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Nutritional Status and Susceptibility of Advanced Chickpea Germplasm to Low Soil Zinc and Boron

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Abstract: Shoot samples at preflowering stage and grains at maturity from four replicated field trials on advanced germplasm of chickpea along with some of the commercial varieties were collected. Three trials consisted of Desi germplasm with, 12, 12, and 8 entries while the fourth one had 11 entries of Kabuli material. The advanced lines appeared to be highly promising as they gave maximum increase over the old check varieties in grain yield upto 60 percent in first trial followed by 58 percent in second, 53 percent in third and 43 percent in the 4th one. On the overall basis, the whole germplasm under study contained sufficient B and Cu, while Zn and P (in grain) were marginal if not deficient. Almost all the material had relatively higher B in the grain than that of cereals like wheat. After field survey, a followup soil pot culture study was conducted employing 5 varieties and 2 lines on a soil with marginal Zn and B. Variety 6153 responded to 5 mg kg^{-1} Zn application by 39, CM 72 by 26, NIFA 95 by 17 and mutant CM 1571-1-A by 11 percent, while remaining responded negligibly. Mutant CM 31-1 responded to 1 mg kg^{-1} B application by 30, CM 1571-1-A, C 44 and 6153 shared the response by 27 percent. Remaining three did not respond or responded negatively. All the entries in the four trials contained marginal Zn i.e., <20 mg kg^{-1} and sufficient B i.e., >30 mg kg^{-1}, yet some of them responded to the applications markedly indicating their high B and Zn requirement than reported in the literature.

Key words: Status, chickpea, Zn, Cu, B, P

Introduction

Micronutrient disorders particularly that of Zn and B have been known in Pakistan for more than two decades (Yoshida and Tanaka, 1969; Chaudhry and Hisbani, 1970). Therefore, substantial efforts have been made for the amelioration of these particularly that of Zn in rice (Tahir, 1981). But a little attention has been diverted towards the investigation of B disorders mainly because of tedious analytical procedures (Sillanpaa, 1982; Kausar, 1998a). Besides application of chemical fertilizers, these problems could also be avoided by growing efficient/tolerant crop varieties (Brown *et al*., 1972). Zinc and B requirement of different crops vary greatly. Therefore, they do differ in their response to Zn and B applications (Singh, 1990; Kausar, 1998b). In 21 field trials on rice, variety Basmati-370 was found more prone to B deficiency than that of IR-6 and reverse was true in case of Zn (Chaudhry *et al.,* 1977). Tahir (1981), on the basis of 19 field trials on wheat, reported that variety Chenab-70 was less susceptible to Zn and B deficiency than Maxi-Pak. Deficiency tolerance by the former was attributed to its lower requirement for these micronutrients. Differential uptake and response to applied micronutrients were also confirmed in a number of rice cultivars (Tahir *et al.,* 1990). Comparison of several crop species has shown that chickpea is more sensitive to Zn deficiency than cereals and oil seeds (Tiwari and Pathak, 1982). Sakal *et al*. (1988) obtained increased yield of chickpea with increasing levels of B from 0-2.5 kg B/ha application. Higher rates caused reduction in yield, while fruiting was most adversely affected in B deficient plants. Soil application of 1-2.5 kg B/ha or foliar application of 0.25 kg B ha^{-1} was adequate to mitigate B deficiency in chickpea. Srivastava *et al.* (1997) discovered B deficiency a major nutritional disorder in chickpea production in Nepal. In a susceptible variety, no pod or grain was formed in the absence of applied B in the field. Differential responses in many wheat and rice varieties to B and Zn application were recorded in pot culture studies (Kausar *et al*., 1990, 1994; Kausar and Tahir, 1994). This sort of information is lacking in chickpea despite it is the major legume crop traditionally grown in the sub-continent. However some reports from India have revealed Zn and B requirement of chickpea as 17 to 30 and 12 mg kg^{-1}, respectively (Katyal and Sharma, 1981; Katyal and Agarwala, 1982). The results regarding Zn nutrition have recently been confirmed by Khan *et al*. (1998) where they found about 21 mg kg^{-1} Zn in the whole shoot of chickpea as the critical level. They also concluded that various chickpea genotypes vary in their sensitivity to Zn deficiency. Advanced breeding germplasm was found more Zn efficient compared with old Australian cultivar Tyson. Zinc efficiency in the genotypes was probably related to an efficient Zn absorption coupled with a better root to shoot transport.

