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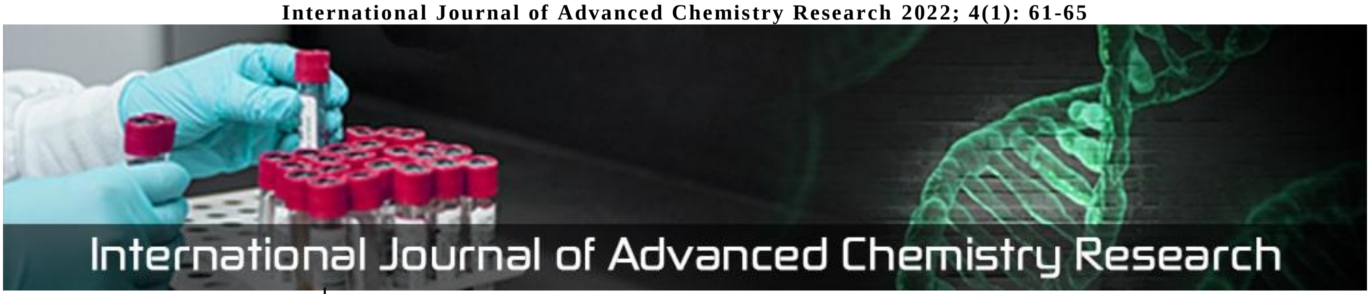

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Effect of spacing and nipping on growth, yield attributes and yield of pigeonpea (*Cajanus cajan* L. Millsp.)

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Abstract
The experimental study for the research named "Effect of spacing and nipping on growth, yield attributes and yield of pigeonpea (*Cajanus cajan* L. Millsp.)" was performed out at the Research farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.) during *kharif* 2021-22 located at 22.09° N latitude, 82.15° E longitude and altitude of 298 m above sea level. The experiment was carried in clayey loam type of soil with low availability of Nitrogen and medium availabilty of Phosphorous and Potassium content. The maximum and minimum temperature recorded during the crop growth period were (33.3 °C and 6.4 °C), relative humidity ranged between 84.6% - 96 % and rainfall (841.06 mm). The crop was sown on 17th July and the recommended dose of fertilizer was 20:50:20 NPK kg ha^{-1}. The investigation was carried out in Randomized complete block design with two factors namely spacing (Three spacings: (S_1) 40cm x 20 cm, (S_2) 60 cm x 20 cm, (S_3) 80 cm x 20 cm) and nipping (Three stages: (N_1) No nipping, (N_2) Nipping at 30 DAS, (N_3) Nipping at 30 DAS and 60 DAS) with nine treatment combinations. Each experimental unit was replicated thrice with gross plot size of 4.8 m x 4 m and net plot size of 4 m x 3.6 m for 40 cm x 20 cm spacing, 3.6 m x 3.6 m for 60 cm x 20 cm spacing, 3.2 m x 3.6 m for 80 cm x 20 cm respectively. Amongst the growth parameters, significantly higher plant height, number of primary branches and secondary branches were seen in the spacing (S_3) 80 cm x 20 cm and lowest in (S_1) however in nipping, highest plant height was seen in the nipping treatment (N_1) no nipping, and maximum number of primary branches and secondary branches were discovered in nipping at 30 DAS and 60 DAS (N_3). Eventually with yield attributes, the highest number of pods plant^{-1}, number of grains pod^{-1}, 1000 grain weight gave best result in the spacing (S_3) 80 cm x 20 cm although in nipping, they were maximum in (N_3) Nipping at 30 DAS and 60 DAS. Similarly, higher grain yield, gross returns, net returns and B:C ratio were found in spacing (S_3) 80 cm x 20 cm and least was observed in the spacing (S_1) 40 cm x 20 cm and in nipping at 30 DAS and 60 DAS (N_3) as compared to No nipping (N_1).

