International Journal of Agricultural Sciences
Volume **10** | Issue 1| January, 2014 | 309-313

RESEARCH PAPER

Effect of application of zinc on yield and yield attributes of chickpea genotypes in calciorthent soil

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Abstract : A field experiment was conducted in calciorthent soils at Tirhut College of Agriculture, Research Farm, Rajendra Agricultural University, Pusa (Samastipur) Bihar, India to screen chickpea (*Cicer arietinum* L.) genotypes against zinc stress. The treatment included eight genotypes from tolerant, moderately tolerant and susceptible groups, and three levels of zinc application (0.0, 5.0 and 10.0 Zn/ha) in three replicates in a split plot design with zinc in main plots and genotypes in sub-plots. The result indicated that the yield of seed and straw of tolerant genotypes in control plots exhibited higher values. The similar result was also obtained in case of pods per plant, seeds per pod and test weight. The values increased on zinc application in moderately tolerant and susceptible genotypes. The higher total uptake of zinc was observed in tolerant genotypes in control plots.

Key Words : Chickpea, Calciorthent, Zinc stress

View Point Article : Kavita and Singh, R.A. (2014). Effect of application of zinc on yield and yield attributes of chickpea genotypes in calciorthent soil. *Internat. J. agric. Sci.*, **10** (1): 309-313.

Article History : Received : 08.08.2013**; Revised :** 29.10.2013**; Accepted :** 25.11.2013

INTRODUCTION

India is the largest producer of pulses in the world representing 25 per cent of total production (61.34 million tonnes), 30 per cent of total consumption and 33 per cent of global acreage (73.33 million hectares) under pulses (Banerjee and Palke, 2010). Productivity of pulses in India has been very low at 679 kg/ha in 2011-12. Per capita consumption of pulses reduced drastically over the years from 69.0 g/day in 1960-61 to 36.0 g/day in 2007-08. India accounts for 33 per cent of the world areas and 22 per cent of the world production of pulses. About 65 per cent of the global chickpea area falls in India but productivity is very low. Micronutrient deficiencies had emerged as serious problem in many intensively cultivated areas. The deficiency of Zn is the major micronutrient causing poor yield or even crop failure particularly in calciorthent (calcareous) soils of arid and semi-arid regions (Takkar and Walker, 1993). Zinc plays an important role in chlorophyll formation, carbohydrate metabolism and synthesis of protein. About 55 per cent area in different districts of Bihar state, concentrated mainly in calcareous belts of North Bihar, is deficient in Zn (Sakal *et al.*, 1988). The symptoms of deficiency are observed in many crops (Sakal and Singh, 1979). Research is being conducted to identify cultivars tolerant to micronutrient stresses as a means of overcoming these constraints. The magnitude of response of Zn varies widely among genotypes of the same crop. Keeping these facts in view, the present investigation was carried out to find the effect of application of zinc on yield and yield attributes of chickpea (*Cicer arietinum* L.) genotypes under calcareous soil conditions of Bihar.

MATERIAL AND METHODS

A field experiment was conducted consecutively for two years at Tirhut College of Agriculture, Dholi (Muzaffarpur, Bihar). This is situated on the southern bank of the river *Burhi Gandak* at $25^{0}39'$ North latitude and $85^{0}40'$ East longitude at an elevation of 52.1 m mean sea level. The

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climate is semi-arid, sub-tropical with hot dry summer and cold winter with moderate rainfall. The soil of the experimental plot was alluvial, calciorthent in nature having pH 7.9, EC 0.25 dS/m, poor in organic carbon (0.42 %), free $CaCO_3$ 34%, available N 140 kg/ha, available P_2O_5 16.2 kg/ha, available K_2O 114 kg/ha and available Zn 0.50 ppm. The experiment was conducted in split plot design keeping genotypes in sub-plots and doses of Zn in the main plots. Fifteen genotypes collected from Rajendra Agricultural University, Pusa, Bihar and Indian Institute of Pulse Research, Kanpur, India were grouped into tolerant, moderately tolerant and susceptible genotypes based on percentage response of grain yield to Zn application and out of these, three from tolerant (T), two from moderately tolerant (MT) and three from susceptible (S) genotypes were selected for the study. The different doses of Zn were Zn_0 (control), Zn_5 (5.0 kg/ha) and Zn_{10} (10.0 kg/ha). Source of Zn was $ZnSO_4$. The row to row spacing was 30 cm and seed rate was 80 kg/ha. The recommended dose of fertilizer was applied before sowing of crop. All improved agronomical practices were adopted to raise the crop. Zinc content was estimated with the help of atomic absorption spectrophotometer following the method described by Jackson (1978). The mean values of data were subjected to statistical analysis to obtain analysis of variance using Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The trend of effects of various treatment on all parameters recorded during both years of experimentation was almost similar and hence, data were pooled. The result on the basis of pooled data has been discussed in the following sub heads:

