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Productivity and Economics of Pigeonpea Genotypes as Influenced by Planting Geometry, Growth Retardant

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ABSTRACT

Background: In pigeonpea, nipping is a common process which induces sprouting of secondary and tertiary branches and increases the number of pods/plant. Nipping is tedious process and requires more number of labours. Hence, it is advised to use growth retardant for better source- sink relationship and better fruit retention in pigeonpea. Chlormequat Chloride is well known growth retardant and is quickly metabolized by plants, animals and soil microbes compared to other growth retardants. Current study was planned to know the effect of growth retardants and planting geometry on yield and economics of pigeonpea genotypes.

Methods: Experiment conducted during 2014-2015, comprised of twelve treatments and laid out in split-split plot design with three replications. Treatments were comprised of two genotypes [BSMR-736 and TS-3(R)], three planting geometry (90 x 20 cm, 120 x 20 cm and 150 x 20 cm) and three nipping practices (without nipping, with nipping and growth retardant chlormequat chloride spray @3ml/l).

Result: Pooled data of two years indicated that planting geometry of 120 x 20 cm was significantly higher in grain yield (2408 kg/ha) over others. Spraying of growth retardant chlormequot chloride recorded the highest yield (2368 kg/ha) over nipping at 50 DAS (2138 kg/ha) and without nipping (2091 kg/ha). Net returns and B:C ratio were obtained significantly at highest level with the planting of BSMR-736 genotype at 120 x 20 cm along with spraying of chlormequot chloride at 70 DAS. Phosphatase and dehydrogenase activities were un-affected by the spray of chloromequat chloride.

Key words: Growth retardant, Net returns, Nipping, Pigeonpea, Planting geometry.

INTRODUCTION

The control of plant growth for reducing the size through the use of plant growth regulators is a common practice to make a plant more compact and commercially more acceptable. A number of synthetic compounds are known to manage shoot growth in higher plants without being phytotoxic or causing malformation or damage (Salisbury and Ross, 1994). Pigeonpea (*Cajunus cajan*) is an important pulse crop of India with > 90 per cent contribution to the world's pigeonpea production. Long duration pigeonpea can adjust to a wide range of population due to its elastic nature in adjusting to different spacing. It greatly varies with varieties, soil fertility and soil climate. Deeper soils with high fertility and semi arid situation demands wider row space while the soils with lower depth and fertility and arid climate required narrow row space.

Pigeonpea has an indeterminate growth habit, it requires to restrict its vertical vegetative growth and to increase horizontal growth by increasing secondary branches which in turn increase the reproductive sink (pods) and increase the yield. Nipping is the process of removal of top 4-5 cm portion of shoot at 50 days after sowing which results in sprouting of secondary and tertiary branches in pigeonpea. Lakshmi *et al.* (2015) reported that, apical pinching could be advocated to the fenugreek in order to obtain higher seed yield with better quality. Dhaka *et al.* (2020) stating that, nipping at start of branching reduced the plant height, while increased primary and secondary branches, pods/plant and yield over no nipping in pigeon pea. Even though many researchers reported the advantages of nipping, it is tedious process and requires more number of labours. Hence, it is advised to use growth retardant for better source- sink relationship and better fruit retention in pigeonpea (Kaur *et al*., 2013). Chlormequat Chloride is well known growth retardant and is quickly metabolized by plants, animals and soil microbes compared to other growth retardants. However, limited information is available regarding the effect of planting geometry and growth retardant on pigeonpea. Therefore, an experiment was planned to study the effect of growth retardants and planting geometry on yield and economics of pigeonpea genotypes.

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MATERIALS AND METHODS

The field experiment was conducted at Main Agricultural

Research Station, Dharwad, India during *kharif* seasons of 2014 and 2015 to evaluate the performance of pigeonpea genotypes at different planting geometries and nipping methods. Physiographic co-ordinates of the location were 15°26′ N latitude and 75°01′ E longitude and 678 m above mean sea level altitude.

