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Performance of Pigeonpea [*Cajanus cajan* (L.) Mill sp.] under Rainfed Condition of Telangana through Nipping Technology

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A B S T R A C T

A field investigation was carried out at Regional Agricultural Research Station, Warangal on Vertisols during *Kharif* 2016-17, 2017-18, 2018-19 to study the effect of nipping and plant geometries in medium duration pigeonpea productivity under rainfed conditions of Telangana. Nipping terminal bud at 45 and 60 days after sowing significantly reduced the plant height and increased the number of primary and secondary branches and pods per plant. Pooled results inferred that one time nipping at 45 days (1688 kg ha^{-1}) has significantly out yielded the other treatments. With single time nipping at 60 days after sowing, nipping twice at 45 and 60 days after sowing and control there is an increase in grain yield by 12 %, 18 % and 16 % respectively over single time nipping at 45 days after sowing. While, grain yield was not influenced by the plant geometries. Interaction was also found significant with single time nipping at 45 days after sowing with 41,666 plants ha^{-1}plant geometry(1763 kg ha^{-1}) and it was at par with single time nipping at 45 days after sowing at 27,777 plants ha^{-1}plant geometry (1748 kg ha^{-1}) over the other treatments.

Introduction

Pigeonpea [*Cajanus cajan* (L.) Mill sp.] is the fifth grain legume in the world and second in India after chickpea. It is an important pulse legume crop in the tropics and subtropics, endowed with several unique characteristics. Pigeonpea is used in more diversified ways than other pulses. Pulses are considered to be the major sources of protein among the vegetarians in India and complement the staple cereals in the diet with proteins, essential amino acids, vitamins and minerals. It contains 22-25% protein, which compares well with that of other important grain legumes which is almost twice the protein in wheat and thrice that of rice. India has the largest acreage under pigeonpea (4.42 m ha) with a total production and productivity of 4.02 mt and 909 kg ha^{-1}, respectively. The increase in area cultivated under pigeonpea, production and productivity from 1950-51 to 2017-18 is 102% (2.18 m ha to 4.42 m ha), 133% and 15.4%, respectively (AICRPP, 2018).

In Telangana, pigeonpea is being cultivated in array of soils under erratic distribution of rainfall cultivation occupying area, production, and productivity of 3.0 Lakh ha, 219'000 t and 744 kg ha^{-1} (AICRPP, 2018). Pigeonpea is the most preferable crop of rainfed areas because of its well-developed tap root system as well as lateral root system, it has ability to extract moisture from deeper soil layers made short duration pigeonpea variety a preferable option even in moisture stress conditions which might be the probable reason for increase in area cultivated under pigeonpea in these areas.

The productivity potential of pigeonpea in Telangana is low (744 kg ha^{-1}) compared to the national productivity (909 kg ha^{-1}) and that of Philippines (1858kg ha^{-1}). The productivity of pulse crop is low due to cultivation on marginal and sub marginal agricultural lands under poor management. So, it needs earnest attention in adoption of desirable production technologies to exploit the yield potential of the pigeonpea as it has high elasticity, indeterminate growth habit, poor source-sink relationship, poor translocation efficiency, shedding of floral parts and low harvest index.

Modification of plant canopy architecture can strongly affect light distribution in the canopy and total photosynthetic efficiency in turn greatly determine crop yield and yield attributes. Aslam *et al.,* (2008) witnessed an increased in height and number of pod bearing branches with respect to topping of chickpea at various levels under water deficit systems. In general, when the vertical growth of the plant *i.e.,* apical bud is arrested or restricted the growth of lateral branches gets induced. With this concept in view, the terminal buds are usually removed in crops like cotton, castor, field peas, chickpea and chrysanthemum to induce more auxiliary branches. As pigeonpea is largely grown under rainfed conditions in Telangana, its agronomic practices are required to be standardized for realizing yield potential. Among them optimum plant population and the number of reproductive sink/plant are the key factors determining the yield. In normal farmers' practice, pigeonpea crop grows taller and plant height coupled with branching pattern results in interlocking effect, excessive flower drop and decreased pod set which effects yield. Removal of apical bud induces branching as in other crops at lower levels thus resulting in trained canopy, which influence setting and yield. Hence, while recommending nipping in pigeonpea, the details such as time of nipping, numbers and economic feasibility for higher yielding need to be verified.