Effect of Zn application on seed yield:

It was evident from the data that tolerant genotypes recorded higher seed yield in control plots (Zn_0). While the Zn treatments enhanced the seed yield of susceptible and moderately tolerant genotypes, reverse trend was observed in tolerant genotypes. The mean values of seed yield recorded under Zn_0, Zn_5 and Zn_{10} levels were 10.76 q/ha, 11.14 q/ha and 10.08 q/ha, respectively (Table 1).

The mean seed yield of different genotypes varied from 8.55 to 12.41 q/ha. The genotype FG 897 in tolerant, CSG 9505 in moderately tolerant and BG 256 in susceptible group exhibited maximum seed yield under control condition (Zn_0) (Table 1). This differential behavior of genotypes is due to genetical make up which finds support from findings of Singh *et al*. (1987). The higher seed yield in moderately tolerant and susceptible groups on Zn application is in consonance with the findings of Tripathy *et al*. (1997) for chickpea.

The interaction effect of genotypes and Zn application was significant which indicated that the effect of one factor is dependent on other factor and *vice versa*. The treatment combination of susceptible genotype BG 372 at 5.0 kg Zn/ha produced maximum seed yield (15.20 q/ha) which was at par with genotype BG 256 (S) at the same level of Zn (14.31 q/ha).

Effect of Zn application on straw yield:

Zn application significantly reduced the straw yield of tolerant genotypes but increased the yield in moderately tolerant and susceptible genotypes. The mean values of the Zn application indicated that the maximum straw yield were recorded to the extent of 12.44 q/ha with the application of 5.0 kg Zn/ha.

The performance of genotypes revealed that FG 897 in

Table 1: Effect of different levels of zinc on yield of chickpea genotypes

Genotypes	Seeds				Straw				Harvest Index			
	Treatments				Treatments				Treatments			
	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean
FG 897 (T)	12.55	7.40	7.09	9.51	13.46	10.60	9.00	11.02	48.25	41.11	44.06	46.32
BG 1084 (T)	10.90	7.45	7.29	8.55	11.51	7.86	7.73	9.03	48.64	48.66	48.54	48.63
PBG 126 (T)	10.91	8.06	8.23	9.07	12.49	9.44	8.64	10.19	46.62	46.06	48.78	47.09
CSJ 128 (MT)	10.29	11.19	11.14	10.87	10.40	11.48	11.65	11.17	49.73	49.36	48.88	49.32
CSG 9505 (MT)	10.68	13.18	9.15	11.00	13.18	15.28	10.03	12.83	44.76	46.31	47.71	46.16
BG 372 (S)	10.24	15.20	11.78	12.41	11.06	13.75	9.67	10.49	48.08	52.50	54.92	54.19
BG 256 (S)	10.79	14.31	13.41	12.17	11.78	17.72	14.38	14.62	47.81	44.68	48.25	45.43
BGM 535(S)	9.74	12.35	11.03	11.04	10.97	13.37	11.36	11.90	47.03	48.02	49.26	48.13
Mean	10.76	11.14	10.08		11.86	12.44	10.31		47.62	47.08	48.80	
		CD (P = 0.05)				CD (P = 0.05)						
Genotypes (G)		0.66				1.21						
Zn treatments (T)		0.43				0.55						
G x T		1.26				NS						

T = Tolerant genotype MT = Moderately tolerant genotype S = Susceptible genotype tolerant, CSG 9505 in moderately tolerant and BG 256 in susceptible group had significantly higher mean straw yield than other genotypes, the values were 11.02 q/ha, 12.83 q/ha and 14.62 q/ha, respectively (Table 1). The decrease in straw yield of tolerant genotypes and increase in moderately tolerant and susceptible genotypes on zinc application was also reported by Singh *et al.* (1983) in chick pea.

Effect of Zn application on yield attributes:

A decrease in number of pods per plant was observed in tolerant genotypes while in moderately tolerant and susceptible genotypes reverse trend was observed with increasing level of Zn. The mean values were 32.80, 33.63 and 30.21 with Zn_0, Zn_5 and Zn_{10} levels of Zn application, respectively (Table 2). Significantly higher no. of pods/ plant (38.85 - 41.67) was recorded in tolerant genotypes under Zn_0 (control) condition. The interaction effect was also significant. Ghildiyal *et al.* (1978) reported that the increased realization of flowers into pod due to higher Zn content enhanced the number of pods obtained at final harvest. Khan *et al.* (2000) had also reported findings in chickpea.