Eexperiment consisting of twelve treatments was laid out in split plot design with three replications. Treatments were comprised of two genotypes (BSMR-736 and TS-3R), three planting geometry (90 x 20 cm, 120 x 20 cm and 150 x 20 cm) and three nipping practices (without nipping, with nipping and chlormequat chloride spray@3ml/l as growth retardant). The entire quantity of recommended dose of fertilizer for pigeonpea (25:50 N: P_20_5 kg ha^{-l}) was applied as basal dose at the time of sowing (Pavan *et al.,* 2011). The soil texture was clay loam and available N, P_2O_5, K_2O of soil was 220, 32 and 360 kg ha^{-1}, respectively. The organic carbon and soil pH of the soil were 0.52% and 7.4, respectively.

The rainfall received during the year 2014-15 and 2015-16 were 962.2 mm and716.8 mm, respectively. Certified seeds of both genotypes were selected for sowing. Seeds were sown by providing recommended spacing as per treatments. The TS-3R was sown on 14th and 16th of July and harvested on 28th and 30th December during 2014 and 2015, respectively. Similarly, BSMR was sown on 14th and 16th of July and harvested on 22nd and 24th of January during 2014 and 2015, respectively. The gross plot size was 6.0 m x 4.0 m. Net plot size varied according to the planting geometries. The cultural operations were carried out during the course of investigation as per the university recommendation.

Nipping (removal of top 4-5 cm portion of shoot) was done at 50 DAS and growth retardant chlormequat chloride was sprayed at 70 DAS for enhancing the number of secondary and tertiary branches and number of flowers in pigeonpea.

Dehydeogenase activity in the soil samples were determined by following the procedure as described by Casida *et al*. (1964). Ten grams of soil and 0.2 g $CaCO_3$ were thoroughly mixed and dispensed in test tubes. To each tube, one ml of 3% aqueous solution of 2, 3, 5- Triphenyl tetrazolium chloride (TTC), one ml of 1% glucose solution and eight ml of distilled water were added. This was sufficient to leave a thin film of water above the soil layer. The tubes were stoppered with rubber cork and incubated at 30°C for 24 h. At the end of incubation, the contents of the tube were rinsed down into a small beaker and slurry was made by adding 10 ml methanol. The slurry was filtered through Whatman No. 50 filter paper. Repeated rinsing of soil with one ml methanol was continued till the filtrate ran free of red color. The filtrate was pooled and made up to 50 ml with methanol in a volumetric flask. The intensity of red color was measured at 485 nm against methanol as blank using UV- vis spectrophotometer (Thermo Scientific, USA). The concentration of formazon in soil samples were determined by referring to a standard curve prepared using the graded concentration of formazon. The results were expressed as µg TPF g^{-1} soil 24 hr^{-1}.

Phosphatase activity of soil samples was determined by following the procedure of Evazi and Tabatabai (1979). One gram of soil sample was placed in 50 ml Erlenmeyer flask to which 0.2 ml toluene followed by four ml of modified universal buffer (pH 7.5) was added. One ml of para-nitro-phenol phosphate solution made in modified universal buffer was added to the flasks and contents of the flasks were mixed by swirling for 2 minutes. The flasks were stoppered and incubated at 37°C for one hour. After incubation, one ml of 0.5 M $CaCl_2$ and four ml of 0.5 M NaOH were added to the flask, swirled and filtered through Whatman No. 42 filter paper. The intensity of yellow colour developed was measured at 420 nm against the reagent blank by using spectrophotometer. Controls were maintained for each soil sample and were analyzed by following the same procedure described above except that the para-nitro-phenol phosphate solution was added after the addition of 0.5 M CaCl2 and 0.5 M NaOH and just before solution. The phosphatase activity of soil samples was expressed as µg p-nitro phenol g^{-1} soil hr^{-1} with reference to the standard curve prepared by using graded concentrations of p-nitro phenol phosphate.