Materials and Methods

Experimental site

A field experiment was conducted during *kharif*, 2016, 2017, 2018 at experimental farm of Regional Agricultural Research Station, Warangal on Vertisols situated at 17^o $58'$ N latitude, 79^o $28'$ E longitude and at an altitude of 270 m above mean sea level falls under the Central Telangana zone of Telangana, India. The total rainfall received during the crop growth period of 2016, 2017 and 2018 was 1337 mm (57 days), 787 mm (46 days), 690 mm (40 days) respectively. The per cent deviation in rainfall received in 2016, 2017 and 2018 was +64.6, -3.2, -15 % respectively within crop period (June to January). The experimental soil was clay loam texture with slightly alkaline (pH 8.01) reaction, low organic carbon content (0.40), available nitrogen (175 kg ha^{-1}), medium available phosphorus (40 kg $P_2O_5 ha^{-1}$) and high available potassium (355 kg K_2O ha^{-1}).

Field layout and treatment details

Field site was ploughed once with mould board plough, twice with cultivator and fine tilth was prepared by rotavator. The experiment was laid out in a Factorial Randomized Block Design with Factor A with three geometries (41,666 plants ha^{-1}, 33,333 plants ha^{-1} and 27,777 plants ha^{-1}), Factor B with four nipping levels (single time nipping at 45 days after sowing, single time nipping at 60 days after sowing and nipping twice at 45 and 60 DAS, control- without nipping) which were replicated thrice. WRG-65 was the high yielding medium duration pigeonpea variety moderately tolerant to *Fusarium* wilt.

The sowing was done on 24^{th} June in 2016 and 2017, 11^{th} July 2018. The crop was purely rainfed except one irrigation (50 mm) was given in *kharif* 2018-19, as there is moisture stress at critical (flower bud initiation) stage. The crop received the recommended dose of fertilizer 20: 50 kg N and P_2O_5 ha^{-1} with complete dose basally. Nipping technology was carried out manually by pinching 10 cm of terminal shoot from top at the crop stage as per treatment compared with control without nipping. Weeds, pests and diseases were controlled by maintaining good management practices.

Data recording and harvesting

Growth parameters and yield attributing characters were recorded at harvest on randomly tagged five plants within net plot. Seed yield was arrived from finally harvested plants from the net plot during the experimentation of respective years. The data was analysed statistically in a factorial randomized block design using INDOSTAT and the details of ANOVA (summary) are presented in Table 1.

Results and Discussion

Effect of plant geometries on the growth, yield attributes and seed yield

Plant height was not influenced by different plant geometries (Table 2), a perusal of yield attributes such as no. of pods $plant^{-1}$, no. of seeds pod^{-1}, test weight, grain yield were not significantly affected by plant geometries. Plant geometries of 27,777 plants ha^{-1} (11.1) resulted in significantly more no. of branches $plant^{-1}$ as compared to 41,666 plants ha^{-1} (9.8) but was found to be at par with 33,333 plants ha^{-1} (10.4).

This may be because the pigeonpea plant shows great plasticity by adjusting its branching behavior depending on the available space between plants leading to increase in no. of branches per plant compensating the lesser plant population. The harvest index was significantly higher with 27,777 plants ha^{-1} over the other treatments.

Mula *et al.,* 2013 planting distance 150 cm x 50 cm generated the highest mean height of 228 cm at 50% flowering, weight of dry biomass of 0.25 kg per plant, 359 pods per plant, 3.32 seeds per pod, 14.55 g of 100 seed weight, and yield per plant of 98.61 g revealing that wider spacing has not influenced the increased in seed yield of ICPA 2043 which confirms to the findings of Kumar *et al.,* 2001. In contrast, Alse *et al.,* 2017 numbers of pods $plant^{-1}$ found to be increased with every increase in inter row spacing from 90 to 120 cm.

Table.1 Anova table for important characters studied (Summary)

