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INFLUENCE OF IAA, KINETIN AND BORON ON BIOCHEMICAL PARAMETERS, YIELD AND YIELD ATTRIBUTES OF CHICKPEA

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ABSTRACT

In India, 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. A field experiment was conducted during *rabi* 2022-23, to study the influence of IAA, kinetin and boron on biochemical parameters, yield and yield attributes of chickpea var. JAKI-9218. 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. Biochemical parameters such as total chlorophyll content in leaf, protein content in seeds and nitrogen content in leaves were estimated. 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. It is inferred from the data 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 biochemical and yield contributing parameters of chickpea. From overall results, it can be stated that foliar application of IAA, kinetin and boron individually or in combination with different concentrations improved the biochemical and yield contributing parameters in attaining better seed yield in the present investigation.

(Key words: Chickpea, pulses, biochemical parameters, IAA, kinetin, boron)

INTRODUCTION

Chickpea (*Cicer arietinum* L.) belongs to genus *Cicer*, tribe cicereae, family Fabaceae, subfamily Papilionaceae having chromosome number 2n=14. It is the second most important *rabi* pulse crop after pigeon pea in the world for human diet and other use which has high digestible protein, iron, vitamin B and C. Its leaves contain malic acid which is very useful as stomach ailments and blood purification (Karad *et al*., 2022). It is also used as a feed for livestock and has a significant role in farming system as a substitute for fallow in cereal rotations, where it contributes to the sustainability of production and reduce the need for nitrogen fertilizer through fixing atmospheric nitrogen. The crop has the capacity to fix 140 kg N ha^{-1} in a growing season. Among pulses, for production, chickpea occupies the first position in India and third position at global level.

The plant growth regulators are organic compounds other than the nutrients which in small concentration influences the physiological processes of plants. They are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates there by helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops. The effect of plant growth regulators is also influenced by light, temperature, moisture, nutrients and environmental factors (Salunke *et al*., 2008).

In the absence of micronutrients, plant show physiological disorders which eventually lead to reduction in crop yield and quality. In micro nutrients, boron is an essential micronutrient indispensable for the normal growth and development of plants. It plays an important role in flowering and fertilization process, boosting yield and quality of crop produce. Boron also involved in sugar transfer, carbohydrate metabolism, as well as indole acetic acid and ascorbate phenol metabolism. Boron is closely related to the function that calcium performs in the plant. It has also been suggested that boron is necessary for the lignin polymerization process. Since, there is an association between flavonoids content and lignin production (Kaur *et al*., 2023). It is recognized as one of the most commonly deficient micronutrients in soils as its deficiency has been reported in 132 crops over 80 countries. The deficiency of

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boron in soils is a major cause of crop yield reduction in China, India, Nepal and Bangladesh. Considering above facts present investigation was undertake to study the influence of IAA, kinetin and boron on biochemical parameters, yield and yield attributes of chickpea.

MATERIALS AND METHODS

In the *rabi* season of 2022-23, the investigation was carried out at agriculture research farm, part of the Section of Agricultural Botany at college of agriculture in Nagpur, Maharashtra. 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. Immediately after germination gap filling was carried out on 9th December, 2022. Only one plant was kept at each hill and others were removed by thinning after full emergence to maintain a required number of plants $plot^{-1}$. Intercultural operations were also undertaken as and when required. Spraying of IAA, kinetin and boron was done at 20 and 40 DAS with hand sprayer. 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 biochemical characters. Total chlorophyll content of oven dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982). Nitrogen content in leaves was estimated by micro kjeldahl's method as given by Somichi *et al.* (1972). Protein content in seed was estimated by micro kjeldahl's method as given by Somichi *et al.* (1972) for nitrogen determination in seeds and it was converted to crude protein by multiplying N percentage with the factor 6.25. Test weight, number of pods, seed yield $plant^{-1}$, $plot^{-1}$, ha^{-1} and harvest index were recorded and calculated after harvest. The data were analysed statistically by following Panse and Sukhathme (1954).

RESULTS AND DISCUSSION

Biochemical parameters

The biochemical parameters studied with respect to chlorophyll and nitrogen content in leaves as well as protein content in seed estimated at various stages of observations have been presented below.

Total chlorophyll content in leaf (mg g^{-1})

The estimation of chlorophyll pigments is important because increase in chlorophyll leads to increase in production of photosynthates and as a result of more photosynthetic production and accumulation improved growth and development of plant occur and therefore improved growth and development lead to higher crop yield. Data on leaf chlorophyll content in leaf gave significant variation at 30, 45, 60 and 75 DAS.

