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Physiological response of plant growth regulator and micronutrient in chickpea

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Abstract
A study was carried out to evaluate the foliar sprays of IAA, kinetin and boron on morpho-physiological and yield contributing parameters of chickpea. The treatments included in this experiment were (T_1) control, (T_2) 40 ppm IAA, (T_3) 10 ppm kinetin, (T_4) 5000 ppm boron, (T_5) 40 ppm IAA + 10 ppm kinetin, (T_6) 10 ppm kinetin + 5000 ppm boron, (T_7) 40 ppm IAA + 5000 ppm boron and (T_8) 40 ppm IAA + 10 ppm kinetin + 5000 ppm boron. Experiment was laid out in randomized block design with three replications and eight treatments at research farm of Agricultural Botany Section, College of Agriculture, Nagpur. Observations about morpho-physiological parameters such as plant height, number of branches, leaf area, leaf area index and total dry weight plant^{-1} were recorded. Observations on yield and yield contributing parameters like 100 seed weight, number of pods, seed yield plant^{-1}, plot^{-1}, ha^{-1} and harvest index were recorded. From overall results, it can be stated that foliar application of IAA 40 ppm + kinetin 10 ppm + boron 5000 ppm at 20 and 40 DAS could be considered as most suitable concentration and time to enhance growth and yield of chickpea.

Keywords: Chickpea, foliar spray, yield contributing parameters, IAA, Kinetin, Boron

Introduction
Indian agriculture is diverse in nature in terms of agro-ecology and natural resource availability. Self-sustainable agriculture systems have evolved with time by integration of pulses as they enrich the soil through symbiotic nitrogen fixation from atmosphere. Pulses are important constituents of the Indian diet and supply a major part of the protein requirement, particularly for vegetarians. Among the pulses, chickpea is an important *Rabi* crop of India. Chickpea belongs to genus *Cicer*, it comprises one cultivated species of the chickpea (*Cicer arietinum* L.) and 42 wild species. The malic and oxalic acid present in green leaves is very useful for recovering from intestinal disorder. In India, chickpea Occupies 65% of area and contributes to 70% of total *Rabi* pulse production. More than 98% of chickpea production is realized from 10 states of Madhya Pradesh (37%), Rajasthan (17%), Maharashtra (16%), Karnataka (7%), Uttar Pradesh (6%), Andhra Pradesh (5%), Gujarat, Chhattisgarh (each 3%), Jharkhand (2%) & Telangana (1%). According to the International Crop Research Institute for the Semi-Arid Tropics, chickpea seeds contain on an average 23% protein, 64% total carbohydrate (47% starch, 6% soluble sugar, 5% fat, 6% crude fiber) and 3% ash. They also reported a high mineral content of phosphorus 340 mg, calcium 190 mg, magnesium 140 mg, iron 7 mg and zinc 3 mg per 100 g (Chauhan *et al.* 2018) [2]. Due to low production cost, wide climate adaptation, use in crop rotation and atmospheric nitrogen fixation ability, chickpea is an important legume plant in a sustainable agricultural system. It is one of the earliest cultivated legumes: 7,500-year-old remains have been found in the Middle East. (Hoque *et al.* 2021) [5].

Materials and Methods
In the *Rabi* season of 2022-23, the investigation was carried out at agriculture research farm, part of the Department of Agricultural Botany at PDKV University in Akola, Maharashtra (INDIA). The temperature ranged anywhere from 4.1 °C to 37.3 °C while the crop was actively growing. Likewise, the minimum and highest relative humidity ranged from 39.42% to 62.04%. At the same time, the crop season's overall rainfall totaled 129.4 mm. The research work was done successfully with Randomized block design (RBD) in three replications and eight treatments comprising of different doses of IAA, kinetin and boron. The chickpea variety JAKI-9218 was sown on November 28, 2022 The experiment comprised eight treatments *viz.*, T_1: control, T_2: 40 ppm IAA, T_3: 10 ppm kinetin, T_4: 5000 ppm boron, T_5: 40 ppm IAA + 10

ppm kinetin, T_6: 10 ppm kinetin + 5000 ppm boron, T_7: 40 ppm IAA + 5000 ppm boron and T_8: 40 ppm IAA + 10 ppm kinetin + 5000 ppm boron. The basal dose of 25 kg N and 50 kg P_2O_5 was given through urea and single super phosphate ha^{-1} at the time of sowing, respectively. The gross plot size was 2.20 m x 2.00 m and net plot size was 1.60 m x 1.80 m with spacing of 30 cm x 10 cm. Five plants from each plot were selected randomly and data were collected at 30, 45, 60 and 75 DAS on morpho-physiological characters. The data were analysed statistically by following Panse and Sukhathme (1978) [13].

