaf litter and biological nitrogen fixation (Dhandayuthapani *et al.*, 2015).

Plant growth regulators are known to regulate the metabolism of plants. Paclobutrazol, also known as PP333, is a novel growth inhibitor that acts by blocking the synthesis of gibberellin. In 1978, the chemical was first utilised in England, followed by other European countries, including the United States of America in 1982. Burondkar *et al.* (1991) in India were the first to report the economic use of this chemical for the introduction of early and regular cropping in the Alphonso mango.

Paclobutrazol treatment has been shown to enhance grain production in a range of crops, despite a lack of understanding concerning Paclobutrazol's mode of action under doubt. Increased grain yield was ascribed in part to decreased above-ground component investment due to a thicker canopy on Paclobutrazol-treated plants, as well as increased The treated plants had more grain filling owing to a stronger roots system, which may have enhanced nutrient and water intake. On the other hand, the mechanism of Paclobutrazol's effect on chlorophyll content, stress tolerance, and soil residue effect remains unknown, and additional study is needed. The effect of Paclobutrazol and chlormequat chloride on the yield of pigeonpea of a particular interest is the effect of Paclobutrazol as reported point to its height reducing ability while taking into cognizance the possibility of synergism in interaction of these PGRs, which could lead to better morphological and yield performances (Tekalign and Hammes 2005; Kalyankar *et al*., 2008). Paclobutrazol concentrations of 200 mg/L to 600 mg/L decreased gibberellin content in the leaves compared to that of control when applied to rice plant during preanthesis (Syahputra *et al.,* 2013). So, considering the all above mention threats, the present investigation was conducted to study effect of planting geometry and growth retardants on yield and economics of pigeonpea under rainfed.

MATERIALS AND METHOD

A. Experimental site characteristics

The soil of the experimental plot was clayey in texture and slightly alkaline in in reaction, but with low levels of organic carbon, accessible nitrogen, and phosphorus, but marginally high levels of available potassium. A Field experiment was conducted at experimental farms of department of Agronomy, Vasantrao Naik Marathwada Agriculture University, Parbhani (MS) during *kharif* season 2019-20 and 2020-21. The topography of the experimental field was fairly uniform and levelled.

B. Treatments and Experimental Design

Treatment consists of sixteen treatment combinations comprising four planting geometry in main plot, four foliar application of growth retardants in sub plot. The treatments were allotted randomly in each replication. Main plot planting geometry P_1: 60 cm × 20 cm, P_2: 90cm × 20cm (55,555 ha^{-1}), P_3: 120 × 20 cm (37,037 ha^{-1}), P_4: 120 cm × 20 cm (41,666 ha^{-1}) Sub plot treatments G_1: Control, G_2: CCC @ 60 ppm, G_3: Paclobutrazol @ 100 ppm, G_4: Paclobutrazol @ 125 ppm (30 and 60 DAS).

C. Crop establishment

Certified seed was used in both experimentation. The sowing was done by dibbling method. The BDN-711 variety seed used for sowing. The recommended dose of fertilizer (RDF) used for Pigeonpea was 25: 50: 25 kg N, P_2O_5 and K_2O ha^{-1} respectively. During both years of experimentation there is sufficient amount of moisture present throughout the growing season hence no need given any protective irrigation.

RESULTS AND DISCUSSION

Yield. The planting geometry 120cm × 20cm recorded significantly higher seed yield (1587, 1547 and 1567 kg ha^{-1}) over 60cm × 20cm and 90cm × 20cm and found statistically at par with planting geometry 90cm × 20cm. The planting geometry 90cm × 20cm which was next best planting geometry (1513, 1480 and 1496 kg ha^{-1}) as compared to 60cm × 20cm and 90cm × 30cm planting geometry. Planting geometry 60cm × 20cm recorded lowest seed yield (1385, 1341 and 1363 kg ha^{-1}). This might be due to higher values of various yield attributing characters *viz.,* number of pods $plant^{-1}$, weight of pods $plant^{-1}$ (g), number of seeds $plant^{-1}$, seed yield $plant^{-1}$ and seed index (g) are found higher in wider planting geometry. Pavan *et al*. (2009); Telgote and Tamgadge (2010) all observed similar benefits with broader planting geometry on pigeonpea production.

