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Effect of Exogenous Application of Silicon with Drought Stress on Protein and Carbohydrate Contents of Edible Beans (*Vigna radiate* & *Vigna unguiculata*)

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ABSTRACT
An experiment was carried out under field conditions to determine the impact of silicon application with different concentrations (20, 40, 60 ppm), on selected physiological characteristics of the leaves of mungbean (*Vignaradiata*) and cowpea (*Vigna unguiculata*) under different 100%, 75%, 50% and 25% soil moisture regimes. Stock solution (100 ppm) of silicon was prepared by MgSi3 salt but apply as 20, 40, 60 ppm solution in both treated and control plants. Results showed that silicon application significantly increases total carbohydrate & protein contents in treated samples as compare to control plants. In present study we concluded that silicon promoted growth in the drought susceptible species to greater extent & it's more beneficial for carbohydrates and protein metabolism of cowpea (*Vigna unguiculata*) as compare to mungbean (*Vignaradiata*) plants.

Keywords: silicon, drought stress, protein, carbohydrate, *vigna radiata*, *vigna unguiculata*

1. INTRODUCTION
Silicon (Si) is the second most abundant element both on the Earth's crust and in the soil.[1] All plants growing in soils take up Si, but Si content in plant tissues varies greatly among plants.[2] The beneficial effects of Si on stimulating plant growth, however, have recently received increasing attention, particularly in plants subject to both a biotic and biotic stresses.[3,1,4] Research shows that silicon benefits plants by improving the resistance to wilt, and resistance to water stress.[5]

Drought continues to be a challenge to agricultural scientists as drought, often causes decrease or unsteadiness of crop production. Therefore, studying the drought-tolerance of crops is very significant to solve the problem of food supplies.[6] Drought stress lead a reduction of xylem vessel diameter and a modification of conductivity components of transpiration pathway (root, shoot, stomata) that may contribute to the reduction of water flow from root to shoot.[7] In turn, a drought stress affects such physiological processes as translocation at the whole plant level, leaf expansion and gas exchange at the organ level, and photosynthesis at the sub cellular level and at the end, it reduces growth and yield.[8]

The reasons for inhibition the growth and photosynthetic abilities of plants by the environmental stress is the breakdown of the balance between the production of reactive oxygen species (ROS) and the antioxidant defense causing accumulation of ROS, which induces oxidative stress to proteins, membrane lipids and other cellular components.[8,9] In drought, high activities of antioxidant enzymes and high contents of non enzymatic constituents are important for plants to tolerate stresses.[10]

Soil moisture is a principal environmental factor limiting legume productivity in the tropics and sub-tropics.[11-12] The lack of adequate soil moisture affects both vegetative and reproductive growth of food legumes, resulting in significant yield losses.[13] However, most studies on legumes have concentrated on the impact of moisture stress on the growth and development of one species.[13-12] Comparative studies on the effect of soil moisture on different food legumes have not been carried out, although these species are grown under the same environmental conditions.[14]Mungbean (*Vigna radiata* L.Wilczek) and Cowpea (*Vigna unguiculata* L. Walp) are two important tropical food legumes grown extensively under marginal conditions. Cowpea is considered a drought tolerant species,[15-16] while mungbean requires adequate soil moisture for growth and development.[17] Silicon application would therefore be expected to have different effects on these different food legumes in overcoming moisture stress.
The objectives of this study were to find possibility of the role of silicon to cut off the effects of water stress on carbohydrate and protein contents of plants.

