Indian J. Plant Physiol., Vol. 12, No. 3, (N.S.) pp. 290-292 (July-Sept., 2007)

SHORT COMMUNICATION

PHYSIOLOGICAL BEHAVIOUR OF CHICKPEA GENOTYPES GROWN IN ZINC DEFICIENT CALCAREOUS SOIL

KAVITA*, R.A. SINGH AND VINOD KUMAR[1]

Department of Botany and Plant Physiology, Rajendra Agricultural University, Pusa, Samastipur, Bihar - 848 125

Received on 31 May, 2005, Revised on 16 July, 2007

Field experiments were conducted on zinc deficient calcareous soil with eight chickpea (*Cicer arietinum* L.) genotypes. Tolerant genotypes (FG 897, BG 1084, PBG 126) recorded higher content of zinc, total chlorophylls, cartenoids, soluble protein and the activities of enzymes superoxide dismutase, catalase, peroxidase, carbonic anhydrase as compared to moderately tolerant (CSJ 128, CSG 9505) and suspectible (BG 372, BG 256, BGM 535) genotypes. However, total free amino acids content was found to be higher in susceptible genotypes.

Key words: **Antioxidant enzymes, carbonic anhydrase, chickpea, photosynthetic pigments, soluble protein, total free amino acids, zinc**

The deficiency of zinc has been emerging worldwide particularly in calcareous belts of arid and semi-arid regions and is causing nutritional constraint to crop productivity (Takkar and Walker 1993). A major portion of soil in North Bihar have been rated as deficient in available zinc (Sinha *et al.* 1997). About 8.4 million hectare area in India is under chickpea cultivation and tops the list of pulse crop grown in varied edaphic situations. Soils low in available zinc occur in many areas of the world where chickpea is grown. Thus, efforts were made to understand the physiological behaviour of chickpea genotypes grown under zinc stress condition.

Field experiments were conducted during *Rabi* season of 2000-2002 with screened chickpea genotypes (Kavita and Singh 2005) in randomized block design with four replications at Research Farm of Tirhut College of Agriculture, Dholi, Bihar. The soil of experimental field was calcareous, deficient in available Zn (0.50 ppm) and the pH, E.C., organic carbon and free $CaCO_3$ as determined by standard methods were 7.9, 0.25 dS/m, 0.42% and 34.0% respectively. The recommended dose of N, P, K were applied and the agronomic practices were followed to raise the crop. Shoots of 70 day old plants were used for estimation of zinc content (Jackson 1978), photosynthetic pigments content (Hiscox and Israelstam 1979), soluble protein content (Lowry *et al.* 1951), total free amino acids content (Lee and Takahashi 1966) and the activitties of enzymes superoxide dismutase (Giannopolitis and Rice 1977), catalase (Euler and Josephson 1927), peroxidase (Palmiano and Juliano 1973) and carbonic anhydrase (Dwivedi and Randhawa 1974).

Zinc coontent in the shoots of tolerant genotypes was significantly higher than moderately tolerant and susceptible genotypes (Table 1). Sakal *et al.* (1988) explained that genotypes tolerant to zinc stress have higher root cation exchange capacity than that of susceptible ones and so are capable of absorbing higher zinc from soil. The roots of these genotypes might also released phytosiderophores, compound responsible for facilitating the absorption of zinc (Shankhdhar and Pant 2003).

*Corresponding author, [1]Present address: Scientist, Plant Protection, N.R.C.G., P.B.-5, Ivnagar Road, Junagadh, Gujarat

Tolerant genotypes recorded significantly higher values of total chlorophylls and carotenoides as compred to susceptible genotypes (Table 1). Higher chlorophylls content might be due to involvement of zinc in the biosynthesis of this pigment (Beale 1999). Zinc is known to catalyse the condensation of two molecules of δ-aminolevalenic acid to from porphobilinogen (Jaffe 1995) which is ultimately responsible for protoporphyrin 9 formation, a precursor of chlorophyll biosynthesis.

