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# Effect of Foliar Spray of Kinetin and Homobrassinolide on Root and Leaf Development and Yield of Chickpea (*Cicer arietinum* L.) under Water Stress

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**ABSTRACT**

Two field experiments were conducted at Agricultural College Farm, Bapatla during rabi 2008-09 and 2009-10 to study the effect of kinetin and brassinosteroids on root and leaf development in chickpea (*Cicer arietinum* L) under water stress conditions in split plot design with nine treatments, replicated four times. Stressed plants from vegetative stage with no spray recorded the maximum root length, volume and dry weight; followed by the plants of homobrassinolide spray. No stress recorded more leaf area (28.5%) than water stressed plants. The plants undergone kinetin spray @ 5ppm performed well with higher leaf area (6.5%) than that of no spray; and it was on par with that of homobrassinolide spray @ 1ppm. The unstressed plants with kinetin spray attained the maximum leaf area and it was on par with that of homobrassinolide spray. It was noticed delayed senescence by homobrassinolide spray besides kinetin; which resulted in higher leaf area. Homobrassinolide spray @ 1ppm recorded higher values of SCMR followed by kinetin spray @ 5ppm. Unstressed plants with homobrassinolide spray recorded maximum seed yield (2451.3 kg/ha) and the plants stressed from vegetative stage recorded the minimum due to severe detrimental effects of water stress. Among sprays, homobrassinolide @ 1 ppm resulted in more seed yield (20.9%) than no spray and it was on par with kinetin spray @ 5 ppm.

**Key words :** Chickpea, Seed yield, Soil moisture content, Root and leaf characters, Brassinosteroid (BR), Kinetin.

Chickpea (*Cicer arietinum* L) is the fourth largest grain legume crop in the world, with a total production of 10.9 million tons from an area of 12.0 million ha and a productivity of 0.91 t $ha^{-1}$ (Food and Agriculture Organization of the United Nations (FAO, 2010)). India ranked first in terms of chickpea production and consumption in the world contributing production of 7.3 million tones in 8.2 million hectares with productivity of 895 kg/ha (Amarender Reddy and Devraj Mishra, 2010). Andhra Pradesh is categorized among the states which show high growth rate of chickpea production in India. Water stress is the single most important abiotic constraint limiting the chickpea production. To overcome ill effects of water stress and to increase crop yields it is suggested to exploit the soil moisture content to its full extent by which plant roots are able to maximize their use of resources. Among many factors associated with higher productivity root and leaf characters have been well organized for successful production of chickpea to combat water stress.

Brassinosteroids (BRs) are a group of naturally occurring plant steroidal compounds, considering as sixth group of phytohormones with significant growth promoting activity as they influence varied developmental processes like growth, germination of seeds, rhizogenesis, flowering and senescence. In order to reduce the premature senescence, kinetin application is receiving a great deal of importance towards improving crop production.

In view of this, a study was conducted to know the influence of foliar spray of kinetin and homobrassinolide on root and leaf development and yield of chickpea (*Cicer arietinum*) under water stress conditions

## MATERIAL AND METHODS

A field experiment was conducted at College Farm, Agricultural College, Bapatla, A.P., during two consecutive seasons of *rabi* 2008-09 (season I) and *rabi* 2009-10 (season II) in split plot design with nine treatments replicated four times. The treatments consist of water stress levels *viz.*, $M_0$ (No stress), $M_1$ (water stress from vegetative stage) and $M_2$ (water stress from flowering stage) as main plots. Each main plot consists of three subplots i.e., foliar sprays at 40 DAS *viz.*, $S_0$ (No spray), $S_1$ (Kinetin spray @ 5ppm) and $S_2$ (Homobrassinolide spray @ 1ppm).

The experimental soil was black clay loam in texture, slightly alkaline in reaction, low in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. One day after sowing, herbicide Pendimethalin was sprayed @ 10 ml $L^{-1}$ to arrest the weed growth. Treatments were imposed as per schedule. The data pertaining to soil moisture, root length, root volume, root weight and leaf moisture retention index (LMRI) were measured at 15 days interval. Soil moisture was measured by gravimetric method. Soil sample was dried in oven at $80^0$C for 48 hr and dry weight was recorded.

$$\text{Soil Moisture Content (SMC)} = \frac{\text{Fresh weight - Dry weight}}{\text{Dry weight}} \text{X } 100$$