In Pakistan, chickpea is grown on light textured sandy soils which are inherently low in micronutrients (Kausar *et al*., 1979; Sillanpaa, 1982). Therefore, the chances of adverse effect on yield are higher. Lack of information on Zn and B nutrition of chickpea genotypes necessitated the study pertaining to examining the nutritional status of the advanced germplasm and comparison of some promising genotypes for their susceptibility to low soil Zn and B.

Materials and Methods

Field trials: In total, four field trials were conducted. First three trials had 12, 12 and 8 entries of Desi material, while the last one had 11 entries of Kabuli material. Details of the germplasm have been given in the respective tables. Each trial was replicated four times with a plot size of 5 x 1.8 m with a plant to plant and row to row distance of 15 and 30 cm, respectively. Shoot samples were collected at preflowering stage while grain yield was recorded of at maturity. Shoot and grain samples were analysed for B, Zn, Cu and P after dry ashing the plant material at 450°C for 5 hours and dissolving the ash in 0.1 M HCl for over night. Zinc and Cu was determined on atomic absorption spectrophotometer and P by colour development with Barton's reagent (Jackson, 1965). Boron was determined by colour development with Azomethine-H (Wolf, 1971).

Pot cultures: A bulk soil sample from 0-15 cm depth of a Hafizabad series (Typic Ustochrepts) after crushing, drying and passing through 4 mm sieve, was filled in polythene-lined plastic pots at the rate of 4 kg pot^{-1}. Some of the soil properties were: clay, 16 percent; pH, 7.9; EC, 1.6 dS/m; $CaCO_3$ 2.2 percent; organic matter, 0.65 percent; DTPA-Zn and HWS-B 0.4 mg kg^{-1} and DTPA-Cu, 0.65 mg kg^{-1}. A basal dose of N and P at the rate of 20 and 50 mg kg^{-1} was also given. Besides control, Zn and B at the rate of 5 and 1 mg kg^{-1} were applied as $ZnSO_4$ and H_3BO_3. Two plants of the varieties/lines viz., CM 72, CM 88, C 44, NIFA 95, CM 31-1, CM 1571-1-A and 6153 were grown in each pot. One plant was harvested at the mid growth stage (30 cm tall) for chemical composition, while the other was taken to maturity for grain yield. The experiment was replicated thrice in a completely randomized design. Irrigation was done with deionized water at field capacity moisture level. Plant shoots were dried at 70°C in a stainless steel forced air driven oven for three days and then ground to 40 mesh in a Wiley type micromill. After dry ashing, plant tissue was analysed for Zn on atomic absorption spectrophotometer and B by color development with Azomethine-H (Wolf, 1971).

Results and Discussion

Grain yield in field trials: In the first trial with 12 entries of Desi germplasm, grain yield of various lines was different from each other ($p<05$). With the exception of line 90313, yields of all the varieties were better than the check varieties, CM 88 and Pb 91. Yield of five lines was significantly better than the checks. Line 90122, CM 2995/91, 92127, P-40/89 and CM 3864/91 gave yields of 1596, 1546, 3490, 1389 and 1299 against yields of 1122 and 1014 kg ha^{-1} of checks CM 88 and Pb 91, respectively (Table 1).

In the second trial 12 entries of advanced mutants, all the lines were better than the check Pb 91, while six were better than the other check CM 88. Six mutants were significantly better than the check Pb 91 while three were better ($p<0.05$) than the check CM 88. Lines 138/96, 102196, 202/96, 209/96, 120/96 and 237196 yielded 1936, 1806, 1743, 1598, 1588 and 1579 against 1218 and 1493 kg ha^{-1} of local check varieties Pb 91 and CM 88, respectively (Table 1).

In the third field trial with eight entries of advanced mutants, yields of various lines were different from each other ($p<0.05$). Here the checks were again at the bottom with yields of 1170 and 1262 kg ha^{-1} for Pb 91 and CM 88. While the yield of mutants ranged from 1367 in case of CM 988/93 to 1791 kg ha^{-1} in P 1-1/92 (Table 2).

Fourth trial had 11 entries of Kabuli material with two local checks of varieties Noor 91 and Pb 1 with yields of 1058 and 1218 kg ha^{-1} which were at the bottom. Other entries yielded significantly better ranging from 1372 in case of CH5/85 to 1541 kg ha^{-1} from CM 1571-22/84 (Table 2).

