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# Mitigation of Drought and Heat for Improving Productivity by Use of Foliar Application of Salicylic Acid in Chickpea

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**A B S T R A C T**

Drought stress is a critical limiting factor in plant growth. Substances such as salicylic acid (SA) may enhance drought tolerance in plants. The present investigation focused on biochemical changes in JG14 and Dahod yellow seed by salicylic acid (SA) and Hydro-Priming with foliar application of SA and water in the drought and excessive moisture stress (EMS). The impacts on yields of chickpea bean were assessed for normal (3November 2014) and late (1 January 2015) sowing environments and foliar spray of salicylic acid (5 nano mole). Significantly higher yield parameters, yield, were recorded with foliar spray of salicylic acid. The experiment was Randomized Block Design (RBD) with six treatment viz, $T_1$-No treatments (control), $T_2$-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root),$T_3$- Foliar spray of water at 1st flower and one week after 1st flower, $T_4$-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding, $T_5$-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower and$T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding. The highest seed yield (33.15 g in V1 and 46.49 g in $V_2$ plant$^{-1}$) was obtained by the treatment $T_5$-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1$^{st}$ flower in the timely sown and 17.08 g in $V_1$ and 7.00 g in $V_2$ was found in late sowing treatment followed by treatment$T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding, grain yield plant$^{-1}$ was recorded 27.70 ($V_1$) and 31.70 ($V_2$) g plant$^{-1}$ and 8.27 ($V_1$) & 7.63 g ($V_2$) plant$^{-1}$ in timely sown and late sown respectively presented in Table 2. Grain yield significantly increase over control 216.01% ($V_1$) & 206.46% ($V_2$) under normal sowing and 100.24% ($V_1$) and 59.62% ($V_2$)grain yield plant$^{-1}$ under late sown condition, followed by $T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding normal sowing grain yield plant$^{-1}$ , respectively.

**Keywords**

Foliar spray, Salicylic acid, Nano mole, Podding and grain yield

## Introduction

Chickpea (*Cicer arietinum* L.) is a legume belongs in the family, Fabaceae, subfamily Faboideae. It is one of the most widely consumed pulse legumes and ranking third after peas and soybean, and also covers a total of 15% of the world's pulse productions (Montenegro *et al.*, 2010). It is an important source of protein, carbohydrate, B-group vitamins, and different minerals (Williams and Singh, 1988). It is considered an important source of cheap protein with high energy and nutritional values (Karamany and Bahr, 1999; Hulse, 1994). Drought stress is the most prevalent environmental factor that limits growth, survival, and productivity of chickpeas (Bohnert and Jensen, 1996). Globally chickpea (*Cicer arietinum L.*) is the third most important legume crop after dry bean (*Phaseolus vulgaris* L.) and peas (*Pisumsativum* L.) with a wide distribution across tropics, subtropics and temperate regions (Singh, 2006). It contained about 38-59% carbohydrates, 20-22% protein, 3% fiber and 4.8-5.5% oil (Miao *et al.*, 2009). The Ten top chickpea producing countries in order of importance are India, Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Spain, Canada and Mexico; out of which Pakistan accounts for 8.7% of the total global chickpea production and ranked in second position (FAOSTAT, 2012). Chickpea is important source of dietary protein for the predominantly vegetarian population of Subcontinent (Viveros *et al.,* 2001). India ranks I in area and production in the world, followed by Pakistan, Iran and Australia. The highest productivity of 3759 kg/ha is observed in China followed by Israel, Repbl. of Moldova and Bosnia & Herzegovina. It is a small herbaceous branched plant with maximum height of 45-60 cm roots include a strong central tap root with extensive lateral branches spread out in all directions in upper soil layers. India's productivity was 995 kg/ha. In India chickpea is the most important pulse crop and mostly grown under rainfed conditions (65%), remaining 35% with critical irrigation support. During XIIth Plan (2012-2017), it was grown in > 35 per cent of total pulse area (252.43 Lha) contributing to about 45% of total pulse production. It is mainly consumed as 'Dal' (split cotyledons) and chole. Many attractive dishes *viz*., sweets, snacks and namkeen are also prepared from its flour called besan. Also eaten as whole fried or boiled and salted. Fresh green leaves (sag) are used as vegetables and green grains as hare chole or cholia. Straw of gram is an excellent fodder while both husk and bits of 'Dal' are valuable cattle feed. Leaves consist of mallic and citric acid and are very useful for stomach ailments and blood purifier. Nutrition value given below-

