(Mechri et al., 2015). Phenolic compounds increase plants resistance under drought stress condition by reducing the ROS formation (Gnanasekaran and Kalavathy, 2017). Erdogan et al. (2016) who reported that use of multi-trait bacteria increased leaf TPC of strawberry under drought stress. Accumulation of TPC in the inoculated plant may be due to the effect of PGPR on increasing PAL activity. These results are in agreement with our finding on cucumber plant growth under drought stress. Increased antioxidant activities and phenolic compounds in cucumber plants help to increase drought tolerance by protecting from oxidative stress.

3.5. PAL activity

ANOVA indicated significant effect of interactions drought and bacterial strains on PAL activity ($P \leq 0.05$) (Table 2). PAL activity in control and inoculated plants was enhanced under drought stress. The maximum increase in PAL activity was recorded in VUPF5 by 1.5 fold and the minimum increase was observed in the plants inoculated with T17-4 strain by 1 fold in comparison to control (Figure. 8).

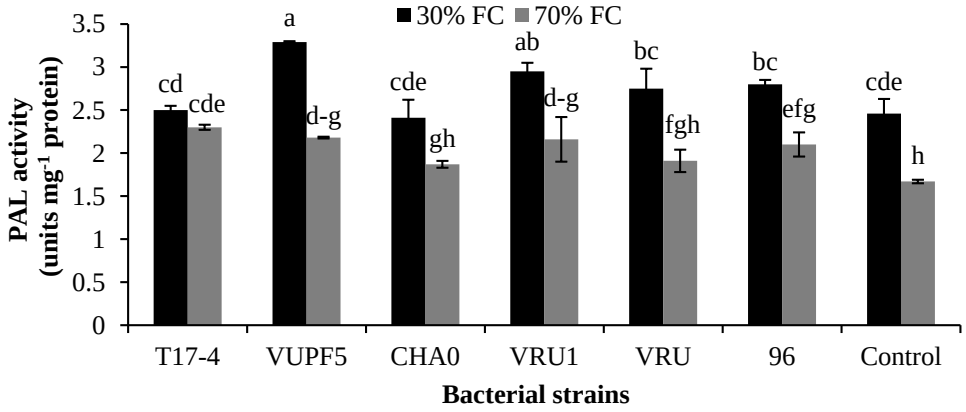

Figure. 8 Effect of bacterial strains on PAL activity of cucumber plants under drought stress. Bar indicate standard error. Columns with different letters are significantly different at $P \geq 0.05$.

Stress regulates activity of PAL enzyme, which plays a main role in the first and pivotal steps of the phenyl propanoid pathway. Phenyl propanoid pathway is the pathway of phenols biosynthesis (Tovar et al., 2002). There is a significant correlation between phenylalanine ammonia-lyase activity and soluble phenolic content in roots (Caliskan et al., 2017). Therefore high PAL activity causes more phenolic compound synthesis. Accumulation of TPC in inoculated plant may be due to the effect of PGPR on increasing PAL activity. Basha et al. (2006) reported that use of PGPR on chickpea plant induced synthesis of PAL activity under stress condition.

3.6. Antioxidant activity

In our study, based on ANOVA results, SOD, PPO and GPX were influenced by interaction of drought and bacterial strains ($P \leq 0.05$) (Table 2). As shown in figure 8, SOD activity in control plant and inoculated plants were significantly induced by increasing drought stress. The increment in SOD activity due to drought stress was generally higher in the control plant fallowed by CHA0> T17-4> BsVRU1> Bs96> VUPF5> BsVRU (Fig. 9).

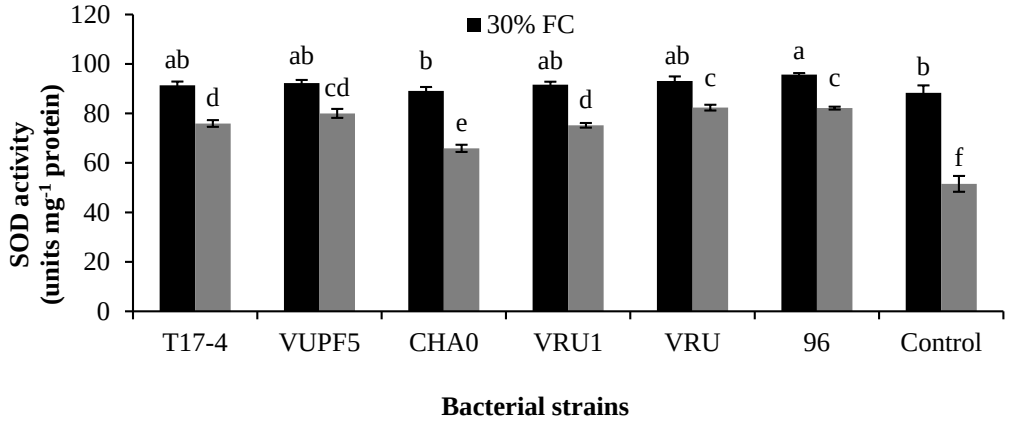

Figure 9. Effect of bacterial strains on SOD activity of cucumber plants under drought stress. Bar indicate standard error. Columns with different letters are significantly different at $P \geq 0.05$.