Susceptible genotypes maintained lower values of soluble protein content over moderately tolerant and tolerant genotypes (Table 1). Falchuk *et al.* (1977) suggested that zinc is an essential component of RNA polymerase, an enzyme responsible for protein synthesis at transcription level. The other possible reason could be enhanced rates of RNA degradation, resulting from an increase in RNase activity (Sharma *et al.* 1981) thereby decreasing the pool of RNA. The difference in protein content might be also due to different amounts of amino acids. Contrary to protein, susceptible genotypes accumulated higher content of total free amino acids (Table 1). Zinc deficiency might restrain the transformation of amino acids into protein on account of low RNA content (Ghildiyal *et al* 1977, 1986 and Ren *et al* 1993).

The activity of enzyme superoxide dismutase (SOD) was significantly higher in tolerant group (Table 1). Marschner (1986) reported that zinc is an essential component of SOD, an enzyme responsible for inactivation of O_2 (superoxide) formed in various enzyme reactions in which a single electron is transmitted to O_2. Hence, higher activity of SOD in tolerant group is an indication of increased ability to decompose O_2, thus maintaining the structural integrity and normal functioning of cell.

The activities of enzymes catalase as well as peroxidase were higher in tolerant genotypes (Table 1). Catalase, mainly localized in glyxysomes and peroxisomes is responsible for scavenging H_2O_2 produced in B-oxidation and photorespiration (Inze and Montague 2002) while H_2O_2 in chloroplasts is scavenged by peroxidase reaction using the photoreductant produced in the thylakoid as the electron donor which

Table 1. Effect of Zn stress on Zn content, metabolites and enzyme activities of 70 days old shoots of chickpea genotypes (pooled of two years)

Genotypes		Zinc content (ppm)	Total chlorophyll (mg/g fw)	Carotenoides (mg/g fw)	Soluble protein (mg/g dw)	Total free amino acids (mg/g dw)	Superoxide dismutase (units/mg protein)	Catalase (U/mg protein)	Peroxidase (Units/mg protein)	Carbonic anhydrase (units/mg protein)
FG 879 (T)		36.13	1.90	0.35	7.49	8.25	0.30	1.07	66.08	7.92
BG 1084 (T)		31.45	1.69	0.30	6.92	8.02	0.31	1.15	85.64	6.25
PBG 126 (T)		33.41	1.62	0.32	6.93	7.61	0.37	0.98	70.03	7.25
CSJ 128 (MT)		28.30	1.48	0.23	6.03	8.68	0.27	0.95	59.70	5.42
CSG 9505 (MT)		25.69	1.49	0.33	6.36	7.94	0.24	0.90	63.43	5.00
BG 372 (S)		22.21	1.01	0.20	5.46	9.45	0.23	0.66	45.06	4.25
BG 256 (S)		24.55	1.15	0.23	5.10	9.12	0.25	0.75	41.39	4.00
BGM 535 (S)		17.83	1.05	0.20	4.77	8.75	0.22	0.75	41.08	4.25
Years (Y)	CD (5%)	0.78	0.05	0.009	0.14	0.06	0.009	0.01	1.61	0.14
	SEm (±)	0.27	0.019	0.003	0.05	0.02	0.003	0.005	0.56	0.05
Geno-types(G)	CD (5%)	1.56	0.11	0.017	0.31	0.13	0.022	0.03	3.23	0.29
	SEm (±)	0.54	0.039	0.006	0.11	0.04	0.008	0.017	1.12	0.10
Y x G	CD (5%)	2.20	0.16	0.023	0.43	NS	0.030	0.04	4.57	0.41
	SEm (±)	0.76	0.056	0.008	0.15	0.06	0.011	0.015	1.58	0.14

T=Tolerant genotype, MT=Moderately tolerant genotype, S=Susceptible genotype

was identified as ascorbate (Arora *et al.* 2002). Tolerant group maintained higher activity of enzyme carbonic anhydrase (CA) as compared to other two groups (Table 1). CA is a zinc containing metalloenzyme, localized both in cytoplasm and chloroplast (Marschner 1986) where the enzyme maintains the pool size of dissolved CO_2 by regulating pH changes (Jacobson *et al.* 1975) thereby increasing the availability of CO_2 at the site of RuBP caboxylase.

REFERENCES

Arora, A., Sairam, R.K. and Srivastava, G.C. (2002). Oxidative stress and antioxidative system in plants. *Curr. Sci.* **82:** 1227-1237.

Beale, S.I. (1999). Enzymes of chlorophyll biosynthesis. *Photosynth. Res.* **60:** 43-73.