2. MATERIAL AND METHODS
Experiments were conducted on two different edible beans i.e Cowpea *(Vigna unguiculata)* and Mungbean *(Vigna radiata)*. The seeds were obtained from local Market. Average soil PH was estimated about 7.75 by pH meter (Mettler Toledo, mp 220 pH meter).[18] Soil E.C was estimated at 0.73 ms by E.C. meter (Hanna instruments, HI 8733, conductivity meter).[19] Soil organic matter % was estimated 1.4% by "LOSS ON IGNITION METHOD - LOI".% soil moisture estimated 15.31%healthy seeds of Mung bean *(Vigna radiate)*, Cowpea *(Vigna unguiculata)* obtained and sterilized with 1% mercuric chloride solution. Equal sized plastic pots of were filled with approximately equal amount of ordinary soil and sterilized seeds were sown in each pot. After seedling establishment silicon treatments were applied and watering pattern was changed according to the drought treatments. Leaf samples from both control

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and treated plants were collected weekly up to a period of 5 weeks in the early hour of the morning and were kept in labeled plastic bags. Silicon treatments were applied, as $MgSi_3$100-ppm stock solution of $MgSi_3$ was prepared. And 3 different silicon treatments were maintained as: S1, S2, S3 having 20, 40, 60 ppm solution respectively. Control treatments were applied, as $MgSO_4$100-ppm stock solution of $MgSO_4$ was prepared. And 3 different control treatments were maintained as C1, C2, C3 having 20, 40, 60 ppm solution respectively. Drought treatments were maintained as D0, D1, D2, and D3 100%, 75%, 50% and 25% moisture in soil respectively. Protein contents estimated in leaf samples according to the method of Lowry's.[20]The carbohydrates were estimated by Yemm& Willis method using anthrone reagent.[21]

3. RESULTS

The results obtained by the different combination of drought stress and silicon treatments are shown by Figures (1-4).