With increasing level of application of Zn, tolerant genotypes recorded decline while moderately tolerant and susceptible genotypes recorded an increase in no. of seeds/ pod. The mean number of seeds/pod significantly varied from 1.47 to 1.37 with different levels of Zn application (Table 02). The mean values at Zn_5 and Zn_{10} were at par. The higher values in tolerant group (untreated condition) and susceptible group of genotypes (treated condition) might be due to channelization of photosynthates during reproductive stage as suggested by Baker *et al.* (1982). The differences in mean value of genotypes, which ranged from 1.07 to 1.79 seeds/ pod, and the interaction between genotype and zinc application were statistically significant.

It was also evident that test weight of tolerant genotypes declined while the same increased in moderately tolerant and susceptible group on application of Zn (Table 2). At Zn_0 level genotypes FG 897 of tolerant group recorded higher values (142.76 g) while BGM 535 of susceptible group recorded the lowest value (104.25 g). Singh and Singh (1995) suggested that there might be beneficial effect of Zn on chlorophyll content and so it might have helped in more photosynthate formation and its translocation during seed formation, thus resulting in increase in test weight.

Effect of Zn application on Zn uptake:

The genotype FG 897 of tolerant group recorded highest value of zinc uptake (69.14 g/ha) by seed in the control condition (Zn_0), while the genotype BGM 535 of susceptible group recorded lowest value (21.73 g/ha). The uptake decreased in tolerant genotypes but reverse trend was observed in moderately tolerant and susceptible genotypes. Their mean values ranged from 40.40 g/ha to 45.05 g/ha at Zn_0 and Zn_{10} levels, respectively (Table 3). The interaction effects were significant which indicated that all the genotypes responded differently to zinc application.

At Zn_0 level the genotype FG 897 of tolerant group recorded highest value of zinc uptake (27.36 g/ha) by straw. The mean values of genotypes were found to be statistically significant which increased from 18.02 g/ha at Zn_0 level to 35.39 g/ha at Zn_{10} level (Table 3). The observations pertaining to total zinc uptake revealed that in untreated condition, genotype FG 897 of tolerant group recorded highest value

Table 2: Influence of different levels of zinc on yield attributes of chickpea genotypes

Genotypes	Pods/ plant				Seeds/ pod				Test weight (g)			
	Treatments				Treatments				Treatments			
	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean
FG 897 (T)	38.85	29.07	29.08	32.33	1.46	1.56	1.23	1.28	142.76	140.60	137.30	140.22
BG 1084 (T)	41.67	32.18	28.07	34.11	1.69	1.47	1.46	1.54	126.81	125.92	120.23	124.32
PBG 126(T)	39.70	23.37	20.33	27.80	2.24	1.57	1.54	1.79	124.00	120.77	115.36	120.04
CSJ 128 (MT)	35.63	41.65	36.27	37.85	1.20	1.35	1.22	1.26	119.94	139.55	128.62	129.37
CSG 9505 (MT)	29.25	48.25	39.23	38.91	1.49	1.61	1.65	1.59	107.47	112.90	111.24	110.54
BG 372 (S)	36.13	43.80	42.65	40.86	1.33	1.54	1.56	1.47	108.08	128.01	121.66	119.25
BG 256 (S)	25.88	29.77	29.00	28.22	0.97	1.07	1.19	1.07	114.47	155.05	167.15	145.56
BGM 535 (S)	15.30	20.94	16.62	17.62	1.14	1.58	1.33	1.30	104.25	141.23	115.68	120.39
Mean	32.80	33.63	30.21		1.47	1.37	1.37		118.47	133.00	127.16	
	CD (P = 0.05)				CD (P = 0.05)				CD (P = 0.05)			
Genotypes (G)	2.70				0.20				4.25			
Zn Treatments (T)	1.32				0.08				2.67			
G x T	3.74				0.26				7.53			

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

(96.50 g/ha) while genotype BGM 535 of susceptible group recorded lowest value (28.01 g/ha). The differences of mean values were found to be statistically significant. Zinc application resulted in increase in total zinc uptake by tolerant genotypes, while decrease was observed in moderately tolerant and susceptible genotypes. Their mean values ranged from 58.40 g/ha at Zn_0 level to 80.44 g/ha at Zn_{10} level. Interaction between genotypes and treatments were significant. It is quite evident from Table 3 that partitioning of Zn in seeds and straw was 70.09 per cent and 29.91 per cent in tolerant group (average) while it was only 60.01 per cent and 36.99 per cent in susceptible group (average). Thus tolerant group showed efficient partitioning of Zn towards seeds as compared to susceptible group.