Foliar application of Paclobutrazol @125 ppm (30 and 60 DAS) produced higher seed yield (1594, 1536 and 1565 kg ha^{-1}) in both year of investigation and in pooled analysis and found statistically at par with foliar application of Paclobutrazol @100 ppm during both year of investigation and in pooled analysis. This may be due to lower plant height, a rise in the mean number of branches $plant^{-1}$, pods $plant^{-1}$, pod weight, number of seeds, and seed yield $plant^{-1}$, as well as greater dry matter accumulation $plant^{-1}$. These findings are similar to those published by Koli, (2008). Sul, (2012) also found an increase in seed production in pigeonpea after using Paclobutrazol @ 100 ppm.

During both years of investigation as well as pooled analysis planting geometry 90cm × 20cm recorded (4039, 3970 and 4004 kg ha^{-1}) higher straw yield and found statistically at par with planting geometry 60cm × 20cm (3919, 3862 and 3890 kg ha^{-1}). Pavan *et al*. (2009); Telgote and Tamgadge (2010) all observed similar benefits with broader planting geometry on pigeonpea production.

Foliar application of Paclobutrazol @ 125 ppm (G_4) (30 and 60 DAS) recorded higher straw yield (3825 kg ha^{-1}) in 2019-20, (3903 kg ha^{-1}) in 2020-21 and in pooled analysis (3864 kg ha^{-1}) and it was found statistically at par with foliar application of Paclobutrazol @ 100 ppm (G_3) in both year of investigation and in pooled analysis. These results are correlates with findings reported by Koli, (2008); Sul, (2012) reported increase seed yield with the application of Paclobutrazol @ 100 ppm in pigeonpea, Setia *et al*. (1995), observed increased yield with application of Paclobutrazol at 5, 10 and 20 g ml^{-1} concentrations.

Planting geometry 90cm × 20cm (P_2) was recorded significantly higher biological yield (5552,5450 and 5501 kg ha^{-1}) which were found statistically at par with planting geometry 120cm × 20cm (P_4) and 60cm × 20cm (P_1) significantly superior over planting geometry 90cm × 30cm (P_3).

Table 1: Mean seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), gross monetary returns (Rs. ha^{-1}), net monetary returns (Rs. ha^{-1}) and Benefit cost ratio influenced by different treatments during 2019-20, 2020-21 and pooled analysis.

Treatments	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			GMR (Rs, ha^{-1})			NMR (Rs, ha^{-1})			B: C ratio	
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020
Main factor-Planting geometry														
P_1-60 cm × 20 cm (83,333 ha^{-1})	1385	1341	1363	3919	3862	3890	84249	86253	85251	55521	58525	57023	2.93	2.93
P_2- 90 cm × 20 cm (55,555 ha^{-1})	1513	1480	1496	4039	3970	4004	91793	94755	93274	63377	66340	64858	3.23	3.26
P_3-90 cm × 30 cm (37,037 ha^{-1})	1267	1217	1242	2914	2859	2886	76400	77308	76854	48193	49101	48647	2.70	2.69
P_4-120 cm × 20 cm (41,666 ha^{-1})	1587	1547	1567	3820	3790	3805	95342	98505	96923	67082	70243	68662	3.37	3.42
S. E m ±	32.6	34.9	33.65	55.3	50	53.03	1420	1296	1328	1296.6	1340	2580	0.14	0.12
C. D. (0.05)	95.2	120	116.43	191	147	154.54	4138	3778	4597	3778.8	3906	3843	0.40	0.34
Sub factor-Plant growth retardants (02 sprays 30 & 60 DAS)														
G_1- Control	1251	1219	1235	3602	3589	3595	76160	77252	76706	48369	49461	48915	2.74	2.62
G_2- CCC @ 60 ppm	1405	1329	1367	3653	3761	3707	85143	85381	85262	56752	55990	56371	2.99	2.84
G_3-Paclobutrazol @ 100 ppm	1519	1521	1520	3797	3886	3841	91899	96969	94434	62124	67194	64659	3.08	3.07
G_4-Paclobutrazol @ 125 ppm	1594	1536	1565	3825	3903	3864	96277	98014	97145	66012	67749	66880	3.18	3.19
S. E m ±	32.7	37.4	34.75	49	50	49.92	1610	1688	1669	1655.9	1747	3330	0.05	0.07
C. D. (0.05)	95.3	109	101.44	143	147	145.92	4692	4920	4946	4826.0	5092	9959	0.14	0.20
P × G (Interaction)														
S. E m ±	65	74.9	69.51	98	100	99.80	3220	3376	3298	3311.8	3494	3660	0.15	0.14
C. D. (0.05)	190	218	202.88	287	294	290.98	9384	9840	9894	9651	10184	10989	0.44	0.41
GM	1440	1398	1419	3696	3702	3699	87316	87511	87413	59768	59109	59438	3.00	2.98