On the average, advanced mutants had high yield i.e., 1528 compared with 1269, 1310 kg ha^{-1} of the local germplasm. Kabuli material on an average had 1389 kg ha^{-1} grain yield.

Nutritional status of the germplasm: Boron, Zn, Cu and P concentrations in the various varieties/lines were significantly different ($p<0.05$) in all the four trials. Boron in the first trial ranged from 21.2 to 29.5 and 4.8 to 8.6 mg kg^{-1} in shoot and grain, respectively. Shoot B was more than the critical level i.e., 12 mg kg^{-1} (Katyal and Sharma, 1981). Boron concentration in the grain was also quite high compared with cereals like wheat (Kausar *et al.,* 1990). Shoot B had no relationship with the grain yield. Shoot Zn in the first trial ranged from 17.5 to 22.1 mg kg^{-1} while corresponding values in the grain were higher ranging from 20.4 to 28.1 mg kg^{-1}. In the literature different critical levels of plant Zn have been suggested ranging from 12 to 32 mg kg^{-1} (Katyal and Agarwala, 1982; Katyal and Sharma, 1981; Khan *et al*., 1998). Keeping these levels in view, most of the germplasm fall in the deficient/marginal range with respect to Zn composition. Copper concentration in the shoot ranged from 6.4 to 15.2 and in the grain from 6.5 to 9.2 mg kg^{-1} (Table 1). Copper in the chickpea has rarely been explored but comparing with other crops Cu levels were sufficient by any standard (Jones *et* al.,1991). Phosphorus ranged from 0.25 to 0.39 and 0.22 to 0.29 percent in shoot and grain, respectively. Values of P in the shoot were sufficient, while that of grain fall in the deficient range. Rashid and Bughio (1993) reported 0.18, 0.38 and 0.37 percent P in the shoot, leaf and grain of chickpea as the critical levels.

Advanced mutants had B ranging from 19.7 to 33.2 with an average of 26.3 mg kg^{-1} in the shoot and 3.0 to 9.3 with an average of 6.3 mg kg^{-1} in the grain. Zinc in the shoots ranged from 16.1 to 21.8 with an average of 20.7 and in the grain it ranged from 20.6 to 28.4 with an average of 23.9 mg kg^{-1}. Cu ranged from 8.0 to 14.0 with an average of 11.6 in the shoots and grain Cu ranged from 5.0 to 13.0 with an average of 6.4 mg kg^{-1}. Phosphorus in the shoots ranged from 0.28 to 0.32 averaging 0.31 and in grains it ranged from 0.21 to 0.27 with an average of 0.23 per cent (Table 1).

In the third trial consisting of eight entries of mutants, B in the shoots and grain averaged 16.8 and 7.3 mg kg^{-1}, Zn 20.3 and 26.9, Cu 7.2 and 7.7 mg kg^{-1} and P 0.31 and 0.25 percent, respectively (Table 2).

In the fourth trial on Kabuli material, B in the shoot and grain averaged 19.5 and 7.3, Zn 24.7 and 25.4, Cu 10.8 and 8.5 mg kg^{-1} and P 0.28 and 0.26 percent, respectively (Table 2).

To sum up, advanced mutants contained on an average highest B (26.3 mg kg^{-1}) in the shoot followed by the gerrnplasm in the first trial (Desi advanved germplasm from AARI and NIAB), Kabuli and lowest in the NIAB mutants (19.5 mg kg^{-1}). Grain of Kabuli and NIAB mutants had highest B (7.3 mg kg") followed by AARI and NIAB material (Desi material in the first trial) lowest in the advanced mutant (6.3 mg kg^{-1}). Zinc in the shoots of Kabuli material was highest i.e., 24.7 mg kg^{-1} while other three had similar Zn around 20 mg kg'. In grain, Zn was highest in NIAB mutants i.e., 26.8 followed by Kabuli and other two had the lowest i.e. 23.8 mg kg^{-1}. Copper was highest in shoots of advanced mutants i.e., 11.6 mg kg^{-1} followed by Kabuli, NIAB+AARI material and lowest in NIAB mutants i.e., 7.2 mg kg^{-1}. Grain of Kabuli and advanced mutants had the highest and lowest Cu of 8.5 and 6.4 mg kg^{-1}, respectively. NIAB+AARI lines in the first trial had highest P (0.34 percent) and Kabuli material had the lowest P (0.28 percent) in their shoots, while P in the grain was highest (0.26 percent) in the NIAB+AARI material and lowest in advanced mutants while NIAB mutants and Kabuli material had both 0.25 percent P in their grains.