Results and Discussion

Plant height: Plant height at 75 DAS were found statistically significant and range recorded was 45.20 to 60.87 cm. The significantly superior plant height was registered in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). The increase in plant height might be due to the role of IAA in regulating growth and developmental process. Kinetin plays crucial role as promoter of cell division and act in the induction and development of meristematic tissues, thus increased the shoot length and number of nodes. Boron also increases plant height by formation of new plant cells, cell elongation, tissue differentiation and elevated level of IAA which in turn, leads to an increase in plant height. These findings were supported by Menaka *et al.* (2018) [10] who recorded the highest plant height (49.0 cm) with the spray of 10 ppm kinetin + 0.25% boron in chickpea. Manpuhro and Dawson (2023) [9] showed that treatment with foliar application of IAA (90 ppm) and boron (1.5%) recorded higher growth with plant height (185.70 cm) in maize.

Number of branches $plant^{-1}$: More number of branches $plant^{-1}$ is one of the main parameter which contributes to high yield. At 75 DAS effective enhancement in number of branches $plant^{-1}$ was obtained in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). The increased number of branches with kinetin might be due to its counteracting role in apical dominance. These results are in accordance with Menaka *et al.* (2018) [10] who stated that spray of 10 ppm kinetin resulted in higher number of branches than all other treatments and which was increased by 67.3% over control. Prasad *et al.* (2023) [14] data shows that number branches $plant^{-1}$ was significantly increase under 50 ppm IAA in lentil.

Days to flower initiation

The days to flower initiation was determined by recording the number of days after sowing to at least one open flower. Treatments of IAA, kinetin and boron found delay flower initiation when compared with treatment T_1 (control) and rest of the treatments. Prasad *et al.* (2023) [14] reported that application of 50 ppm IAA delayed the initiation of flowering in lentil. A perusal of data clearly indicates that application of IAA delayed the flowering by 5 days over the control.

Total dry weight $plant^{-1}$

It determines source-sink relationship and depends upon the net gain in processes on anabolism and catabolism of plant. An increase in total dry matter (TDM) was noticed with increased age of the crop. All the treatments differed significantly in influencing total dry matter production. The application of nutrients and plant growth regulators helps in improving the canopy structure and also increases productivity through the manipulation of the source-sink relationship. These might be the reasons for the increase in dry matter production in the present investigation. Hussain *et al.* (2020) [6] result indicate that shoot fresh and dry weights of chickpea plant were increased significantly at seedling and vegetative stages by the foliar applications of IAA and GA_3. Manpuhro and Dawson (2023) [9] results showed that foliar application of IAA at 90 ppm + boron at 1.5% was recorded with significant dry weight (182.15 g/plant) over all the treatments in maize.

Days to maturity: Treatments of IAA, kinetin and boron delayed maturity when compared with treatment T_1 (control) and rest of the treatments. Kassem *et al.* (2009) [7] observed significant reduction in earliness % obtained by the treatment of 50 ppm IAA. It could be a result of its enhancing effect on plant vegetative growth which might delay crop maturity in cotton. Negi *et al.* (2023) [11] reported that application of growth regulators IAA @ 50 ppm and IAA @ 25 ppm showed delay in attaining maturity by 4 and 3 days respectively in comparison to the control.

Leaf area $plant^{-1}$

Area of leaf depends upon the number and size of leaves. It is an important parameter in determining plant productivity. Leaf area $plant^{-1}$ gradually increased from 30 DAS and reached a maximum value at 75 DAS in all the treatments. All the growth regulators stimulated significantly the leaf area at successive stages of growth because it improves the transport mechanism and utilization process for stimulation of leaf growth. A field experiment was conducted by Verma *et al.* (2018) [17] who studied the effect of 40 ppm IAA and 10 ppm kinetin foliar application on leaf area of chickpea and reported that the application of 40 ppm IAA was increases the leaf area $plant^{-1}$. Negi *et al.* (2023) [11] studied the effect of foliar sprays of IAA on the growth of chickpea. The data revealed that maximum significant increase in leaf area $plant^{-1}$ (cm^2) was showed by IAA @ 50 ppm over control. Least increase in this aspect was shown by growth regulator kinetin @ 5 ppm over control in all the crop growth stages.

Leaf Area Index

Leaf Area Index is the ratio of the total area of all leaves on a plant to the area of ground covered by the plant. LAI is related to photosynthesis and biomass production. Significantly maximum LAI was registered in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). These results are in accordance with the findings of the following scientists. Newaj *et al.* (2002) [12] investigated a field experiment to study the effect of foliar application of IAA on the growth analysis of mung bean. The results exhibited that foliar application of IAA was found to be statistically significant and superior in increasing the LAI at all the growth stages. Awadalla *et al.* (2018) [1] examined the influence of IAA and kinetin on the growth of faba bean. The treatment of 75 ppm IAA gave high values of 4.18 for leaf area index and also, kinetin at a level of 20 and 40 ppm recorded significantly higher value of leaf area index.

