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Research Article

# APPRAISAL OF SALINITY STRESS TOLERANCE INDUCED BY PACLOBUTRAZOL IN CHICKPEA (*Cicer arietinum* L.)

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**Abstract-** In the present investigation, it was revealed that treatment with paclobutrazol (PBZ) @ 2.5, 5.0, 10 and 20 µg mL$^{-1}$ resulted in shoot length and shoot dry weight to decrease significantly under normal condition, but increased significantly in salinity (4 dS m$^{-1}$ and 8 dS m$^{-1}$) with respect to control. Treatment with PBZ resulted in a significant increase in root length and root dry weight as compared to control under both normal (PBZ) and saline conditions. Total chlorophyll was recorded to increase significantly at vegetative and flowering stages as compared to control. Hydrogen peroxide decreased significantly at vegetative and flowering stages. Treatment with PBZ resulted in a significant increase in protein and total sugar content at vegetative stage. Proline content decreased significantly at vegetative and flowering stages as compared to control under both normal (PBZ) and saline conditions. Peroxidase, catalase and nitrate reductase activity increased significantly at vegetative and flowering stages as compared to control under both normal (PBZ) and saline conditions.

**Keywords**- Salinity stress, Chickpea, Paclobutrazol

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## Introduction

Chickpea (*Cicer arietinum* L.) is a cool season pulse crop and is grown in several countries worldwide as a food source of protein. It contains appreciable amounts of crude protein that ranges from 17 to 24%. It is also a good source of carbohydrates, and both proteins and carbohydrates constitute 80% of total dry seed weight. It has essential amino acids such as lysine, tyrosine, glutamic, histidine and sulphur rich amino acids (methionine and cysteine) which are limited in pulses [1, 2]. The leaves and seeds of chickpea are used as medicine due to the presence of glandular secretions. The leaves are used to cure chronic bronchitis and the seeds are considered as antibilious, used as tonic, stimulant. Aphrodisiac acid is also supposed to lower the blood cholesterol level [3]. It is cultivated on 11.98 mha across the world producing 10.91 mt with productivity of 9112 kg ha-1. India is the largest producer in the world accounting for 66% of the total world production. The yield potential of present day chickpea cultivars is affected due to the different kinds of stresses showered on it. The difference between potential yield and average yield is mostly due to diseases, pests and poor management practices. Among abiotic stresses, salinity is the one of the most important stress in chickpea [4]. It is extremely vulnerable to salinity like other leguminous crops [5].Soil salinity is a major abiotic stress, which adversely affects physiological and biochemical processes, resulting in diminished growth and yield [6]. It occurs due to natural or human-induced activities resulting in the accumulation of soluble salt in soil [7]. It causes the low availability of water and nutrients due to the osmotic effects and retards the growth and photosynthesis in plants [8]. About 20% of all the irrigated lands are salt-affected [9]. The salt-affected areas have recently been estimated to be approximately 830 million hectares at global level [10]. Application of plant growth regulators is one of the ways to increase salt tolerance in plants. Treatments with paclobutrazol proved effective in reducing adverse effects of salinity. Paclobutrazol (PBZ) is a triazole fungicide; it is a known antagonist of the plant hormone gibberellin. PBZ is an inhibitor of cell elongation and inter node extension that hinders plant growth by inhibition of gibberellins biosynthesis. It is also induces morphological alterations of leaves, leading to smaller stomatal pores, thicker leaves, increased root density and increased number and size of surface appendages that may provide improved environmental stress tolerance [11]. The present study was undertaken to study the response of chickpea genotype under salinity stress to paclobutrazol.

