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Effect of bioregulators on growth and yield of chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted on Chickpea (*Cicer arietinum* L.) during *Rabi* season of 2017-18 at Agronomy Farm, Department of Agronomy, Dr. P.D.K.V., Akola to study the effect of bioregulators on growth and yield of chickpea. The experiment was laid out in FRBD with three replications and fifteen treatment combinations in each. The treatment consists of five bioregulators viz., water spray, Salicylic acid @ 50 ppm, Ethrel @ 200 ppm, Brassinosteroid @ 0.25 ppm and Nitrobenzene (20%) @ 500 ppm and three stages of application of bioregulators viz., at flower initiation, at pod formation and twice at flower initiation and pod formation stage. The result of study revealed that application of Nitrobenzene (20%) @ 500 ppm and Brassinosteroid @ 0.25 ppm remained at par and recorded higher values of all the growth characters except for root volume and root dry weight which, were not significantly influenced.

Keywords: Chickpea, bio-regulators, growth, yield attributes, stages of application

Introduction
The chickpea (*Cicer arietinum* L.) is a legume of the family Fabaceae, subfamily Faboideae. Formerly known as the gram, it is also commonly known as ceci, cece, channak or bengal gram. According to the International Crops Research Institute for the Semi-Arid Tropics chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar, 5% fat, 6% crude fibre) and 3% ash. They also reported a high mineral content of phosphorus 340 mg per 100g, calcium 190 mg per 100g, magnesium 140 mg per 100g, iron 7 mg per 100g and zinc 3 mg per 100g (Zohary *et al.* 2000 and Chauhan *et al.* 2018) [24, 4].
Plant growth regulators are well known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops. Also they can improve physiological efficiency including photosynthetic ability and can enhance the effective partitioning of accumulates from source and sink in the field crops. (Solamani *et al.* 2001 and Umabarkar *et al.* 2018) [18]. Most commonly used bioregulators includes Salicylic acid, Ethrel, Nitrobenzene and Brassinosteroid. Nitrobenzene is combination of nitrogen and plant growth regulators, extracted from seaweed. It is known to increase flowering in plant, prevent flower shedding, increase yield by 35-50%.
Nitrobenzene ($C_6H_5NO_2$) is used which is an organic compound, coming under aromatic nitro group. It helps in increasing the flower forming substances like amino acids, enzymes, vitamins, hormones, etc. It alters gibberellins, auxin, cytokinin, ethylene ratio so as to increase the flowering by more than 60% and ultimately yield upto 50% (Lone, 2009) [10].
Foliar application of Brassinosteroid when used in combination with GA_3 gives best results, increases photosynthetic activity, seed weight, pods/plants. Exogenous SA reduced transpiration and increased nitrate reductase activity, flower longevity as well as the yield of some plants (Raskin 1992) [15].
Salicylic acid ($C_7H_6O_3$) is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plant, such as stomatal closure, ion uptake, inhibition of ethylene biosynthesis, transpiration and stress tolerance (Khan *et al.*,2003 and Shakirova *et al.*, 2003) [9, 16].
Ethrel @ at 500 ppm significantly increased the chlorophyll content in leaves and yield of mustard (Grewal *et al.*, 1993). Ethrel (ethylene producing commercial preparation) has been reported to improve productivity of pulse crops like cowpea, pigeonpea, mungbean and soybean by increasing the number of pods, seed weight and seed yield (Chandra 1985, Singh 1984, Yadav *et al.*,1980, Bora and Bohra 1989) [3, 17, 2]. The present study was undertaken to observe the response of nitrobenzene given as foliar spray on growth and yield of chickpea (*Cicer arietinum* L.).

Material and Methods

The field experiment was conducted during *Rabi* season of 2017-18 at the Agronomy Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field selected for conducting the experiment was fairly uniform and leveled. In order to determine the chemical properties of soil, the soil sample were collected at 0-30 cm depth from randomly selected spots spread over the experimental area prior to sowing. A composite soil sample was analyzed for the fertility status of soil.