**Nutritive Value**

| | | | |
|---|---|---|---|
| Protein | 18-22% | Calcium | 280mg/ 100g |
| Carbohydrate | 61-62% | Iron | 12.3mg/ 100g |
| Fat | 4.5% | Phosphorus | 301mg/ 100g |
| Fiber | 22-23% | Calorific value | 368-396Kcal/ 100g |

Three main mechanisms reduce crop yield by soil water deficit: (i) reduced canopy absorption of photosynthetically active radiation, (ii) decreased radiation-use efficiency and (iii) reduced harvest index (Earl and Davis, 2003). The reproducibility of drought stress treatments is very cumbersome, which significantly impedes research on plant drought tolerance. A slow pace in revealing drought tolerance mechanisms has hampered both traditional breeding eff orts and use of modern genetics approaches in the improvement of drought tolerance of crop plants (Xiong *et al.*, 2006). More than 75% of Indian chickpea farmers has own small or marginal holdings of less than two hectares, the production of chickpea is also affected in excessive cold conditions, it is mainly grown as a cool-season crop under both rain fed (79%) and irrigated condition and often maturing in the driest and hottest part of the year, about one third of flowers produced do not develop in to fruits, pests and diseases reduce the yields further as chickpea pods are mere prone to these, sudden excessive rain soon after sowing or at flowering does great harm, an early hot summer shortens the growing period, hastens maturity and reduces yield, hailstorms at ripening cause much damage.

PGRs significantly influence agronomical, morphological and physiological traits in crops and it was observed that at limited concentration they stimulate rapid cell division resulting faster vegetative and reproductive growth (Tiwari KN and BR Gupta,2006). They supplies either carbon and energy or essential mineral elements and active in very small quantity (e.g.,<1mM, often 1µM) which found in certain parts of the plant and usually translocated to other sites, where they evokes specific biochemical, physiological and or morphological responses (Salisbury and Ross, 1992, Davies, 1995; Khan *et al.*, 1998). Moreover, PGRs are important agents in the response of plants to the external physiological environment (Steudle, 2000). The increase in yield with the application of various PGRs might be due to increased yield attributes, which in turn resulted from effective translocation of photosynthesis.

In our country, there are insufficient research studies regarding the effects of plant growth regulators on agronomic and physiological characteristics of crop plants in drought stress conditions. Therefore, this experiment was aimed to study the reaction of two chickpea cultivars to the application of two plant growth regulators (i.e salicylic acid and ascorbic acid) under drought stress conditions.

## Materials and Methods

The experiment was sown in RBD with three replications on 3$^{rd}$ November, 2014 and 1$^{st}$ January, 2015 during *Rabi* 2014-15 at S.I.F. Farm, Kumarganj, with six treatment and two date of sowing normal sowing 3-11-14 and late sowing 01-01-2015 with two variety of chickpea JG 14 and V2-Dahod yellow *viz*,$T_1$-No treatments (control), $T_2$-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root),$T_3$- Foliar spray of water at 1st flower and one week after 1st flower,$T_4$-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding,$T_5$-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower and$T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding.