Application of Paclobutrazol @ 125 ppm (G_4) (30 and 60 DAS) recorded (5419, 5439 and 5429 kg ha^{-1}) highest biological yield and found statistically at par with foliar application of paclobutrazol @ 100 ppm (G_3) (5312, 5407 and 5359 kg ha^{-1}) and significantly superior than CCC @ 60 ppm (G_2) and control (G_1). Similar results were recorded by koli (2008) who observed maximum yield as compare to control in rice due to application of Paclobutrazol at 750 ppm. SulReshma (2012) also reported increased biological yield with the soil application of Paclobutrazol @ 100 ppm in pigeonpea.

Economics. During both years of investigation as well as pooled analysis planting geometry 120cm × 20cm recorded (95342, 98505 and 96923 Rs ha^{-1}) higher gross monetary returns and found statistically at par with planting geometry 90cm × 20cm (91793, 94755 and 93274 Rs ha^{-1}) and significantly superior than planting geometry 60cm × 20cm (P_1) and 90cm × 30cm (P_3).Greater gross returns with wider planting geometry may be attributable to higher overall grain and straw yields at wider spacing's, which come from compensation of higher plant^{-1} yield with wider spacing's by optimal number of plants per unit area, as well as the most effective use of available resources. Similar findings were also reported by Nedunzhiyan and Reddy (1993); Antaravalli *et al*., (2002).

Foliar application of Paclobutrazol @ 125 ppm (G_4) (30 and 60 DAS) recorded higher gross monetary returns (96277 Rs ha^{-}1) in 2019-20, (98014 Rs ha^{-1}) in 2020-21 and in pooled analysis (97145 Rs ha^{-1}) and it was found statistically at par with foliar application of Paclobutrazol @ 100 ppm (G_3) in both year of investigation and in pooled analysis. This was mainly because of higher seed yield with growth retardants application. These findings are in close conformity with those reported by Manashi Barman *et al.* (2017); Kumar *et al.* (2016).

Net monetary returns. Planting geometry 120 cm × 20 cm (P_4) recorded (67082,70243 and 68662 Rs. ha^{-1}) higher net monetary returns and found at par with planting geometry 90 cm × 20 cm (P_2) (63377,66340 and 64858 Rs. ha^{-1}) and significantly superior over rest of the planting geometry both the year of investigation and in pooled results. Lowest net monetary returns recorded in planting geometry 90 cm × 30 cm (P_3) (48193, 49101 and 48647 Rs ha^{-1}) during both years of investigation and pooled analysis. Similar findings also reported by Nedunzhiyan and Reddy (1993); Antaravalli *et al*. (2002).

Foliar application of Paclobutrazol @ 125 ppm recorded higher net monetary returns in pigeonpea (66012, 67749 and 66880), and it was found at par with foliar application of Paclobutrazol @ 100 ppm (G_3), (62124,67194 and 64659) and found significantly superior over rest of the treatments. During both years of investigation and in pooled result, respectively. Ramesh and Ramprasad (2013); Sharma *et al*. (2019) also reported similar kind of results.