PPO activity was also increased under drought condition. The maximum and minimum increase of PPO activity was recorded in control and BsVRU1 inoculated plants by 78.66% and 72.56%, respectively (Fig. 10). With increasing drought severity, the GPX activity increased considerably. The maximum increase in GPX activity was observed in control plants by 6.6 fold and the minimum increase was recorded in the plants inoculated with 96 strain by 1.75 fold in comparison to control (Fig. 11). Another response of drought-stressed plants is reactive oxygen species (ROS) production. Cucumber plants inoculated with bacterial strains significantly had higher activity of antioxidant enzymes and phenolic compounds as compared to un-inoculated plants. These bacterial strains can induced stress related enzymes (SOD, GPX, and PPO) in cucumber plants. In plants, fast removal of hydrogen peroxidase is critical for cell function; otherwise, hydrogen peroxidase can diffuse across membrane to react with singlet oxygen resulting in destructive hydroxyl radicals production (Sanchez-Rodrıguez et al., 2012).

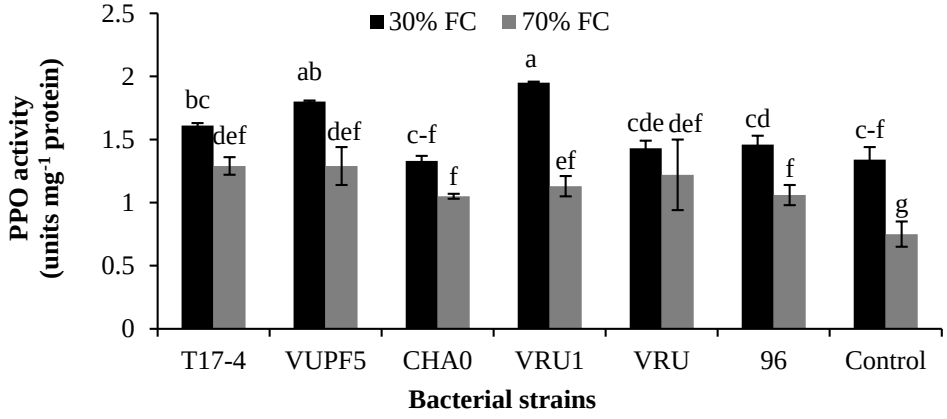

Figure 10. Effect of bacterial strains on PPO activity of cucumber plants under drought stress. Bar indicate standard error. Columns with different letters are significantly different at $P \geq 0.05$.

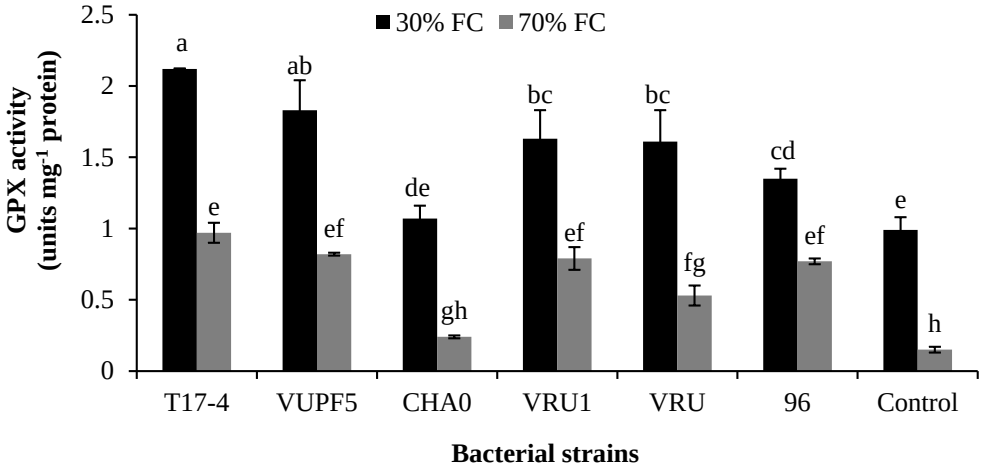

Figure. 11 Effect of bacterial strains on GPX activity of cucumber plants under drought stress. Bar indicate standard error. Columns with different letters are significantly different at $P \geq 0.05$.

Enzymatic antioxidants scavenge reactive oxygen species and reduce the oxidative damage under environmental stress (Miller et al., 2010). Peroxidase can decompose hydrogen peroxidase to H2O and O2. It uses hydrogen peroxidase as an electron donor to metabolize phenolic compounds (Caverzan et al., 2012). Kumar et al. (2016) showed that use of PGPR induced antioxidant activity in chickpea plant compared to control plants. Li and Jiang (2017) indicated that inoculation of maize plant with *B. aquimaris* DY-3 reduced the salt stress by activating of the antioxidant enzymes and the non-antioxidant systems that increase the plant tolerance. Generally, difference between strains on proline, sugar, TPC, and antioxidant activity may be due to following reasons; (i) production of phytohormones like abscisic acid (ABA), gibberellic acid, cytokinins, and indole-3-acetic acid (IAA); (ii) lowering ethylene levels by ACC deaminase production; (iii) The bacterial release compounds induced systemic tolerance; (iv) Exopolysaccharides (EPS) production by bacteria, which change physiological responses.

4. Conclusion

Our results showed that probiotic application could alleviate drought stress effect by increasing in proline, sugar, TPC, PAL and antioxidant activity and chlorophyll content. Probiotic bacteria have a critical role in induction of tolerance and adaptation of plants to environmental stresses. These results suggest that when cucumber roots were treated with probiotic bacteria, they can stimulate plant defense system and alleviate the harmful effect of drought stress by increasing osomoregulators and antioxidant enzymes in plants.

Conflict of interest

The authors declare no conflict of interest.

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