At 30 DAS total chlorophyll content in leaf ranged between 1.02-1.20 mg g^{-1}. Significantly highest chlorophyll content was observed in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatments T_5 (40 ppm IAA + 10 ppm kinetin) and T_6 (10 ppm kinetin + 5000 ppm boron).

At 45 DAS total chlorophyll content in leaf ranged between 1.48-1.98 mg g^{-1}. Significantly highest chlorophyll content was observed in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatments T_5 (40 ppm IAA + 10 ppm kinetin), T_6 (10 ppm kinetin + 5000 ppm boron) and T_7 (40 ppm IAA + 5000 ppm boron).

At this stage (60 DAS) total chlorophyll content in leaf varied from 2.19-3.16 mg g^{-1}. The significantly maximum chlorophyll noticed in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatments T_5 (40 ppm IAA + 10 ppm kinetin), T_6 (10 ppm kinetin + 5000 ppm boron), T_7 (40 ppm IAA + 5000 ppm boron), T_2 (40 ppm IAA) and T_3 (10 ppm kinetin).

At 75 DAS significantly highest total chlorophyll content in leaf was registered in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatment T_5 (40 ppm IAA + 10 ppm kinetin) and T_6 (10 ppm kinetin + 5000 ppm boron).

The results were in compliance with the findings of Kassem *et al.* (2009), who recorded highest chlorophyll concentration by the application of the lower kinetin level (10 ppm) alone or with the application of 25 ppm IAA. IAA is known to stimulate photosynthetic rate through enhancing chlorophyll content in cotton. Taslima *et al.* (2011) studied the growth and yield of cowpea. The results of the experiment revealed that chlorophyll a and b content in leaves increased due to foliar spray of IAA treatments with different concentrations (20 ppm, 40 ppm, 60 ppm and 80 ppm) at three different stages.

Protein content in seeds (%)

Protein content of the seed is one of the considerable factor for seed quality determination. Data regarding protein content was significantly highest in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) *i.e.* 22.72 %, while control (T_1) treatment recorded minimum *i.e.* 20.35 %. However, it was at par with treatments T_5 (40 ppm IAA + 10 ppm kinetin), T_6 (10 ppm kinetin + 5000 ppm boron), T_7 (40 ppm IAA + 5000 ppm boron), T_2 (40 ppm IAA) and T_3 (10 ppm kinetin).

The increase in chemical composition of seeds due to applying IAA and kinetin may be due to its role on regulating ions and modifying the uptake movement and

metabolism of nutrients within the plant tissues, besides activating the photosynthetic process through their effect on some enzymatic actions, leading to the increase in protein accumulation. A field experiment was carried out by Taslimaa *et al.* (2011) to study the effects of foliar application of IAA on quantitative and qualitative yield of cowpea, results showed that highest protein content (22.8%) was recorded from the seeds of the cowpea plants treated with 80 ppm IAA. Awadalla *et al.* (2018) reported that seeds produced from plants treated with IAA at 75 ppm possessed the highest values of 29.86% for protein in faba bean.

Nitrogen content in leaves (%)

It is a major component of amino acids, the building block of proteins. The nitrogen present mostly as protein is constantly moving and concentration of nitrogen is found in young leaves, tender plant tissues like tips of shoots, buds and new leaves.

Among all the treatments significantly maximum nitrogen content at 30, 45, 60 and 75 DAS was recorded in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatments T_5 (40 ppm IAA + 10 ppm kinetin) and T_6 (10 ppm kinetin + 5000 ppm boron).

Younger leaves and developing organs such as seeds act as strong sink demand and may heavily draw nitrogen for their growth from older leaves. So, a decrease in the nitrogen content may occur in later stages of plant growth. Similar results were obtained by the following scientist. Fatima *et al.* (2008) reported that higher nitrogen status of the plants is always correlated with a higher endogenous level of cytokinin in chickpea.

Awadalla *et al.* (2018) revealed that the seeds produced from the plants of faba bean treated with IAA at 75 or 50 ppm (4.84% N) and kinetin 40 and 20 ppm (4.76% N) had significant increase in nitrogen.

Menaka *et al.* (2018) observed significant differences at all stages of plant growth in nitrate reductase activity (NAR) of chickpea leaves with the influence of ethrel, kinetin and boron. At 45 DAS, significantly higher value recorded with spray of 10 ppm kinetin.