Benefit cost ratio (B: C ratio). Planting geometry 120 cm × 20 cm (P_4) recorded higher benefit cost ratio (3.37 and 3.42) and found at par with planting geometry 90 cm × 20 cm (P_2), (3.23 and 3.26) and found significantly superior over rest of the planting geometry treatments both the year of investigation and in pooled results (3.45). Lowest benefit cost ratio recorded in planting geometry 90 cm × 30 cm (P_3) (2.70, 2.69).

Data presented in Table 2 revealed that, foliar application of Paclobutrazol @ 125 ppm (G_4) recorded (3.18 and 3.19) highest B: C ratio and found statistically at par with application of Paclobutrazol @ 100 ppm (3.08 and 3.07) during both years of investigation and pooled analysis. These findings obtained are in line with earlier finding Saritha *et al.*, (2012). These result correlate with findings Sathe and Patil (2011); Tigga *et al.*, (2017).

Table 2: Interaction effect of planting geometry and plant growth retardants on seed yield (kg ha^{-1}) of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2-CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	1186.61	1300.97	1476.28	1613.00
P_2-90 cm × 20 cm	1194.61	1435.25	1612.51	1859.03
P_3-90 cm × 30 cm	1324.89	1336.05	1261.19	1235.73
P_4-120 cm × 20 cm	1503.68	1559.00	1736.97	1679.39
S. Em ±	65.46			
C. D. (0.05)	191.05			
C. D. (0.05)	294.54			

Interaction Effect. The treatment combination P_2G_4 (planting geometry 90 cm × 20 cm with foliar application of Paclobutrazol @ 125 ppm) recorded highest seed yield kg ha^{-1}and found statistically at par with treatment combination P_4G_3, P_4G_4, during both years of experimentation and in pooled analysis. This might be achieved due to efficient utilization of growth resources under the planting geometry 90 cm × 20 cm (P_2) and 120 cm × 20 cm (P_4) alongwith the growth retardants translocation of photo assimilates to the developing reproductive organs with foliar application of Paclobutrazol which resulted in enhanced growth as well as yield attributes like number of branches, number of pods, weight of pods etc. and ultimately better yield as well as increased economic returns. Ramesh and Ramprasad (2013); Sharma *et al*. (2019) also reported similar kind of results.

Table 3: Interaction effect of planting geometry and plant growth retardants on seed yield (kg ha^{-1}) of pigeonpea during 2020-21.

P × G	At harvest			
	G_1- Control	G_2-CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	1128.32	1249.30	1424.28	1561.00
P_2-90 cm × 20 cm	1140.61	1387.25	1564.51	1811.03
P_3-90 cm × 30 cm	1247.89	1265.05	1190.19	1164.73
P_4-120 cm × 20 cm	1426.68	1488.00	1665.97	1608.39
S. Em ±	74.97			
C. D. (0.05)	218.82			

Table 4: Interaction effect of planting geometry and plant growth retardants seed yield (kg ha^{-1}) of pigeonpea in pooled result

P × G	At harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	1157.46	1275.13	1450.28	1587.00
P_2-90 cm × 20 cm	1167.61	1411.25	1588.51	1835.03
P_3-90 cm × 30 cm	1286.39	1300.55	1225.69	1200.23
P_4-120 cm × 20 cm	1465.18	1523.50	1701.47	1643.89
S. Em ±	69.51			
C. D. (0.05)	202.88			

The Table 5, 6 and 7 revealed that, treatment combination P_2G_4 (planting geometry 90 cm × 20 cm with foliar application of Paclobutrazol @ 125 ppm) recorded maximum straw yield kg ha^{-1} and found statistically at par with treatment combination P_1G_4 during 2019.