The tolerant genotypes recorded higher total uptake values in untreated condition which might be due to better internal utilization of Zn in order to maintain high growth rates as suggested by Cakmak *et al.* (1997) and due to larger and finer root system (Dong *et al.*, 1995). Zn application resulted in increase in total Zn uptake by moderately tolerant and susceptible genotypes which might be due to the fact that increasing levels of Zn increased its concentration in

Table 3: Influence of different levels of zinc on zinc uptake (g/ha) of chickpea genotypes

Genotypes	Seeds				Straw				Total			
	Treatments				Treatments				Treatments			
	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean
FG 897 (T)	69.14	40.14	43.02	50.77	27.36	34.47	32.20	31.34	96.50	74.65	75.22	82.12
BG 1084 (T)	44.68	33.52	33.53	37.24	22.20	22.94	26.15	23.76	66.87	56.45	59.68	61.00
PBG 126(T)	46.06	36.68	38.87	40.54	18.67	25.93	30.92	25.17	64.73	62.60	69.79	65.71
CSJ 128 (MT)	39.64	48.87	52.04	46.80	16.43	30.06	35.32	27.27	56.07	78.93	87.36	74.12
CSG 9505 (MT)	40.94	56.02	39.50	45.49	20.40	37.82	29.42	29.31	61.34	93.84	68.92	74.70
BG 372 (S)	26.90	54.35	49.79	43.68	15.79	33.80	33.48	27.69	42.69	88.15	83.27	71.37
BG 256 (S)	34.08	54.38	58.78	49.08	16.93	52.23	57.82	42.33	51.61	106.61	116.60	91.41
BGM 535 (S)	21.73	46.10	44.86	37.56	6.35	25.75	37.78	23.29	28.01	71.85	82.64	60.83
Mean	40.40	46.26	45.05		18.02	32.88	35.39		58.40	79.15	80.44	
	CD (P = 0.05)				CD (P = 0.05)				CD (P = 0.05)			
Genotypes (G)	4.14				2.40				4.84			
Zn Treatments (T)	2.37				1.21				2.86			
G x T	6.72				3.43				8.08			

T= Tolerant genotypes MT= Moderately tolerant genotypes S= Susceptible genotypes

Table 4: Influence of different levels of zinc on zinc content (ppm) of chickpea genotypes

Genotypes	Seed				Straw			
	Treatments				Treatments			
	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean	Zn_0 (0.0 kg Zn/ha)	Zn_5 (5.0 kg Zn/ha)	Zn_{10} (10.0 kg Zn/ha)	Mean
FG 897 (T)	54.00	55.83 (3)	60.67 (12)	56.83	20.33	32.41 (59)	35.78 (74)	29.51
BG 1084 (T)	40.83	44.33 (9)	45.83 (12)	43.67	19.20	29.45 (53)	33.83 (76)	27.49
PBG 126(T)	42.50	45.83 (8)	47.50 (12)	45.28	16.40	27.16 (66)	31.12 (90)	24.89
CSJ 128 (MT)	39.83	43.67 (10)	48.67 (22)	44.06	15.83	25.88 (63)	29.50 (86)	23.76
CSG 9505 (MT)	38.33	42.50 (11)	43.17 (13)	41.33	15.48	24.75 (69)	29.33 (90)	23.18
BG 372 (S)	30.00	33.67 (12)	41.33 (38)	35.00	13.00	24.58 (89)	34.62 (166)	23.95
BG 256 (S)	31.67	38.00 (20)	43.83 (38)	37.83	14.26	29.51 (107)	38.96 (173)	27.58
BGM 535 (S)	26.33	37.33 (42)	40.67 (55)	34.78	5.88	19.81 (237)	33.28 (466)	19.66
Mean	37.94	42.65	45.22		15.05	26.47	33.26	
	CD (P = 0.05)				CD (P = 0.05)			
Genotypes (G)	1.65				2.02			
Zn Treatments (T)	1.64				0.98			
G x T	4.64				2.79			

T = Tolerant genotype, MT = Moderately tolerant genotype, S = Susceptible genotype
Figures in parentheses indicate per cent increase over control (Zn_0)

soil solution which in turn might have increased the absorption of zinc by plants (Enania and Vyas, 1994). Shankhdhar and Pant (2003) suggested the enhanced release of phytosiderophores, a compound responsible for chelating Zn in rhizosphere from root of such genotypes, and releasing them across the root cell wall at absorption sites where transporters transfer the Zn ions efficiently in symplast.