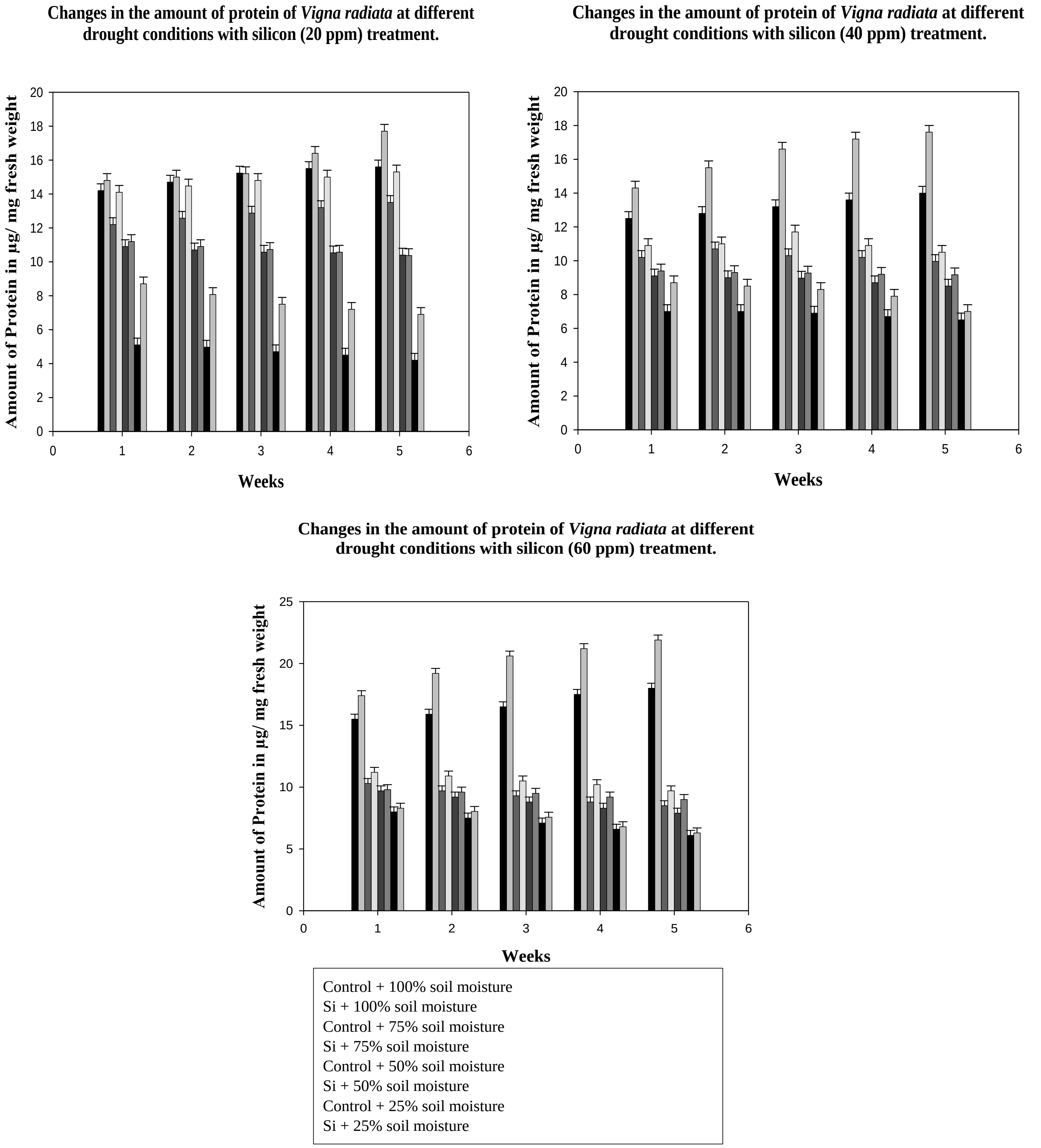
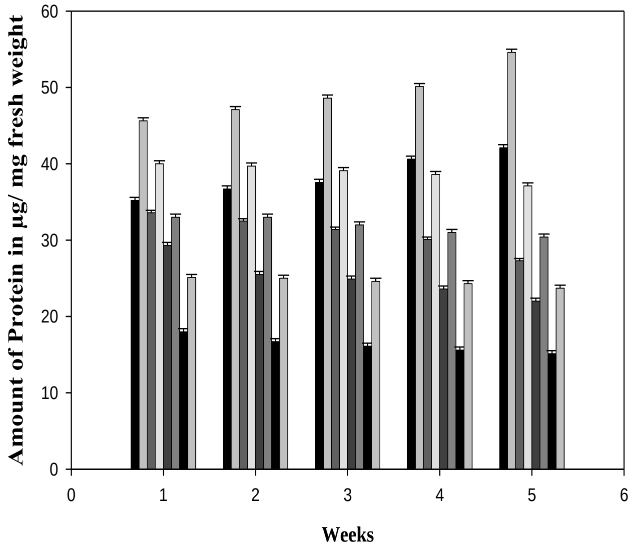
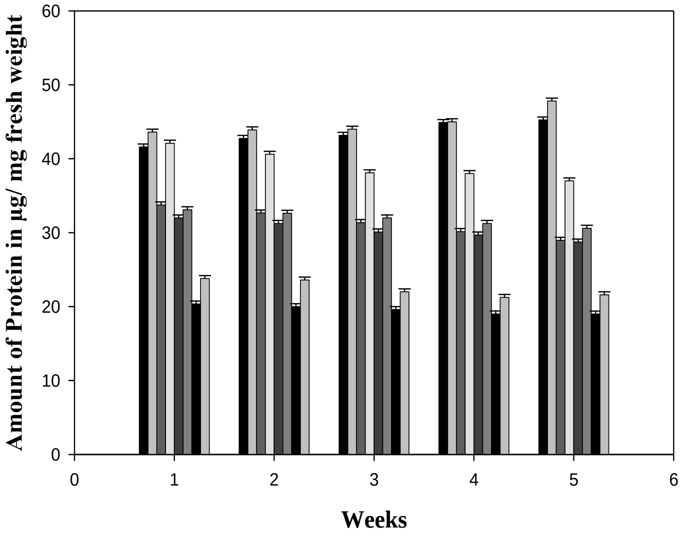


