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# Effect of bioregulators on yield and yield attributes 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 yield and yield attributes 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 yield parameters *viz.*, number of pods plant $^{-1}$, weight of pods plant $^{-1}$, seed wt. plant $^{-1}$, test wt., seed yield, straw yield were significantly higher with the application of Nitrobenezene @ 500 ppm.

**Keywords:** Bio-regulators, Chickpea, yield and yield attributes, stages of application

## Introduction
Pulses occupy a unique position in farming system all over the world. Pulses are major and cheaper source of protein particularly for vegetarians and contribute about 14% of Indian diet. Chickpea (*Cicer arietinum* L.) also known as Bengal gram or Gram belongs to the family Leguminoceae and is believed to have originated from South Western Asia. It is the third most important pulse crop in the world (after beans and peas). Its seeds have been eaten by humans since around 7000 BC. It is a rich source of protein (18-22%), carbohydrate (61-63%), fat (4-5%), and also contains calcium (280 mg/100 g), phosphorous (301 mg/100 g), iron (12.3 mg/100 g), niacin, Vitamin B, Vitamin C and having Calorific value of 396.

The role of Bioregulators in enhancing the production of crop has long been recognized and now this low cost technology has emerged as a boon for enhancing the agricultural production at an unprecedented rate. It has been observed that synthesis and translocation of photosynthates into sink is very poor at later stages of the crop besides poor vegetative growth and flowering. Plant hormones play important role as the small quantities regulate the various physiological processes and balance the source and sink thereby increase the productivity. Number of various bioregulators like Nitrobenzene, Salicylic acid, Brassinosteroid and Ethylene are being used on different crops at various concentrations and at different stages of development. In view of this, the present study was undertaken to access the effect of bioregulators on yield and yield attributes in chickpea.

## 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 14$^{th}$ November 2017 and harvested on 4$^{th}$ 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) [9].

Electrical conductivity of soil was determined by 1: 2.5 soil water suspensions using Electrical conductivity meter (Jackson, 1967) [9]. Organic carbon content in soil was determined by Walkley and Blacks method (1934) [24] (Jackson, 1967) [9]. The available nitrogen from soil was estimated by alkaline permanganate method by Subbiah and Asija (1956) [20]. The available phosphorus from soil was estimated by Olsen's method (1954) [13]. The available potassium from soil was determined by neutral normal ammonium acetate extract using Flame Photometer (Hanway and Heidel, 1952) [7]. 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

### Yield attributes

**Table 1:** Yield attributes *viz*., number of pods plant$^{-1}$, Wt. of seeds pod$^{-1}$ (g), seed weight plant$^{-1}$ (g) and test weight (g) as influenced by different treatments.

| Treatments | Number of pods plant$^{-1}$ | Wt. of pods plant$^{-1}$ (g) | Seed weight plant$^{-1}$ (g) | Test weight (g) |
|---|---|---|---|---|
| **Factor A- Application of Bioregulators** | | | | |
| B1: Water Spray | 34.68 | 10.85 | 8.48 | 21.56 |
| B2: Salicylic acid @ 50 ppm | 41.37 | 11.54 | 9.35 | 22.40 |
| B3: Ethrel @ 200 ppm | 36.92 | 11.22 | 9.23 | 22.15 |
| B4: Brassinosteroid @ 0.25 ppm | 42.40 | 11.96 | 9.65 | 23.10 |
| B5: Nitrobenzene @ 500 ppm | 43.57 | 12.99 | 10.00 | 24.40 |
| SE(m)± | 0.82 | 0.29 | 0.18 | 0.35 |
| C.D. at 5% | 2.39 | 0.83 | 0.54 | 1.02 |
| **Factor B- Stage of Application** | | | | |
| S1: At Flowering (40 DAS) | 38.51 | 11.40 | 8.98 | 22.15 |
| S2: At Pod Formation (60 DAS) | 39.94 | 11.56 | 9.35 | 22.94 |
| S3: At Flowering and pod formation (40 and 60 DAS) | 40.91 | 12.18 | 9.69 | 23.08 |
| SE(m)± | 0.64 | 0.22 | 0.14 | 0.27 |
| C.D. at 5% | 1.85 | 0.65 | 0.41 | 0.79 |
| **Interaction** | | | | |
| SE(m)± | 1.427 | 0.498 | 0.320 | 0.611 |
| CD at 5% | NS | NS | 0.911 | NS |
| GM | 39.79 | 11.71 | 9.34 | 22.72 |