The soil of experimental plot was vertisol, clayey in texture with fairly uniform and leveled topography. As regards to fertility status, the soil was medium in available Nitrogen (176 kg ha^{-1}), low in available Phosphorus (18 kg ha^{-1}), fairly high in available Potassium (365 kg ha^{-1}), and moderate in organic carbon (0.50 %). Soil was slightly alkaline in reaction with pH- 7.8 and Electric conductivity- 0.5 dSm^{-1}.

The experiment was laid out in Factorial Randomized block Design (FRBD) with two different factors. The factor ‘A’ consisted of application of different bioregulators viz., water spray, Salicylic acid @ 50 ppm, Ethrel @ 200 ppm, Brassinosteroid @ 0.25 ppm and Nitrobenzene (20%) @ 500 ppm. While, Factor ‘B’ comprised of three stages of application of bioregulators viz., at flower initiation (45 DAS), at pod formation (60 DAS) and twice at flower initiation and pod formation stage (45 & 60 DAS) with three replications and fifteen treatment combinations. The variety used was PDKV- Kanchan (AKG-1109) released in 2017 with 20.60% protein content, 19.7 gm of seed weight, maturing in 109 days and yield was 1935 kg ha^{-1}. The chickpea crop was sown on 14th November 2017 and harvested on 4th March 2018.

All recommended package of practices were followed. The rainfall received during the season (November- March 2017-18) was 0.7 mm in 0 rainy days against normal rainfall of 51.7 mm in 4.2 rainy days.

The chickpea crop was fertilized with recommended dose of 25:50:30 NPK kg ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}. The source of nutrient used was by Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP). Fertilizer were mixed thoroughly in required quantity and placed in the soil at 3-5 cm deep and away from seed. Soil pH was determined by pH meter after equilibrating soil with water for 60 minutes in the ratio of 1:2.5 soil water suspensions (Jackson, 1967) [8].

Electrical conductivity of soil was determined by 1: 2.5 soil water suspensions using Electrical conductivity meter (Jackson, 1967) [8]. Organic carbon content in soil was determined by Walkley and Blacks method (1934) (Jackson, 1967) [8]. The available nitrogen from soil was estimated by alkaline permanganate method by Subbiah and Asija (1956) [19]. The available phosphorus from soil was estimated by Olsen’s method (1954). The available potassium from soil was determined by neutral normal ammonium acetate extract using Flame Photometer (Hanway and Heidel, 1952) [6]. Chemical analysis of plant was done after harvest for determining the nutrient uptake (N, P, and K) by plant and seed.

The experimental data collected during the course of investigation were analyzed with Factorial Randomized Block Design programmed on computer by adopting standard statistical techniques of analysis of variance (Gomez and Gomez, 1984) [5].

Results and Discussion

Morphological traits

Effect of Bioregulators: An emergence count and final plant stand were not significantly affected due to application of different bioregulators, thereby indicating uniform emergence and its persistence throughout the crop growth period. Also, bioregulators have significant effect on growth characters like plant height, number of branches per plant, number of functional leaves per plant, leaf area per plant, dry matter accumulation per plant, number of nodules and root length per plant. Application of Nitrobenzene (20%) @ 500 ppm and Brassinosteroid @ 0.25 ppm remained at par and recorded higher values of all these growth characters followed by Salicylic acid @ 50 ppm, Ethrel @ 200 ppm over water spray.