Keywords: Spacing, nipping, Yield, B:C ratio

Introduction
Pulses are an important part of the vegetarian diet in India. They preserve soil fertility through biological nitrogen fixation and improve soil organic matter by defoliation at maturity stage thus being a good source of protein. As a result, pulses are widely used in various cropping system and crop mixtures and play an important role in promoting sustainable agriculture. Pigeonpea (*Cajanus cajan* L.) is the world's fifth most popular grain legume and India's second important pulse crop after chickpea (Narendra *et al*., 2013) [11]. In the tropics and subtropics, it is a major multi-functional pulse legume crop with various distinct properties. Pigeonpea is utilized in a wider range of applications than other pulses. Pulses are an important source of protein for vegetarians in India as they provide necessary amino acids, vitamins and minerals to supplement the diet's staple grains. It has a protein content of 22-24 %, which is comparable to that of other grain legumes and is nearly twice that of wheat and thrice that of rice. Pigeonpea's total area, production and productivity are roughly 4.54 million ha, 3.83 million tonnes and 842 kg ha^{-1} respectively, at the global level in 2019-20 (4th Advance estimates, Directorate of Economics and Statistics). Currently (2019-20), total area under pulses in India is 28.34 million hectares with a production of 23.15 million tones and yield of 817 kg ha^{-1}. In Chhattisgarh as of 2020-2021, the area for pigeonpea growth is about 119.3 thousand ha and productivity of about 601 kg ha^{-1}.
Pigeonpea, also known as red gram, arhar and tur is the most important *kharif* grain legume crop. A variety of factors that includes agronomic, pathogenic, entomological, genetic and environmental factors, limit pigeonpea production.

Some important elements that inhibit pigeonpea production are adoption of an inappropriate geometry (plant spacing), optimum population, irrigation facilities, fertilizers and other agronomic practices.

Pigeonpea requires a certain amount of moisture and an ideal temperature particularly during their pod development stage. However, the crop's productivity is extremely low. One method of enhancing its productivity is intensive cultivation with the right crop geometry (inter and intra row spacing). Pigeonpea reacts well to spacing due to its photosensitivity, high branching and indeterminate growth habit. As a result, both inter and intra row spacing have a significant impact on yield. To achieve maximum yield, it is essential to maintain optimum plant population for effective use of moisture, nutrients and solar radiation.

Nipping is an important agronomic measure that reduces apical dominance, increases the number of branches, increases % pod set, improves the source-sink relationship and increases plant production thus involving removing of the tendrils. These tendrils operate as a sink in the plant, inhibiting photosynthate transfer to the reproductive parts of the plant. It has been discovered that nipping tendrils increases the number of branches and pods plant^{-1}.

For increased production, larger canopy requires more spacing, while smaller canopy requires closer spacing (Panda *et al.*, 2019) [12]. As a result, nipping and plant density are closely related and must be standardized.

Hence, keeping this above facts in view an experiment was laid out to study-

1. The effect of spacing on growth, yield attributes and yield of pigeonpea
2. The effect of nipping on growth, yield attributes and yield of pigeonpea
3. To workout the economics under study.

