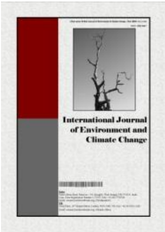

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Effect of Plant Growth Regulators and Spacing on Growth and Yield of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Chickpea is leguminous crop, which offers a good nutrition to people across the world. As a rich source of vitamins, minerals, and fiber, chickpeas may offer a variety of health benefits, such as aiding weight management, improving digestion, and reducing your risk of disease.
Objectives: To evaluate the effect of Plant growth regulators and spacing in growth and yield of Chickpea
Methods: With the goal of studying the effect of plant growth regulators and spacing on growth and yield of Chickpea under a Randomized block design with 9 treatments (T1-T9) The experimental results revealed that GA3@10ppm+30cmx10cm produced maximum plant height (56.84), plant dry weight (17.45g/plant) no of nodules per plant (23.33) and yield parameters no of pods per plant (65.50) no of seeds per pod (1.84) seed yield (2.07 ta/ha) and stover yield (3.11ta /ha).
Conclusion: The combination of GA3@10ppm and 30cmx10cm proved to be the most advantageous to farmers, resulting in (56.84cm) plant height, (17.45-gm) plant dry weight, no of nodules per plant (23.33) and yield parameters no of pods per plant (65.50) no of seeds per pod (1.84) seed yield (2.07 ta/ha) and stover yield (3.11ta /ha), respectively**.**

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Keywords: Chickpea; plant growth regulators; growth and productivity.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the second-most important pulse crop after pigeon pea in the world for human diet and other use. Chickpea is an important winter season pulse crop in India grown as a dry pulse crop or as a green vegetable with the former use being most common. It is cultivated in area of 13.54 million hectares with a total production of 13.10 million tonnes and average productivity of 967.6 kg ha^{-1}. Chickpea is a key source of protein and it plays an important role in human nutrition for large population in the developing world. It is valued for its nutritive seeds with an inexpensive and high quality source of protein (12-22%),carbohydrate (52-70%),fat (4-10%),crude fibres (1.37%),lysine(195-205 mg^{-1}),carotene (89-94 mg^{-1}),fat (3%),minerals (calcium, magnesium, phosphorus, iron, zinc) and vitamins [1].

Plant growth regulators (PGRs) are the chemicals used to modify plant growth such as increasing branching, suppressing shoot growth, removing excess fruit or altering fruit maturity. They are expected to play an important role in rectifying the hurdles in manifestation of biological productivity even in pulse crops. Naphthalene acetic acid (NAA) when it is applied in significant concentrations, promotes adventitious root formation and better rooting activities, thus increasing nutrient absorption. It also works to promote cell division and cell enlargement, thus enhancing plant growth. Gibberellic acid (GA_3) application increases the plant and first node height and increases cell elongation and division and inter nodal elongation [2]. Salicylic acid (SA) promotes reduction in the harmful effects of a biotic and stress, which reflects in the increase in germination percentage, seedlings height, and many physiological processes of plant including flowering, [3].

Optimum plant population density is an important factor to realize the potential yields as it directly affects plant growth and development of chickpea [4], and different crops like sesame [5] and groundnut [6]. Earlier studies show that chickpea yields are remarkably stable over a wide range of population densities. The plants are able to fill available space by initiating lateral branches and, thus, can compensate for poor emergence and thin stands. Increasing row spacing significantly influenced of growth, yield attributes and yield characters. Number of plants per unit area influenced plant size, yield components and ultimately the seed yield. Both over and under plant densities resulted significant yield decrease [7].

2. MATERIALS AND METHODS

The experiment carried out during *Rabi* season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (UP.), India. The site is located at 25^o 39’ 42’’N latitude, 81^{o}67’ 56” E longitude and 98 m altitude above the mean sea level (MSL). The soil texture in the experimental plot was sandy loam, with a practically neutral soil reaction (PH 7.1), low in organic carbon (0.36%), available N (171.49 kg ha^{-1}), available P (15.3 kg ha^{-1}) and available K (232.4 kg ha^{-1}The crop was sown on 25 October 2021 using variety PUSA-362. The experiment was set up in a Randomized Block Design with three replications and nine treatments in total of 27 plots *Viz.,* T1: NAA at 50 ppm + 20 cm x 10 cm, T2: NAA at 50 ppm + 30 cm x 10 cm, T3: NAA at 50 ppm + 30 cm x 10 cm, T4: GA3 at 10 ppm + 20 cm x 10 cm, T5: GA3 at 10 ppm + 30 cm x 10 cm, T6: GA3 at 10 ppm + 40 cm x 10 cm, T7: Salicylic acid at 100 ppm + 20 cm x 10 cm, T8: Salicylic acid at 100 ppm + 30 cm x 10 cm and T9: Salicylic acid at 100 ppm + 40 cm x 10 cm. Urea, single super phosphate (SSP), and muriate of potash (MOP) were applied as a basal dose in all plots, and the treatments were applied as foliar spray at 20 and 40 days following sowing in the corresponding plots. The growth parameters were measured at 20, 40, 60, 80, 100, 120 days after sowing (DAS), as well as at harvest stage, from randomly selected plants in each treatment. A statistical analysis was performed, and the mean was compared at a 5% probability level of significance [8].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters Plant Height