## MaterialsandMethods

Pot experiment was conducted to study the effect of paclobutrazol in chickpea growth and development under induced salinity stress in the wire house of the Department of Plant Physiology, IAS, Banaras Hindu University. It was laid out in a Completely Randomized Design in 3 replications with 7 treatments. Wilt resistant and healthy seeds of chickpea *cv.* Uday (KPG-75) were procured from the Department of Genetics and Plant Breeding, IAS, Banaras Hindu University. Field dry soil was taken for experiment in the ratio of 1: 3: 1 (soil, sand and FYM) were mixed and then sterilized by using 4% formaldehyde (HCHO). The pots were washed with tap water and then sterilized by using 70% methanol and kept for drying. 6 days after sterilization pots were filled with soil mixture. Six to eight primed seeds with paclobutrazol @ 5, 10, and 20µg mL–1 were sown in each pot with induced salinity levels (4dSm-1 and 8dSm-1). Salinity stress treatment was given as a combination of NaCl, $CaCl_2$ and $Na_2SO_4$ in the ratio of 7: 3: 1 respectively into the pots upto saturation level. After drainage of excess solution, electrical conductivity was measured using Auto ranging conductivity/TDS meter TCM-15 supplied by Toshniwal instrument Mfg. Pvt. Ltd., Ajmer with a purpose to maintain the required salinity levels (4dSm-1 and 8dSm-1) in pots. The amounts of

salt solution added to pots were altered accordingly based on EC measurements, at weekly intervals. After germination, a population of four plants per pot was maintained. Fertilizer was applied in the ratio of 20: 40: 40 ppm of N P K respectively to each pot two days before sowing. Observations on different parameters were recorded at vegetative and flowering stages. Samples for physiological parameters and chlorophyll content were collected between 9.00 to 10.00 am. The morphological and growth parameters were recorded such as root length (cm), shoot length (cm), root dry weight (mg plant-1) and shoot dry weight (mg plant-1) and biological parameters such as total chlorophyll content was estimated by the method of Arnon [12], Free Proline content was determined by the method of Bates [13], Protein in the crude extract was determined according to the Coomasie Brilliant Blue G-250 dye binding method [14], Total sugar content in the plant samples was measured by following the method as proposed by Morris [15], Hydrogen peroxide was determined by Mukherjee and Choudhary [16], Peroxidase activity enzyme assay was performed as per the protocol of Kar and Mishra [17], For estimation of nitrate reductase activity, leaves from uniformly grown seedlings in a homogeneous population were selected for enzyme induction. The enzyme activity was assayed in vitro in the first fully expanded leaf according to the method of Srivastava [18]. The activity of catalase was assayed by the method of Sinha [19].

## Results

### Morphological Parameters

**Shoot length (cm):** Significant differences were observed in shoot length among different treatments at vegetative stage under two levels of salinity stress and three different concentrations of paclobutrazol [Table-1]. It was found that maximum shoot length without salinity and paclobutrazol treatments (S0C0) and least recorded in S0C0 (without PBZ) at vegetative stage There was increase in shoot length with increasing paclobutrazol concentrations under (S1- 4 dS m-1) and (S2- 8 dS m-1) of salinity stresses. Among all the PBZ treatment 5 µg mL-1 and 20 µg mL-1 concentrations of PBZ increased shoot length under S1 (4 dS m-1) and S2 (8 dS m-1) levels of salinity stress respectively. Therefore, PBZ @ 20 µg mL-1 significantly increased shoot length under both salinity levels but not more than the S0C0 (distill water and without PBZ). Under without saline condition 5 µg mL-1 PBZ performing better while in S1 and S2 condition 20 µg mL-1 performing better in relation to shoot length. Velagaleti and Marsh demonstrated that salt stress inhibits the shoot growth and decreases intrinsic photosynthetic capacity [20]. These results are in agreement with the findings of Hawkins and his coworkers who reported that PBZ markedly decreased plant height, increased root length and number of leaf cells mm-1 of the soybean plant [21].