Leaf area from the samples collected for dry matter was measured by using Delta T Automatic leaf area meter. LMRI is calculated using the formula of Gupta and Sharma (2006). The detached leaf after taking its fresh weight (Fr) was kept in the field at ambient temperature for about 5 hrs. After 5 hrs, its weight was recorded as ambient weight (Sr). Then the leaf was kept in hot air oven at $80^0$C for two days to attain its constant dry weight (Dr).

$$\text{LMRI} = \frac{\text{Sr} - \text{Dr}}{\text{Fr} - \text{Dr}}$$

The total chlorophyll content was measured with SPAD (Soil Plant Analytical Development) Chlorophyll Meter Readings (SCMR) following the method of Turner and Jund (1991) before and after the imposition of treatments. SCMR data were recorded on $6^{th}$ or $7^{th}$ leaf from top of each representative plant, between 10.00 a.m. and 12 noon of the day. A mean of 25 readings from five representative plants per plot was taken. The yield data was recorded at the time of harvest and made to kg/ha.

## RESULTS AND DISCUSSION

Soil moisture at flowering reduced to 56% of the initial moisture and further reduced to 34% at pod formation stage (Table 1). Root characters like root length and volume increased under water stress. Plants exposed to stress from vegetative stage recorded higher values of root length (26.5%), root volume (17.9%) and root dry weight (1.7%) over the unstressed. Plants subjected to stress from vegetative stage with no spray recorded the maximum root length (28.97 cm), volume (10.50 cc) and dry weight (1.17 g) followed by the plants that received homobrassinolide spray. Under stress conditions, there was no significant difference among effects of hormonal sprays. The plots under no stress recorded more soil moisture content (54.1%) over stress from vegetative stage; and it was on par with stress from flowering stage, as irrigation being the main reason for increased soil moisture content. Rooting depth has been negatively correlated with seed yield (Table 3), which has allowed better water capture. These results are in accordance with Benjamin and Nielsen (2006) and Kashiwagi *et al.* (2007).

The unstressed plants with kinetin spray possessed maximum leaf area (597.62 $cm^2$) compared to the plants stressed from vegetative stage (Table 2). It might be due to anti-senescence character of kinetin. Minimum leaf area (386.27 $cm^2$) was observed with the plants stressed from vegetative stage without spray indicating its pre-maturity nature due to unavailability of water. These results are in agreement with the findings of Karim and Fattah (2007). No stress with homobrassinolide spray recorded the maximum leaf moisture retention index (LMRI) (0.89) and it was on par with that of kinetin spray. No stress recorded more leaf moisture retention index (17.2%) over stress from vegetative stage; and it was on par with stress from flowering stage.

No stress with homobrassinolide spray recorded the maximum SCMR (0.84) indicating its influence in increasing the water status and recorded more chlorophyll content (Table 2). It might be due to inhibition of chlorophyllase enzyme which is responsible for chlorophyll depletion, leading to higher accumulation of chlorophyll. The deleterious effect of depleted soil moisture was reflected in the plants exposed to stress from vegetative stage with no spray which showed least

Table 1.Soil Moisture Content (%) of Chickpea grown plots influenced by kinetin and homobrassinolide spray under water stress.