Yield and yield attributing characters

The present investigation was carried out to study the influence of IAA, kinetin and boron on yield and yield attributing parameters *viz.,* number of pods plant^{-1}, number of seeds plant^{-1}, seed yield, test weight and harvest index.

Number of pods plant^{-1}

The range of number of pod plant^{-1} after harvest was 39.84-56.66. All treatments were found significantly superior over control (T_1). The significantly highest number of pods plant^{-1} was registered in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron). However, it was at par with treatments T_7 (40 ppm IAA + 5000 ppm boron), T_6 (10 ppm kinetin + 5000 ppm boron), T_4 (5000 ppm boron) and T_5 (40 ppm IAA + 10 ppm kinetin).

Reedy and Majumder (2004) revealed that the foliar application of 0.02% B + 40 ppm IAA gave increased number of flowers plant^{-1} (56.77) and greater number of pods plant^{-1} (25.93) in black gram. Prasad *et al.* (2023) revealed that foliar application of 50 ppm IAA followed by 5 ppm cytokinin in chickpea showed highest number of pods plant^{-1}.

Number of seeds plant^{-1}

A close perusal of data on number of seeds plant^{-1} indicated that there was significant difference due to the different treatments. It varied from a minimum 41.17 to maximum of 59.03 seeds plant^{-1}. Data regarding number of seeds plant^{-1} was subjected to statistical analysis and it was found to be significant. Foliar application of 40 ppm IAA + 10 ppm kinetin + 5000 ppm boron (T_8) gave significantly maximum number of seeds plant^{-1}. However, it was at par with treatments T_7 (40 ppm IAA + 5000 ppm boron), T_6 (10 ppm kinetin + 5000 ppm boron), T_4 (5000 ppm boron) and T_5 (40 ppm IAA + 10 ppm kinetin). A field experiment was conducted by El-Saeid *et al.* (2010) indicated that application of 25 and 50 mg l^{-1} IAA significantly increased number of seeds plant^{-1} in cow pea.

Seed yield plant^{-1} (g), plot^{-1} (kg) and ha^{-1} (kg)

Seed yield is a quantitative trait which is final result of physiological activities of plant. Seed yield is the combined effect of yield attributes and physiological efficiency of plant during the present investigation. Source-sink relationship includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilate synthesis by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both.

Among the entire treatments superior seed yield plant^{-1}, plot^{-1} and ha^{-1} (9.24 g, 0.68 kg and 2354 kg) manifested in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) followed by T_7 (40 ppm IAA + 5000 ppm boron), T_6 (10 ppm kinetin + 5000 ppm boron), T_4 (5000 ppm boron) and T_5 (40 ppm IAA + 10 ppm kinetin).

Movalia *et al.* (2018) through the experimental results concluded that the application of boron @ 2 kg ha^{-1} enhanced the seed yield of green gram. Prasad *et al.* (2023) revealed that the highest seed weight plant^{-1} and seed yield (kg ha^{-1}) of lentil recorded by the application of 50 ppm IAA followed by 5 ppm cytokinin and 25 ppm IAA. Kundu (2023) reported that foliar application of 0.25 kg of B ha^{-1} in two equal splits *i.e.* 25 and 45 days after planting of potato, recorded highest plant yield (7.03 t ha^{-1}) and tuber yield (32.60 t ha^{-1}). During both stages significantly increased plant yield by 28.2% and tuber yield by 35.0% over control.

Test weight (g)

Higher photosynthesis rate, translocation and assimilation metabolites in the sink ultimately results in

increasing the size of seed. Test weight varied from 19.77 to 22.67 g among the treatments. Among all the treatments tested the highest 100 seed weight was obtained in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) over control and rest of the treatments. Next to these treatments significantly more test weight was also recorded in treatments T_7 (40 ppm IAA + 5000 ppm boron), T_6 (10 ppm kinetin + 5000 ppm boron), T_4 (5000 ppm boron), T_5 (40 ppm IAA + 10 ppm kinetin) and T_2 (40 ppm IAA).

Menaka *et al.* (2018) 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. These results are in accordance with findings of Manpuhro and Dawson (2023), who found highest 100-seed weight (24.79 g) by the application of IAA at 90 ppm + boron at 1.5% in maize.