Five randomly selected plants in the net plot area were tagged and used for making observations on various growth parameters at crop growth stages and yield parameters at harvest. Observations on five random plants from each plot were recorded for primary and secondary branches $plant^{-1}$, pods $plant^{-1}$ and seed yield $plant^{-1}$. From the total produce of the net plot, 100 seeds were taken randomly and counted and weighed for 100-seed weight.

Pods from each net plot were threshed, cleaned and the seed weight was recorded. From this, seed yield per hectare was computed. Price of pigeonpea grains was Rs. 5,750 q^{-1}.

The costs of the following items were considered for working out the cost of cultivation of pigeonpea. The prices of the inputs that were prevailing at the time of their use were taken into account to work out the cost of cultivation. Gross returns were calculated using the pooled pigeonpea yield (kg ha^{-1}) and the price of crop commodity at the time of marketing was taken into account. The net returns per hectare was calculated by deducting the cost of cultivation from gross returns per hectare. The benefit cost ratio was calculated as follows.

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

The level of significance used in 'F' and 't' test was P = 0.05. Critical differences were calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

Planting geometry

Pooled data of two years indicated that planting geometry of 120 x 20 cm was significantly superior (2408 kg/ha) over others. Even then maximum number of pods/plant (322) was registered by 150 X 20 cm compared to others. This was due to the fact that wider spacing has registered more number of primary and secondary branches/plant which enhanced the more number of pods/plant (Table 1). Similarly, 100 seed weight was also more in 150 x 20 cm spacing regime than 90 x 20 cm and 120 X 20 cm. Since the plant population was less in 150 X 20 cm (33,333) compared to 120 X 20 cm (41,666), yield was not compensated. The similar results were observed by Pavan *et al.* (2011) who indicated that even though the grain yield recorded in wider row spacing of 150 cm x 90 cm was lower, plants tended to develop higher number of secondary branches in addition to primary branches due to greater availability of space per plant and less interplant competition for growth resources and improved micro climate. In the present study, the higher yield in 120 x 20 cm than 90 x 20 cm was due to the better availability of growth resources like water, nutrients, air, better cultural practices and effective weed control in wider plant geometry helped the plants to exhibit their full potential and produced higher yield than closely spaced plants (90 x 20 cm) .These results are in accordance with the findings of Channabasavanna *et al*. (2017).

Nipping practices

Spraying of growth retardant chlormequot chloride recorded significantly higher yield (2368 kg/ha) over N2-nipping at 50 DAS (2120 kg/ha) and N1-without nipping (2180 kg/ha). The increase in yield was due to increase in number of branches, flowers and pods. Tripathi *et al.* (2009) also observed that spraying of growth retardant TIBA (50 mg l^{-1}) increased flowering, number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-seed weight during both the seasons. It also increased seed yield and harvest index of pigeonpea by 20.9% and 25.0% over control, respectively. The Improvement of seed yield of *Brassica juncea* in response to the chlormequat was observed by Lone (2001). He also observed Chlormequat application increased the number of pods per plant in *B. juncea.* In the present investigation the spraying of Chlormequat recorded significantly higher number of branches per plant (51.3 g) and number of pods (313) than no nipping treatment (44.7 g and 271, respectively) (Table 1). The increase in number of pods and branches /plant were due to increased photosynthetic rate (Dayal *et al.,* 1993), stimulation in the rate of ribulose biphospahte carboxylase activity and rate of CO_2 fixation (Numi, 1979; Pando and Srivastava, 1985) and beneficial effect on chlorophyll content (Shah and Prathapasenan, 1991; Mandal *et al*., 1997) due to application of growth retardant.

Genotypes

Genotype BSMR -736 recorded significantly higher yield (2308 kg/ha) than TS-3 (R) (2066 kg/ha). Channabasavanna *et al*., (2017) also reported that the genotype BSMR-736 produced significantly the highest grain yield (1667 kg/ ha) over Laksmi (1369 kg/ha) and TS-3R (823 kg/ha).