Comparing the values of various elements with the critical values of various elements given in the literature, it could be concluded that B, Cu and P (with a little exception in grains) in the germplasm under study were sufficient and Zn was marginal if not deficient (Katyal and Sharma, 1981; Katyal and Agarwala, 1982; Rashid and Bughio, 1993; Jones *et al.,* 1991).

Pot trial

Effect of zinc application on the grain yield of chickpea: Various varieties were different ($p<.05$) from each other with respect to their grain yield. These were significantly improved with the Zn application (Table 3). At control, line CM 1571-1-A gave highest yield of 8.93 g $plant^{-1}$ followed by C 44, CM 72, CM 88, CM 31-1, 6153 and lowest of 5.85 g $plant^{-1}$ in case of NIFA 95. Similarly, CM 1571-1-A and NIFA 95 were highest and lowest yielders at Zn application. In terms of grain yield response, CM 88 was not sensitive to low soil Zn, while CM 31-1 and C 44 were mildly sensitive and remaining four were highly sensitive as they responded to the extent of 11 in case of CM1571-1-A, 17 in NIFA 95, 26 in CM 72 and 39 per cent in 6153. Response of various varieties to Zn application could be attributed to low soil Zn while non/low responsive ones seemed to have avoided the deficiency by meeting their requirement through their better efficiency to extract native soil Zn or due to their lower requirement. Varietal response to applied Zn was not correlated with their yields at control.

Various researchers have reported differential response of various plant species to Zn application. Some have reported their escape from the deficiency because of their high efficiency for the Zn uptake to meet the requirements from the native soil reserves

Table 1: Grain yield and composition of chickpea (Coop. Yield Trial AARI-NIAB)

Variety/line	Yield- (kg ha^{-1})	B (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		P (percent)	
		shoot	grain	shoot	grain	shoot	grain	shoot	grain
90122	1596	24.3	8.6	22.1	25.9	15.2	6.5	0.34	
CM 2995/91	1546	28.0	6.7	18.5	27.1	8.5	8.1	0.35	
92127	1490	22.3	7.1	17.8	22.5	7.6	8.1	0.31	
P40/89	1389	23.2	6.6	18.6	23.9	10.2	9.2	0.25	
CM 3864/91	1299	24.0	8.3	17.5	24.0	8.2	7.6	0.31	
93081	1246	26.0	5.1	19.4	20.4	8.0	6.5	0.39	
CM 210/90	1201	29.5	6.4	19.8	23.0	6.4	7.9	0.36	
A-16	1178	28.0	4.8	20.9	28.1	7.8	7.9	0.37	
CM 3444/92	1144	21.2	5.6	19.6	23.3	12.0	8.6	0.36	
CM 88'	1122	27.2	7.4	17.7	23.5	7.8	6.9	0.27	
Pb 91*	1014	22.3	6.8	20.0	21.2	12.6	7.2	0.39	
90313	1006	22.0	6.4	19.8	22.6	7.8	7.4	0.38	
L.S.D. (<0.05)	171	1.75	.35	1.65	1.77	0.45	0.36	0.022	
Advanced Mutants									
138/96	1936	24.3	5.3	20.8	24.0	9.8	6.5	0.31	
102/96	1806	25.5	9.3	21.0	22.7	8.2	9.7	0.32	
202/96	1743	32.0	6.1	21.8	24.0	12.2	7.8	0.32	
209/96	1598	27.2	7.4	19.2	24.1	11.0	5.0	0.33	
120/96	1588	28.9	7.4	16.1	22.4	8.0	6.0	0.28	
237/96	1579	28.9	4.8	21.4	23.8	13.0	8.0	0.31	
CM 88*	1493	22.6	6.8	14.6	23.0	8.0	5.0	0.28	
129/96	1373	22.0	3.0	19.2	28.4	13.0	13.0	0.31	
140/96	1371	28.9	6.0	21.1	23.4	13.0	7.0	0.30	
101/96	1369	33.2	7.1	19.5	24.3	14.0	5.0	0.31	
212/96	1259	22.3	6.6	19.9	20.6	12.0	8.0	0.31	
Pb 91*	1218	19.7	5.8	19.4	25.7	10.0	8.0	0.31	
L.S.D. (<0.05)	193	1.56	.41	1.48	1.53	0.54	0.41	.021	