The normal period for the onset of monsoons in this region is the third week of June and it lasts up to the end of September or sometimes extends to the first week of October. Winter showers are often experienced between December and mid-February. However, March to May is generally dry. Of the total annual rainfall, ~75% is received from June to September. The winter months (with the temperature of <10 $^{0}$C ) are cool whereas summers are hot (~45 $^{0}$C) and dry. The coldest and hottest months are January and May, respectively. The temperature begins to rise in February and reaches the maximum in May. Experimental plots were laid out in main and sub-plots according to a standard statistical spilt-plot design with three replications. The seeds were covered by the soil from the other side of furrow. Gap filling and thinning were also done at appropriate stages. Periodic hand weeding was done as and when needed. Grain and straw yields of clusterbean were recorded. The border rows were harvested first and kept aside. Thereafter, the net plots were harvested and brought to the threshing floor after proper tagging and sun drying for per ha yield calculation. The soils of experimental field were found sandy loam PH is 8.5 with low organic carbon (0.30

%).The gross plot size was 12 sq meters and all packages of practices were followed for conducting the experiment. This experiment was laid out in randomized block design with three replications. Observations were recorded from three plants in each plot. Three plants were chosen diagonally. The data taken on flower initiation, days to 50% flowering, plant height (cm) at maturity, total dry biomass (g) at maturity, grain yield (g) per plant, number of filled pods per plant, number of empty pods per plant, total number pods per plant, dry biomass without pods (g) per plant, 100 grains weight (g), total dry biomass (g) at maturity (3.6 square meter area) and grain yield (g) at maturity (3.6 square meter area) of each plot were recorded separately. Threshing the harvested chickpea on tarpaulin followed by proper sun drying and winnowing, grain yield measured in gram. Recognition of outliers and clustering of accessions becomes easier with the help of PCA (Chatfield and Collins, 1990; Johnson and Wichem, 1996). Effect of environmental factors like; temperature, rainfall, humidity and soil moisture contents. Following drought tolerance indices were used evaluate the performance of chickpea yield; Mean Productivity (Rosielle and Hambling, 1981), Geometric Mean Productivity (Fernandez, 1992), % change (Choukan *et al.,* 2006). The Microsoft Excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameters (McCullough and Wilson, 2005). The standard level of significance used to justify a claim of a statistically significant effect is 0.05 (Fisher, 1954).

## Results and Discussion

### Effect of sowing dates

The data showed significantly higher grain yield, plant height, days to maturity and yield parameters for normal DOS (Date of Sowing) than those for the late sowing. These differences are primarily due to the differences in the environmental conditions and growth habit of the crop as evidenced from the variation in crop growth and yield parameters with sowing dates. The variable behavior of crop could be explained by the DOS. Efficiency of utilization of temperature depends on crop type, genetic factors and sowing (Ayaz, 2004; Nicholson, 2001). Crop sown at the normal DOS had longer duration of growth and used more heat and perform better than did the crop sown at the later DOS. Similar results were observed by (Meena *et al.,* 2015b; Subrahmaniyan *et al.,* 2008). The nodulation pattern on the root system is also important for biological N fixation for enhanced plant growth and development (Fatima *et al.,* 2008).This trend in nodulation is due to a longer growing season. Thus, there were variations in growth and yield parameters with sowing environments, the growth, yield protein and nutrient uptake were also affected by sowing time due to the variation in moisture availability vis-a-vis environmental factor. In comparisons to late sowing, normal sowing significantly enhanced nutrient uptake by the crop. Nutrient uptake is the function of nutrient concentration and yield. Therefore, increase in yield caused by normal DOS.

Data on morphological characters of growth of chickpea plants as affected by foliar application with different concentrations of salicylic acid are assumed in Table (1). The investigated morphological characters included plant height, and dry weight of shoot plant.