Harvest Index (%)

The harvest index of the crop generally remains unchanged but some crucial management practices make some changes in HI. The range of harvest index was significantly maximum in treatment T_8 (40 ppm IAA + 10 ppm kinetin + 5000 ppm boron) and minimum in T_1 (control). However, it was at par with treatments T_7 (40 ppm IAA + 5000 ppm boron), T_6 (10 ppm kinetin + 5000 ppm boron), T_4 (5000 ppm boron) and T_5 (40 ppm IAA + 10 ppm kinetin).

Paul *et al.* (2021) conducted an experiment to study the response of lentil to four levels of boron and recorded maximum harvest index (53.34%) with 60% recommended dose as basal + rest 40% of boron. Manpuhro and Dawson (2023) conducted field experiment to evaluate the influence of IAA and boron on the growth and yield of maize. The results showed that foliar application of IAA (90 ppm) and boron (1.5%) recorded high harvest index (32.85%).

Table 1. Effect of IAA, kinetin and boron on leaf chlorophyll content (mg g^{-1}), nitrogen content in leaves (%) and protein content in seeds (%)

Treatments	Leaf chlorophyll content (mg g^{-1})				Nitrogen content in leaves (%)				Protein content in
	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45 DAS	60 DAS	75 DAS	seeds (%)
T_1 (Control)	1.02	1.48	2.19	1.84	1.34	1.62	2.18	2.06	20.35
T_2 (40 ppm IAA)	1.06	1.78	2.95	2.30	1.42	1.83	2.65	2.44	21.49
T_3 (10 ppm Kinetin)	1.05	1.69	2.87	2.25	1.40	1.80	2.52	2.37	21.28
T_4 (5000 ppm Boron)	1.03	1.62	2.80	2.18	1.38	1.76	2.42	2.28	20.48
T_5 (40 ppm IAA + 10 ppm Kinetin)	1.14	1.93	3.14	2.58	1.52	2.10	3.06	2.86	22.66
T_6 (10 ppm Kinetin + 5000 ppm Boron)	1.10	1.86	3.08	2.47	1.50	1.98	3.00	2.83	22.19
T_7 (40 ppm IAA + 5000 ppm Boron)	1.08	1.81	3.04	2.36	1.45	1.88	2.66	2.56	21.77
T_8 (40 ppm IAA + 10 ppm Kinetin + 5000 ppm Boron)	1.20	1.98	3.16	2.62	1.61	2.12	3.08	2.88	22.72
SE (m)±	**0.034**	**0.056**	**0.095**	**0.073**	**0.036**	**0.048**	**0.064**	**0.069**	**0.504**
CD at 5%	**0.10**	**0.16**	**0.28**	**0.22**	**0.11**	**0.14**	**0.19**	**0.20**	**1.51**

Table 2. Effect of IAA, kinetin and boron on yield and yield attributing characters

Treatments	Number of pods $plant^{-1}$	Number of seeds $plant^{-1}$(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	41.17	6.97	0.56	1959	19.77	27.71
T_2 (40 ppm IAA)	45.55	48.26	7.73	0.59	2052	20.83	31.18
T_3 (10 ppm Kinetin)	42.76	45.67	7.37	0.58	2018	20.01	29.51
T_4 (5000 ppm Boron)	49.88	52.93	8.48	0.64	2201	21.34	35.56
T_5 (40 ppm IAA + 10 ppm Kinetin)	48.24	50.81	8.19	0.62	2156	21.14	33.06
T_6 (10 ppm Kinetin + 5000 ppm Boron)	53.36	55.44	8.61	0.66	2279	21.76	36.29
T_7 (40 ppm IAA + 5000 ppm Boron)	54.63	57.76	8.98	0.67	2304	22.44	37.75
T_8 (40 ppm IAA + 10 ppm Kinetin + 5000 ppm Boron)	56.66	59.03	9.24	0.68	2354	22.67	39.03
SE (m)±	**3.001**	**3.012**	**0.478**	**0.027**	**88.21**	**0.639**	**2.065**
CD at 5%	**8.99**	**9.03**	**1.43**	**0.08**	**264**	**1.91**	**6.19**

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 various biochemical parameters and yield attributes of chickpea var. JAKI-9218. The highest per cent increase in yield (20.16 %) over control was observed by the application of 40 ppm IAA + 10 ppm kinetin + 5000 ppm boron. Next to this treatment foliar spray of 40 ppm IAA + 5000 ppm boron also enhanced yield by 17.61 % over control. From overall result it can be stated that foliar application of IAA, kinetin and boron with different concentrations might have helped in attaining better seed yield in the present investigation.

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