*Check varieties

Table 2: Grain yield and composition of chickpea (Ad. Yield Trial NJAB)

Variety/line	Yield (kg ha^{-1})	B (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		P percent	
		shoot	grain	shoot	grain	shoot	grain	shoot	grain
P 1-1/92	1791	19.7	8.2	20.1	29.0	7.6	8.8	0.36	
P6-2/92	1592	17.7	6.8	21.4	25.0	7.6	7.6	0.29	
CM 1448/93	1554	19.7	8.3	19.0	34.6	8.3	5.4	0.39	
CM 929/93	1524	18.3	6.6	23.5	21.9	7.2	9.0	0.37	
CM 368/93	1424	21.3	7.9	18.3	25.3	7.8	6.3	0.29	
CM 988/93	1367	18.9	6.3	21.0	26.3	6.5	7.4	0.24	
CM 88*	1262	17.5	7.4	20.1	28.9	6.0	8.3	0.25	
Pb 91*	1170	14.3	6.7	19.4	24.3	6.3	9,2	0.33	
L.S.D. (<0.05)	129	1.33	0.54	1.23	1.67	0.56	0.65	0.031	
Advanced Yield Trial Kabuli									
CM1571-22	1541	19.4	5.7	21.9	19.7	10.7	7.4	0.30	
P 40/91	1512	20.0	6.6	24.3	20:3	9.8	6.5	0.23	
CH 9/85	1471	21.2	8.4	22.6	25.8	11.2	8.3	0.31	
P 41/91	1463	22.0	7.4	23.8	23.4	10.1	8.5	0.27	
P 6-8/91	1448	19.2	11.4	23.5	28.1	10.5	12.1	0.21	
P14-1/91	1410	20.6	6.7	29.3	21.5	11.0	7.9	0.30	
P 21/91	1413	18.6	5.8	23.4	24.7	10.7	11.2	0.24	
P 22/91	1378	18.6	6.6	21.4	27.9	10.5	7.0	0.28	
CH 5185	1372	18.0	6.3	25.9	23.2	11.0	9.2	0.31	
Pb 1*	1218	17.7	7.6	28.7	38.4	12.5	5.4	0.23	
Noor 91 *	1058	19.7	7.7	27.3	26.6	11.2	10.3	0.43	
L.S.D. (<0.05)	173.0	94.0	0.57	1.66	1.58	0.69	0.46	0.032	

*Check varieties

Table 3: Effect of applied Zn on the yield and Zn concentration of chickpea varieties

Varieties	Grain yield (g $plant^{-1}$)		Response percent	Mean	Zn concentration (mg kg^{-1})		
	Cont.	+Zn			Cont.	+Zn	Mean
6153	6.14 e	8.53 c	39	7.33 d	15.5e	25.5 a	20.5b
CM 72	7.65 c	9.65 b	26	8.65 b	16.0d	22.5 e	19.3c
NIFA 95	5.85 f	6.87 f	17	6.36 e	16.0d	20.0 f	18.0d
CM1571-1-A	8.93 a	9.95 a	11	9.44 a	17.0c	23.8 c	20.4b
C 44	8.05 b	8.43 c	5	8.24 c	15.0c	20.0 f	17.5e
CM 31-1	7.37 d	7.69 d	4	7.53 d	18.5a	23.0 d	20.7ab
CM 88 a	7.40 cd	7.38 e	-	7.39 d	17.5b	24.5 b	21.0
Mean	7.34 b		8.36 a			16.5b	22.8 a
LSD ($p<.05$)		0.255		0.21	0.342		0.321

Table 4: Effect of applied B on yield and B concentration of chickpea varieties.