Effect of Spacing on growth, yield attributes and yield of pigeonpea

Sekhon *et al.* (2000) [15] in Ludhiana, Punjab found that pigeonpea yield with row spacing of 67.5 cm x 20 cm (2280 kg ha^{-1}) and 67.5 cm x 25 cm (2330 kg ha^{-1}) produced significantly higher grain yield than 30 cm x 15 cm (1460 kg ha^{-1}), 40 cm x 15 cm (1700 kg ha^{-1}), 60 cm x 15 cm (1890 kg ha^{-1}) and 67.5 cm x 30 cm (2000 kg ha^{-1}) spacing on sandy loam soil. Nagaraju *et al.* (2001) [10] investigated the response of short duration pigeonpea to row spacing of 30 cm and 45 cm and found out that row spacing of 30 cm resulted in a higher grain yield (920 kg ha^{-1}) with 6.5 g of 100 seed weight than row spacing of 45 cm. Darshan (2008) [6] recorded that sole pigeonpea with wider planting geometry of 120 cm × 15 cm followed by 90 cm × 20 cm recorded significantly higher seed yield (1919 kg ha^{-1} and 1776 kg ha^{-1}, respectively), stalk yield (4852 kg ha^{-1} and 4614 kg ha^{-1}, respectively), number of pods plant^{-1}, seed weight plant^{-1}, plant height, number of primary and secondary branches, leaf area index, canopy spread, total dry matter production and its distribution in different plant parts than the other treatments. Birendra Tigga *et al.* (2017) [4] conducted a field experiment during winter season of 2013-14 at the Instructional Research Farm, I.G.K.V., Raipur (C.G.) to study the performance of different genotypes of pigeonpea with planting geometry. The genotype and planting geometry significantly influenced the growth parameter, seed yield, stalk yield, harvest index, yield attributes (viz. pod plant^{-1}, seed pod^{-1}, seed plant^{-1} and 100 seed weight). Pigeonpea sown with wider geometry of 60 cm × 10 cm gave maximum seed pod^{-1} (4.05), pod plant^{-1} (496.67) and 100 seed weight (11.10 g) compared to narrow spacing of 45 cm × 10 cm. In conclusion, among the spacing treatments, the spacing 60 cm x 10 cm proved the best in terms of growth and yield in winter season planting of pigeonpea. S. Kitturmath and A.M. Talwar *et al.* (2017) showed that irrespective of genotypes, pigeonpea yield decreased with decrease in the plant population.The grain yields of 1525 kg ha^{-1}, 1483 kg ha^{-1} and 1448 kg ha^{-1} were significantly higher at 90 cm x 20 cm (55,556 plants ha^{-1}), 120 cm x 20 cm (41,667 plants ha^{-1}) and 150 cm x 20 cm (33,333 plants ha^{-1}) spacings, respectively and further increase in spacing decreased the grain yield. Regardless of the fact that intra row competition resulted in lower seed weight plant^{-1}, seeds pod^{-1} and pods plant^{-1}, the total grain production was enhanced at closer spacing because the negative effect was compensated by a 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. Y. M. Waghmare and D. N. Gokhale *et al.* (2018) observed that plant geometry of 90-180 cm x 45 cm was significantly higher than any other plant geometry. Plant geometry of 90-180 cm x 45 cm influenced the number of functional leaves, leaf area, number of branches plant^{-1} and dry matter accumulation plant^{-1} significantly more than other plant geometries, with the exception of 75-150 cm x 45 cm plant geometry, which was found to be similar during both years. Legha and Dhingra (1992) of Ludhiana observed increased grain yield (17.6 q ha^{-1}) with 100 cm row spacing over 50 cm (14.2 q ha^{-1}) and 75 cm (13.8 q ha^{-1}).

Effect of nipping on growth, yield attributes and yield of pigeonpea

Arjun Sharma *et al.* (2003) [1] found that nipping of pigeonpea terminal bud at 50 DAS reduced plant height while increasing number of primary and secondary branches, pods plant^{-1}, test weight, and grain production. Nipping twice (50 and 70DAS) and thrice (50, 70, and 90 DAS) significantly reduced growth and yield parameters. Prashant Reddy *et al.* (2009) observed that number of pods, pod length, number of seeds per pod, 100 seed weight and seed yield increased significantly when lateral branches were nipped one week after tendril formation in cowpea. Dhaka *et al.* (2018) noticed that in pigeonpea nipping at beginning of branching reduced the plant height, while increasing primary and secondary branches, pods plant^{-1} and yield over no nipping. Nipping at the beginning of branching improved total N intake, protein content, net return, B:C ratio, agronomical NUE, physiological NUE, agro-physiological NUE, apparent recovery efficiency, N utilisation efficiency, and partial N balance. Bikram Singh *et al.* (2013) observed that nipping of terminal bud by hand clipping at 30 DAS in sesame recorded significantly higher seed yield (4.46 q ha^{-1}) and maximum net returns (Rs.8359 ha^{-1}) and B:C ratio (1.79) over the other treatments under semi–arid climatic conditions of South–Western Haryana.

Materials and Methods

An experiment entitled "Effect of spacing on growth, yield attributes and yield of pigeonpea" variety 'Rajeev lochan' was conducted at the research farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.). The topography of the experimental site was leveled and the soil was clayey loam, well drained with poor nitrogen content and medium availability of phosphorous and potassium. The maximum and minimum temperature recorded during the crop growth period were (33.3°C and 6.4°C), relative humidity ranged between 84.6% - 96 % and rainfall (841.06 mm). The crop was sown on 17th July and the recommended dose of fertilizer was 20:50:20 NPK kg ha^{-1}.

The experiment was laid out in Randomized complete block design with two factors namely spacing (Three spacings: (S_1) 40cm x 20 cm, (S_2) 60 cm x 20 cm, (S_3) 80 cm x 20 cm) and nipping (Three stages: (N_1) No nipping, (N_2) Nipping at 30 DAS, (N_3) Nipping at 30 DAS and 60 DAS) with nine treatment combinations. Each experimental unit was replicated thrice with gross plot size of 4.8 m x 4 m and net plot size of 4 m x 3.6 m for 40 cm x 20 cm spacing, 3.6 m x 3.6 m for 60 cm x 20 cm spacing, 3.2 m x 3.6 m for 80 cm x 20 cm respectively.