| Treatments | SEASON-I | | | | | | | SEASON -II | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS | At Harvest | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS | At Harvest |
| $M_0$ | 15.8 | 23.5 | 21.1 | 19.9 | 18.0 | 16.2 | 13.8 | 16.0 | 23.5 | 21.7 | 21.1 | 20.0 | 18.9 | 15.9 |
| $M_1$ | 15.9 | 14.8 | 12.5 | 10.2 | 9.0 | 7.7 | 7.2 | 16.0 | 16.3 | 14.6 | 12.3 | 11.6 | 9.4 | 8.3 |
| $M_2$ | 15.9 | 22.9 | 20.0 | 17.4 | 14.7 | 13.6 | 12.8 | 16.1 | 23.8 | 21.6 | 20.0 | 18.5 | 15.9 | 14.5 |
| SEm $\pm$ | 0.7 | 0.8 | 0.9 | 1.2 | 0.2 | 0.6 | 0.4 | 0.7 | 1.1 | 1.3 | 0.8 | 0.6 | 0.8 | 0.5 |
| CD (0.05) | NS | 2.7 | 3.2 | 4.4 | 0.8 | 2.0 | 1.3 | NS | 4.0 | 4.7 | 2.8 | 2.0 | 2.9 | 1.7 |
| $S_0$ | 16.0 | 20.5 | 18.3 | 16.3 | 14.3 | 13.1 | 12.0 | 16.0 | 20.9 | 19.5 | 18.2 | 17.4 | 15.6 | 13.8 |
| $S_1$ | 15.8 | 20.3 | 17.6 | 15.6 | 14.1 | 12.3 | 11.3 | 16.0 | 21.3 | 19.2 | 17.6 | 16.5 | 14.7 | 13.0 |
| $S_2$ | 15.9 | 20.4 | 17.7 | 15.7 | 13.3 | 12.2 | 10.5 | 16.1 | 21.3 | 19.3 | 17.6 | 16.4 | 14.0 | 11.9 |
| SEm $\pm$ | 0.6 | 0.7 | 0.7 | 0.7 | 0.8 | 0.4 | 0.5 | 0.6 | 0.8 | 0.8 | 0.8 | 0.6 | 0.6 | 0.6 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| $M_0S_0$ | 15.9 | 23.8 | 21.4 | 20.3 | 18.2 | 16.4 | 14.1 | 15.9 | 23.7 | 21.9 | 21.5 | 21.0 | 19.1 | 16.4 |
| $M_0S_1$ | 15.8 | 22.9 | 20.4 | 19.4 | 18.2 | 15.8 | 13.8 | 16.0 | 23.2 | 21.6 | 20.8 | 19.3 | 18.7 | 16.0 |
| $M_0S_2$ | 15.8 | 23.7 | 21.3 | 20.1 | 17.7 | 16.4 | 13.5 | 16.1 | 23.6 | 21.7 | 21.1 | 19.9 | 19.0 | 15.4 |
| $M_1S_0$ | 16.0 | 15.0 | 13.1 | 10.7 | 9.5 | 8.4 | 8.0 | 16.2 | 15.8 | 14.9 | 12.6 | 12.2 | 11.1 | 10.2 |
| $M_1S_1$ | 15.8 | 14.7 | 12.3 | 9.9 | 9.2 | 7.6 | 7.3 | 16.0 | 16.6 | 14.5 | 12.2 | 11.5 | 9.5 | 8.5 |
| $M_1S_2$ | 15.9 | 14.8 | 12.2 | 9.9 | 8.4 | 7.2 | 6.4 | 16.0 | 16.5 | 14.5 | 12.1 | 11.2 | 7.7 | 6.4 |
| $M_2S_0$ | 16.0 | 22.7 | 20.3 | 17.9 | 15.2 | 14.6 | 13.9 | 16.1 | 23.3 | 21.6 | 20.7 | 18.9 | 16.4 | 15.0 |
| $M_2S_1$ | 15.9 | 23.3 | 20.2 | 17.4 | 14.9 | 13.4 | 12.7 | 16.2 | 24.2 | 21.5 | 19.8 | 18.6 | 15.9 | 14.5 |
| $M_2S_2$ | 15.9 | 22.9 | 19.5 | 17.0 | 13.9 | 12.9 | 11.6 | 16.1 | 23.9 | 21.6 | 19.6 | 18.0 | 15.4 | 14.0 |
| SEm $\pm$ | 0.9 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 | 0.5 | 0.9 | 1.2 | 0.8 | 0.9 | 0.6 | 0.6 | 0.5 |
| CD (0.05) | NS | 2.1 | 1.8 | 1.9 | 1.6 | 1.6 | 1.0 | NS | 2.5 | 1.8 | 1.8 | 1.2 | 1.3 | 1.0 |
| CV(%) | 17.7 | 19.2 | 18.9 | 17.7 | 19.2 | 19.6 | 18.5 | 18.0 | 19.5 | 18.4 | 18.3 | 15.0 | 19.2 | 12.7 |

Table 2. Effect of kinetin and homobrassinolide spray on root and leaf development of chickpea under water stress.