Varieties	Grain yield (g/plant)		Response percent	Mean	B concentration (mg kg^{-1}) leaf			grain		
	Cont.	+B			Cont.	+B	Mean	Cant	+B	Mean
CM 31-1	7.35 d	9.55 c	30	8.45c	33.9 c	95.1 b	64.5b	2.3e	5.0 f	3.7f
CM 1571-1-A	8.94 a	11.56 a	28	10.25a	32.6 e	83.3 d	57.9d	3.6c	5.6d	4.6d
6153	6.15 e	7.83 d	27	6.99d	28.7 f	71.4 e	50.0 e	3.7 c	5.3 e	4.5 d
C 44	8.05 b	0.25 b	27	9.15b	35.5 a	117.4a	76.5 a	5.6 b	6.3 c	6.0 c
NIFA 95	5.87 f	5.79 e		5.83g	33.1 d	84.7 d	58.9 cd	3.4 d	5.0 f	4.2 e
CM 72	7.62 cd	5.22 f	-31	6.42e	33.0 d	91.5 c	62.3 bc	6.6 a	8.0 a	7.3 a
CM 88	7.73 c	4.65 g	-40	6.19f	34.7 b	93.2 be	63.9 b	5.7 b	7.5 b	6.6 b
Mean	7.39 b	7.83 a			33.1b	90.9a		4.4 b	6.1a	
LSD ($p<0.05$)	0.276			0.211	2.79		3.88	0.141		0.132

while others have attributed it to their internal requirements (Brown *et al.,* 1972; Chaudhry *et al.,* 1977; Singh, 1990; Kausar, 1998b; Tahir, 1981; Tahir *et al*., 1990; Khan *et al*., 1998).

Effect of zinc application on the zn concentration in the whole sh000t of chickpea varieties/lines: Various varieties were different from each other ($p<0.05$) with respect to their Zn contents (Table 3). At control, line CM 31-1 contained maximum of 18.5 mg kg^{-1} Zn followed by CM 88, CM 1571-1-A, CM 72, NIFA 95, 6153 and C 44. These concentrations in the whole shoots were improved ($p<0.05$) by Zn application. At applied Zn, variety 6153 had maximum Zn of 25.5 mg kg^{-1} and least of 20 mg kg^{-1} in CM 1571-1-A and. C 44, while others were in between. Varietal response was not related to their grain yield or Zn concentration in the whole shoot at control as variety C 44 with lowest Zn of 15.0 mg kg^{-1}, responded to the extent of 5 percent and variety 6153 with the similar concentration responded to the extent of 39 percent. Contrarily varieties with higher Zn efficiency like that of CM 88 and CM 31-1 either did not respond or responded negligibly indicating their low Zn requirement which might have been met from the native soil reserves. However, varietal efficiency seemed to have some sort of relatioship with the plant response as varieties with relatively less Zn e.g. 6153, CM 72, NIFA 95 responded to greater extents than that of efficient varieties like CM 31-1 and CM 88 with higher Zn. In the literature, 12-32 mg kg^{-1} Zn in the chickpea shoot has been reported as the critical level by various workers (Katyal and Agarwala, 1982; Katyal and Sharma, 1981). Recent report in this regard is from Australia where Khan *et al*. (1998) discovered 20-21 mg kg^{-1} Zn in the shoot as critical level. Their results regarding the escape of efficient genotypes from Zn deficiency also support our results. The varieties in our study contained <21 mg kg^{-1} Zn, averaging 16 mg kg^{-1}. That was probably the reason for their response to applied Zn. Research workers (Kausar and Tahir, 1994; Kausar,1998b) have reported that response of various varieties of wheat and rice to Zn was not necessarily related to their Zn concentration in the whole shoot rather it was the function of their internal requirement which could vary for various genotypes. But on the other hand some efficient genotypes escaped Zn deficiency. Tolerance to Zn deficiency has been considered a genetic trait, termed as Zn efficiency, which can be defined as the ability of a cultivar to grow and yield well in soil too deficient in Zn for a standard cultivar (Graham *et al*., 1992).

Effect of boron application on the grain yield of chickpea varieties: Various varieties were different from each other with respect to their grain yields ($p<0.05$). These were significantly affected by the applied B (Table 4). At control, line CM 1571-1-A gave the highest yield of 8.94 g/pot followed by C 44, CM 88, CM 72, CM 31-1, 6153 and least of 5.87 $plant^{-1}$ by NIFA 95. Line CM 1571-1-A also gave highest yield of 11.56 g/pot at applied B but least of 4.65 g/plant by CM 88. Line CM 31-1 was most sensitive to low soil B as it responded maximum to the extent of 30 percent followed by CM1571-1-A, 6153 and C 44 with a joint response of 27 percent. The remaining three were not sensitive, as they either did not respond or responded negatively. Varieties response was not related to the grain yield at control as the lowest yielding variety at control, NIFA 95 did not respond at all, while highest yielding CM 1571-1-A responded to the extent of 28 percent. Similar results were reported by Kausar *et al*. (1990, 1994) on various varieties of wheat and rice.