Yield and yield attributing characters

Seed yield and its related parameters in chickpea were influenced by the application of growth regulator which have different influence on the allocation of assimilates between vegetative and reproductive organs. Data on foliar spray of IAA, kinetin and boron effect on yield and yield contributing

characters like number of pods plant^{-1}, pod weight plant^{-1}, seed yield plant^{-1}, plot^{-1}, ha^{-1}, test weight and harvest index are presented, and results obtained are discussed under following headings.

Number of pods plant^{-1}

Pod is the output of total metabolic activities taking place in plant body. It differs significantly among the treatments. It varied from a minimum 39.84 to maximum of 56.66 pods plant^{-1}. Among all the treatment significantly highest number of pods plant^{-1} was registered in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). El-Awadi *et al.* (2017) [3] reported that enhancement of plant growth by IAA application may be attribute to its role in enlarging leaves and increasing photosynthetic activities in plants and activating the translocation of carbohydrates during their synthesis thus leading to increase crop yield. Menaka *et al.* (2018) [10] stated that boron spray enhances the pod yield as evident from the study. This might be due to its positive influence on number of pods plant^{-1} and pod set and mobilization of assimilate reserves to the sink. Tiwari and Kushwaha (2020) [16] advocated the beneficial effects of boron on yield attributes and reported that the number of pods plant^{-1} was found significantly superior with the spray of boron 0.25 ppm at flower initiation.

Pods weight plant^{-1}: At harvest the range of pods weight plant^{-1} was observed in the range of 10.56-15.34 g. El-Saeid *et al.* (2010) [4] indicated that application of 25 and 50 mg L^{-1} IAA significantly increased weight of pods in cow pea. Mahadule and Sale (2018) [8] observed that foliar application of boron (0.33 mg lit^{-1}) showed enhancement in pod dry weight plant^{-1} (7.23 g) of French bean.

Seed yield: It is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product. Source-sink relation contributes to the seed yield. The range of increase in seed yield plant^{-1}, plot^{-1} and ha^{-1} were 6.97 g, 0.56 kg and 1959 kg in treatment T_1 (control) and 9.24 g, 0.68 kg and 2354 kg in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) respectively. Field experiments were conducted by Reedy and Majumder (2004) [15] revealed that the foliar application of 0.02% B + 40 ppm IAA gave increased yield (11.25 q/ha) in black gram. Negi *et al.* (2023) [11] shows that all the PGRs applied significantly increased the grain yield plant^{-1} over the control with most effective results obtained with the application of IAA @ 50 ppm in chickpea. Among all these growth regulators, kinetin @ 5 ppm was found to be least effective.

Test weight: The range of test weight was 19.77 to 22.67 g among the treatments. The present study demonstrated that foliar application of IAA, kinetin and boron alone or in combination significantly increased the 100-seed weight over control. Recorded observation are comparable with observation of Menaka *et al.* (2018) [10] found that 0.25% boron foliar spray at 45 DAS in chickpea possessed the highest test weight (33.9 g), which was resulted an increase of 12.6% in test weight over control and Prasad *et al.* (2023) [14] revealed that foliar application of IAA (25 and 50 ppm) was found significantly superior in 100-seed weight in lentil compared to control and rest of all other treatments.

Harvest Index

Harvest index (HI) indicates ability of genotypes in converting relatively large part of dry matter in to the form of economic product. The range of increased harvest index was 39.03% in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) to 27.71% in T_1 (control).

Table 1: Effect of IAA, kinetin and boron on Plant height (cm), Number of branches plant^{-1}, Days to flower initiation and Days to maturity

Details of treatments	Plant height (cm)				Number of branches plant^{-1}				Days to flower initiation	Days to maturity
	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS		
T_1 (Control)	20.39	26.43	37.20	45.20	1.33	3.07	4.33	5.07	34.47	97.47
T_2 (40 ppm IAA)	25.85	34.67	46.89	54.43	1.80	3.13	5.07	5.47	37.27	104.10
T_3 (10 ppm Kinetin)	24.96	33.80	45.27	52.74	2.20	3.53	5.47	5.93	35.80	100.33
T_4 (5000 ppm Boron)	23.78	32.91	43.25	50.17	1.67	3.00	4.93	5.33	34.93	99.20
T_5 (40 ppm IAA + 10 ppm Kinetin)	27.49	36.13	49.64	58.51	2.33	3.80	5.60	6.13	38.27	107.03
T_6 (10 ppm Kinetin + 5000 ppm Boron)	26.35	35.90	47.09	56.25	2.47	4.07	5.80	6.47	36.87	102.67
T_7 (40 ppm IAA + 5000 ppm Boron)	28.13	37.04	50.45	60.15	2.00	3.33	5.27	5.67	40.20	110.27
T_8 (40 ppm IAA + 10 ppm Kinetin + 5000 ppm Boron)	28.42	37.60	50.78	60.87	2.80	4.40	5.93	6.80	41.53	112.60
SE (m)±	1.59	2.13	2.70	3.20	0.13	0.22	0.31	0.35	0.62	1.84
CD at 5%	4.82	6.47	8.19	9.71	0.38	0.66	0.94	1.05	1.87	5.59