Fig. 1

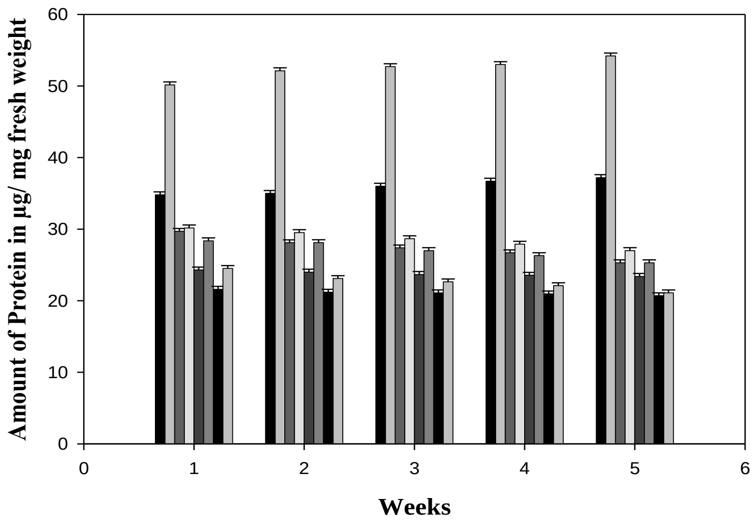
Changes in the amount of protein of *Vigna unguiculata* at different drought conditions with silicon (20 ppm) treatment.



Changes in the amount of protein of *Vigna unguiculata* at different drought conditions with silicon (40 ppm) treatment.



Changes in the amount of protein of *Vigna unguiculata* at different drought conditions with silicon (60 ppm) treatment.



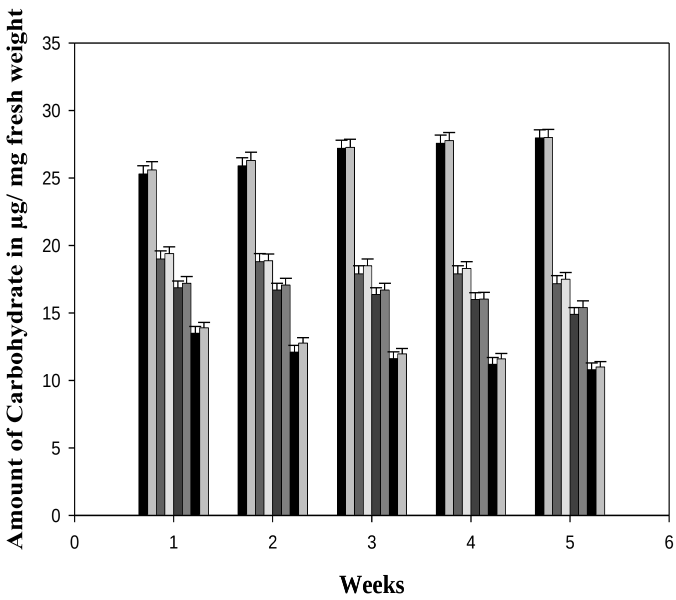
Control + 100% soil moisture
Si + 100% soil moisture
Control + 75% soil moisture
Si + 75% soil moisture
Control + 50% soil moisture
Si + 50% soil moisture
Control + 25% soil moisture
Si + 25% soil moisture

Fig. 2

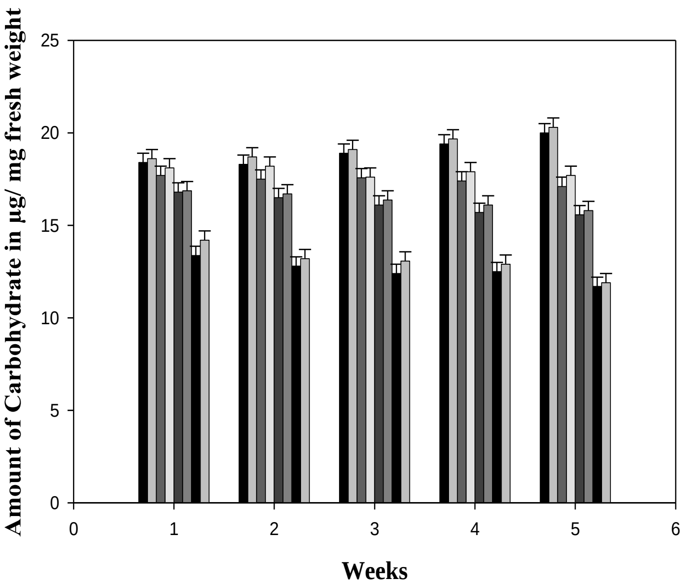
Protein contents found to be reduced with the increasing drought treatments weekly in both silicon treated and non-treated plants. By the silicon application the reduction in protein contents, observed lesser than non-silicon treated plants (Fig. 1 & 2). And the second treatment of silicon (40 ppm) is found to be more beneficial for protein contents (Fig. 1 & 2).