Effect of applied boron on the boron concentration of whole shoot and grain of chickpea varieties: Various varieties were different with respect to their B concentration in the whole shoot and grain which were significantly affected by B application ($p<0.05$). At control and at applied B, variety C 44 had maximum B concentration of 35.5 and 117.4, and variety 6153 had minimum of 28.7 and 71.4 mg kg^{-1}, respectively in their whole shoot. Variety CM 72 had maximum B of 6.6 and 8.0 and mutant CM 31-1 had minimum B of 2.3 and 5.0 mg kg^{-1} in their grain at control and applied B treatment, respectively (Table 4). Boron application to each variety caused a pronounced increment in the shoot as well as in grain. However, this increment in shoot was drastic compared with grain. Similar results were also reported by many workers elsewhere, where most of the absorbed B was found dumped in the shoot with little translocation in grain. The brown spots in various plant species caused due to excessive B application were found to contain thousands ppm of B while grain contained only a few ppm (Kausar and Cartwright, 1984; Oertli and Kohl, 1961).

Critical B concentration in the plant shoot available in the literature is 12 mg kg^{-1} (Katyal and Agarwala, 1982). But non of the variety contained less than 12 mg kg^{-1} B, yet four of them responded to the application remarkably indicating their higher demand of B than that of reporfed in the literature. Cartwright *et al.* (1987) have reported that differential response of various wheat varieties was not exclusively controlled genetically as different varieties with similar pedigree behaved differently to applied B. Other factors like earliness, root pattern, nutrient distribution in soil and weather conditions at a given time were also important. They also questioned the use of so called "critical level" to estimate their status as various varieties behaved differently when they were subjected to B application. This necessitates the study on B requirement of various varieties as about 40 percent of our agricultural soils are suspected to contain deficient B (Sillanpaa, 1982). Research workers have recorded response of various crops to Zn and B application even under Barani conditions (Rashid *et al.* 1997a,b). Therefore, it is imperative to investigate the requirement of various varieties for Zn and B to have the optimal yields. Plant breeders and nutritionist should coordinate to evolve varieties which could escape the deficiencies through their efficiency. For the varieties with high nutrient requirements, the applications shall have to be made any way.

References

Brown, J.C., J.E. Ambler, R.L. Chaney and C.D. Foy, 1972. Differential Responses of Plant Genotypes to Micronutrients. In: Micronutrients in Agriculture, Mortvedt, J.J., P.M. Giordano and W.L. Lindsay (Eds.). Soil Science Society of America, Madison, Wisconsin, USA., pp: 389-413.

Cartwright, B., A.J. Rathjen, D.H.B. Sparrow, J.G. Pawl and B.A. Zarcinas, 1987. Boron Tolerance in Australian Varieties of Wheat and Barley. In: Genetic Aspect of Plant Mineral Nutrition, Gabelman, H.W. and B.C. Longman (Eds.). Martinus Nijhoff, Dordrecht, Netherland, pp: 139-151.

Chaudhry, F.M. and G.R. Hisbani, 1970. Effect of boron on the yield of seed cotton. Pak. Cottons, 15: 13-15.

Chaudhry, F.M., A. Latif, A. Rashid and S.M. Alam, 1977. Response of rice varieties to field application of micronutrient fertilizer. Pak. J. Sci. Ind. Res., 19: 134-139.

Graham, R.D., J.S. Ascher and S.C. Hynes, 1992. Selecting zinc-efficient cereal genotypes for soils of low zinc status. Plant Soil, 146: 241-250.

Jackson, M.L., 1965. Soil Chemical Analysis. Prentrice Hall, Englewood, Cliffs New York, USA.

Jones, Jr., J.B., B. Wolf and H.A. Mills, 1991. Plant Analysis Handbook: A Practical Sampling, Preparation, Analysis and Interpretation Guide. Micro Macro Publishing, Athens, USA., ISBN-13: 9781878148001, Pages: 213.

Katyal, J.C. and B.D. Sharma, 1981. 15th Annual report 1981-182. All India Coordinated Scheme on Micronutrients in Soils and Plants, ICAR., New Delhi.

Katyal, J.C. and S.C. Agarwala, 1982. Micronutrient research in India. Fert. News, 27: 66-86.

