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**Vikram Chauhan**
Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**Hirpara DS**
Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**Bheda MK**
Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**Sutaria GS**
Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

**Correspondence**
**Vikram Chauhan**
Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

# Response of chickpea (*Cicer arietinum* L.) to plant growth regulators

**Vikram Chauhan, Hirpara DS, Bheda Mk and Sutaria GS**

**Abstract**
A field experiment was conducted during *rabi* season of 2015-16 on clayey soil at Instructional farm, JAU, Junagadh to study the response of chickpea (*Cicer arietinum* L.) to plant growth regulators in randomised block design with three replications. The results revealed that higher values of growth parameters *viz*., plant height, number of branches per plant and yield attributes *viz*., number of pods per plant along with seed and stover yields were recorded under $GA_3$ 100 ppm at flowering stage, kinetin 10 ppm at flowering stage, $GA_3$ 50 ppm at flowering stage and kinetin 5 ppm at flowering stage over control. The highest net return of ₹ 74381 $ha^{-1}$ was realized with kinetin 10 ppm at flowering stage followed by the treatments $T_5$ ($GA_3$ 100 ppm at flowering stage), $T_3$ ($GA_3$ 50 ppm at flowering stage) and $T_7$ (kinetin 5 ppm at flowering stage) by recording net return of 73113, 70355 and 68004 $ha^{-1}$ respectively. However, maximum BCR of 3.51 and 3.31 was obtained with the treatment $T_9$ kinetin 10 ppm at flowering stage. It could be concluded that spraying of plant growth regulators kinetin or $GA_3$ at the time of flowering stage gave higher yield net return of chickpea under South Saurashtra Agro-climatic conditions.

**Keywords:** Chickpea, growth regulators, yield and economics

## 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, channa 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) [11].
The use of PGRs, as gibberellins and cytokinins or their synthetic compounds, is becoming popular to ensure efficient production. There are many reports which indicate that application of PGRs enhanced plant growth and crop yield (Mostafa and Abou Al-Hamd, 2011) [7]. PGRs modify growth and development in various ways under normal growth conditions. Gibberellins ($GA_3$) have been known as growth promoters that mediate many responses in plants, from seed germination to senescence. One frequently used, gibberellic acid ($GA_3$) increases stem length, the number of flower per plant and induces pod setting. Cytokinins have been shown to participate in the regulation of numerous aspects of plant development including initiation of buds, flowering, abscission and yield by enhancing the cell expansion. Kinetin is a cytokinin type PGR with primary role to extend plant life by promoting cell division and cell enlargement.
The judicious use of plant growth regulators (PGRs) on crop results in: (1) Increase in chickpea yield, (2) Improvement in quality and (3) Reduction in overall production cost. Thus, chickpea growth, yield and nutritive quality enhanced by PGRs.

## Material and Method
Field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat, India) during *rabi* season of 2015-16. The soil of the experimental plot was clayey in texture and slightly alkaline reaction with pH 8.0 and EC 0.56 dS $m^{-1}$. The soil was low in available nitrogen (248 kg $ha^{-1}$), medium in available phosphorus (37 kg $ha^{-1}$) and potash (272 kg $ha^{-1}$). The experiment comprised ten treatments combinations control, water sprays, $GA_3$ 50 and 100 ppm, Kinetin 5 and 10 ppm at flowering and pod filling stage were laid in randomized block design with three replications. The mean minimum and maximum temperature during the crop growth and development period ranged between 10.4 to 19.4 $^0$C and 28.2 to 37.7 $^0$C, respectively.

The range of average minimum and maximum relative humidity, bright sun shine and maximum evaporation was 22 to 47% and 55 to 82%, 9.2 h and 7.8 mm, respectively. The chickpea variety 'Gujarat Gram-5' was sown in third week of November,2015 at a spacing of 45 × 10 cm using seed rate of 60 kg/ha and fertilized with 20-40-00 kg N-$P_2O_5$-$K_2O$/ha by applying full doses at the time of sowing and crop harvested at fourth week of February,2016. All the standard package of practices including appropriate plant protection measures were followed throughout the cropping season. Plant growth regulator treatments were given at flowering and pod filling stages with the help of barber sprayer. The experimental data recorded for growth parameters, quality parameters, yield attributes and yield parameters and economics were statistically analyzed for level of significance.