At 100 DAS, treatment with GA_3 at 10 ppm + 30 cm x 10 cm was recorded significantly highest plant height (56.84 cm), However, SA at 100 ppm + 20 cm x 10 cm (56.32 cm) was statistically at par with treatment GA_3 at 10 ppm + 30 cm x 10 cm. The increase in plant height might be due to the fact that as the spacing among plants decreased the interplant competition for light increased, while sparsely populated plants intercepted sufficient sunlight that enhanced the lateral growth which were in conformation with the results of [9],[10].

3.1.1 Number of nodules per plant

PGRs and plant spacing significantly influenced the number of nodules per plant. However, the highest number of nodules per plant (23.33) was recorded with the treatment of GA_3 at 10 ppm + 30 cm x 10 cm at 100 DAS, which was statistically similar (22) with the SA at 100 ppm + 20 cm x 10 cm. The application of GA_3 increased nodule number in all chickpea varieties at 40, 60 and 80 DAS compared to control condition. From the results of the present study, it was observed that the number of nodules per plant was higher in all chickpea varieties at 60 DAS than at 40 DAS [141.

3.1.2 Dry weight (g/plant)

The treatment with GA_3 at 10 ppm + 30 cm x 10 cm recorded the highest plant dry weight (17.45 g) at 100 DAS, which was statistically at par with treatment SA at 100 ppm + 20 cm x 10 cm (17.4g). The dry matter production increased steadily with advancing growth stages and reached the maximum at harvest. The dry matter production (kg/ha) was found to be more with closer spacing, which could be attributed to higher population and accumulation of nutrients per unit area compared to wider spacing. This is in accordance with earlier findings of [12].

3.2 Yield Attributes

3.2.1 Number of pods/plant

The statistical analysis of pods per plant revealed the enormous impact of pods forming period. The treatment of GA3 @10ppm + 30 cm x 10 cm resulted in a significant and maximal no of pods per plant (65.50). The statistical parity between SA at 100 ppm + 20 cm x 10 cm (64.86) and GA3 @10ppm + 30 cm x 10 cm was achieved Row spacing had significantly effect on yield attributes viz., number of pods per plant, seed yield per plant and seed index. All these yield attributes were remarkably high with closer row spacing than those with wider row spacing. Number of seeds per pod and harvest index vary with row spacing. Increase in yield might be due to sufficient plant population which caused for higher growth and development along with proper utilization of production inputs and ultimate results was maximum yield was reported by Neeraj and Pandey [13].

3.2.2Number of seeds/pod

The statistical analysis of the amount of seeds per pod revealed a significant influence. Significant and the largest number of seeds per pod were recorded in treatment of GA3 @10ppm + 30 cm x 10 cm (1.84). The statistical parity between SA at 100 ppm + 20 cm x 10 cm (1.68) and GA3 @10ppm + 30 cm x 10 cm was achieved. Number of seeds per pod is considered an important factor that directly imparts an exploiting potential recovery in leguminous crops. That it was significantly affected by row spacing. Maximum number of seeds per pod were recorded in 45 cm row spacing followed by 15/45 cm row spacing reported by Khan et al. [14].

3.2.3 Test weight (g)

Maximum Test weight (190.84 g) was recorded with the treatment GA3 at 10 ppm + 30 cm x 10 cm which was superior over rest of all treatments However no other treatment achieved statistical parity. Foliar application of GA3 increased the 100-seed weight in all chickpea varieties at different magnitude [11].