### Seed yield

Effects of drought stress on seed yield were statistically significant. The highest seed yield (33.15 g in V1 and 46.49 g in $V_2$ plant$^{-1}$) was obtained by the treatment $T_5$-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after $1^{st}$ flower in the timely sown and 17.08 g in $V_1$ and 7.00 g in $V_2$ was found in late sowing treatment followed by treatment $T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding, grain yield plant$^{-1}$ was recorded 27.70 ($V_1$) and 31.70 ($V_2$) g plant$^{-1}$ and 8.27 ($V_1$ )& 7.63 g ($V_2$ ) plant$^{-1}$ in timely sown and late sown respectively presented in Table 2. Grain yield significantly increase over control 216.01% ($V_1$) & 206.46% ($V_2$) under normal sowing and 100.24% ($V_1$) and 59.62% ($V_2$) grain yield plant$^{-1}$ under late sown condition, followed by $T_6$- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding normal sowing grain yield plant$^{-1}$ , respectively. The other treatment $T_2$-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root) grain yield per plant(g) 24.59 $V_1$,29.47 $V_2$ normal sowing and under late planting 6.76 $V_1$, 6.42 $V_2$ and increase % over control in normal sown condition it was 134.41 $V_1$, 94.26 $V_2$ and under late sown 63.68, 34.30, respectively. In the plot treated with treatment $T_3$- Foliar spray of water at 1st flower and one week after 1st flower, grain yield per plant (g) under normal sowing 22.72 V1, 27.92 V2, 5.69 $V_1$, 6.10 $V_2$ (late sowing) and grain yield increased 116.58.$V_1$, 84.05 $V_2$ (normal sowing), 37.77, 19.04 (late sowing) % over control, respectively. The treatment $T_4$-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding, grain yield (g) per plant under normal sowing 12.53 $V_1$, 17.11 $V_2$ and late sowing 5.40 $V_1$, 5.83in $V_2$ over control, under normal sown 19.44 $V_1$, 12.78 in $V_2$, respectively. Results in the elevation of seed yield through increasing in seed filling rate and seed weight. Terminal drought stress is considered as a primary constraint to chickpea productivity in countries such as Iran, where the crop is generally sown after the main rainy season and grown on stored soil moisture (Serraj *et al.*, 2004). Reduction in chickpea seed yield by means of terminal drought stress has been previously reported by other authors (Behboudian *et al.,* 2001; Fallah *et al.,* 2005). Ascorbic acid is considered as one of the plant responses in drought stress conditions which is involved in detoxification of reactive oxygen species (Gou *et al.,* 2005).

## Pods number per plant

The results showed that significantly affected the pods number per plant (Tab. 2). The maximum number of pods per plant was obtained by the treatment of foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding. When leaves senescence is induced as the result of drought stress, the abscission of pods will take place (Siddique and Sedgley, 1986).

## Test Weight (100 seeds)

The results showed that significantly affected the test weight (g 100 seeds) (Tab. 3). The maximum number of pods per plant was obtained by the treatment of foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding,

According to the results of this study, the reduction of yield parameters by reproductive stress was more pronounced as compared to vegetative stress, indicating the susceptibility of crop growth and yield to terminal drought stress conditions. Plant biomass was significantly increased through SA foliar spraying. Supplying the plants with SA in complete drought stress condition resulted in a high accumulation of proline in chickpea leaves.