In the present study, the higher grain yield of BSMR - 736 was attributed to its longer duration (170 days) compared to TS- 3R (150 days). It had opportunity of longer period for the development of reproductive parts. Hence more number of pods per plant was recorded in BSMR-736 (320) compared to TS-3R (245). The higher yield components in BSMR-736 was attributed to higher growth parameters like higher total number of branches $plant^{-1}$ (49.0) than TS-3R (44.9), which can be attributed to its genetic potential.

Table 1: Seed yield, number of branches/plant and pods/plant of pigeonpea as influenced by planting geometry, genotypes and nipping practices.

Treatments		Seed yield(kg/ha)			Number of branches/plant			Number of pods/plant		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Planting geometry										
P_1	90 x 20cm	1953	2310	2015	42.7	46.2	44.4	198	265	231
P_2	120 x 20cm	2167	2648	2408	46.8	47.8	47.3	251	338	295
P_3	150 x 20cm	1934	2222	2078	47.3	47.7	46.9	286	357	322
	Sem±	64	121	64	0.15	0.14	0.12	26	18	22
	CD at 5%	192	363	192	0.45	0.42	0.36	78	54	66
Nipping practices										
N_1	Without Nipping	1973	2209	2091	42.3	47.1	44.7	228	329	279
N_2	Nipping	1845	2431	2138	47.5	44.7	46.1	250	294	271
N_3	Chlormequat chloride	2237	2500	2368	52.7	50.0	51.3	272	354	313
	Sem±	39	99	66	0.4	0.2	0.32	11	23	12
	CD at 5%	117	NS	198	1.2	0.6	0.96	33	68	36
Genotypes										
V_1	BSMR-736	2105	2586	2308	46.8	49.1	48.0	264	376	320
V_2	TS-3R	1930	2201	2066	44.4	45.4	44.9	225	264	245
	Sem±	42	77	54	0.68	0.4	0.54	12	8.4	10
	CD at 5%	126	232	162	2.0	0.2	1.63	36	25.2	11

Table 2: Interaction effect of planting geometry, genotypes and nipping practices on pigeonpea yield.

Planting geometry (P)	Genotypes (V)	Nipping practices (N)			
		N1	N2	N3	Mean
90 x 20 cm	BSMR-736	2158	2281	2374	2271
	TS-3R	1906	2009	2063	1993
	Mean(SxN)	2032	2084	2111	
120 x 20 cm	BSMR-736	2418	2311	3013	2581
	TS-3R	2229	2125	2353	2236
	Mean(SxN)	2324	2218	2683	
150 x 20 cm	BSMR-736	2065	2114	2382	2187
	TS-3R	1942	1880	2088	1970
	Mean(PxN)	2004	1997	2235	
	PxV	PxN	PxVxN		
Sem±	93	82	156		
CD at 5%	279	248	476		

Similar observations were made by Meena *et al*., (2015) who reported that higher grain yield with ICPH2671 was due to significantly higher number of pods per plant (181.2) pod weight per plant (117.9 g), grain weight per plant (63.1 g), test weight (10.2 g) and harvest index (25%) over Maruti (139.9, 65.3 g, 33.7 g, 9.2 g and 19%, respectively).

Interaction of planting geometry and varieties

Among the P x V interactions, BSMR-736 with 120 x 20 cm recorded significantly highest yield (2581 kg ha^{-1}) than others (1970-2271 kg ha^{-1}), which was due to longer duration of BSMR-736 which provided the longer period for accumulation of photosynthates in reproductive parts (sink) and coupled with optimum population of 120 x 20 cm. Channabasavanna *et al*. (2017) reported that suitable planting geometry minimize the competition between plants, helps in utilizing the resources very efficiently and ultimately enhance the total productivity. In their study they observed that irrespective of genotypes, pigeonpea yield decreased with the decrease in the plant population. The spacing of 90 x 20 cm (55,556 plants/ha), 120 x 20 cm (41,667 plants/ha) and 150 x 20 cm (33,333 plants/ha) produced significantly the highest grain yield of 1525 kg/ha, 1483 kg/ha and 1448 kg/ha, respectively and further increase in spacing reduced the gain yield. Though these treatments showed less seed weight per plant, seeds per pod and pods per plant as a result of intra row competition, the total grain yield was increased at closer spacing as the ill effect was compensated by higher plant population. The better performance of pigeonpea plants at wider spacing may be attributed to less plant competition and greater availability of growth resources *viz*., light, moisture, nutrient and space for each plant. The more space facilitated in increasing branches per plant. This in turn accommodated higher inflorescence and thus increased the pods per plant. However, the extent of increase was not sufficient to compensate the yield attained with that at higher plant population. The planting geometry influences the performance.