**Table-1** *Effect of different concentrations of paclobutrazol on shoot length (cm), root length (cm), shoot dry weight (g) and root dry weight (g) under two levels of salinity stress in chickpea at vegetative stage*

| Treatments | Shoot length (cm) | Shoot DW (g) | Root length (cm) | Root DW (g) |
|---|---|---|---|---|
| $S_0C_0$ | 21.06 | 1.34 | 15.12 | 2.54 |
| $S_0C_1$ | 20.86 | 1.43 | 15.69 | 2.55 |
| $S_0C_2$ | 19.91 | 1.40 | 16.33 | 2.61 |
| $S_0C_3$ | 18.33 | 1.35 | 17.10 | 2.73 |
| $S_1C_0$ | 14.12 | 1.10 | 10.82 | 1.55 |
| $S_1C_1$ | 14.22 | 1.19 | 11.71 | 1.56 |
| $S_1C_2$ | 14.51 | 1.20 | 12.01 | 1.67 |
| $S_1C_3$ | 14.83 | 1.19 | 13.30 | 1.78 |
| $S_2C_0$ | 9.99 | 0.94 | 8.65 | 1.19 |
| $S_2C_1$ | 9.45 | 0.97 | 8.74 | 1.26 |
| $S_2C_2$ | 10.07 | 0.96 | 9.07 | 1.32 |
| $S_2C_3$ | 12.26 | 0.98 | 9.39 | 1.31 |
| Mean | 14.97 | 1.17 | 12.33 | 1.84 |
| SEm± | 0.29 | 0.14 | 0.26 | 0.12 |
| CD at 1% | 1.14 | 0.54 | 1.03 | 0.47 |

Where, **$S_0$-** Distill Water, **$S_1$-** Salinity (4dSm$^{-1}$), **$S_2$-** Salinity (8dSm$^{-1}$), **$C_0$-** No PBZ, **$C_1$-** PBZ (5.0µg mL$^{-1}$), **$C_2$-** PBZ (10.0µg mL$^{-1}$), **$C_3$-** PBZ (20.0µg mL$^{-1}$)

**Shoot dry weight:** Significant differences were observed in shoot dry weight among different treatments of PBZ at vegetative stage under two levels of salinity stress and three different concentrations of PBZ [Table-1]. Shoot dry weight were observed maximum under salinity stress in S1 (8 dS m-1) with 10 µg mL-1 PBZ treatment among all the salinity stress as well as PBZ treatments. Shoot dry weight were increased significantly with 5 µg mL-1 (C1), 10 µg mL-1 (C2) and 20 µg mL-1 (C3) PBZ treatments with salinity levels of S0, S1 and S2 respectively as compared to the without PBZ treatments i.e., C0 (distill water) at vegetative stage. There was an increase in shoot dry weight with increase in PBZ concentrations under salinity stress. In S1C3 (first level of salinity, 4 dS m-1) plus 20 µg mL-1 treated with PBZ) shoot dry weight was decreased but not less than control and equal to S1C1 (first level of salinity, 4 dS m-1) plus 0.5 µg mL-1 treated with PBZ). Researchers reported that roots were more sensitive to salt stress than shoots in chickpea [22-24].

**Root length:** Under distill water condition (S0) 20 µg mL-1 of PBZ increased the root length followed by 10 and 5 µg mL-1 of PBZ. Similar trends were observed in the root length with S1 and S2 salinity levels along with different concentrations of PBZ. The maximum root length was observed with 20 µg mL-1 PBZ treatment with all three salinity levels (S0, S1 and S2) at vegetative stage [Table-1]. First level of salinity (S1- 4 dS m-1) with their all concentrations of paclobutrazol has greater root length than the second level of salinity (S2-8 dS m-1). The differences in the root length among the salinity levels as well as treatments were not more but salinity stress affects the root length with all concentrations of paclobutrazol. It was observed the increasing concentration of paclobutrazol is responsible for increase in the root length with all levels of salinity stress. The root growth of safflower was more adversely affected compared to shoot growth under salinity stress [25].

**Root dry weight:** Significant differences were recorded in the root dry weight with all concentrations of paclobutrazol under different levels of salinity stress. Without salinity stress (distill water) increased the root dry weight with all concentrations of PBZ treatment but 20 µg mL-1 is more effective than the others. Salinity stress decreased the root dry weight at 8 dSm-1 than the control (S0 - distill water) and first level of salinity stress (S1 4 dSm-1). 20 µg mL-1 PBZ increased the dry weight under salinity stress as well as under control (S0 -distilled water) [Table-1]. There was increasing trends were observed in root dry weight with increase PBZ treatments with different levels of salinity stress.