During the second year of investigation (2020) the treatment combination P_1G_4 (planting geometry 60 cm × 20 cm with foliar application of Paclobutrazol @ 125 ppm) recorded maximum straw yield kg ha^{-1} and found statistically at par with treatment combination P_2G_4 during 2020. In pooled analysis observed that the treatment combination P_3G_4 (planting geometry 90 cm × 30 cm with foliar application of Paclobutrazol @ 125 ppm) recorded maximum straw yield kg ha^{-1} and found statistically at par with treatment combination P_2G_2, P_3G_2, P_4G_2.

Table 5: Interaction effect of planting geometry and plant growth retardants on Straw yield (kg ha^{-1}) of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	3748.98	3519.63	4006.80	4401.71
P_2-90 cm × 20 cm	3612.48	4052.03	4087.29	4407.56
P_3-90 cm × 30 cm	2935.54	3049.43	2980.87	2690.15
P_4-120 cm × 20 cm	3505.53	4118.12	3983.22	3759.24
S. Em ±	98.78			
C. D. (0.05)	288.32			

Table 6: Interaction effect of planting geometry and plant growth retardants on Straw yield (kg ha^{-1}) of pigeonpea during 2020-21.

P × G	At Harvest			
	G_1- Control	G_2-CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	3691.98	3462.63	3949.80	4344.71
P_2-90 cm × 20 cm	3543.48	3983.03	4018.29	4338.56
P_3-90 cm × 30 cm	2880.54	2994.43	2925.87	2635.15
P_4-120 cm × 20 cm	3454.53	4067.12	3932.22	3708.24
S. Em ±	100.91			

Table 7: Interaction effect of planting geometry and plant growth retardants straw yield (kg ha^{-1}) of pigeonpea in pooled result.

P × G	At Harvest			
	G_1- Control	G_2-CCC @ 60 ppm	G_3-PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	3583.25	3643.16	3332.24	4110.95
P_2-90 cm × 20 cm	3660.50	4228.43	3426.28	4513.46
P_3-90 cm × 30 cm	4140.31	4479.38	3351.32	4659.87
P_4-120 cm × 20 cm	4536.01	4988.35	3208.75	4473.03
S. Em ±	163.40			
C. D. (0.05)	476.92			

The Tables 8, 9 and 10 revealed that treatment combination P_4G_3 (planting geometry 120 cm × 20 cm with foliar application of Paclobutrazol @ 100 ppm) recorded (6638 kg ha^{-1}) maximum biological yield kg ha^{-1}and found statistically at par with treatment combination P_2G_4, P_4G_2 and P_4G_4 during 2019. During the second year of investigation (2020) the treatment combination P_2G_4 (planting geometry 90 cm x 20 cm with foliar application of Paclobutrazol @ 125 ppm) recorded (6172 kg ha^{-1}) maximum biological yield kg ha^{-1}and found statistically at par with treatment combination P_2G_3 and P_1G_4 during 2020. In pooled analysis observed that the treatment combination P_2G_4 (planting geometry 90 cm × 20 cm with foliar application of Paclobutrazol @ 125 ppm) recorded maximum straw yield kg ha^{-1} and found statistically at par with treatment combination P_4G_2, P_4G_3, P_4G_4. This might be achieved due to efficient utilization of growth resources under the planting geometry 90 cm × 20 cm (P_2) and 120 cm× 20 cm (P_4) along with the growth retardants translocation of photo assimilates to the developing reproductive organs with foliar application of Paclobutrazol which resulted in enhanced growth as well as yield attributes like number of branches, number of pods, weight of pods etc. and ultimately better yield as well as increased economic returns. However, Ramesh and Ramprasad (2013); Sharma *et al*. (2019) also reported similar kind of results.

The treatment combination P_2G_4 (planting geometry 90 cm × 20 cm with foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded significantly highest gross monetary returns and found statistically at par with treatment combination P_4G_4 and P_4G_3 during 2019. During second year of investigation (2020) treatment combination P_2G_4 (planting geometry 90 cm × 20 cm and foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded higher gross monetary returns and statistically at par with treatment combination P_4G_4. While, in pooled analysis treatment combination P_2G_4 (planting geometry 90 cm × 20 cm and foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded significantly highest gross monetary returns and found statistically at par with treatment combination P_4G_4 and P_4G_3. Ramesh and Ramprasad (2013); Sharma *et al*. (2019) also reported similar kind of results.