Total carbohydrate contents found to be reduced with the increasing drought treatments weekly in all plants. The reduction in total carbohydrate contents by the silicon application, observed lesser in treated than non-silicon treated plants (Fig. 3 & 4).

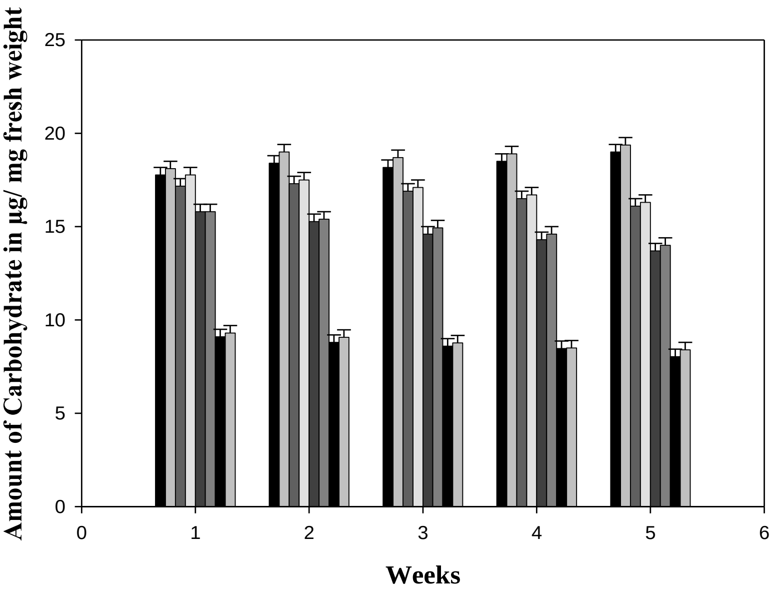
Changes in the amount of carbohydrate of *Vigna radiata* at different drought conditions with silicon (20 ppm) treatment.



Changes in the amount of carbohydrate of *Vigna radiata* at different drought conditions with silicon (40 ppm) treatment.



Changes in the amount of total carbohydrate of *Vigna radiata* at different drought conditions with silicon (60 ppm) treatment.

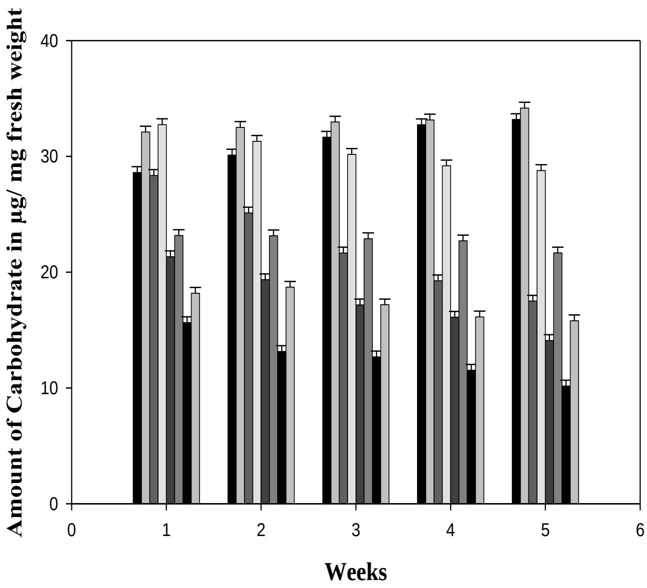


Control + 100% soil moisture
Si + 100% soil moisture
Control + 75% soil moisture
Si + 75% soil moisture
Control + 50% soil moisture
Si + 50% soil moisture
Control + 25% soil moisture
Si + 25% soil moisture