Interaction of planting geometry and nipping practices

The interaction of planting geometry and nipping practice was also significant. Among the PxN interactions, planting geometry of 120 x 20 cm and chlormequat chloride application recorded significantly the highest yield (2683 ha^{-1}). At 90 x 20 cm and 150 x 20 cm planting geometries, N2-nipping (2084 and 1997 kg ha^{-1}, respectively) and without nipping (2004 and 2032 kg ha^{-1}, respectively) recorded significantly lower yield than 120 x 20 cm planting geometry with N3 (chlormequat chloride) application (2683 kg ha^{-1}). Planting geometry 120 x 20 cm with N3 (chlormequat chloride) application was also significantly higher than 120 x 20 cm with nipping (2218 kg/ha^{-1}) and without nipping (2324 kg ha^{-1}). Jaidka *et al.* (2020) observed a significant decrease in abscission of reproductive parts by the mepiquat chloride application treatment as compared to control in soybean. Further they revealed that detopping and mepiquat chloride application, registered significantly higher number of pods/ plant, pod setting percentage and 100-seed weight than control. Cessation of apical dominance by detopping put favourable effect on plant growth and development which was clearly reflected in terms of decreased plant height, optimized source-sink relationship, enhanced yield attributes and seed yield. Mepiquat chloride posed a favourable impact on soybean in terms of decreased leaf area index, enhanced SPAD value, high specific leaf weight, dry matter accumulation, optimized source-sink relationship resulting into better seed yield and yield attributes.

Interaction of P x V x N

The interaction of P x V x N revealed that genotype BSMR-736 with 120 x 20 cm spacing with chlormequat chloride significantly recorded highest yield (3013 kg ha^{-1}) than others. The increase in yield was due to optimum population, longer period for accumulation of photosynthates in reproductive parts and more number of secondary branches and pods per plant.

Phosphatase activity

Nipping practices did not have significant effect on the phosphatase activity and indicated that there was no adverse effect of chlormequat chloride on microbial acivity (Fig 1). Genotypes showed different responses to nipping practices and planting geometries. Genotype TS-3R recorded similar phasphatase activity at all the nipping practices. Where, it was significant for planting geometry. Phosphatase activity increased with increase in planting geometry, it was highest at 150 x 20 cm.

Genotype BSMR-736 did not show any significant effect with planting geometry (Fig 1). At 90 x 20 cm and 120 x 20 cm, both N1-without nipping and N2-with nipping recorded similar phosphatase activity. Where, N3-chlormequat chloride application with 150 x 20 cm was significantly higher than 90 x 20 cm and 120 x 20 cm. Since there was wider space availability, phosphatase activity was improved with increase in planting geometry (Fig 1).

Dehydrogenase activity

Genotypes showed significant difference on the dehydrogenase activity at 120 DAS (Fig 2). Genotype BSMR-736 recorded superior dehydrogenase activity to TS-3R. Genotype BSMR-736 recorded similar dehydrogenase activity at all the planting geometries under different nipping practices (Fig 2) and indicated that there was no adverse effect on effect of chlormequat chloride effect on dehydrogenase activity.