Table 8: Interaction effect of planting geometry and plant growth retardants on Biological yield (kg ha^{-1}) of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2-CCC @ 60 ppm	G_3-PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	4872.15	5119.83	5465.93	5825.30
P_2-90 cm × 20 cm	4874.24	5407.49	5827.34	6269.74
P_3-90 cm × 30 cm	4209.84	4217.42	4233.12	4064.86
P_4-120 cm × 20 cm	6155.76	6588.71	6638.41	6504.24
S. Em ±	89.00			
C. D. (0.05)	259.40			

Table 9: Interaction effect of planting geometry and plant growth retardants on Biological yield (kg ha^{-1}) of pigeonpea during 2020-21.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	4702.15	4986.83	5389.93	5758.30
P_2-90 cm × 20 cm	4674.24	5244.49	5721.34	6172.74
P_3-90 cm × 30 cm	4102.84	3947.42	4220.12	4060.86
P_4-120 cm × 20 cm	4968.76	5438.71	5545.41	5420.24
S. Em ±	187.89			
C. D. (0.05)	548.41			

Table 10: Interaction effect of planting geometry and plant growth retardants on Biological yield (kg ha^{-1}) of pigeonpea pooled results.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	4787.15	5053.33	5427.93	5791.80
P_2-90 cm × 20 cm	4774.24	5325.99	5774.34	6221.24
P_3-90 cm × 30 cm	4156.34	4082.42	4226.62	4062.86
P_4-120 cm × 20 cm	5562.26	6013.71	6091.91	5962.24
S. Em ±	129.95			
C. D. (0.05)	379.31			

Table 11: Interaction effect of planting geometry and plant growth retardants on gross monetary returns of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	76009.70	81697.20	92418.30	89653.60
P_2-90 cm × 20 cm	74482.80	89455.50	95133.20	112608.90
P_3-90 cm × 30 cm	76991.50	80457.90	78503.70	77342.20
P_4-120 cm × 20 cm	85165.60	93792.30	104379.80	111351.20
S. Em ±	3220.22			
C. D. (0.05)	9384.16			

Table 12: Interaction effect of planting geometry and plant growth retardantss on gross monetary returns of pigeonpea during 2020-21.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	74912	79475	91213	89359
P_2-90 cm × 20 cm	73667	87515	94210	112596
P_3-90 cm × 30 cm	74131	76472	75535	75285
P_4-120 cm × 20 cm	82820	90322	101926	109809
S. Em ±	3376.50			
C. D. (0.05)	9840			

Table 13: Interaction effect of planting geometry and plant growth retardantss on gross monetary returns of pigeonpea in pooled result.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	75461.20	80586.20	91815.80	89506.60
P_2-90 cm × 20 cm	74075.30	88485.50	94671.70	112602.90
P_3-90 cm × 30 cm	75561.50	78465.40	77019.70	103153.30
P_4-120 cm × 20 cm	83993.10	92057.30	103153.30	110581.20
S. Em ±	3298			
C. D. (0.05)	9894			

The Table 14, 15 and 16 revealed that the, treatment combination P_2G_4 (planting geometry 90 cm × 20 cm and foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded higher net monetary returns and found statistically at par with treatment combination P_4G_4, P_4G_3, during both years of investigation and pooled analysis, respectively. Bhavi *et al.,* (2013); Channabasavanna *et al.* (2017) reported similar kind of results.

The Table 17 and 18 revealed that, the interaction effect between planting geometry and foliar application of plant growth retardants (P × G) on benefit cost ratio of pigeonpea was found to be significant during both years of examination. The treatment combination P_4G_4 (Planting geometry 120 cm × 20 cm and foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded higher benefit cost ratio and found significantly superior than all other treatment combination, during first years of experimentation. During second year of investigation (2020-21) The treatment combination P_4G_4 (Planting geometry 120 cm × 20 cm and foliar application of plant growth retardants Paclobutrazol @ 125 ppm) recorded higher benefit cost ratio it was found statistically at par with treatment combination $P_2G_3$and P_2G_4.

