Indian Journal of Plant Sciences ISSN: 2319–3824
An Open Access, Online International Journal Available at http://www.cibtech.org/jps.htm
2018 Vol. 7(4) October-December, pp.37-41/Preeti et al.

Research Article

METABOLIC ADJUSTMENT IN TUBEROUS ROOTS OF *ASPARAGUS RACEMOSUS* UNDER DROUGHT STRESS

Preeti Sharma[1], Upma Bhatt[2], Sunita Parihar[2], *Vineet Soni[2], P.L. Swarnkar[3]
[1]School of Life Science, Jaipur National University, Jaipur-302017, Rajasthan, India
[2]Department of Botany, Mohanlal Sukhadia University, Udaipur-313001, Rajasthan, India
[3]Department of Botany, University of Rajasthan, Jaipur-302020, Rajasthan, India
**Author for Correspondence*

ABSTRACT

Metabolic adjustment to cope with drought stress in tuberous roots of *Asparagus racemosus* was evaluated. A significant rise in activities of antioxidant enzymes (superoxide dismutase and catalase) and non-antioxidant enzymes (α-amylase and acid phosphomonoesterase) were noted with increasing period of drought treatment. Over and down-expression of other metabolites (reducing sugars, starch, soluble protein and proline) also indicates high potential of drought tolerance in tuberous roots of *A. racemosus* to survive under severe drought in a state of quiescence, when the above-ground vegetative tissues desiccate and die. The findings provide biochemical basis of drought tolerance in succulent- and semi-succulent plants of arid and semiarid regions.

Keywords: *Asparagus racemosus,* Tuberous roots, Drought, Metabolic adjustment

INTRODUCTION

Drought stress is one of the main abiotic stresses that negatively influence the growth, development and productivity of plants. Plant adaption to drought relies on natural strategies mainly related to: (1) increase of water uptake and storage; (2) reduction of water loss during dry periods; and (3) mechanical reinforcement of tissues to prevent wilting. Plants grown in arid and semi-arid regions are quite resistant to extreme drought and are well developed morphologically as well as physiologically to survive through such conditions. These plants cope with drought stress by manipulating key physiological processes such as photosynthesis, respiration, antioxidant and hormonal metabolism. At arid and semi-arid conditions, plant survival depends upon the ability to harmonize structure and function to withstand desiccation without permanent damage. Therefore, every plant organ of these regions is ideally designed during the evolution to fulfill metabolic and physiological processes in adverse environmental conditions.

Asparagus racemosus Willd. (Asparagaceae) is one of the important medicinal plants of arid and semi-arid areas. The underground tuberous roots of *A. racemosus* are adapted to survive under severe drought in a state of quiescence, when the above-ground vegetative tissues desiccate and die. *A. racemosus* represents a special type of resurrection geophyte, which survives under unfavorable environmental conditions in the form of underground succulent tuberous roots, and is ecologically adapted to harsh drought condition. It may provide a useful model plant for investigating mechanisms of plant adaptations to severe drought conditions of arid and semi-arid regions. The present was undertaken to access the metabolic adaptation in tuberous roots of *A. racemosus* subjected to water deficit condition.

MATERIALS AND METHODS

Plant Materials and Growing Conditions: One year old plants of *A. racemosus*, growing in pots at research nursery, School of Life Science, Jaipur National University, Jaipur, were used for the biochemical studies. The plants were divided into two sets (each of four plants), out of which one set was subjected to water stress by withholding of water supply till wilting symptoms appeared, while the second set was watered regularly and served as a control. Biochemical analyses of enzymes and cellular metabolites were carried out in tuberous roots of *A. racemosus.* The samples were collected regularly at an interval of three days till day 21 (Fig. 1 A-H).

Biochemical assay: The activity of superoxide dismutase (SOD) was assayed following the method of Kono (1978). Catalase (CAT) activity was determined by the method of Teranishi *et al.* (1974).