Observations on growth parameters, viz., plant height, number of primary branches and secondary branches were taken at crop growth stage and yield attributes, grain yield, stover yield and harvest index were taken at harvest, calculated and analysed as per statistical procedure described by Panse and Sukhatme (1985). Economics of the treatment combinations including gross return, net return and B:C ratio were calculated and compared for economic feasibility.

Results and Discussion

Plant Height

Spacing influenced the plant height of pigeonpea significantly at different growth stages. Amongst the growth parameters, significantly higher plant height (146.11 cm), were seen in the spacing (S_3) 80 cm x 20 cm at harvest followed by (S2) 60 cm x 20 cm and least was recorded in (S1) 40 cm x 20 cm, however in nipping, highest plant height (144.89 cm) was seen in the nipping treatment (N_1) no nipping. Similar outcomes were observed by Singh and Singh (1992) in pea which stated that nipping at 60, 75, 90 DAS and at harvest affected the plant height at different stages of plant growth. The maximum height at harvest was observed with control (104.5 cm), which clearly indicated that the energy which was provisionally used by the plant was diverted towards branching and higher pod formation.

Number of primary and secondary branches

Number of primary branches showed significant variation due to both varying spacing and nipping. Maximum number of primary branches at harvest (17.59) were recorded in the spacing (S_3) 80 cm x 20 cm followed by (S_2) and least was recorded in (S_1) and in nipping number of primary branches (18.42) were found maximum with Nipping at 30 DAS and 60 DAS followed by Nipping at 30 DAS and minimum in no nipping treatment.

Number of secondary branches also showed significant effect due to different spacing and nipping. Maximum number of secondary branches at harvest (25.56) were recorded in the spacing (S_3) 80 cm x 20 cm followed by (S_2) and least was recorded in (S_1) and in nipping number of secondary branches (25.72) were found maximum with Nipping at 30 DAS and 60 DAS followed by Nipping at 30 DAS and minimum in no nipping treatment. Due to more space being available plant^{-1}, it was observed that the wider geometry plants tended to generate more secondary branches (23.32) per plant at harvest. On the other hand, due to reduced space per plant and intensive interplant competition, narrow spacings reduced the formation of secondary branches. Similar findings were made by Srinivasan and Srinivasa Raju (1997), who also noted that there were more branches on each plant with wider spacings. Additionally, as the apical dominance is reduced, the plant tends to make modifications to promote the formation of auxiliary buds that may develop into branches. Arjun *et al*. found comparable result with pigeonpea (2003). Due to the successful translocation of growth regulators, particularly auxins, to the potential and tertiary shoot buds that normally remain dormant, nipping led to the formation of more total branches and promotes the stop of vertical growth.

Yield Attributes

Various yield attributes of pigeonpea were taken at harvest. The number of pods plant^{-1} (139.91), number of grains pod^{-1} (5.11) and 1000 grain weight (g) (103.51) were observed in the spacing (S_3) 80 cm x 20 cm followed by (S2) 60 cm x 20 cm and least was recorded in (S1) 40 cm x 20 cm while in case of nipping maximum number of pods plant^{-1} (139.04), number of grains pod^{-1} (4.93) and 1000 grain weight (g) (103.70) in nipping at 30 DAS and 60 DAS (N_3) followed by nipping at 30 DAS (N_2) and least was recorded in no nipping treatment (N_1).Increased number of pods plant^{-1} is another factor contributing to the higher grain yield by nipping at 30 DAS and 60 DAS. Due to more number of primary and secondary branches plant^{-1}, there were also more pods produced plant^{-1}. Reddy and Narayanan (1987) confirmed similar findings in sesame, where encouraging results were achieved by nipping.The increase in pod weight and number of pods plant^{-1} contributed to the increase in grain weight plant^{-1}. The findings are consistent with those of Tripathi and Chauhan (1990), Legha and Dhingra (1992) and others.

Yield

Among yield, spacing (S_3) 80 cm x 20 cm recorded the highest grain yield (17.23 q ha^{-1}) and stover yield (42.41 q ha^{-1}) followed by (S2) 60 cm x 20 cm and least was observed in (S1) 40 cm x 20 cm. In nipping the highest grain yield (17.36 q ha^{-1}) and stover yield (43.46 q ha^{-1}) were recorded in nipping at 30 DAS and 60 DAS (N_3) and minimum was found to be in no nipping treatment (N_1).