### Biochemical Parameters

**Total Chlorophyll content:** Significant differences were observed in the total chlorophyll at vegetative and flowering stages under two levels of salinity levels (S1 and S2) and three concentrations of PBZ i.e., 5, 10 and 20 µg mL-1 [Table-2]. Among four concentration of PBZ under S0 salinity level 20 µg mL-1 (S0C3) PBZ increased total chlorophyll content at both vegetative and flowering stages and least total chlorophyll was recorded in S0C0 (control). There was increase in total chlorophyll content recorded with increasing different concentrations of PBZ. Under S1 level of salinity, it was observed that maximum chlorophyll was found in

S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ) and minimum total chlorophyll was recorded in S1C0 (4 dSm-1 plus without PBZ) at both vegetative and flowering stages. Under S2 (8 dSm-1) levels of salinity stress, it was found that maximum chlorophyll was found in S2C3 (8 dSm-1 plus 20µg mL-1 of PBZ) and minimum total chlorophyll was recorded in S2C0 (8 dSm-1 plus without PBZ) at both vegetative and flowering stages. There was increase in total chlorophyll with different concentrations of PBZ treatments at both vegetative and flowering stages under different levels of salinity stresses, but flowering stages has higher amount of total chlorophyll content at different concentrations of PBZ under different levels of salinity stress. Chlorophyll content of leaves decreased in generally under salt stress. The oldest leaves start to develop chlorosis and fall with prolonged period of salt stress [26, 27-28). PBZ enhanced the formation of chlorophyll biosynthesis through the increasing in mass of root system which is the major site of cytokinin biosynthesis [29].

**Table-2** *Effect of different concentrations of paclobutrazol on total chlorophyll content (mg g$^{-1}$ fresh weight), proline content (µg g$^{-1}$ fresh weight), protein content (mg g$^{-1}$ fresh weight) and total soluble sugar (mg g$^{-1}$ fresh weight) under two levels of salinity stress in chickpea at vegetative and flowering stages*

| Treatments | Vegetative Stage | | | | Flowering Stage | | | |
|---|---|---|---|---|---|---|---|---|
| | Total Chl. | Proline | Protein | TSS | Total Chl. | Proline | Protein | TSS |
| $S_0C_0$ | 1.99 | 0.24 | 6.28 | 69.23 | 2.20 | 0.22 | 8.11 | 82.28 |
| $S_0C_1$ | 2.09 | 0.22 | 6.86 | 72.13 | 2.30 | 0.19 | 8.28 | 83.84 |
| $S_0C_2$ | 2.17 | 0.20 | 7.38 | 73.55 | 2.40 | 0.17 | 8.33 | 84.76 |
| $S_0C_3$ | 2.21 | 0.21 | 7.27 | 72.48 | 2.51 | 0.16 | 8.45 | 83.95 |
| $S_1C_0$ | 1.36 | 0.30 | 4.86 | 50.05 | 1.50 | 0.24 | 6.90 | 57.07 |
| $S_1C_1$ | 1.38 | 0.28 | 4.95 | 50.76 | 1.54 | 0.21 | 7.05 | 58.23 |
| $S_1C_2$ | 1.49 | 0.26 | 5.13 | 51.88 | 1.69 | 0.19 | 7.33 | 59.38 |
| $S_1C_3$ | 1.74 | 0.25 | 5.25 | 53.24 | 1.76 | 0.18 | 7.77 | 60.95 |
| $S_2C_0$ | 1.06 | 0.35 | 3.86 | 27.66 | 1.17 | 0.26 | 5.69 | 33.67 |
| $S_2C_1$ | 1.13 | 0.33 | 3.98 | 27.74 | 1.26 | 0.24 | 5.84 | 35.08 |
| $S_2C_2$ | 1.18 | 0.31 | 4.34 | 28.70 | 1.31 | 0.21 | 6.02 | 36.43 |
| $S_2C_3$ | 1.26 | 0.29 | 4.51 | 29.88 | 1.36 | 0.19 | 6.37 | 37.14 |
| Mean | 1.59 | 0.27 | 5.39 | 50.61 | 1.75 | 0.21 | 7.17 | 59.40 |
| SEm± | 0.06 | 0.02 | 0.03 | 0.54 | 0.06 | 0.01 | 0.09 | 0.36 |
| CD at 1% | 0.22 | 0.07 | 0.12 | 2.12 | 0.24 | 0.05 | 0.34 | 1.42 |