| Treatments | SEASON-I | | | | | | SEASON -II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RL(cm) | RV(cc) | RW(g) | LA(sq.cm) | LMRI | SCMR | RL(cm) | RV(cc) | RW(g) | LA (sq.cm) | LMRI | SCMR |
| **Main** | | | | | | | | | | | | |
| $M_0$ | 22.1 | 8.7 | 1.1 | 587.8 | 0.70 | 42.6 | 23.7 | 9.0 | 1.22 | 575.5 | 0.81 | 46.2 |
| $M_1$ | 28.5 | 10.4 | 1.1 | 428.3 | 0.61 | 34.6 | 29.4 | 10.5 | 1.25 | 401.7 | 0.74 | 43.3 |
| $M_2$ | 22.4 | 8.7 | 1.1 | 523.6 | 0.67 | 40.4 | 23.3 | 9.4 | 1.23 | 407.2 | 2.35 | 40.7 |
| SEm $\pm$ | 0.7 | 0.1 | 0.03 | 29.4 | 0.02 | 1.1 | 0.5 | 0.2 | 0.03 | 24.5 | 0.03 | 0.5 |
| CD (0.05) | 2.6 | 0.4 | 0.10 | 103.6 | 0.00 | 4.0 | 1.7 | 0.6 | 0.09 | 86.2 | 0.09 | 1.9 |
| **Sub** | | | | | | | | | | | | |
| $S_0$ | 24.1 | 9.3 | 1.10 | 504.6 | 0.57 | 37.6 | 24.9 | 9.6 | 1.19 | 492.8 | 0.74 | 40.5 |
| $S_1$ | 24.4 | 9.2 | 1.13 | 524.3 | 0.70 | 39.1 | 25.6 | 9.6 | 1.22 | 515.2 | 0.81 | 41.9 |
| $S_2$ | 24.5 | 9.4 | 1.16 | 510.7 | 0.72 | 41.0 | 25.9 | 9.8 | 1.28 | 509.7 | 0.80 | 42.7 |
| SEm $\pm$ | 0.6 | 0.1 | 0.03 | 19.7 | 0.04 | 1.1 | 0.6 | 0.2 | 0.03 | 21.0 | 0.04 | 1.1 |
| CD (0.05) | NS | NS | NS | NS | 0.13 | NS | NS | NS | NS | NS | 0.13 | NS |
| **Interactions** | | | | | | | | | | | | |
| $M_0S_0$ | 21.5 | 8.6 | 1.09 | 578.7 | 0.57 | 40.7 | 22.5 | 8.9 | 1.15 | 579.3 | 0.74 | 45.3 |
| $M_0S_1$ | 22.1 | 8.7 | 1.13 | 597.6 | 0.76 | 41.3 | 24.0 | 9.0 | 1.22 | 585.0 | 0.80 | 46.2 |
| $M_0S_2$ | 22.6 | 8.7 | 1.19 | 587.0 | 0.77 | 45.7 | 24.6 | 9.1 | 1.30 | 562.4 | 0.89 | 47.2 |
| $M_1S_0$ | 28.6 | 10.5 | 1.12 | 418.7 | 0.56 | 33.3 | 29.4 | 10.5 | 1.22 | 386.3 | 0.72 | 36.5 |
| $M_1S_1$ | 28.3 | 10.1 | 1.14 | 442.5 | 0.62 | 34.2 | 29.3 | 10.3 | 1.22 | 413.6 | 0.74 | 38.4 |
| $M_1S_2$ | 28.6 | 10.7 | 1.17 | 423.7 | 0.64 | 36.4 | 29.5 | 10.65 | 1.30 | 405.4 | 0.75 | 40.2 |
| $M_2S_0$ | 22.2 | 8.7 | 1.10 | 516.4 | 0.57 | 38.7 | 22.8 | 9.22 | 1.22 | 512.7 | 0.76 | 39.9 |
| $M_2S_1$ | 22.7 | 8.6 | 1.11 | 532.9 | 0.71 | 41.8 | 23.5 | 9.57 | 1.21 | 561.8 | 0.77 | 41.2 |
| $M_2S_2$ | 22.4 | 8.7 | 1.15 | 521.5 | 0.74 | 40.8 | 23.7 | 9.49 | 1.25 | 547.2 | 0.88 | 40.7 |
| SEm $\pm$ | 1.2 | 0.2 | 0.05 | 41.0 | 0.07 | 1.2 | 1.0 | 0.26 | 0.05 | 38.6 | 0.07 | 1.6 |
| CD (0.05) | 2.5 | 0.5 | 0.10 | 86.6 | 0.12 | 4.2 | 1.2 | 0.55 | 0.10 | 81.6 | 0.11 | 3.4 |
| CV(%) | 9.0 | 5.4 | 12.31 | 13.3 | 17.60 | 9.6 | 7.7 | 5.27 | 11.99 | 14.8 | 17.16 | 8.7 |