Table 2: Effect of IAA, kinetin and boron on Total dry weight plant^{-1}, Leaf area plant^{-1} and Leaf area index

Details of treatments	Total dry weight plant^{-1} (g)				Leaf area plant^{-1} (cm^2)				Leaf area index			
	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS
T_1 (Control)	0.58	1.04	4.52	8.84	83.67	129.26	300.06	532.70	0.275	0.431	0.993	1.775
T_2 (40 ppm IAA)	0.92	1.76	5.80	11.30	99.49	182.62	411.73	674.23	0.332	0.609	1.372	2.247
T_3 (10 ppm Kinetin)	0.79	1.51	5.13	10.04	87.53	161.58	346.46	641.80	0.292	0.538	1.154	2.139
T_4 (5000 ppm Boron)	0.67	1.34	4.93	9.77	85.98	157.79	328.60	590.77	0.287	0.526	1.095	1.969
T_5 (40 ppm IAA + 10 ppm Kinetin)	0.99	1.88	6.02	12.14	102.08	186.49	418.66	684.63	0.341	0.622	1.395	2.282
T_6 (10 ppm Kinetin + 5000 ppm Boron)	0.86	1.66	5.57	10.63	95.98	172.83	396.20	657.53	0.320	0.576	1.320	2.192
T_7 (40 ppm IAA + 5000 ppm Boron)	1.09	2.01	6.39	12.74	106.03	194.23	426.33	696.00	0.353	0.647	1.421	2.319
T_8 (40 ppm IAA + 10 ppm Kinetin + 5000 ppm Boron)	1.15	2.08	6.59	13.22	107.02	196.22	434.72	702.90	0.357	0.654	1.449	2.343
SE (m)±	0.05	0.10	0.34	0.65	5.54	10.12	22.41	34.82	0.019	0.034	0.075	0.116
CD at 5%	0.17	0.31	1.04	1.97	16.82	30.71	67.99	105.63	0.057	0.102	0.226	0.352

Table 3: Effect of IAA, kinetin and boron on yield and yield attributing characters

Details of treatments	Number of pods plant^{-1}	Pods weight plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (kg)	Seed yield ha^{-1} (kg)	Test weight (g)	Harvest index (%)
T_1 (Control)	39.84	10.56	6.97	0.56	1959	19.77	27.71
T_2 (40 ppm IAA)	45.55	12.27	7.73	0.59	2052	20.83	31.18
T_3 (10 ppm Kinetin)	42.76	11.84	7.37	0.58	2018	20.01	29.51
T_4 (5000 ppm Boron)	49.88	13.06	8.48	0.64	2201	21.34	35.56
T_5 (40 ppm IAA + 10 ppm Kinetin)	48.24	12.73	8.19	0.62	2156	21.14	33.06
T_6 (10 ppm Kinetin + 5000 ppm Boron)	53.36	13.89	8.61	0.66	2279	21.76	36.29
T_7 (40 ppm IAA + 5000 ppm Boron)	54.63	14.19	8.98	0.67	2304	22.44	37.75
T_8 (40 ppm IAA + 10 ppm Kinetin + 5000 ppm Boron)	56.66	15.34	9.24	0.68	2354	22.67	39.03
SE (m)±	2.96	0.75	0.47	0.03	869	0.63	2.04
CD at 5%	8.99	2.29	1.43	0.08	264	1.91	6.19

Conclusions

From the present research results, it can be concluded that foliar sprays of 40 ppm IAA + 10 ppm kinetin + 5000 ppm boron at 20 and 40 DAS were found to be most effective in increasing the translocation of assimilates toward the pod development, dry matter production and its efficient partitioning, various morpho-physiological characters, growth functions and yield attributes etc. of chickpea var. JAKI-9218. Based on the result obtained from the results of the investigation, it may be assumed that morpho-physiological and yield contributing characters improved in chickpea by using foliar sprays of PGRs and micronutrient, which ultimately increased the production of this crop and would help in farmers for obtaining higher yields of chickpea as well as breeders in selecting breeding material for evolving high yielding varieties in chickpea.

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