Particulars	df	Plant Height (cm)	No. of Branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 grain weight (g)	Grain yield (kg ha^{-1})	Stalk Yield (kg ha^{-1})	HI
Year	2	48274.07***	8.67	14424.75***	0.10*	1.88*	2743487**	104758600***	7300.02***
Spacing	2	163.79	15.03***	721.58	0.01	0.44	59506	3221389***	126.44***
Year*Plant geometry	4	127.41	12.52***	1800.75*	0.02*	1.24**	785099***	568079**	96.78***
Nipping	3	403.22*	19.95***	6604.42***	0.00	1.91***	505686***	2204869***	27.07*
Year*Nipping	6	229.99	6.90***	1383.75*	0.01	0.21	121856*	542629**	29.93**
Plant geometry*Nipping	6	241.42	1.39	177.59*	0.01	0.18	125351*	114481	28.03**
Year* Plant geometry *Nipping	12	116.28	2.11	641.14	0.01	0.32	50179	204271	12.74
Pooled error	66	130.91	1.35	498.73	0.01	0.26	42111	132751	7.82
General Mean	1	216.46	10.45	264.71	3.99	8.58	1495	3830	30.89
CV (%)	1	5.29	11.09	8.44	2.43	5.88	14	10	9.05
Ai-Aj (Year)	1	11.05	1.11	15.23	0.07	0.24	195	383	0.51
Bi-Bj (Spacing)	1	5.38	0.55	10.51	0.05	0.24	97	171	1.32
AiBi-AiBj	1	9.33	0.95	18.20	0.08	0.41	167	297	2.28
AiBi-AjBi	1	13.25	1.34	19.00	0.09	0.41	235	448	1.93
Ci-Cj (Nipping)	1	6.22	0.63	12.14	0.05	0.27	112	198	1.52
AiCi-AiCj	1	10.77	1.09	11.02	0.09	0.48	193	343	2.63
AiCi-AjCi	1	14.27	1.44	20.45	0.10	0.47	253	478	2.33
BiCi-BiCj	1	10.77	1.09	11.02	0.09	0.48	193	343	2.63
BiCi-BjCi	1	10.77	1.09	11.02	0.09	0.48	193	343	2.63

***Significant at 5% level, ** Significant at 1% level, ***Significant at 0.1 % level**

Table.2 Growth parameters, yield attributes, grain yield and harvest index influenced by plant geometries and nipping stages (Pooled data of 2016-17, 2017-18 and 2018-19)

Treatment	Plant Height (cm)	No. of Branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 grain weight (g)	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	HI
Years								
2016-17	194.1	9.9	241.7	3.94	8.83	1771	2073	47.3
2017-18	258.7	10.9	277.9	3.98	8.39	1493	5480	21.8
2018-19	196.6	10.5	274.6	4.04	8.50	1219	3937	23.6
SEm+	2.81	0.28	3.88	0.017	0.062	50	98	0.13
LSD at 5%	11.05	NS	15.23	0.067	0.24	195	383	0.51
Plant geometries								
S1	214.8	9.8	260.3	3.97	8.55	1450	3902	29.5
S2	215.8	10.4	269.2	3.98	8.48	1529	4087	30.1
S3	218.9	11.1	264.6	4.01	8.70	1505	3501	33.0
SEm+	1.97	0.2	3.73	0.016	0.08	34.2	60.77	0.47
LSD at 5%	NS	0.56	NS	NS	NS	NS	171.46	1.32
Nipping stages								
N1	215.9	11.6	285.9	3.99	8.93	1688	4209	31.9
N2	215.1	10.6	267.2	3.99	8.60	1493	3876	30.0
N3	213	10	253.6	4.01	8.45	1386	3551	30.1
N4	221	9.6	252.2	3.98	8.32	1412	3683	31.5
SEm+	2.28	0.23	4.30	0.019	0.096	39.99	70.12	0.54
LSD at 5%	6.42	0.65	12.14	NS	0.274	112.51	197.99	1.52

S1: 41,666 plants ha^{-1} S2: 33,333 plants ha^{-1} S3: 27,777 plants ha^{-1}) N1: Nipping at 45 days after sowing N2: Nipping at 60 days after sowing N3: Nipping twice at 45 and 60 DAS, N4: Control (without Nipping)

Table.3 Interaction effect of plant geometries and nipping stages on grain yield of Pigeonpea (Pooled data of 2016-17, 2017-18 and 2018-19)

Treatment	No. of podsplant^{-1}	Grain yield(kg ha^{-1})	HI
S1N1	277.6	1763	31.1
S1N2	263.7	1438	28.47
S1N3	252.4	1337	29.77
S1N4	247.4	1262	28.85
S2N1	292.5	1554	30.55
S2N2	266.1	1507	27.74
S2N3	258.6	1514	30.86
S2N4	259.7	1541	31.24
S3N1	287.4	1748	34.28
S3N2	271.9	1532	33.82
S3N3	249.8	1307	29.6
S3N4	249.3	1432	34.44
SEm+	3.89	68.4	0.93
LSD at 5%	11.02	193.14	2.63

S1: 41,666 plants ha^{-1} S2: 33,333 plants ha^{-1} S3: 27,777 plants ha^{-1}) N1: Nipping at 45 days after sowing N2: Nipping at 60 days after sowing N3: Nipping twice at 45 and 60 DAS, N4: Control (without Nipping)

Effect of nipping on the growth, yield attributes and seed yield

Growth parameters like plant height were significantly influenced by nipping stages. The plant height was significantly higher with control *i.e*., plants without nipping compared to the nipping treatments.