Table 14: Interaction effect of planting geometry and plant growth retardants on net monetary returns of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	49229.70	52889.20	62278.30	58293.60
P_2-90 cm × 20 cm	48014.80	60959.50	65305.20	81560.90
P_3-90 cm × 30 cm	50732.50	52170.90	48884.70	46503.20
P_4-120 cm × 20 cm	58853.60	65452.30	74707.80	80459.20
S. Em ±	3311.81			
C. D. (0.05)	9651.92			

Table 15 : Interaction effect of planting geometry and plant growth retardants on net monetary returns of pigeonpea during 2020-21.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	48143.70	53669.20	61656.30	59312.60
P_2-90 cm × 20 cm	47210.80	62021.50	64965.20	82861.90
P_3-90 cm × 30 cm	47883.50	51187.90	46499.70	45759.20
P_4-120 cm × 20 cm	56519.60	93262.30	104341.80	80230.20
S. Em ±	3494.55			
C. D. (0.05)	10184.00			

Table 16: Interaction effect of planting geometry and plant growth retardants on net monetary returns of pigeonpea in pooled result

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	77345.70	81167.20	92380.30	88883.60
P_2-90 cm × 20 cm	75818.80	88925.50	95095.20	111838.90
P_3-90 cm × 30 cm	78327.50	79927.90	78465.70	76572.20
P_4-120 cm × 20 cm	86501.60	93262.30	1043441.80	110581.20
S. Em ±	3660.3			
C. D. (0.05)	10989			

Table 17: Interaction effect of planting geometry and plant growth retardants on benefit: cost ratio of pigeonpea during 2019-20.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	2.97	2.92	2.76	2.67
P_2-90 cm × 20 cm	2.85	2.97	3.43	3.39
P_3-90 cm × 30 cm	2.17	2.57	2.84	2.80
P_4-120 cm × 20 cm	3.01	3.27	3.36	3.94
S. Em ±	0.15			
C. D. (0.05)	0.44			

Table 18: Interaction effect of planting geometry and plant growth retardants on benefit: cost ratio of pigeonpea during 2020-21.

P × G	At Harvest			
	G_1- Control	G_2- CCC @ 60 ppm	G_3- PBZ @ 100 ppm	G_4-PBZ @ 125 ppm
P_1- 60cm × 20 cm	2.96	2.95	2.70	2.77
P_2-90 cm × 20 cm	2.84	2.94	3.37	3.49
P_3-90 cm × 30 cm	2.16	2.54	2.78	3.30
P_4-120 cm × 20 cm	3.00	3.24	3.30	3.74
S. Em ±	0.14			
C. D. (0.05)	0.41			

CONCLUSION

Based on two years investigation, following conclusions are drawn.

1. The planting geometry 120 cm × 20 cm and 90 cm × 20 cm found beneficial and productive for improving yield attributes, yield and economics of pigeonpea.

2. Foliar application of paclobutrazol @ 100 ppm (30 and 60 DAS) was found effective increasing yield attributes as well as seed yield, GMR, NMR and B:C ratio of pigeonpea.

3. The planting geometry120 cm × 20 cm and 90 cm × 20 cm with foliar application Paclobutrazol @100 ppm (30 and 60 DAS) was suitable for getting higher seed yield and economic returns from pigeonpea as compared to other treatment combination of planting geometry and foliar application of plant growth retardants.

Planting geometry of 120 cm × 20 cm and 90 cm × 20 cm for pigeonpea along with foliar application Paclobutrazol @ 125 ppm and 100 ppm (30 and 60 DAS) was found highly productive, profitable and remunerative as compared to other planting geometry and foliar application of plant growth retardants under study.

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Conflict of Interest. None.

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