Table 3. Correlation of root & leaf characters and seed yield of chickpea with soil moisture content.

| Parameter | SMC | RL | RV | RW | LA | LMRI | SCMR | SY |
|---|---|---|---|---|---|---|---|---|
| SMC | 1 | | | | | | | |
| RL | -0.972 | 1 | | | | | | |
| RV | -0.958 | 0.986 | 1 | | | | | |
| RW | -0.346 | 0.285 | 0.29 | 1 | | | | |
| LA | 0.926 | -0.918 | -0.90 | -0.101 | 1 | | | |
| LMRI | 0.317 | -0.402 | -0.43 | 0.589 | 0.54 | 1 | | |
| SCMR | 0.799 | -0.833 | -0.83 | 0.213 | 0.89 | 0.710 | 1 | |
| SY | 0.493 | -0.534 | -0.48 | -0.533 | 0.53 | 0.096 | 0.220 | 1 |

SMC : Soil Moisture Content RL : Root Length RV : Root Volume
LMRI : Leaf Moisture Retention Index SCMR : SPAD Chlorophyll Meter Reading RW : Dry weight of root
LA : Leaf Area SY : Seed Yield

Table 4. Seed yield (kg $ha^{-1}$) influenced by kinetin and homobrassinolide sprays under water stress.

| Treatment | Season I | Season II |
|---|---|---|
| **Main Treatments** | | |
| $M_0$ (No stress) | 2104.2 | 2461.9 |
| $M_1$ (Water Stress from vegetative stage) | 1454.5 | 1495.4 |
| $M_2$ (Water Stress from flowering stage) | 1752.1 | 1817.6 |
| SEm $\pm$ | 231.5 | 226.0 |
| CD (0.05) | 528.3 | 796.0 |
| **Sub Treatments** | | |
| $S_0$ No spray | 1627.8 | 1785.4 |
| $S_1$ (spray with Kinetin @ 5.0 ppm) | 1782.0 | 1937.6 |
| $S_2$ (spray with Homobrassinolide @1.0 ppm) | 1900.9 | 2052.0 |
| SEm $\pm$ | 69.6 | 80.4 |
| CD (0.05) | 207.1 | 238.8 |
| **Interactions** | | |
| $M_0S_0$ | 1876.5 | 2296.4 |
| $M_0S_1$ | 2129.8 | 2493.1 |
| $M_0S_2$ | 2306.4 | 2596.2 |
| $M_1S_0$ | 1337.1 | 1346.5 |
| $M_1S_1$ | 1443.1 | 1496.5 |
| $M_1S_2$ | 1583.1 | 1643.2 |
| $M_2S_0$ | 1669.8 | 1713.2 |
| $M_2S_1$ | 1773.2 | 1823.2 |
| $M_2S_2$ | 1813.2 | 1916.5 |
| SEm $\pm$ | 103.3 | 253.0 |
| CD (0.05) | 213.4 | 551.9 |
| CV(%) | 13.6 | 14.5 |

SCMR values. These results are in concurrence with the findings of Nigam and Aruna (2008) and Babitha *et al*. (2006) and Kasiwagi *et al.* (2006).

In case of seed yield, no water stress with homobrassinolide spray recorded maximum seed yield i.e., 2451.3 kg/ha (Table 4). Water stress from vegetative stage with no spray recorded the minimum seed yield indicating the adverse effect of water stress. Among foliar sprays, spray with homobrassinolide @ 1ppm resulted higher seed yield to the extent of 20.9% than no spray and it was on par with kinetin spray @ 5ppm (Bajguz and Hayat, 2009). More limited availability of photoassimilates could be one reason for fewer pods on water stressed plants. These results were in concurrent with the earlier results of Yadava and Singh (2008) and Singh *et al.,* (2008).

These findings concluded that water stress induced from vegetative stage to harvest was deleterious than that of water stress from flowering to harvest and soil moisture content had significant negative correlation with root length, root volume, dry weight of roots and positive correlation with leaf area, LMRI, SCMR, seed yield. Since chickpea crop is generally grown on receding soil moisture conditions one irrigation at vegetative stage and another one at pod development stage are essential to obtain sustainable crop yields under unfavourable environmental conditions particularly under water stress. Homobrassinolide spray can be recommended in stress conditions to enhance the root and leaf characters by which consequently the final yield increases.

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