**Table.1** Effect of foliar spray of salicylic acid and water on yield contributing characters of chickpea

| | Days to flower initiation | | days to 50% flowering | | plant height (cm) at maturity | | total dry biomass (g) at maturity | |
|---|---|---|---|---|---|---|---|---|
| **Ttratments** | **Normal Sowing** | **Late Sowing** | **Normal Sowing** | **Late Sowing** | **Normal Sowing** | **Late Sowing** | **Normal Sowing** | **Late Sowing** |
| T1V1-No treatments (control) | 86 | 53 | 106 | 68 | 56 | 38 | 43.01 | 17.2 |
| T1V2- No treatments (control) | 86 | 54 | 108 | 70 | 62 | 44 | 37.83 | 14.38 |
| T2V1-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root) | 86 | 56 | 104 | 69 | 52 | 50 | 68.38 | 19.45 |
| T2V2-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root). | 86 | 59 | 106 | 72 | 55 | 52 | 70.46 | 21.64 |
| T3V1- Foliar spray of water at 1st flower and one week after 1st flower. | 85 | 52 | 106 | 67 | 60 | 46 | 60.18 | 15.57 |
| T3V2- Foliar spray of water at 1st flower and one week after 1st flower | 86 | 54 | 108 | 69 | 66 | 50 | 55.34 | 18.55 |
| T4V1-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 84 | 52 | 107 | 67 | 54 | 45 | 49.88 | 18.91 |
| T4V2-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 85 | 53 | 108 | 68 | 59 | 49 | 44.93 | 16.46 |
| T5V1-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 86 | 53 | 102 | 66 | 53 | 40 | 90.22 | 25.08 |
| T5V2- Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 86 | 54 | 104 | 67 | 57 | 47 | 96.58 | 24.48 |
| T6V1- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding | 84 | 53 | 107 | 68 | 56 | 39 | 74.38 | 22.31 |
| T6V2-Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding. | 86 | 54 | 108 | 70 | 57 | 44 | 72.16 | 30.01 |
| **SEm±** | **0.46** | **0.55** | **0.35** | **0.55** | **3.15** | **2.85** | **2.86** | **1.34** |
| **CD (0.05%)** | **1.35** | **1.61** | **1.04** | **1.61** | **NS** | **8.36** | **8.38** | **3.94** |
| **CV (%)** | **0.84** | **1.77** | **0.58** | **1.39** | **9.53** | **10.88** | **7.78** | **11.44** |

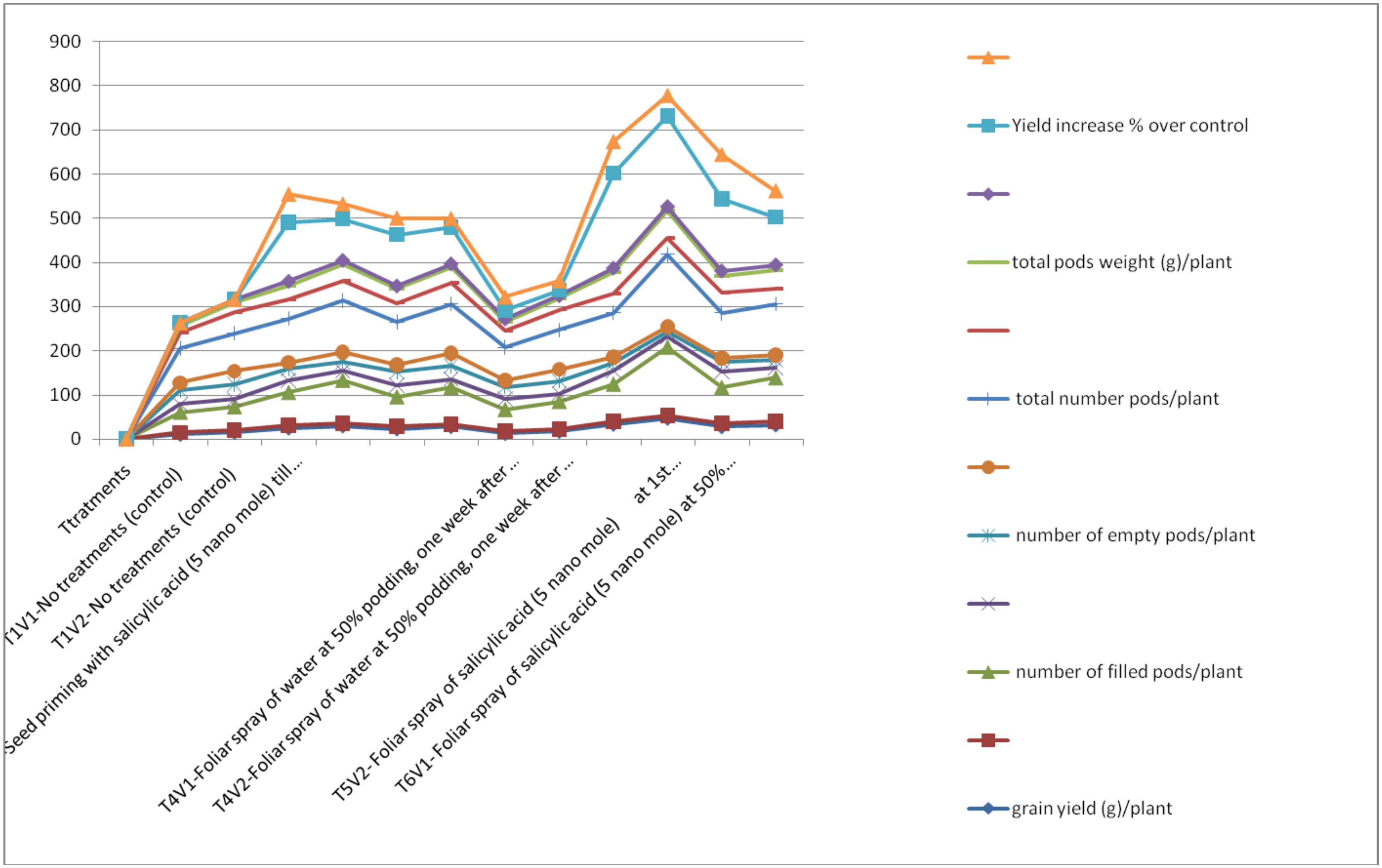
**Table.2** Effect of foliar spray of salicylic acid and water on yield and yield contributing characters of chickpea