No. of branches per plant was significantly higher in plants nipped single time at 45 days after sowing followed by single time nipping at 60 days after sowing, nipping twice at 45 and 60 days after sowing and control. While there is manual pinching it lead to increase in the lateral branches underneath it by reducing the apical dominance, leading to increase in the no. of branches at the time of nipping than the control.

Single time nipping at 45 days after sowing resulted in significantly higher grain yield of pigeonpea (1688 kg ha^{-1}) (Table 2). This mainly due to significantly more no. of branches, pods per plant, test weight (Table 2). With single time nipping at 60 days after sowing, nipping twice at 45 and 60 days after sowing and control there is an increase in grain yield by 12 %, 18 % and 16 % respectively over single time nipping at 45 days after sowing. Control *i.e.,* plants without nipping was more in growth parameters like plant height as the canopy was not disturbed externally leading to less no. of branches per plant due to the apical dominance. Plants which were nipped at 45 days after sowing the plant tissue was tender and it is the stage where start of the branching compared to than the older tissue at 60 days after sowing may be the reason for affecting the no. of branches per plant other than apical dominance.

Dhaka *et al.,* 2018, nipping of apical bud at start of branching is economically viable agronomical practice to enhance seed yield of pigeonpea due to significant improvement in primary and secondary branches. Apical bud pinching leads to production of side shoots or branches thus increased canopy size and photosynthetic activity and accumulation of more photosynthates resulting in increased seed size and yield (Lakshmi *et al.,* 2015, Vasudevan *et al.,* 2008). Baloch and Zubair (2010), nipping or cutting back chickpea at various levels would enhance yield and yield contributing parameters of this crop. Similarly, in pigeonpea also nipping of terminal bud significantly increased the number of primary and secondary branches and pods $plant^{-1}$ (Arjun Sharma *et al.*, 2003). Reddy and Narayanan (1987) reported that nipping of terminal bud in sesamum activated the dormant lateral buds to produce more branches which finally resulted in yield increase. The increased yield components may be attributed to activation of lateral dormant buds by arresting the terminal growth through nipping of terminal bud which might have facilitated the significant increase in the yield attributes.

Interaction of the spacing and nipping on growth, yield attributes and seed yield

It is the evident from Table 3 that interaction between nipping and spacing was found to be significant for no. of pods per plant and grain yield of pigeonpea. There is also the significant difference between the years 2016-17, 2017-18 and 2018-19 (Table 2). The rainfall received during the three years of the experimentation can explain the true reason behind the difference in the grain yields. The total rainfall received during the crop growth period was 1337 mm (57 days), 787 mm (46 days), 690 mm (40 days) respectively in 2016-17, 2017-18 and 2018-19 indicating the moisture stress of the crop at critical pod filling stages. The no. of rainfall events were also very less (40 and 46 days) in 2018-19 and 2017-18 respectively leading to the lower yields than the 2016-17 with 57 days.

Because of the heavy rainfall in 2016-17, there was excess foliage growth, by simple nipping technology lead to increase in the diversion of translocates towards sink from source by increasing the photosynthetic efficiency clearly than the remaining years of experimentation.

Significantly higher yield was recorded with S1N1 (1763 kg ha^{-1}) which was at par with S3N1 (1748 kg ha^{-1}) (Table 3) over the other treatments. This may be because of plasticity of the pigeonpea with regard to the different levels of plant geometry. This result is in agreement with Imayavaramban *et al.,* (2004) that of nipping of terminal bud activated the dormant lateral buds to produce more branches in sesame. Moreover, by nipping the terminal buds, the utilization of photosynthates leads to increased number of branches $plant^{-1}$. A similar result of finding was in concomitance with Amruta *et al.*, (2015) and Srinivasan *et al.,* (2019).

In conclusion, under rainfed conditions of Telangana plant geometries of 41,666 plants ha^{-1} and 27,777 plants ha^{-1} coupled with single time nipping at 45 days after sowing is the best stage of pinching tender 10 cm terminal bud are recommended for realizing higher pigeonpea grain yield on Vertisols.

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