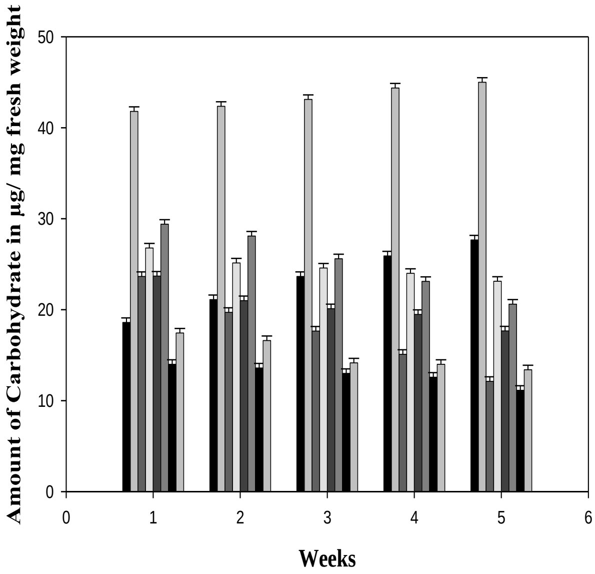
Fig. 3

And the first and second treatments of silicon (20, 40 ppm) are found to be more beneficial for total carbohydrate contents than the third one (60 ppm). In cow peas, we found a slight increase in total carbohydrate contents with the increasing drought treatments on first week only to the moderately drought extend. But with the passage of time these contents decreased in comparison with the control in both silicon treated and non-treated plants. By the silicon application the reduction in total carbohydrate contents, observed lesser than non-silicon treated plants (Fig. 3 & 4).

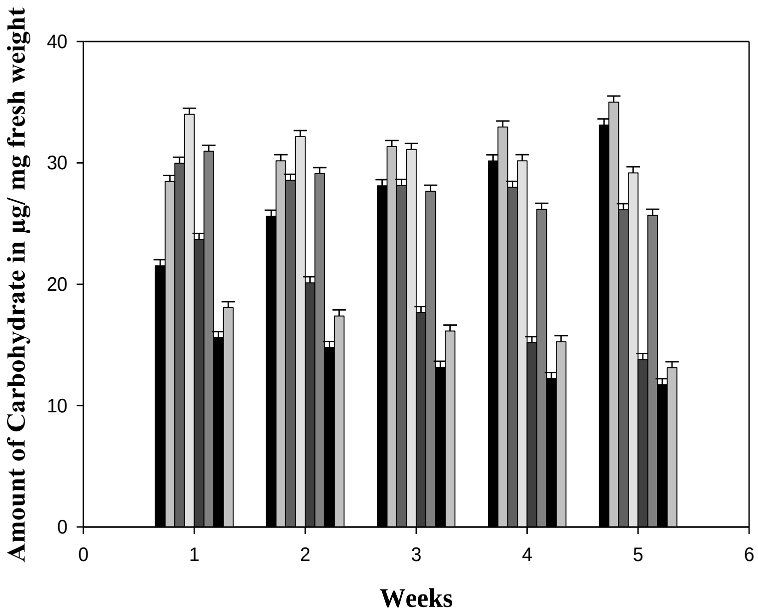
Changes in the amount of carbohydrate of *Vigna unguiculata* at different drought conditions with silicon (20 ppm) treatment.



Changes in the amount of carbohydrate of *Vigna unguiculata* at different drought conditions with silicon (40 ppm) treatment.



Changes in the amount of carbohydrate of *Vigna unguiculata* at different drought conditions with silicon (60 ppm) treatment.