Dwivedi, R.S. and Randhawa, N.S. (1974). Evaluation of a rapid test for the hidden hunger of zinc in plants *Plant & Soil* **40:** 445-451.

Euler, V.H. and Josephson, K. (1927). *Ober katalase*. I. *Ann. Der. Chem.* **432:** 158-162.

Falchuk, K.H., Ulpino, L., Mazus, B. and Valee, B.L. (1977). *E. gracilis* RNA polymerase. I. *A zinc metalloenzyme*. *Biochem. Biophys. Res. Commun.* **74:** 1206-1212.

Ghildiyal, M.C., Pandey, M. and Sirohi, G.S. (1977). Proline accumulation under zinc deficiency in mustard. *Curr. Sci.* **46:** 792-794.

Ghildiyal, M.C., Pandey, M. and Sirohi, G.S. (1986). Proline content in linseed varities as influenced by zinc nutrition. *Indian J. Plant Physiol.* **27:** 368-374.

Giannopolitis, G.N. and Rice, S.K. (1977). Superoxide dismutase. I: Occurrence in higher palnt. *Plant Physiol.* **59:** 309-314.

Hiscox, J.D. and Israelstam, G.F. (1979). A method for extraction of chlorophyll from leaf tissue without maceration. *Can. J. Bot.* **57:** 1332-1334.

Inze, D. and Montague, M.V. (2002). Oxidative Stress in Plants. Taylor and Francis Inc. New York.

Jacobson, B.S., Forg, F. and Heath, R.L. (1975). Carbonic anhydrase of spinach. Studies on its location, inhibition and physiological function. *Plant Physiol.* **55:** 468-474.

Jaffe, E.K. (1995). Porphobilinogen synthase, the first source of hemis asymmetry. *J. Bioenerg. Biomember* **27:** 169-179.

Jakson, M.L. (1978). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kavita and Singh, R.A. (2005). Differential response of chickpea (*Cicer arietinum* L.) genotypes against zinc stress in calcareous soil. *J. Appl. Biol.* **15:** .

Lee, Y.P. and Takahashi, T. (1966). An improved colorimetric determination od amino acids with the use of ninhydrine. *Anal. Biochem.* **14:** 71.

Lowry, O.H., Rosenbrough, N.J., Farr, A.L. and Randall, R.J. (1951). Protein measurement with folin phenol reagent. *J. Biol. Chem.* **193:** 265-275.

Marschner, H. (1986). Mineral Nutirtion of Higher Plants. Academic Press Inc., London.

Palmiano, E.P. and Juliano, B.C. (1973). Changes in the activity of some hydrolases, peroxidae and catalase in rice seed during germination. *Plant Physiol.* **52:** 274-277.

Ren, Fu-cheng, Liu, Tie-Cheng, Liu, Hui-Qing and Hu, Bing-Y. (1993). Influence of zinc on the growth, distribution of elements and metabolism of one year old American Ginseng plants. *J. Plant Nutr.* **16:** 393-405.

Sakal, R., Verma, M.K., Singh, A.P. and Sinha, M.K. (1988). Relative tolerance of some rice varities to zinc deficiency in calcareous soil.. *J. Indian Soc. Soil Sci.* **36:** 492-495.

Shankhadhar, S.C. and Pant, R.C. (2003). Improving iron and zinc content of crops for better human health. In: R.C. Pant and M.C. Ghildiyal (eds.), Souvenir, 2nd International Congress of Plant Physiology on Sustainable Plant Productivity under Changing Enviornment, 8-12 January, 2003, pp. 39-51. New Delhi.

Sharma, D.K., Singh, K.N. and Nitant, H.C. (1985). Effect of missing application of phosphorus and zinc along with nitrogen on growth and yield of paddy and wheat on sodic soil. *Indian J. Agron.* **30:** 158-162.

Sinha, R.B., Sakal, R., Singh, A.P. and Bhogal, N.S. (1997). Response of pea genotypes to applied zinc on calciorthents. *J. Indian Soc. Soil Sci.* **28:** 547-549.

Takkar, P.N. and Walker, C.D. (1993). The distribution and correction of zinc deficiency. In: A.D. Robson (ed.), Zinc in Soils and Plants, pp. 161-156. Kluwer Academic Publishers. Dordrecht, The Netherlands.