The harvest index was found to be non significant in both spacing and nipping treatments. Similar conclusions were achieved in redgram, according to Arjun Sharma *et al.* (2003), who identified an increase in grain output as a result of a considerable decrease in plant height and an increase in the number of primary and secondary branches and pods plant^{-1}. Himayatullah *et al.* (1980) and Aurangzeb *et al*. (1996) also found a correlation in chickpea.

Economics

Economics for each treatment combination was computed to find out economic feasibility of the recommended practice. For spacing, the highest cost of cultivation (Rs 34167.50 ha^{-1}) was in (S_1) 40 cm x 20 cm followed by (S_2) 60 cm x 20 cm and minimum was in (S_3) 80 cm x 20 cm and higher gross returns (Rs 112086.67 ha^{-1}), net returns (Rs 78344.42 ha^{-1}) and B:C ratio (2.32) were significantly maximum in the spacing (S_3) 80 cm x 20 cm and lowest in (S_1) 40 cm x 20 cm. However, in nipping, the highest cost of cultivation, (Rs 34881.25 ha^{-1}), gross returns (Rs 113692.56 ha^{-1}), net returns (Rs 78811.31 ha^{-1}) and B:C ratio (2.26) were maximum with nipping at 30 DAS and 60 DAS (N_3) followed by nipping at 30 DAS (N_2) and minimum was without nipping (N_1).

Conclusion

In terms of spacing, the spacing (S_3) 80 cm x 20 cm produced the highest grain yield, net profitable returns and B:C ratio compared to the spacing (S_2) 60 cm x 20 cm and spacing (S_3) 40 cm x 20 cm. When growth, yield attributes, yield and B:C ratio of pigeonpea were considered, the pigeonpea nipping at 30 DAS and 60 DAS (N_3) were most efficient and profitable for obtaining high returns.

Table 1: Effect on yield attributes as influenced by spacing and nipping

Treatments		Yield attributes		
		Number of pods $plant^{-1}$	Number of grains pod^{-1}	1000 grain weight (g)
Spacing				
S_1	40cm x 20cm	110.63	4.22	94.23
S_2	60cm x 20cm	124.37	4.65	99.13
S_3	80cm x 20cm	139.91	5.11	103.51
SEm±		4.29	0.15	1.36
C.D. (0.05)		12.86	0.43	4.09
Nipping				
N_1	No Nipping	110.67	4.44	94.57
N_2	Nipping at 30 DAS	125.19	4.61	98.59
N_3	Nipping at 30 DAS and 60 DAS	139.04	4.93	103.70
SEm±		4.29	0.15	1.36
C.D. (0.05)		12.86	NS	4.09

Table 2: Effect on yields of pigeonpea as influenced by spacing and nipping

Treatments		Yields		
		Grain yield (quintal ha^{-1})	Stover yield (quintal ha^{-1})	Harvest index (%)
Spacing				
S_1	40cm x 20cm	13.04	35.38	26.90
S_2	60cm x 20cm	15.14	39.75	27.48
S_3	80cm x 20cm	17.23	42.41	28.77
SEm±		0.65	1.36	0.72
C.D.(0.05)		1.96	4.08	NS
Nipping				
N_1	No Nipping	12.80	34.88	26.73
N_2	Nipping at 30 DAS	15.26	39.20	27.94
N_3	Nipping at 30 DAS and 60 DAS	17.36	43.46	28.48
SEm±		0.65	1.36	0.72
C.D.(0.05)		1.96	4.08	NS

Table 3: Effect on economics as influenced by spacing and nipping

Treatments		Economics			
		Gross return (Rs./ha)	Cost (Rs./ha)	Net return (Rs./ha)	B:C ratio
Spacing					
S_1	40cm x 20cm	86414.33	34167.50	52246.83	1.52
S_2	60cm x 20cm	99377.89	33884.00	65493.89	1.93
S_3	80cm x 20cm	112086.67	33742.25	78344.42	2.32
Nipping					
N_1	No Nipping	84107.00	32981.25	51125.75	1.55
N_2	Nipping at 30 DAS	100079.33	33931.25	66148.08	1.95
N_3	Nipping at 30 DAS and 60 DAS	113692.56	34881.25	78811.31	2.26

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