Control + 100% soil moisture
Si + 100% soil moisture
Control + 75% soil moisture
Si + 75% soil moisture
Control + 50% soil moisture
Si + 50% soil moisture
Control + 25% soil moisture
Si + 25% soil moisture

Fig. 4

4. DISCUSSION

Drought is a serious global problem and one of the most important factors contributing to crop yield loss. Water shortages and soil water losses due to environmental change and land use change are challenges for new agricultural society. The dependence of the growth of a plant on its water status makes the measurement of water potential of extreme importance. Since anti-transparent increase plant water potential and can thereby increase plant growth.[22]Research shows that silicon benefits plants by improving the resistance to wilt, resistance to water stress (heat and drought), silicon, deposited in the cell walls, forms a protective layer reducing transpiration through the outer cells.[5]

The adverse effects of drought on plant metabolism were repeatedly studied. These include some disturbances in carbohydrate metabolism as well as in nitrogen metabolism [23-24] particularly proline accumulation.[25-26]The contents of total carbohydrates (mg gm-1. dry weight) tended, in most cases, to decrease with the decrease of moisture level in the different organs of the variously treated plants.

In present study we observed decreased carbohydrate contents with increasing drought in both species. These results are in conformity with those obtained by some other authors.[27]One of the main effect of environmental stress on growth and photosynthetic abilities of plants is the breakdown of the balance between the production of reactive oxygen species (ROS) and the antioxidant defense causing accumulation of ROS, which induces oxidative stress to proteins, membrane lipids and other cellular component.[8-9] In environmental stresses conditions such as drought, high activities of antioxidant enzymes and high contents of non-enzymatic constituents are important for plants to tolerate stresses.[10]When subjected to drought stress, plants responded through alteration in physiological and biochemical processes. Additionally, enzymatic antioxidant systems including SOD, POD, and CAT played an important role in scavenging harmful oxygen species.[28]

In some studies it was observed that drought stress inhibited the activities of antioxidant enzymes SOD, CAT and GR, enhanced the activities of GO and AP, and induced the accumulation of hydrogen peroxide which caused protein decomposition and oxidization, lipid per oxidation and decrease in photosynthetic pigments contents.

By silicon application the reduction in carbohydrate and protein contents reduced in all treatments of both species. This might be due to the beneficial effects of silicon against oxidative damage of macromolecules. As previous studies showed that silicon alleviate the oxidative damage.[10]

Shu & Liu also shows that silicon may be involved in metabolic or physiological activities in higher plants under drought,[29] In some researches the results suggested that the improvement of silicon on drought tolerance of wheat plants was associated with the increase of antioxidant defense abilities, alleviation in oxidative damage of functional molecules and maintenance of many physiological processes such as photosynthesis under drought. [10]

Drought stress causes reduction in growth of the plants. Reduced growth may cause the accumulation of secondary compounds, because more carbon becomes available for their synthesis, since photosynthesis is less affected, and/or there is less biomass to dilute this compounds.[30]

5. CONCLUTION

By the investigation we can conclude that the application of silicon may produces beneficial effects on the primary metabolism of plants under the drought stressed condition and these effects of silicon on plant metabolism depends upon the applied concentration of silicon and the species selected for application.