Where, **$S_0$-** Distill Water, **$S_1$-** Salinity (4dSm$^{-1}$), **$S_2$-** Salinity (8dSm$^{-1}$), **$C_0$-** No PBZ, **$C_1$-** PBZ (5.0µg mL$^{-1}$), **$C_2$-** PBZ (10.0µg mL$^{-1}$), **$C_3$-** PBZ (20.0µg mL$^{-1}$), TSS- Total Soluble Sugar

**Proline Content:** Proline content was observed at vegetative and flowering stages under two levels of salinity stress and three different concentrations of [Table-2]. Proline content observed minimum under S0C3 (without salinity plus 20 µg mL-1 of PBZ) and maximum was recorded in S0C0 (control). Paclobutrazol treatment decreased the proline content under distilled water (S0), 4 dSm-1 (S1) and 8 dSm-1 (S2) salinity stress along with different concentrations of paclobutrazol Paclobutrazol (C1) 5 µg mL-1 increased proline content followed by (C2) 10 and (C3) 20 µg mL-1 with different levels of salinity stress at both vegetative and flowering stages. Under S1 salinity stress it was found that least proline content found in S1C3 (4 dSm-1 plus 20µg mL-1 of paclobutrazol) and maximum was recorded with S1C0 (4 dSm-1 plus without PBZ). It was observed that under S2 level of salinity stress least proline content found with S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and maximum was recorded with S2C0 (8 dSm-1). The amount of proline was higher at vegetative stage as compared to the flowering stage with all concentrations of PBZ treatments under S0, S1 and S2 salinity levels. In salt stress condition proline content was more observed, which is harmful for plants.

**Protein content:** Protein content was observed at vegetative and flowering stages under two levels of salinity stress and three concentrations of PBZ [Table-2]. Under the S0 (distilled water) condition it was observed that maximum protein content with S0C2 (without salinity plus 10 µg mL-1 of PBZ) and least protein content was recorded with S0C0 (control). There was increase in protein content recorded with increasing concentrations of treatment of PBZ, but in S0C3 (without salinity plus 20 µg mL-1 of PBZ) low protein content was found as compared to S0C2. Under S1 (4 dSm-1) salinity level it was observed that maximum protein content found with S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ) and least protein content was recorded with S1C0 (4 dSm-1 plus without PBZ). Under salinity level S2 (8 dSm-1) it was observed that maximum protein content found in S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and protein content was recorded in S2C0 (8dSm-1). There was increase in protein content recorded with PBZ treatment at vegetative stage, but in flowering stage protein content was more as compared to vegetative stage which was in conformity with the findings of Sankhla et al. who reported that PBZ-treated soybean plants showed increased soluble protein contents compared to control [30]. The experiment supported decrease in protein content due to salt stress which was in consonance with the findings reported by Singh and Singh [31].

**Total Soluble Sugar content:** Significant differences were observed in the total soluble sugar content at vegetative and flowering stages under two levels of salinity and three concentrations of PBZ. Under the salinity stress total sugar content was found maximum with S0C2 (without salinity plus 10.0µg mL-1 of PBZ) and least total sugar content was recorded in S0C0 (control). There was increase in total soluble sugar content recorded with treatment of PBZ but in S0C3 (without salinity plus 20 µg mL-1 of PBZ) low total sugar content was found as compared to S0C2 [Table-2]. Under salinity stress (S1) it was observed that maximum total sugar content found in S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ] and least total sugar content was recorded in S1C0 (4 dSm-1) plus without PBZ). Under salinity levels (S2) it was observed that maximum total sugar content was found with S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and the minimum total sugar content was recorded in S2C0 (8 dSm-1) at both vegetative as well as under flowering stage. The amount of total soluble sugar was found more at flowering stage as compared to the vegetative stage under different levels of salinity and PBZ treatments. Salt induced reduction in the amount of sugar has also been reported by Singh and Singh [31].