Bernfeld's method (1955) was used for assaying the activity of α- amylase. The activity of acid phosphomonoesterase was assayed by using p-nitrophenyl phosphate as substrate (Zink & Veliky, 1979). Reducing sugar was analyzed by the method proposed by Fu and Dernoeden (2008). Starch was measured by the method described by McCready *et al.*, (1950). Bradford's method (1976) was used for the estimation of soluble proteins. Free proline content was measured by the method given by Bates *et al.*, (1973).

Experimental design and statistical analysis: All experiments were conducted with a minimum of 30 replicates per treatment and each experiment was repeated thrice. The data were analyzed statistically by one-way analysis of variance (ANOVA) followed by Tukey's test at P=5% using SPSS software version 17.0 (SPSS Inc., Chicago, IL, USA) and data represented as mean ± standard error (SE).

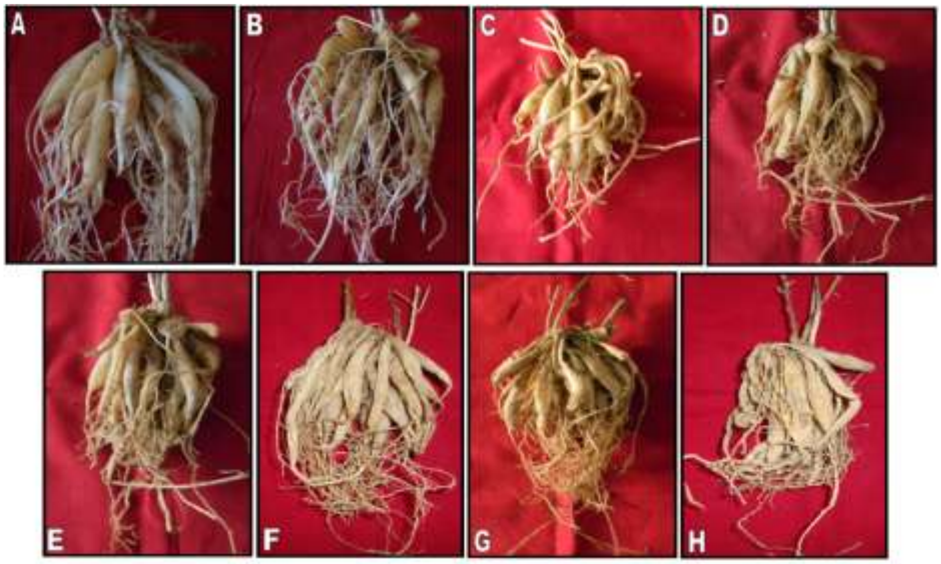

Figure 1: Tuberous roots of *A. racemosus*. (A) control, (B) Drought stress at 3 days, (C) 6 days, (D) 9 days, (E) 12 days, (F) 15 days, (G) 18 days, and (H) 21 days of water deprivation

RESULTS AND DISCUSSION

Drought is the major yield-limiting factor of plants and determines the natural distribution of plant species. During water deficit conditions, concentration of reactive oxygen species (ROS) increases several folds, which oxidize multiple cellular components like proteins and lipids, DNA and RNA. In order to minimize ROS production, plants have ROS scavenging mechanism consisted of various enzymatic and non-enzymatic antioxidants. In present study, SOD activity was increased continuously in the roots of *A. racemosus* subjected under water deficit condition (Fig. 2A). Higher activity of SOD enzyme was recorded in roots on day 21. Similar results were also obtained in wheat (Badiani *et al.*, 1990), in pea (Mittler & Zilinskas, 1994), in common and tepary bean (Turkan *et al.*, 2005), rice (Sharma and Dubey, 2005) and in olive trees (Sofa *et al.*, 2005), where water stress increased SOD activity. On the other hand, in sunflower seedlings and in grass plants (*Aegilops squarrosa*) a decrease in SOD activity was observed under drought stress (Quartacci and Navari-Izzo, 1992). Over expression of SOD indicates high oxidative stress tolerance in tuberous roots of *A. racemosus*. CAT activity remains unchanged till day 9 of water deprivation (Fig. 2B). Severe drought treatment caused a significant rise in activity of CAT enzyme which suggests that under mind and moderate drought stress H_2O_2 scavenging is preferably made by ascorbic acid through the ascorbate/glutathione cycle.