Kausar, M.A. and B. Cartwright, 1984. Responses of barley, wheat and lucerne to high concentrations of soluble B in soils. Proceedings of the National Soils Conference, May 13-18, 1984, Brisbane, Australia, pp: 340.

Kausar, M.A. and M. Tahir, 1994. Susceptibility of eleven wheat varieties to Zn and Cu deficiency. Proceedings of the 4th Congress Soil Science, May 24-26, 1992, Islamabad, Pakistan.

Kausar, M.A., 1998a. Comparison of four extraction methods for soil B estimation. Proceedings of the Symposium on Plant Nutrition Management for Sustainable Agricultural Growth, December 8-10, 1997, NFDC., Islamabad, Pakistan, pp: 203-210.

Kausar, M.A., 1998b. Differential sensitivity of eleven rice varieties to low soil zinc and copper. Pak. J. Soil Sci., 14: 50-53.

Kausar, M.A., A. Hamid and M. Tahir, 1990. Differential susceptibility of eight wheat varieties to boron deficiency. Pak. J. Soil Sci., 5: 5-7.

Kausar, M.A., M. Tahir, R. Ahmed and A. Hamid, 1994. Susceptibility of six rice varieties to B deficiency. Pak. J. Soil Sci., 9: 100-103.

Kausar, M.A., S.M. Alam, M. Sharif and I. Pervaiz, 1979. Micronutrient status of Pakistan soils. Pak. J. Sci. Ind. Res., 22: 156-160.

Khan, H.R., G.K. McDonald and Z. Rengel, 1998. Assessment of the Zn status of chickpea by plant analysis. Plant Soil, 198: 1-9.

Oertli, J.J. and H.C. Kohl, 1961. Some considerations about the tolerance of various plant species to excessive supplies of boron. Soil Sci., 92: 243-247.

Rashid, A. and N. Bughio, 1993. Evaluating internal phosphorus requirement of rapeseed, chickpea, lentil and wheat by seed analysis. Commun. Soil Sci. Plant Anal., 24: 1359-1369.

Rashid, A., E. Rafique and N. Ali, 1997a. Micronutrient deficiencies in rainfed calcareous soils of Pakistan. II. Boron nutrition of the peanut plant. Commun. Soil Sci. Plant Anal., 28: 149-159.

Rashid, A., E. Rafique and N. Bughio, 1997b. Micronutrient deficiencies in rainfed calcareous soils of Pakistan. III. Boron nutrition of sorghum. Commun. Soil Sci. Plant Anal., 28: 441-454.

Sakal, R., R.B. Sinha and A.P. Singh, 1988. Effect of boron application on blackgram and chickpea production in calcareous soil. Fert. News, 33: 27-30.

Sillanpaa, M., 1982. Micronutrients and nutrient status of soil: A global study. Soil Bulletin No. 48, FAO., Rome.

Singh, R.P., 1990. Status of chickpea in the world. Int. Chickpea Newslett., 22: 10-16.

Srivastava, S.P., C.R. Yadav, T.J. Rego, C. Johansen and N.P. Saxena, 1997. Diagnosis and Alleviation of Boron Deficiency Causing Flower and Pod Abortion in Chickpea (*Cicer arietinum* L.) in Nepal. In: Boron in Soils and Plants, Beli, R.W. and B. Rerkasem (Eds.). CRC Press, Boca Raton, pp: 95-99.

Tahir, M., 1981. Availability status of micronutrients in soils of West Pakistan and role and behaviour of selected micronutrients in the nutrition of crops. Final Technical Report PL-480 Project No. Fg-Pa-221, NIAB, Faisalabad.

Tahir, M., F. Hussain, M.A. Kausar and A.S. Bhatti, 1990. Differential uptake and growth response to micronutrients in various rice cultivars. Pak. J. Agric. Sci., 27: 367-373.

Tiwari, K.N. and A.N. Pathak, 1982. Studies of the zinc requirements of different crops. Exp. Agric., 18: 393-398.

Wolf, B., 1971. The determination of boron in soil extracts, plant materials, composts, manures, water and nutrient solutions. Commun. Soil Sci. Plant Anal., 2: 363-374.

Yoshida, S. and A. Tanaka, 1969. Zinc deficiency of the rice plant in calcareous soils. Soil Sci. Plant Nutr., 15: 75-80.