3.3 Yield and Harvest Index

3.3.1 Seed yield (t/ha)

Different combination of plant growth regulators and spacing The treatment GA3 @ 10ppm + 30 cm x 10 cm (2.07 t/ha) produced maximum seed yield, but SA@100 ppm + 20 cm x 10 cm was shown to be statistically equivalent to GA3 @10ppm + 30 cm x 10 cm. It could be stated that the beneficial effect of GA3 on improving yield might be due to the translocation of more photo assimilates to the seeds. Results published by Khan et al. [15] regarding seed yield under GA3 are in line and support the results of the present study.

3.3.2 Stover yield (t/ha)

The administration of plant growth regulators and spacing had a considerate impact on the chickpea crops Stover yield. Although GA3 @10ppm + 30 cm x 10 cm produced the highest stover production (3.11 t/ha), SA@100 ppm + 20 cm x 10 cm was determined to be statistically

Table 1. Effect of Plant growth regulators and spacing on Growth parameters in Chickpea

Treatments	Plant height (cm)	No. of nodules/plant	Dry weight (g/plant)
1. NAA at 50 ppm + 20 cm x 10 cm	50.12	19.66	16.32
2. NAA at 50 ppm + 30 cm x 10 cm	51.64	20.00	16.56
3. NAA at 50 ppm + 40 cm x 10 cm	46.14	18.00	15.23
4. GA3 at 10 ppm + 20 cm x 10 cm	52.46	21.33	17.18
5. GA3 at 10 ppm + 30 cm x 10 cm	56.84	23.33	17.45
6. GA3 at 10 ppm + 40 cm x 10 cm	56.01	20.33	16.84
7. Salicylic acid at 100 ppm + 20 cm x 10 cm	56.32	22.00	17.4
8. Salicylic acid at 100 ppm + 30 cm x 10 cm	47.54	18.67	15.64
9. Salicylic acid at 100 ppm + 40 cm x 10 cm	48.48	19.00	15.87
F-Test	S	S	S
Sem±	0.20	0.60	0.02
CD at 5%	0.60	1.79	0.06

Table 2. Effect of Plant growth regulators and spacing on yield attributes in Chickpea.

Treatments	No. of pods/plant	No. of seeds/pod	Test weight	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
NAA at 50 ppm + 20 cm x 10 cm	59.67	1.28	190.23	2.0	3.50	39.60
NAA at 50 ppm + 30 cm x 10 cm	60.67	1.44	189.71	2.0	3.08	39.37
NAA at 50 ppm + 40 cm x 10 cm	56.67	1.47	189.82	2.0	3.09	39.29
GA3 at 10 ppm + 20 cm x 10 cm	63.67	1.49	189.89	2.04	3.05	40.07
GA3 at 10 ppm + 30 cm x 10 cm	65.50	1.84	190.84	2.07	3.11	40.19
GA3 at 10 ppm + 40 cm x 10 cm	63.18	1.59	190.38	2.00	3.05	39.60
Salicylic acid at 100 ppm + 20 cm x 10 cm	64.86	1.68	189.53	2.06	3.07	40.15
Salicylic acid at 100 ppm + 30 cm x 10 cm	57.33	1.48	190.08	2.03	3.09	39.64
Salicylic acid at 100 ppm + 40 cm x 10 cm	58.67	1.46	190.24	2.00	3.07	39.44
F-Test	S	S	NS	S	S	S
Sem±	0.33	0.05	0.66	0.01	0.01	0.01
CD at 5%	0.99	0.16	-	0.04	0.04	0.03

equivalent to GA3 @10ppm + 30 cm x 10 cm Foliar application of GA3 during stem elongation positively affected straw dry matter production as GA3 has a positive regulatory effect on vegetative growth of plant. The increased biological yield might be due to increase of leaf area results in increased photosynthesis rate. Findings concluded by Nabi et al. [16] support the results of the present study.

3.3.3 Harvest index (%)

Harvest index (40.19 %) was recorded significantly highest with treatment GA3 at 10 ppm + 30 cm x 10 cm which was superior over rest of all treatments SA at 100 ppm + 20 cm x 10 cm (40.15 %) were statistically at par with treatment GA3 at 10 ppm + 30 cm x 10 cm Harvest index was higher at control condition compared to GA3 applied condition because GA3 had more positive regulatory effect on straw dry matter production than seed yield. GA3 increased the both stover yield and seed yield but the increasing rate was more in stover yield than seed yield [11].

4. CONCLUSION

On the basis of one year experimentation the treatment with application of GA3 at 10 ppm + 30 cm x 10 cm was found to be highest plant height (56.84 cm) ,dry weight (17.18 g), no of nodules per plant (23.33) and produced the highest seed yield (2.07 t/ha),stover yield (3.11 t/ha).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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