Drought stress significantly increased the activity of α-amylase enzyme in roots of *A. racemosus*. Maximum enzyme activity was recorded on day 12 in the roots (Fig. 2C). On the other hands, the variation in α-amylase activity in the plants growing under normal irrigated condition was insignificant. Increased amylase activity has been linked to increased maltose content (Nielsen *et al.*, 1997], and its levels are modulated in response to drought (Yang *et al.*, 2007), salt (Datta *et al.*, 1999), and heat stress (Sung, 2001). Mild drought stress could not change the activity of acid phosphomonoesterase enzyme. A marginal increased in enzyme activity was observed on day 9 of water deprivation. Highest acid phosphomonoesterase activity was observed on day 21 (Fig. 2D).

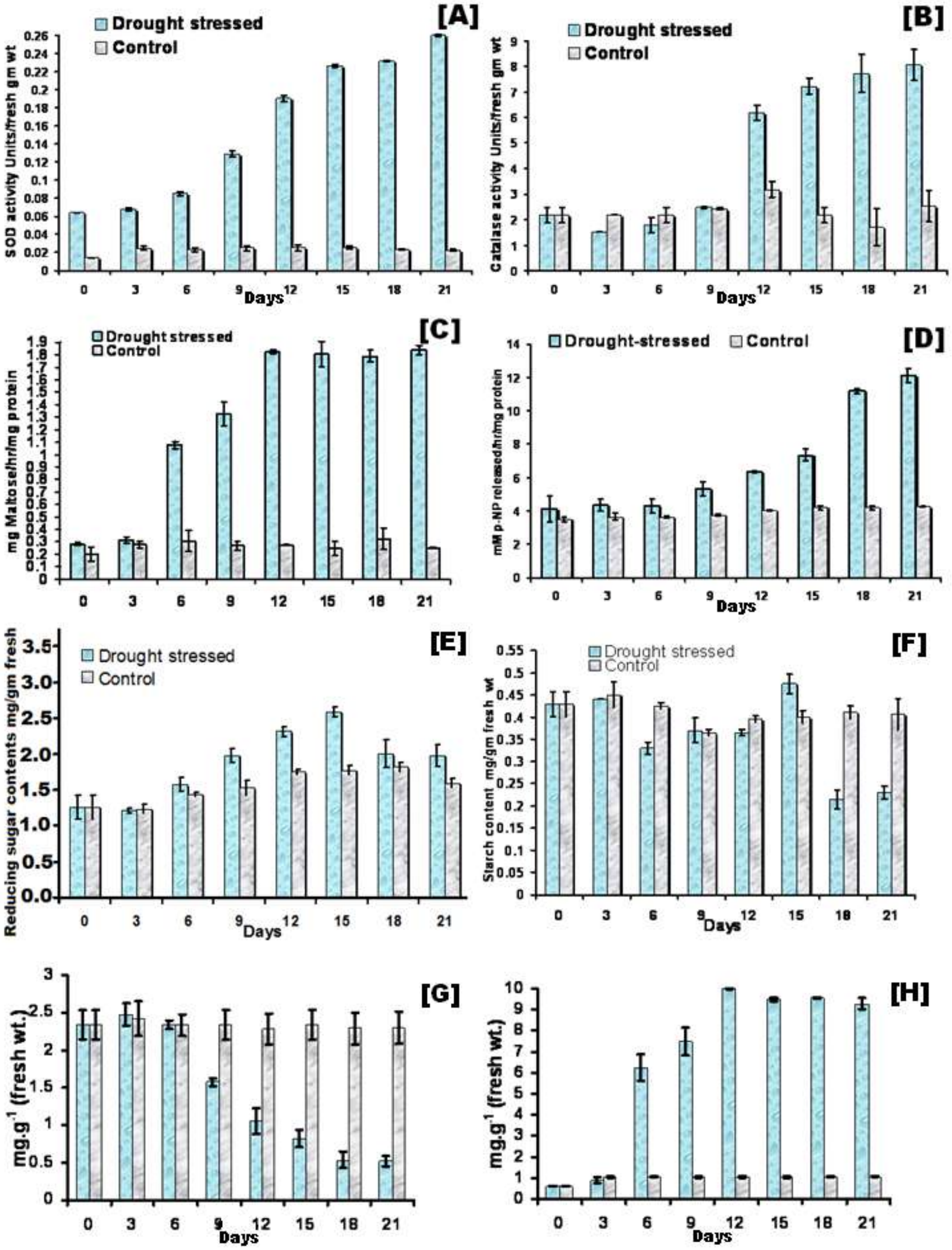

Figure 2: Drought-induced changes in (A) SOD, (B) CAT, (C) α-amylase, (D) acid phosphomonoesterase, (E) reducing sugar, (F) starch, (G) soluble protein and (H) proline in *A. racemosus*

The accumulation of soluble carbohydrates in plants has been widely reported as a response to salinity or drought, despite a significant decrease in net CO_2 assimilation rate (Murakeozy *et al.*, 2003). Accumulation of sugar in different parts of plants is enhanced in response to the variety of environmental stresses (Prado *et al.*, 2000). In the present study, the accumulation of reducing sugar in response to water deficit condition, seem to play an important role in the drought tolerance in *A. racemosus* (Fig. 2E). The starch content reduced in roots when plants were exposed to the severe drought stress condition (Fig. 2F). Reduction in starch might be due to enhanced α-amylase activity. Soluble protein level was initially increased and then sharply declined in the roots of *A. racemosus* plants subjected to the drought stress (Fig. 2G). Decrease in protein under