**Effect of bioregulators:** Yield contributing characters such as number of pods per plant, Wt. of pods plant$^{-1}$, seed weight per plant (g), test weight were significantly influenced due to application of different bioregulators under experimental study.

**Number of pods plant$^{-1}$:** Pods are the major yield determining factor in pulses. Foliar application of bioregulators has effectively increased the pod number. In present investigation application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher number of pods plant$^{-1}$ than the spraying of Ethrel @ 200 ppm and water spray but was remained at par with Brassinosteroid @ 0.25 ppm and Salicylic acid @ 50 ppm which were also at par with each other. Plant growth regulators are known to enhance the source- sink relationship and stimulate the translocation of photoassimilates thereby helping in effective flower formation, pod and seed development and ultimately enhance the productivity of crop. The increase in number of pods plant$^{-1}$ due to application of bioregulators might have increased flower forming substances by altering auxins, cytokinins, gibberellins and Ethylene ratio favourably to a higher level of flower forming substances, thereby increasing flowers and the resultant higher number of pods. Such increase in number of pods due to application of growth regulators was also reported by Jankiram (2015) [8].

**Wt. of pods plant$^{-1}$ (g):** Foliar application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher wt. of pods plant$^{-1}$ over all other treatments of bioregulators. This increase in wt. of pods might be due to significant increase in seed wt. per pod.

**Seed weight plant$^{-1}$:** Spraying of Nitrobenzene (20%) @ 500 ppm recorded significantly more seed weight plant$^{-1}$ than Salicylic acid @ 50 ppm, Ethrel @ 200 ppm and water spray and remained statistically similar with Brassinosteroid @ 0.25 ppm. The increase in seed weight per plant might have attributed to higher number of pods per plant and weight of pods plant$^{-1}$ with the application of bioregulators. These findings are in accordance with Jankiram (2015) [8].

Application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher test weight per plant over all the three bioregulators, *viz*., Brassinosteroid @ 0.25 ppm, Salicylic acid @ 50 ppm and Ethrel @ 200 ppm and water spray. Higher test weight might be the result of enhanced photosynthetic activity, followed by efficient transfer of metabolities and subsequent accumulation of these metabolities in the seed with the resultant increase in size and weight of the individual seed due to the foliar application of bioregulators at reproductive stage of the crop. Similar results are in conformity of Jankiram (2015) [8].

**Test weight (g):** Application of Nitrobenzene (20%) @ 500 ppm recorded significantly higher test weight per plant over all the three bioregulators, *viz*., Brassinosteroid @ 0.25 ppm, Salicylic acid @ 50 ppm and Ethrel @ 200 ppm and water spray. Higher test weight might be the result of enhanced photosynthetic activity, followed by efficient transfer of metabolities and subsequent accumulation of these metabolities in the seed with the resultant increase in size and weight of the individual seed due to the foliar application of bioregulators at reproductive stage of the crop. Similar results are in conformity of Jankiram (2015) [8].

**Effect of stages of application:** Yield attributing characters *viz*., number of pods plant$^{-1}$, Wt. of pods plant$^{-1}$, seed weight plant$^{-1}$, test weight, seed yield and straw yield were significantly influenced due to stages of application. Spraying of bioregulators twice at flowering and pod formation stage remained at par with spraying of bioregulator only at pod formation stage and recorded significantly more yield attributing characters than spraying only at flower initiation stage.

Application of bioregulators twice at flower initiation and pod formation stage due to increased flower forming substances thereby increasing number of flowers, lessen flower shedding, increased pod setting might have resulted in higher number of pods per plant.