6. REFERENCES

1. Epstein, E., Annual Review of Plant Physiology and Plant Molecular Biology. **(1999)**, 50: 641–644, http://dx.doi.org/10.1146/annurev.arplant.50.1.641.
2. Epstein, E., Proc, Natl, Acad, Sci, USA. **(1994)**, 91, 11-17, http://dx.doi.org/10.1073/pnas.91.1.11.
3. Savant, N. K., Korndorfer, G. H., Datnoff, L. E., and Snyder, G. H., J. of Plant Nutr. **(1999)**, 22 (12), 1853–1903, http://dx.doi.org/10.1080/01904169909365761.
4. Liang, Y. C., Shen, Q., Shen, Z., and Ma, T., J. Plant Nutr. **(1996)**, 19:173-183, http://dx.doi.org/10.1080/01904169609365115.
5. Snyder, V., and Schmidt, R. E., Proceedings 2nd International Turf grass Research Conference,Amer. Soc. Agron and Crop Sci. Soc. Amer. 1974, pp. 176-185.
6. Seghatoleslami, M. J., Kafi, M., and Majidi, E., Pak. J. Bot. **(2008)**, 40(4): 1427-1432.
7. Lavisolo, C., and Schubert, A., J. of Exp. Bot. **(1998)**, 49:693-700.
8. Iturbe-Ormaetxe, I., Escuredo, P. R., Arrese-Igor, C., Becana, M., Plant Physiol. **(1998)**, 116: 173–181, http://dx.doi.org/10.1104/pp.116.1.173.
9. Huang, B., Fu, J., Environ. Exp. Bot. **(2001)**, 45: 105–114, http://dx.doi.org/10.1016/S0098-8472(00)00084-8.
10. Gong, H., Zhu, X., Chen, K., Wang, S., and Zhang, C., Plant Science. **(2005)**, 169: 313–321, http://dx.doi.org/10.1016/j.plantsci.2005.02.023.
11. Carranca, C., Varennes, A., de and Rolston, D., Eur. J. Agron. **(1999)**, 10: 49-56, http://dx.doi.org/10.1016/S1161-0301(98)00049-5.
12. De Costa, W. A. J. M., Shaunmugathasan, K. N., and Joseph, K. D. F. M., Field Crops Res. **(1999)**, 61: 1-12, http://dx.doi.org/10.1016/S0378-4290(98)00141-5.
13. Ramirez-Vallejo, P., and Kelly, J. D., Euphytica. **(1998)**, 99:127-136, http://dx.doi.org/10.1023/A:1018353200015.
14. Sangakkara, U. R., Frehner, M., and Nosberger, J. Journal of Agronomy and Crop Science. **(2001)**, 186: 73–81, http://dx.doi.org/10.1046/j.1439-037X.2001.00433.x.
15. Ogbuinya, P. O., Bio-technol. Dev. Monitor. **(1997)**, 33:10-12.

16. Sangakkara, U. R. J., Agron. Crop Sci. **(1998)**, 180: 137-142, http://dx.doi.org/10.1111/j.1439-037X.1998.tb00383.x.
17. Sangakkara, U. R., Hartwig, U. A., and Nosberger, J., In: K. S. Kumarasinghe Eds, Nuclear Techniques in Soil Plant Studies for Sustainable Agriculture and Environment Preservation. International Atomic Energy Agency, Vienna, Austria, **(1995)**, pp. 263-272.
18. Education solution to environmental and economic problems, 1-14, pH meter calibration, Field procedure. **(2008)**, 10: 9 -10.
19. Anonymous. Electrical Conductivity Protocol, Field Guide, Globe. **(2005)**, 6-11.
20. Lowery, O. H., Roseblough, N., Farr, A., and Randall, R., J. Biol. Chem. **(1951)**, 193:265-275
21. Yemm, E. W., and Willis, A., J. Biochem. **(1959)**, 57: 508.
22. Davenpoet, D. C., Fisher, M. A., and Hasan, R. M., PI. Physiol. **(1971)**, 47: 38.
23. Wilson, J. R., Haydock, K. P., Robins, M. F., Aust J Agric. and Anim Husb. **(1970)**, 10:156-165, http://dx.doi.org/10.1071/EA9700156.
24. Gates, C. T., Aust J Biol Sci. **(1957)**, 10:125-146.
25. Barnett, N. M., Naylor, A. W., Plant Physiol. **(1966)**, 41:1222-1230, http://dx.doi.org/10.1104/pp.41.7.1222.
26. Singh, T. N., Aspinall, D., Paleg, L. G., and Boggess, S. F., Aust J Biol Sci. **(1973)**, 26:57-63.
27. Wager, H. G., New Phytol. **(1954)**, 53:265-292, http://dx.doi.org/10.1111/j.1469-8137.1954.tb05246.x.
28. Li-Ping, B., Sui, F., Ge, T., Sun, Z., Lu, Y., Zhou, G., Pedosphere. **(2006)**, 16(3): 326-332, http://dx.doi.org/10.1016/S1002-0160(06)60059-3.
29. Shu, L. Z., Liu, Y. H., Agro-Environ. Prot. **(2001)**, 38–40.
30. Mattson, W. J., and Haack, R. A., In Barbosa P, Schultz JC, Eds. Insect outbreaks. Academic Press, Inc. New York, **(1987)**, 365-407, http://dx.doi.org/10.1016/B978-0-12-078148-5.50019-1.