## Results & Discussion

### Growth parameters

A perusal of data in table-1 indicated that growth parameters *viz.,* plant height at harvest, number of branches per plant at harvest, number of root nodules per plant at 45 DAS, dry weight of root nodules per plant at 45 DAS, dry matter accumulation per plant at 60 and 90 DAS were significantly influenced by plant growth regulators treatments. Significantly the highest value of these growth parameters were recorded under the application of $GA_3$ 100 ppm at flowering stage which remain at par with kinetin 10 ppm, $GA_3$ 50 ppm at flowering and kinetin 5 ppm at flowering stage mainly ascribed to better growth of crop through spraying of plant growth regulators thus, increase water and nutrient, where which might have accelerated photosynthetic rate, thereby increasing the supply of carbohydrates, resulted in increased cell division, multiplication and elongation leading to increased plant height, number of branches, number of root nodules per plant, dry weight of root nodules per plant, dry matter accumulation per plant. These findings are in agreement with those of Bishoi and Krishnamoorthy (1992) [1], Fatima *et al.* (2008) [4], Chovatia *et al.* (2010) [3], Vagner *et al.* (2013) [10] and Sharma and Jain (2016) [8].

**Table 1:** Effect of plant growth regulators on growth of chickpea.

| Treatments | | Plant height (cm) At harvest | No. of branches per plant At harvest | No. of root nodules At 45 DAS | Dry weight of root nodules per plant (mg) At 45 DAS | Dry matter accumulation per plant (gm) At | |
|---|---|---|---|---|---|---|---|
| | | | | | | 60 DAS | 90 DAS |
| $T_1$ | Control | 38.00 | 5.00 | 7.27 | 85.33 | 12.50 | 22.60 |
| $T_2$ | Control with water spray at flowering and pod filling stage | 41.33 | 6.83 | 7.53 | 89.56 | 12.91 | 23.04 |
| $T_3$ | $GA_3$ 50 ppm at flowering stage | 45.67 | 7.50 | 10.00 | 98.65 | 16.00 | 31.53 |
| $T_4$ | $GA_3$ 50 ppm at pod filling stage | 41.33 | 6.37 | 8.73 | 89.60 | 14.13 | 29.43 |
| $T_5$ | $GA_3$ 100 ppm at flowering stage | 48.00 | 8.00 | 10.20 | 99.74 | 17.24 | 32.89 |
| $T_6$ | $GA_3$ 100 ppm at pod filling stage | 43.37 | 7.13 | 7.93 | 89.58 | 13.55 | 23.65 |
| $T_7$ | Kinetin 5 ppm at flowering stage | 44.67 | 7.50 | 9.87 | 98.11 | 15.85 | 30.47 |
| $T_8$ | Kinetin 5 ppm at pod filling stage | 41.67 | 7.33 | 8.13 | 88.23 | 13.61 | 24.86 |
| $T_9$ | Kinetin 10 ppm at flowering stage | 46.00 | 7.67 | 10.07 | 98.90 | 16.33 | 31.70 |
| $T_{10}$ | Kinetin 10 ppm at pod filling stage | 43.67 | 7.43 | 8.53 | 89.54 | 13.84 | 26.67 |
| | S.Em. ± | 0.38 | 1.54 | 0.26 | 3.40 | 0.44 | 1.36 |
| | C.D. at 5% | 1.12 | 4.56 | 1.23 | 10.10 | 2.23 | 4.05 |
| | C.V. % | 9.24 | 6.13 | 8.13 | 6.35 | 8.89 | 8.54 |