water stress might be due to the effect on the rate of protein synthesis. Under water stress, decrease in soluble proteins was also reported in rice *Phaseolus* (Ignacio and Carol, 1999) and Oak and Pine (Schwanz and Polle, 2001). Proline content accumulated significantly in tuberous roots of *A. racemosus* growing under water deficit conditions (Fig. 2H). In roots, higher accumulation of proline was recorded on day 12 of water deprivation. Increased amount of proline under drought indicates its role as osmoprotectant. The results of present study clearly indicate that tuberous roots of *A. racemosus* are biochemically well adapted through metabolic adjustment to survive under severe drought in a state of quiescence, when the above-ground vegetative tissues desiccate and die. The findings provide basic understanding of drought tolerance in succulent- and semi-succulent plants of arid and semiarid regions.

The present study describes biochemical basis of drought tolerance in tuberous roots of *A. racemosus*. Understanding drought-induced metabolic adjustment in succulent tuberous roots of *A. racemosus* will be highly beneficial in development of transgenic plants for arid and semiarid regions.

ACKNOWLEDGEMENT

Authors are grateful to Prof. P.L. Swarnkar, Prof. Reto Strasser and Prof. B. Robert for constant blessing and academic encouragement.

REFERENCES

Badiani M, De Biasi MG, Cologna M. and Artemi F (1990). Catalase, peroxidase and superoxide dismutase activities in seedlings submitted to increasing water deficit. *Agrochimica* **34** 90-102.

Bates LS, Waldren RP and Teare ID (1973). Rapid determination of free proline for water-stress studies. *Plant and Soil* **39**(1) 205-207.

Bernfeld P (1955). Amylases α and β. *Methods in Enzymology*. **1** 149-158.

Bradford MM (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry* **72**(1-2) 248-254.