Table 1: Morphological traits as influenced by different by treatments

Treatments	Emergence count (Per hectare)	Final plant stand (Per hectare)	Plant height (cm)	No. of branches	No. of leaves	Leaf area per plant	Dry matter (gm)	Canopy spread (E-W) per plant	Canopy spread (N-S) per plant	No. of nodules	Root length per plant
Factor A - Application of Bioregulators											
B1 : Water Spray	313034	300392	34.15	22.58	33.63	5.80	17.40	27.24	23.56	17.11	12.52
B2 : Salicylic acid @ 50 ppm	314815	303597	37.08	24.40	39.71	7.90	19.79	29.76	29.20	19.44	13.86
B3 : Ethrel @ 200 ppm	311254	302350	35.70	23.69	37.30	6.56	19.11	28.11	28.15	18.44	13.04
B4 : Brassinosteroid @ 0.25 ppm	319088	305556	38.15	25.21	40.33	8.85	20.36	31.58	30.20	20.22	14.14
B5 : Nitrobenezene @ 500 ppm	316595	308048	39.29	27.84	41.80	9.94	21.00	33.16	31.34	21.22	15.01
SE(m)±	2452	2402	0.67	0.61	3.76	0.35	0.50	0.80	1.25	0.53	0.36
CD at 5%	NS	NS	1.96	1.77	NS	1.02	1.45	2.33	3.64	1.55	1.04
Factor B - Stage of Application											
S1 : At Flowering (40 DAS)	313996	302885	36.19	24.01	38.09	7.52	19.26	29.47	26.99	18.87	13.49
S2 : At Pod Formation (60 DAS)	315812	304060	36.97	24.49	38.24	7.82	19.49	29.94	29.02	19.27	13.68
S3 : At Flowering and Pod Formation (40 and 60 DAS)	315064	305021	37.46	25.73	39.34	8.09	19.84	30.50	29.46	19.73	13.98
SE(m)±	1900	1861	0.52	0.47	2.91	0.27	0.39	0.62	0.97	0.41	0.28
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction											
SE(m)±	4248	4161	1.17	1.06	6.51	0.61	0.87	1.39	2.17	0.92	0.62
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	314957	303989	36.87	24.74	38.55	7.81	19.53	29.97	28.49	19.29	13.72

Plant growth regulators are known to enhance source- sink relationship and stimulate translocation of photosassimilates. The probable reason for increase in plant height with advancement of crop growth might be due to increased cell division, cell elongation and a corresponding increase in epidermal and parenchymatous cell division as Nitrobenzene and brassinosteroid application increased cell division and cell elongation in sub-apical meristems. These results are in accordance with results reported by Bera *et al.* (2014) [1] and Marimuthu S. (2015) [11].

Application of Nitrobenzene might have increased the auxillary buds which give rise to branches and the cells in the region between successive leaves or the internodes continue to divide and elongate thereby increasing the number and length of the branches. Similar results were reported by Bera *et. al* (2014) [1] and Jankiram (2015) [7].

The increase in number of functional leaves per plant with the application of bioregulators might have enhanced the crop growth by cell division in the meristematic region and by activity of growing tips of the crop which increased the plant height and ultimately increased the nodes and thus resulted into increase in number of functional leaves per plant. These findings are similar with results reported by Ramesh *et. al* (2013) [14].

The increase in leaf area might be due to the more number of branches and leaves over a plant which indicates the production of fruiting bodies. Higher the branches ultimately more will be the food production centers i.e. leaves and higher will be the transformation of photosynthesis to the fruiting body.

The photosynthetic activities of the plants are well reflected in their dry matter accumulation. An increased production of dry matter indicated the better utilization of nutrients along with better harvest of solar energy. Increase in dry matter production might be due to foliar application bioregulators which, increased the rate of photosynthesis process which finally resulted in overall growth in terms of increased plant height, number of branches, number of functional leaves, leaf area plant^{-1}, canopy spread (E-W) plant^{-1} and canopy spread (N-S) plant^{-1} increased dry matter production by the plant at each stage of growth. These results are in conformity of Rajesh K. *et al.* (2014) [13] and Sumathi A. *et al*. (2016) [20].

The number of nodules may have increased due to increase in root length. These results are in accordance with the results reported by Bera *et al*. (2014) [1]

The significant increase in growth parameters viz., plant height, number of branches, number of functional leaves mainly ascribed to better growth of crop through spraying of bioregulators thereby, increase in root length might was observed during reproductive stage.

The spraying of different bioregulators did not significantly affect the root volume and root dry weight of chickpea at all the crop growth stages.