Seed weight per plant might have increased due to application of bioregulators twice at flower initiation and pod formation stage which enhanced the source- sink relationship and stimulate the translocation of photoassimilates thereby helping in effective flower formation, pod and seed development and ultimately enhance the productivity of crop.

Higher test weight might be the result of enhanced photosynthetic activity, followed by efficient transfer of metabolities and subsequent accumulation of these metabolities in the seed with the resultant increase in size and weight of the individual seed due to the foliar application of bioregulators at reproductive stage of the crop.

**Effect of interaction**: There was non-significant difference due to the interaction between application of different bioregulators and its stages of application on number of pods plant$^{-1}$, Wt. of pods plant$^{-1}$ and test weight. While, data pertaining to interaction effect between application of different bioregulators and their stages of application on seed weight plant$^{-1}$ is presented in Table 2.

**Table 2:** Seed weight plant$^{-1}$ as influenced by interaction effect between application of bioregulators and stages of application

| Treat. | S1 | S2 | S3 |
|---|---|---|---|
| B1 | 8.10 | 8.57 | 8.78 |
| B2 | 9.24 | 9.24 | 9.57 |
| B3 | 9.23 | 9.23 | 9.23 |
| B4 | 9.61 | 9.61 | 9.72 |
| B5 | 9.63 | 9.80 | 10.75 |
| S.E. m ± | 0.32 | | |
| C.D. at 5% | 0.91 | | |

From the data, it was revealed that, treatment combination of spraying Nitrobenzene (20%) @ 500 ppm twice at flower initiation and pod formation ($B_5S_3$) recorded significantly higher seed weight plant$^{-1}$ than rest of the treatment combinations, but remained at par with the treatment combination of Nitrobenzene (20%) @ 500 ppm only at pod formation ($B_5S_2$), which was also superior in respect of seed weight plant$^{-1}$ than other treatment combinations.

Application of Nitrobenzene twice at flower initiation and pod formation stage might had increased seed weight per plant due to more flowering, less shading of pods, increased translocation of photoassimilates to reproductive parts thereby increasing pod setting.

**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) [22].

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 3:** 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 |

**Interaction effect:** The treatment combination of spraying Nitrobenzene (20%) @ 500 ppm at both flower initiation and pod formation stage ($B_5S_3$) remained at par with treatment combination of Nitrobenzene (20%) @ 500 ppm at pod formation stage ($B_5S_2$) and recorded significantly higher seed yield and straw yield per hectare than all the other treatment combinations.

**Table 4:** Seed yield (kg ha$^{-1}$) as influenced by interaction effect between application of bioregulators and stages of application

| Treat. | S1 | S2 | S3 |
|---|---|---|---|
| B1 | 2397 | 2407 | 2715 |
| B2 | 2620 | 2622 | 2710 |
| B3 | 2617 | 2617 | 2619 |
| B4 | 2711 | 2755 | 2767 |
| B5 | 2604 | 3111 | 3149 |
| S.E. m ± | 89 | | |
| C.D. at 5% | 253 | | |

**Table 5:** Straw yield (kg ha$^{-1}$) as influenced by interaction effect between application of bioregulators and stages of application

| Treat. | S1 | S2 | S3 |
|---|---|---|---|
| B1 | 3297 | 3315 | 3343 |
| B2 | 3471 | 3371 | 3472 |
| B3 | 3412 | 3441 | 3471 |
| B4 | 3472 | 3378 | 3478 |
| B5 | 3286 | 3814 | 3981 |
| S.E. m ± | 99 | | |
| C.D. at 5% | 281 | | |

From the data, it was revealed that, treatment combination of spraying Nitrobenzene (20%) @ 500 ppm twice at flower initiation and pod formation ($B_5S_3$) recorded significantly higher seed weight plant$^{-1}$, seed yield and straw yield per hectare than rest of the treatment combinations, but remained at par with the treatment combination of Nitrobenzene (20%) @ 500 ppm only at pod formation ($B_5S_2$), which was also superior in respect of seed weight plant$^{-1}$, seed yield and straw yield per hectare than other treatment combinations.

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