Datta R, Selvi MT, Seetharama N and Sharma R (1999). Stress mediated enhancement of beta-amylase activity in pearl millet and maize leaves is dependent on light. *Journal of Plant Physiology* **154** 657-666.

Fu J and Dernoeden PH (2008). Carbohydrate metabolism in creeping bentgrass as influenced by two summer irrigation practices. *Journal of the American Society for Horticultural Science* **133**(5) 678-683.

Ignacio LF and Carol JL (1999). Relationship between relative water content, nitrogen pools and growth of *Phaseolus vulgaris* L. and *P. acutifolius* A. during water deficit. *Crop Science* **39** 467-475.

Kono Y (1978). Generation of superoxide radical during autoxidation of hydroxylamine and an assay for superoxide dismutase. *Archives of Biochemistry and Biophysics* **186** 189-195.

Mittler R and Zilinskas BA (1994). Regulation of pea cytosolic ascorbate peroxidase and other antioxidant enzymes during the progression of drought stress and following recovery from drought. *Plant Journal* **5** 397-405.

Mccready RM, Guggolz J, Silviera V and Owens HS (1950). Determination of starch and amylose in vegetables. Application to peas. *Analytical Chemistry* **22** 1156-1158.

Murakeozy EP, Nagy Z, Duhaze C, Bouchereau A and Tuba Z (2003). Seasonal changes in the levels of compatible osmolytes in three halophytic species of inland saline vegetation in Hungary. *Journal of Plant Physiology* **160** 395-401.

Nielsen TM, Deiting U and Stitt M (1997). A [beta]-amylase in potato tubers is induced by storage at low temperature. *Plant Physiology* **113** 503-510.

Prado FE, Boero C, Gallarodo M and Gonzalez JA (2000). Effect of NaCl on germination, growth and soluble sugar content in *Chenopodium quinoa* Willd. seeds. *Botanical Bulletin of Academia Sinica* **41** 27-34.

Quartacci MF and Navari-Izzo F (1992). Water stress and free radical mediated changes in sunflower seedlings. *Journal Plant Physiology* **139** 612-625.

Schwanz P and Polle A (2001). Differential stress response of antioxidative systems to drought in pendunculate oak (*Quercus robur*) and mertime pine (*Pinus pinaster*) growth under high CO_2 concentrations. *Journal of Experimental Botany* **52**(354) 131-143.

Sharma P and Dubey RS (2005). Drought induces oxidative stress and enhances the activities of antioxidant enzymes in growing rice seedlings. *Plant Grow Reg.* **46** 209-221.

Sofo A, Dichio B, Xiloyannis C and Masia A (2005). Antioxidant defenses in olive trees during drought stress: Changes in activity of some antioxidant enzymes. *Functional Plant Biology* **32** 45-53.

Sung DY (2001). Comprehensive expression profile analysis of the Arabidopsis Hsp70 gene family. *Plant Physiology* **126** 789-00.

Teranishi Y, Tanaka A, Osumi M and Fukui S (1974). Catalase activity of hydrocarbon utilizing candida yeast. *Agricultural Biology and Chemistry* **38** 1213-1216.

Turkan I, Bor M, Ozdemir F and Koca H (2005). Differential responses of lipid peroxidation and antioxidants in the leaves of drought-tolerant *P. acutifolius* Gray and drought-sensitive *P. vulgaris* L. subjected to polyethylene glycol mediated water stress. *Plant Sciences* **168** 223-231.

Yang SH, Wang LJ and Lis SH (2007). Ultraviolet-B irradiation induced freeing tolerance in relation to antioxidant system in winter wheat (*Triticum aestivum* L.) leaves. *Environment and Experiemntal Botany* **60** 300-307.

Zink MW and Veliky IA (1979). Acid phosphatase of *Ipomoea* spp. cultured *in vitro*. 1. Influence of pH and inorganic phosphate on the formation of phosphatases. *Canadian Journal of Botany* **57** 739-753.