Effect of stages of application: An emergence count and final plant stand was not significantly influenced due to the stages of application indicating uniform plant stand throughout the crop growth. Growth parameters like plant height, number of branches plant^{-1}, number of functional leaves, leaf area, dry matter accumulation, number of nodules, root length, root volume and root dry weight also had non-significant effect by application of bioregulators at different stages of crop growth.

Effect of interaction

Interaction effect between foliar application of different bioregulators and stages of application were found to be non-significant in respect of all the growth characters.

Yield

Effect of bioregulators: The application of different bioregulators significantly influenced the seed yield per hectare. Foliar application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher seed yield (2955 kg ha^{-1}) than Brassinosteroid @ 0.25 ppm (2744 kg ha^{-1}), Salicylic acid @ 50 ppm (2651 kg ha^{-1}), Ethrel @ 200 ppm (2618 kg ha^{-1}) and water spray (2506 kg ha^{-1}). The mean seed yield of chickpea was 2695 kg ha^{-1}. Beneficial effects of foliar spray of Nitrobenzene on yield attributes have increased the seed yield. These results are in accordance with the findings of Sharma and Sardana (2012) and Umbarkar *et al.* (2018) [21].

Similar trend as that of seed yield was also observed in respect of straw yield. Application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher straw yield (3694 kg ha^{-1}) per hectare than Brassinosteroid @ 0.25 ppm (3443 kg ha^{-1}), Salicylic acid @ 50 ppm (3438 kg ha^{-1}), Ethrel @ 200 ppm (3441 kg ha^{-1}) and water spray (3318 kg ha^{-1}). The increase in straw yield might be due to overall improvement in growth parameters and increased yield attributes.

The highest harvest index value of 44.43% was recorded with the application of Nitrobenzene (20%) @ 500 ppm followed by Brassinosteroid @ 0.25 ppm 44.38%. The lowest harvest index of 42.98% was noticed with application water spray

Effect of Stages of application

Stages of application of bioregulators had significant effect on seed yield and straw yield. The seed yield due to spraying of bioregulators at both flowering and pod initiation (2792 kg ha^{-1}) was at par with spraying only at pod initiation stage (2703 kg ha^{-1}) and recorded significantly higher seed yield per hectare than spraying of bioregulators only at flower initiation stage (2590 kg ha^{-1}). Spraying of bioregulators twice at reproductive stage i.e. flower initiation and pod formation contributed to the increased yield attributes and the resultant final seed yield. Similar pattern was also noticed in case of straw yield.

The highest harvest index of 44.03 % was recorded with the application of bioregulators at both flower initiation and pod formation stage followed by application of bioregulators once at pod formation stage (43.76%). Spraying of bioregulators once at flower initiation recorded the lowest harvest index (43.34%).

Table 2: Seed yield, Straw yield (kg ha^{-1}) and Harvest index (%) as influenced by different treatments

Treatments	Seed Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index %
Factor A- Application of Bioregulators			
B1 : Water Spray	2506	3318	42.98
B2 : Salicylic acid @ 50 ppm	2651	3438	43.55
B3 : Ethrel @ 200 ppm	2618	3441	43.19
B4 : Brassinosteroid @ 0.25 ppm	2744	3443	44.38
B5 : Nitrobenzene @ 500 ppm	2955	3694	44.43
SE(m)±	51	57	-
C.D. at 5%	149	165	-
Factor B- Stage of Application			
S1 : At Flowering (40 DAS)	2590	3388	43.34
S2 : At Pod Formation (60 DAS)	2703	3464	43.76
S3 : At Flowering and pod formation (40 and 60 DAS)	2792	3549	44.03
SE(m)±	40	44	-
C.D. at 5%	115	128	-
Interaction			
SE(m)±	89	99	-
C.D. at 5%	253	281	-
GM	2695	3467	43.71

Conclusion
Based on the above results, it can be concluded that foliar application of bioregulator Nitrobenezene @ 500 ppm significantly improved growth parameters viz., plant height, number of branches, number of functional leaves, canopy spread (E-W & N-S), dry matter accumulation, number of nodules and root length.

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