**Hydrogen peroxide (H2O2):** Hydrogen peroxide content was observed at vegetative and flowering stages under two levels of salinity and three concentrations of PBZ [Table-3]. It was observed that minimum hydrogen peroxide content found with S0C3 (without salinity plus 20 µg mL-1 of PBZ) and maximum H2O2 was recorded with S0C0 (control). There was decreasing trend observed in hydrogen peroxide with increasing the concentration of PBZ treatment at both vegetative and flowering stages. Under the S1 (4 dSm-1) salinity stress it was found that minimum hydrogen peroxide with S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ) and maximum hydrogen peroxide was recorded with S1C0 (4 dSm-1 plus without PBZ) at vegetative and flowering stages. Salinity level S2 revealed that the least hydrogen peroxide was found with S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and maximum hydrogen peroxide was recorded with S2C0, salinity 8 dSm-1 with control.

**Peroxidase Activity:** A significant difference in the peroxidase activity was observed at vegetative and flowering stages under two levels of salinity and three different concentrations of PBZ [Table-3]. Salinity level S0 revealed maximum peroxidase activity with S0C3 (without salinity plus 20 µg mL-1 of PBZ) and

minimum peroxidase activity was recorded with S0C0 (Control). The activity of peroxidase was increased with increasing the concentrations of paclobutrazol treatment at both vegetative and flowering stages. Salinity level S1 resulted that maximum peroxidase activity was found with S1C3 (4dSm-1 plus 20 µg mL-1 of PBZ) and minimum peroxidase activity was recorded with S1C0 (4dSm-1 plus without PBZ). Under the S2 level of salinity stress shows maximum peroxidase activity with S2C3 (8dSm-1 plus 20 µg mL-1 of PBZ) and minimum peroxidase activity was recorded with S2C0 (8 dSm-1 with control) at both vegetative and flowering stages. Nazar et al. also found that salt stress increased the activity of APX in Vigna radiate, since it eliminates H2O2 by converting ascorbate to dehydroascorbate [32].

**Catalase Activity:** Catalase activity was observed maximum with S0C3 (without salinity plus 20 µg mL-1 of PBZ) and slightest catalase activity with S0C0 (control). There was increase in catalase activity with increase in the PBZ concentrations at both vegetative and flowering stages [Table-3]. Under the salinity level S1 it was observed that maximum catalase activity found with S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ) and minimum catalase activity was recorded with S1C0 (4 dSm-1 plus without PBZ) at vegetative and flowering stages. Salinity stress S2 level revealed that the maximum catalase activity shows with S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and minimum catalase activity was recorded with S2C0 (8 dSm-1 salinity with control).

**Table-3** *Effect of different concentrations of paclobutrazol on hydrogen peroxide (µM g$^{-1}$ fresh weight), peroxidase activity (EU g$^{-1}$ fresh weight min$^{-1}$), catalase activity (EU g$^{-1}$ fresh weight min$^{-1}$) and nitrate reductase activity (EU g$^{-1}$ fresh weight min$^{-1}$) under two levels of salinity stress in chickpea at vegetative and flowering stages*