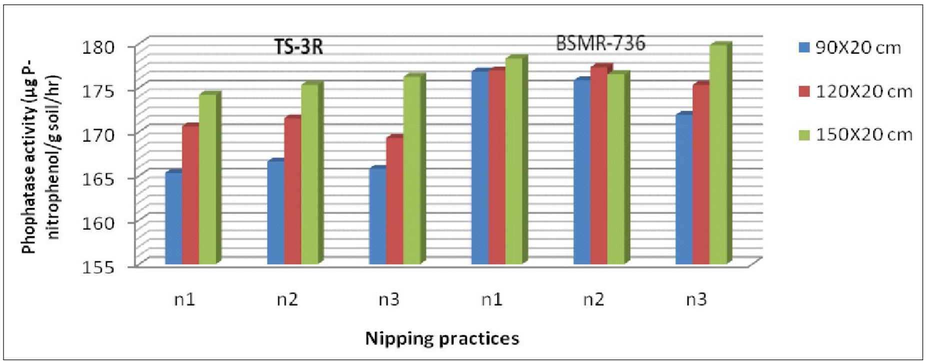

Fig 1: Phosphatise activity as influenced by genotypes, planting geometries and nipping practices.

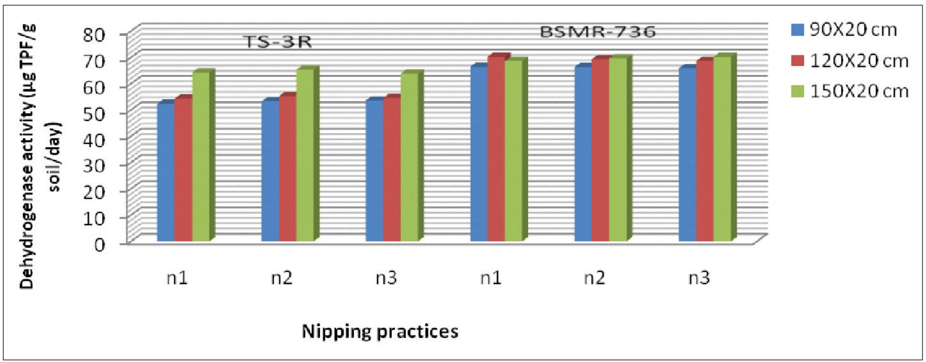

Fig 2: Dehydrogenase activity as influenced by genotypes, planting geometries and nipping practices.

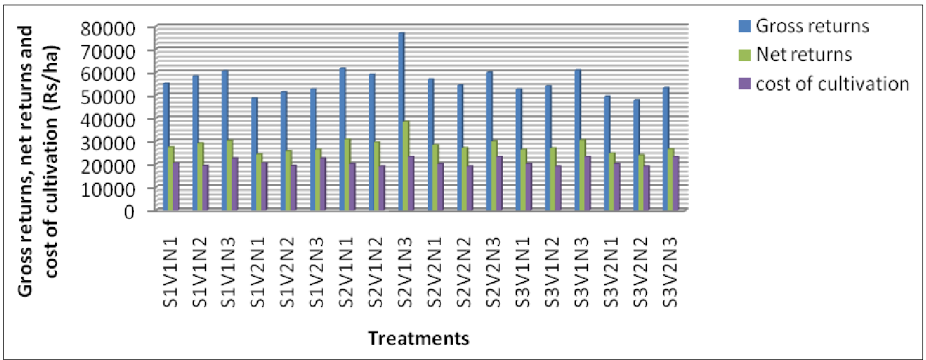

Fig 3: Economics of pigeonpea as influenced by genotypes, planting geometries and nipping practices.

Net returns

Net returns were significantly higher with pigeonpea variety BSMR-736 when planted in 120 cm x 20 cm and sprayed with chlormequot chloride at 70 DAS. This treatment recorded net returns of 38000 Rs/ha (Fig 3). The increase in net returns was attributed to higher yield obtained in this treatment without much variation in cost of cultivation compared to other treatments. Hence there was increase in net returns. Similar results were reported by Channabasavanna *et al*. (2017).

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