DAS: Days after sowing

### Yield attributes and yield

The favourable effects of spraying of plant growth regulators were fully reflected on yield attributes and yield, like number of pods per plant, weight of seed per plant and seed index, seed yield, stover yield and biological yields (Table 2). The enhanced yield attributes and yield under treatments $T_5$ ($GA_3$ 100 ppm at flowering stage), $T_9$ (Kinetin 10 ppm at flowering stage), $T_3$ ($GA_3$ 50 ppm at flowering stage), $T_7$ (Kinetin 5 ppm at flowering stage) and $T_4$ ($GA_3$ 50 ppm at pod filling stage) might be due to $GA_3$ is known to induce an influx of $Ca^{2+}$ into the endoplasmic reticulum of guard cells, thereby initiating a process that leads to increase in stomatal activity. A less stomatal resistance enables an easier exchange of gases. With increasing $CO_2$, photosynthesis was increased and subsequently was improved performance such as seeds. In general, the $GA_3$ treatment may have also strengthened the sink potential of the developing pods and through enhancement of duration rate of assimilate translocation to these reproductive structures caused the observed increase in pod dry weight and 100- seed weight. It is during this critical growth phase that the basic infrastructure of the plant functioning is laid down, the effective dividends of which are reaped when the plant reaches harvest. Supply of photosynthates to various metabolic sinks might have favoured yield attributes. The lowest values of yield attribute *viz*., number of pods per plant, seed index and seed weight per plant under treatment $T_1$ (control). These findings are in close conformity with those reported by Brar *et al*. (1993) [2] and Upadhyay (2002) [9].

**Table 2:** Effect of plant growth regulators on quality, yield attributes and yield of chickpea.

| Treatment | | Podsper plant | Seed weight per plant (g) | Seed index | Seed yield (kg $ha^{-1}$) | Stover Yield (kg $ha^{-1}$) | Biological Yield (kg $ha^{-1}$) | N content in Seed (%) | Protein content in seed (%) |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 55.33 | 13.00 | 16.00 | 1798 | 2294 | 4092 | 3.00 | 18.75 |
| $T_2$ | Control with water spray at flowering and pod filling stage | 57.00 | 16.33 | 17.00 | 1893 | 2547 | 4440 | 3.13 | 19.58 |
| $T_3$ | $GA_3$ 50 ppm at flowering stage | 64.67 | 20.00 | 20.00 | 2811 | 3041 | 5851 | 3.53 | 22.08 |
| $T_4$ | $GA_3$ 50 ppm at pod filling stage | 63.67 | 19.00 | 19.00 | 2394 | 2855 | 5249 | 3.27 | 20.42 |
| $T_5$ | $GA_3$ 100 ppm at flowering stage | 67.67 | 22.66 | 20.67 | 2941 | 3241 | 6181 | 3.93 | 24.58 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $T_6$ | $GA_3$ 100 ppm at pod filling stage | 61.33 | 17.00 | 17.67 | 1982 | 2655 | 4636 | 3.17 | 19.79 |
| $T_7$ | Kinetin 5 ppm at flowering stage | 64.33 | 19.67 | 19.47 | 2696 | 2978 | 5674 | 3.47 | 21.67 |
| $T_8$ | Kinetin 5 ppm at pod filling stage | 60.33 | 18.00 | 18.00 | 2266 | 2713 | 4979 | 3.20 | 20.00 |
| $T_9$ | Kinetin 10 ppm at flowering stage | 65.00 | 21.00 | 20.33 | 2881 | 3136 | 6017 | 3.77 | 23.54 |
| $T_{10}$ | Kinetin 10 ppm at pod filling stage | 61.00 | 18.67 | 18.67 | 2372 | 2757 | 5129 | 3.23 | 20.21 |
| S.Em. ± | | 1.46 | 1.15 | 0.63 | 139.07 | 124.58 | 207.03 | 0.18 | 1.14 |
| C.D. at 5% | | 6.19 | 3.41 | 1.88 | 413.22 | 370.14 | 615.12 | 0.54 | 3.40 |
| C.V. % | | 5.81 | 10.73 | 5.87 | 10.02 | 7.65 | 6.86 | 9.40 | 9.40 |