| **Treatments** | **Grain yield (g)/plant** | | **Number of filled pods/plant** | | **Number of empty pods/plant** | | **Total number pods/plant** | | **Total pods weight (g)/plant** | | **Yield increase % over control** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **NS** | **LS** | **NS** | **LS** | **NS** | **LS** | **NS** | **LS** | **NS** | **LS** | **NS** | **LS** |
| T1V1-No treatments (control) | 10.49 | 4.13 | 46 | 18 | 32 | 17 | 78 | 35 | 15.99 | 6.39 | – | – |
| T1V2- No treatments (control) | 15.17 | 4.78 | 53 | 17 | 33 | 31 | 86 | 48 | 21.97 | 6.27 | – | – |
| T2V1-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root) | 24.59 | 6.76 | 74 | 27 | 26 | 15 | 100 | 42 | 31.80 | 9.57 | 134.41 | 63.68 |
| T2V2-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root). | 29.47 | 6.42 | 97 | 21 | 20 | 23 | 117 | 44 | 37.51 | 8.68 | 94.26 | 34.30 |
| T3V1- Foliar spray of water at 1st flower and one week after 1st flower. | 22.72 | 5.69 | 67 | 26 | 30 | 17 | 97 | 43 | 30.39 | 7.47 | 116.58 | 37.77 |
| T3V2- Foliar spray of water at 1st flower and one week after 1st flower | 27.92 | 6.10 | 83 | 19 | 29 | 29 | 112 | 48 | 34.29 | 7.93 | 84.05 | 19.04 |
| T4V1-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 12.53 | 5.40 | 49 | 24 | 27 | 15 | 75 | 38 | 18.59 | 7.19 | 19.44 | 30.75 |
| T4V2-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 17.11 | 5.83 | 62 | 18 | 28 | 27 | 89 | 46 | 24.10 | 7.14 | 12.78 | 21.96 |
| T5V1-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 33.15 | 7.08 | 84 | 31 | 17 | 13 | 101 | 44 | 46.68 | 9.62 | 216.01 | 71.42 |
| T5V2- Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 46.49 | 7.00 | 154 | 25 | 10 | 12 | 164 | 37 | 60.85 | 9.25 | 206.46 | 46.44 |
| T6V1- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding | 27.70 | 8.27 | 81 | 36 | 21 | 9 | 103 | 45 | 38.06 | 11.22 | 164.06 | 100.2 4 |
| T6V2-Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding. | 31.70 | 7.63 | 99 | 23 | 17 | 12 | 116 | 35 | 40.96 | 11.61 | 108.97 | 59.62 |
| **SEM±** | **1.98** | **0.67** | **6.0** | **2.2** | **4.30** | **3.68** | **3.76** | **2.16** | **2.44** | **0.58** | - | - |
| **CD at (0.05%)** | **5.82** | **1.97** | **17.7** | **6.4** | **12.60** | **10.79** | **11.02** | **6.33** | **7.16** | **1.69** | - | - |
| **CV%** | **13.7 9** | **18.5 6** | **13.3** | **15.9** | **30.7** | **34.9** | **6.3** | **8.9** | **12.6** | **11.7** | - | - |