Effect of Zn application on Zn content:

Zinc application resulted in increase in zinc content in seeds and straw and their mean value ranged from 37.94 - 45.22 ppm and 15.05- 33.26, respectively at Zn_0 level to Zn_{10} level (Table 4). The increase in zinc content on zinc application suggested that zinc is required for crop growth and development (Motiramani *et al.*, 1981). The magnitude of increase was however, higher in susceptible genotypes which might be attributed to the fact that susceptible genotypes could easily remove required content of zinc from their rhizosphere. But in tolerant genotypes, there was comparatively lesser increase in zinc content as these genotypes were capable to absorb native zinc to meet their Zn requirement even under stress condition and might have taken Zn from comparatively less soluble pools.

Among genotypes, tolerant genotypes accumulated higher Zn in seeds (40.83-54.00 ppm) and straw (16.40-20.33 ppm) in untreated plots which might be attributed to the nature of root exudates, differences in root volume and root cation exchange capacity (CEC). Shankhdhar and Pant (2003) had suggested that roots of these genotypes might have released phytosiderophores, a compound responsible for facilitating the absorption of zinc.

REFERENCES

Baker, N.R., Fernyhough, P. and Meek, T.T. (1982). Light dependent inhibition of photosynthetic electron transport by zinc. *Physiol. Plant.*, **56**: 217-222.

Cakmak, I., Ekiz, H., Yilmaz, A., Torun, B., Kaleli, N., Gultekin, I., Alkan, A. and Ekir, S. (1997). Differential response of rye, triticale, bread and durum wheats to zinc deficiency in calcareous soils. *Plant & Soil*, **188** : 1-10.

Dong, B., Rengel, Z. and Graham, R.D. (1995). Root morphology of wheat genotypes differing in zinc efficiency. *J. Plant Nutr.*, **18** : 2761-2773.

Enania, A.R. and Vyas, A.K. (1994). Effect of phosphorus and zinc application on growth, biomass and nutrient uptake by chickpea in calcareous soil. *Ann. Agric. Res.*, **15**: 397-399.

Ghildiyal, M.C., Tomar, O.P.S. and Sirohi, G.S. (1978). Response of cowpea genotypes to zinc in relation to photosynthesis, nodulation and dry matter distribution. *Plant and Soil*, **49**: 506-516.

Khan, H.R., Mc Donald, G.K. and Rengel, Z. (2000). Response of chickpea genotypes to zinc fertilization under field condition in South Australia and Pakistan. *J.Plant Nutr.*, **23**: 1517-1531.

Motiramani , D.P. , Rathore, G.S., Gupta, G.P., Khamparia, R.S. and Sinha, S.B. (1981). Note on available zinc and copper and response of wheat to zinc application in some alluvial soils of Morena, Madhya Pradesh. *Indian J. Agric. Sci.*, **51**(1): 56-59.

Panse, V.G., and Sukhatme, P.V. (1985). *Statistical method for agricultural workers*. I.C.A.R., New Delhi, INDIA.

Sakal, R. and Singh, A.P. (1979). Zinc hunger in *Kharif* crops of North Bihar. *Indian Farming*, **28**: 3-5.

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

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

Singh, B.P, Singh, A.P. and Sakal, R. (1983). Differential response of crop to zinc application in calcareous soil. *J. Indian Soc. Soil Sci.*, **31**: 534-538.

Singh, B.P., Singh, A.P. and Sakal, R. (1987). Screening of lentil varieties for their susceptibility to zinc deficiency in calcareous soil. *Ann. Agric. Res.*, **8**: 26-33.

Singh, D. and Singh, V. (1995). Effect of potassium, zinc and sulphur on growth characters, yield attributes and yield of soybean (*Glycine max*). *Indian J. Agron.*, **40**: 223-227.

Takkar, P.N. and Walker, C.D. (1993). The distribution and correction of zinc deficiency. pp. 151-156. In: *Zinc in soils and plants.* AD Robson (Ed.). Kluwer Academic Publishers, Dordrect, The Netherlands.

Tripathy, N.C., Singh, R.S. and Mishra, V.K. (1997). Effect of sulphur and zinc nutrition on yield and quality of chickpea (*Cicer arietinum* L.). *J. Indian Soc. Soil Sci.*, **45**: 123-126.

WEBLIOGRAPHY

Banerjee, G. and Palke, L.M. (2010). Economics of pulses production and processing of India. Department of Economic Analysis and Research. Occasional Paper-51. National Bank for Agriculture and Rural Development, Mumbai, p-80. http://www.nabard.org/fileupload/DataBank/OccasionalPapers/Economics%20of%20Pulses%20OP-51.pdf. Accessed 15 June 2013.