**Chemical studies**

A perusal of data in table-2 indicated that significantly higher N content in seed (31% over control) was recorded under treatment $T_5$ ($GA_3$ 100 ppm at flowering stage) but it was statistically at par with treatments $T_9$ (Kinetin 10 ppm at flowering stage), $T_3$ ($GA_3$ 50 ppm at flowering stage) and $T_7$ (Kinetin 5 ppm at flowering stage) in descending order and the lower N content in seed was recorded under treatment $T_1$ (control). Because of the highest percentage of nitrogen fixation in chickpea cultivars have been accumulated in the nodes. The nodules are the site of nitrogen fixation in plants and from there nitrogen is exported to other plant organs. Cytokinin has been increased fixation through the induction of photosynthesis and growth, delay in senescence and accelerates the transfer of nutrients and organic matter which leads to increase nitrogen content in seed. These findings corroborate the reports of Hamidian *et al*. (2012) [5].

**Quality parameter**

The data regarding protein content of chickpea crop are presented in table 2. Significantly higher protein content (24.58%) was recorded under treatment $T_5$ ($GA_3$ 100 ppm at flowering stage) but it was statistically at par with treatments $T_9$ (Kinetin 10 ppm at flowering stage), $T_3$ ($GA_3$ 50 ppm at flowering stage) and $T_7$ (Kinetin 5 ppm at flowering stage) in descending order. Treatments $T_1$ (control) produced the lower protein content. Because of $GA_3$ increases in photosynthetic pigments concurrently with the marked increases in reducing sugars and sucrose, increase in protein synthesis including *de novo* synthesis of new proteins and the accumulation of certain existing proteins tended to increase total N and protein-N and caused accumulation of soluble N leading to increased synthesis of proteins. The similar results were also reported by Mohammed (2007) [6].

**Economics**

The data on economics pertaining to gross return, total cost of cultivation, net return and benefit cost ratio (BCR) under different plant growth regulators treatments are presented in Table 3. The data revealed that maximum gross return of 106164 ₹ $ha^{-1}$ was realized with $GA_3$ 100 ppm at flowering stage ($T_5$). However maximum net return of 74318 ₹ $ha^{-1}$ BCR of 3.51 was obtained with the treatment $T_9$ (Kinetin 10 ppm at flowering stage).

**Table 3:** Economics of different treatments.

| Treatment | | Gross return (₹ $ha^{-1}$) | Cost of cultivation (₹ $ha^{-1}$) | Net return (₹ $ha^{-1}$) | BCR |
|---|---|---|---|---|---|
| $T_1$ | Control | 65224 | 28907 | 36317 | 2.25 |
| $T_2$ | Control with water spray at flowering and pod filling stage | 68801 | 29248 | 39553 | 2.35 |
| $T_3$ | $GA_3$ 50 ppm at flowering stage | 101425 | 31070 | 70355 | 3.26 |
| $T_4$ | $GA_3$ 50 ppm at pod filling stage | 86645 | 31070 | 55575 | 2.78 |
| $T_5$ | $GA_3$ 100 ppm at flowering stage | 106176 | 33062 | 73113 | 3.21 |
| $T_6$ | $GA_3$ 100 ppm at pod filling stage | 72025 | 33062 | 38963 | 2.17 |
| $T_7$ | Kinetin 5 ppm at flowering stage | 97338 | 29334 | 68004 | 3.31 |
| $T_8$ | Kinetin 5 ppm at pod filling stage | 82022 | 29334 | 52688 | 2.79 |
| $T_9$ | Kinetin 10 ppm at flowering stage | 103972 | 29590 | 74381 | 3.51 |
| $T_{10}$ | Kinetin 10 ppm at pod filling stage | 85777 | 29590 | 56187 | 2.89 |

**Conclusion**

Based on the results of one year experimentation, it was concluded that the foliar spray of 10 ppm kinetin at flowering stage was found effective due to its advantageous effect on morpho–physiological growth and yield of chickpea along with higher net return (74381 Rs $ha^{-1}$) and 3:51 benefits cost ratio.

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