| Treatments | Vegetative Stage | | | | Flowering Stage | | | |
|---|---|---|---|---|---|---|---|---|
| | $H_2O_2$ | Peroxidase | Catalase | NR | $H_2O_2$ | POX ctivity | Catalase | NR |
| $S_0C_0$ | 28.77 | 40.27 | 12.66 | 17.48 | 36.43 | 32.53 | 13.10 | 66.60 |
| $S_0C_1$ | 27.20 | 40.34 | 13.03 | 18.63 | 34.58 | 33.53 | 13.42 | 66.14 |
| $S_0C_2$ | 26.13 | 42.08 | 13.55 | 19.21 | 32.16 | 34.84 | 14.19 | 68.54 |
| $S_0C_3$ | 25.01 | 42.93 | 13.98 | 19.22 | 31.85 | 35.14 | 14.98 | 68.64 |
| $S_1C_0$ | 29.04 | 36.23 | 9.06 | 12.25 | 37.26 | 29.93 | 10.06 | 46.35 |
| $S_1C_1$ | 29.02 | 36.46 | 9.20 | 13.03 | 37.05 | 30.62 | 10.68 | 46.87 |
| $S_1C_2$ | 28.95 | 37.34 | 10.12 | 13.83 | 36.85 | 31.91 | 11.11 | 47.13 |
| $S_1C_3$ | 28.83 | 37.94 | 11.13 | 13.92 | 36.60 | 32.24 | 11.65 | 48.16 |
| $S_2C_0$ | 29.13 | 32.19 | 7.14 | 5.02 | 38.61 | 25.58 | 8.10 | 26.75 |
| $S_2C_1$ | 29.11 | 33.16 | 7.83 | 6.05 | 38.43 | 26.33 | 8.72 | 26.64 |
| $S_2C_2$ | 29.07 | 33.36 | 8.09 | 6.23 | 38.12 | 27.59 | 9.21 | 26.55 |
| $S_2C_3$ | 29.05 | 33.58 | 8.57 | 7.06 | 37.81 | 27.62 | 9.97 | 27.03 |
| Mean | 28.28 | 37.07 | 10.36 | 12.66 | 36.31 | 30.65 | 11.27 | 47.12 |
| SEm± | 0.68 | 0.37 | 0.33 | 0.40 | 0.27 | 0.54 | 0.17 | 0.45 |
| CD at 1% | 2.68 | 1.45 | 1.32 | 1.60 | 1.09 | 2.13 | 0.66 | 1.78 |

Where, **$S_0$-** Distill Water, **$S_1$-** Salinity (4dSm$^{-1}$), **$S_2$**- Salinity (8dSm$^{-1}$), **$C_0$**- No PBZ, **$C_1$**- PBZ (5.0µg mL$^{-1}$), **$C_2$**- PBZ (10.0µg mL$^{-1}$), **$C_3$**- PBZ (20.0µg mL$^{-1}$), TSS- Total Soluble Sugar.

**Nitrate reductase Activity:** The activity of nitrate reductase was observed maximum with S0C3 (without salinity plus 20 µg mL-1 of PBZ) and minimum nitrate reductase activity was recorded with S0C0 (control) at both vegetative and flowering stages. Salinity stress reduced the catalase activity with all concentrations of paclobutrazol but 20µg mL-1 PBZ has higher activity of catalase with all levels of salinity stress [Table-3]. Under the first level of salinity stress it was observed that maximum nitrate reductase activity found with S1C3 (4 dSm-1 plus 20 µg mL-1 of PBZ) and minimum nitrate reductase activity was recorded with S1C0 (4 dSm-1 plus of PBZ). Under the second level of salinity stress (S2) were observed maximum nitrate reductase activity with S2C3 (8 dSm-1 plus 20 µg mL-1 of PBZ) and minimum nitrate reductase activity was recorded with S2C0 (8 dSm-1 with control).

## Conclusions

It was concluded that the salinity stress affects the shoot length, shoot dry weight, root length, root dry weight, chlorophyll content, proline content, protein content, total soluble sugar content, hydrogen peroxide content, peroxidase, catalase and nitrate reductase activities of chickpea cv. Uday (KPG-75) when increasing its concentration from 4dSm-1 to 8dSm-1 with all concentration of paclobutrazol. Seed primed with paclobutrazol @ 20 µg mL-1 ameliorates the deleterious effect of salinity stress than the 5 and 10 µg mL-1 of PBZ under both salinity levels (S1 - 4dSm-1 and S2 - 8dSm-1) with respect to all physiological and biochemical observations. The significant responses of PBZ @ 20 µg mL-1 were observed with S0 (distill water) and S1 (4dSm-1) salinity level in chickpea with respect to the physiological and biochemical parameters.

**Conflict of Interest:** None declared

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