**Table.2** Effect of foliar spray of salicylic acid and water on test weight and biomass of chickpea

| **Treatments** | **100 grains weight (g)** | | **Total dry biomass (g) at maturity (3.6 square meter area)** | | **Grain yield (kg) at maturity (3.6 $M^2$ area)** | |
|---|---|---|---|---|---|---|
| | **Normal Sowing** | **Late Sowing** | **Normal Sowing** | **Late Sowing** | **Normal Sowing** | **Late Sowing** |
| T1V1-No treatments (control) | 25.20 | 24.84 | 2.050 | 0.898 | 0.570 | 0.110 |
| T1V2- No treatments (control) | 26.43 | 25.12 | 2.308 | 1.021 | 0.675 | 0.187 |
| T2V1-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root) | 25.64 | 25.32 | 2.325 | 1.023 | 0.686 | 0.123 |
| T2V2-Seed priming with salicylic acid (5 nano mole) till initiation of radicle (root). | 26.75 | 26.39 | 2.513 | 1.231 | 0.781 | 0.214 |
| T3V1- Foliar spray of water at 1st flower and one week after 1st flower. | 25.95 | 25.29 | 2.247 | 0.934 | 0.668 | 0.117 |
| T3V2- Foliar spray of water at 1st flower and one week after 1st flower | 26.61 | 26.04 | 2.453 | 1.120 | 0.768 | 0.202 |
| T4V1-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 25.59 | 25.14 | 2.228 | 0.928 | 0.660 | 0.114 |
| T4V2-Foliar spray of water at 50% podding, one week after 50% podding, and two week after 50% podding | 26.58 | 25.92 | 2.396 | 1.163 | 0.713 | 0.191 |
| T5V1-Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 26.73 | 25.48 | 2.286 | 1.105 | 0.700 | 0.130 |
| T5V2- Foliar spray of salicylic acid (5 nano mole) at 1st flower and one week after 1st flower. | 27.06 | 26.54 | 2.640 | 1.318 | 0.871 | 0.226 |
| T6V1- Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding | 26.65 | 25.59 | 2.355 | 1.172 | 0.697 | 0.138 |
| T6V2-Foliar spray of salicylic acid (5 nano mole) at 50% podding, one week after 50% podding, and two week after 50% podding. | 26.91 | 26.49 | 2.574 | 1.377 | 0.831 | 0.238 |
| **SEm±** | **0.29** | **0.30** | **0.089** | **0.057** | **0.036** | **0.017** |
| **CD (0.05%)** | **0.85** | **0.89** | **0.262** | **0.167** | **0.105** | **0.051** |
| **CV (%)** | **1.9** | **2.0** | **6.5** | **8.9** | **8.6** | **18.2** |

**Fig.1** Effect of foliar spray of salicylic acid and water on yield contributing characters of chickpea



Electrolyte leakage in leaves tissue as a sign of cell membrane damage was decreased by foliar application of PGRs both in well watered and drought stress treatments, even though the positive effects of SA on cell membrane stability was more expressive. It is generally concluded that SA may enhance the growth of chickpea because of their protective traits, and it could be suggested that the application of these PGRs in stressed plants will resulted in diminishing the injurious effects of drought stress and consequently the promotion of crop productivity. Similar finding are also reported by Siamak Farjam *et al.,* 2014.

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