GAU Res. J. 1995. 21 (1) : 28-35

Effect of P and Zn on Wheat Crop Grown on Calcareous Soils

B. A. Golakiya, M. S. Patel and G. S. Sutaria

Department of Agricultural Chemistry and Soil Science, Gujarat Agricultural University, Junagadh-362 001

ABSTRACT

A pot experiment was conducted to study the mean and interaction effect of applied phosphorus and zinc on the yield attributes, yield concentration and uptake of nutrients (P, Zn and Ca) by wheat CV GW 120. Application of P (P_3) increased the grain and straw yield by 51 and 30 per cent, respectively, so also the Zn (Zn_3) upto 7 per cent in the both grain and straw through its positive effects on the yield attributes and their respective concentrations and uptake of P and Zn in the grain and straw. The P X Zn interaction became antagonistic at P_2/Zn_3 resulting in a 21 per cent reduction in the grain yield over that in P_2/Zn_0 and also a considerable reduction in the concentration and uptake of P and/or Zn in the plant when compared with that in the respective controls. (key words : Phosphorus, Zinc, Phosphorus x Zinc and Wheat)

(Received on 5th Nov., 1993)

INTRODUCTION

The phosphorus (P) x zinc (Zn) have formed a subject for many workers (Loneragan, 1951; Burleson *et al.*, 1961; Boawn and Brown, 1968; Safaya, 1976). This P X Zn interaction assumes special importance in the calcareous soils. Since P fixation capacity of these soils went up to 92 per cent an extra large amount of phosphatic fertilizer is added to the soils to harvest a better crop which in turn aggravates Zn deficiency as a result of P x Zn antagonism. The above contention has been tested in the present investigation with a view to establish a magnitude of the interaction effects.

MATERIALS AND METHODS

A pot experiment was conducted on a vertisol (medium black calcareous soil) during winter 1986 with four levels each of phosphorus (0-P_0, 25-P_1, 50-P_2 and 100-P_3 mg kg^{-1}) and zinc (0-Zn_0, 5-Zn_1, 10-Zn_2 and 20-Zn_3 mg kg^{-1}) with two replications in a completely randomised factorial design. Monocalcium phosphate ($Ca(H_2PO_4)_2\ H_2O$) and zinc sulphate ($ZnSO_4.7H_2O$) were used as source of phosphorus and zinc, respectively. Some of the soil characteristics are : sand 13.0%, silt 30.3%, clay 56.7%, pH 7.8 EC 0.18 dSm^{-1}, $CaCO_3$ 3.3%, CEC 55.0 m.e. 100 g^{-1}, exchangeable Ca 44.5 and Mg 6.4 m.e. 100 g^{-1}, organic carbon 0.84%, Olsen's P 5.73 ppm P_2O_5, available K 172.5 ppm K_2O and DTPA extractable Zn 0.62, Fe 6.53,Cu 3.22 and Mn 11.50 ppm. The polyethylene lined earthen pots (12 litre volume) were filled with 12 kg of the treated soil. Wheat CV GW 120 was sown, which was thinned to nine plants per pot a week after

germination. The plant samples were digested in a di-acid mixture as described by Jackson and Ulrich (1969). The acid extract was used for analysis of different nutrients viz. P, Zn and Ca. Phosphorus in the acid extract was determined by vanadomolybdophosphoric yellow colour method, Ca by Versanate method (Jackson, 1958) and Zn by Atomic absorption spectrophotometry (Shimadzu Model AA-640-13).

RESULTS AND DISCUSSION

Mean effect of phosphorus and zinc

Phosphorus application at P_3 level increased the effective tillers earhead length, test weight and grain and straw yield by 17, 46, 79, 8 and 51 and 30 per cent, respectively, over the values of the respective parameters under P_0, while zinc fertilization and Zn_3 increased the earhead length and test weight

TABLE 1

Mean and interaction effect of phosphorus and zinc on yield attributes and yield of wheat CV GW 120.

Treatment combination	*Earhead length (cm)*	*Test weight (g)*	*Grain yield (g pot^{-1})*	*Straw yield (g pot^{-1})*
P_0	4.08	38.02	10.81	24.29
P_1	5.01	39.12	11.70	28.48
P_2	6.61	39.91	13.54	31.28
P_3	7.29	41.11	15.05	31.65
CD (0.05)	0.66	0.57	1.03	0.67
Zn_0	5.69	39.44	10.63	27.75
Zn_1	5.72	39.63	12.89	29.27
Zn_2	5.78	39.68	13.32	29.03
Zn_3	5.80	40.41	13.45	29.63
CD (0.05)	0.66	0.57	1.3	0.67
P_0Zn_0	4.02	37.82	8.61	21.98
P_0Zn_1	4.06	37.98	9.00	23.72
P_0Zn_2	4.10	38.05	12.56	24.88
P_0Zn_3	4.15	38.22	13.10	26.56
P_1Zn_0	4.90	38.81	12.00	25.95
P_1Zn_1	4.92	39.10	12.16	28.53
P_1Zn_2	5.07	39.22	11.12	29.23
P_1Zn_3	5.16	39.35	12.10	30.21

1.	2.	3.	4	5.
P_2Zn_0	6.49	39.58	14.82	30.28
P_2Zn_1	6.59	39.80	14.78	31.63
P_2Zn_2	6.73	39.33	12.87	31.73
P_2Zn_3	6.64	39.24	11.68	31.49
P_3Zn_0	7.34	41.55	16.81	32.81
P_3Zn_1	7.33	41.63	16.78	23.23
P_3Zn_2	7.24	39.43	11.75	30.29
P_3Zn_3	7.25	39.83	14.84	30.27
CD (0.05)	1.12	1.04	1.62	1.34

and consequently increased the grain and straw yield by 7 per cent over the values of the respective parameters at Zn_0 (Table 1). Many workers reported phenomenal increase in the yield of wheat due to P fertilization (Randhawa and Tandon, 1982) mostly brought about by positive effects on the yield attributes (Rajput *et al.*, 1987).

Many early workers (Brar and Sekhon, 1978) reported positive effect of Zn on the yield attributes and yield of wheat under varying soil conditions. From the number of field trials, Takkar and Randhawa (1978), Sakal *et al.* (1980), Khamparia *et al.* (1984) reported significant increase in the yield of wheat grains due to Zn application @20 to 25 kg ha^{-1} of $ZnSO_4$.

Fertilization with P increased the concentration of this nutrient by 21 and 20 per cent and its uptake upto 82 and 30 per cent by grain and straw, respectively at P_3 level over that under P_0. However, the Zn concentration under P_3 was reduced by 17 and 16 per cent but its uptake was increased to 25 and 10 per cent by the grain and straw, respectively, over that of control. Similarly, the Ca concentration

TABLE 2

Mean and interaction effect of phosphorus and zinc on the concentration and uptake of phosphorus by wheat CV GW 120.

Treatment combinations	*P concentration (mg g^{-1})*		*P uptake (mg pot^{-1})*	
	Grain	*Straw*	*Grain*	*Straw*
P_0	4.11	0.84	44.04	24.70
P_1	4.82	0.83	56.39	23.63
P_2	4.99	0.96	67.55	30.02
P_3	4.99	1.07	76.94	31.96
CD (0.05)	0.40	0.06	7.46	5.09

1.	*2.*	*3.*	*4.*	*5.*
Zn_0	4.97	1.11	30.80	24.14
Zn_1	4.79	1.15	33.66	27.80
Zn_2	4.64	0.94	27.28	23.51
Zn_3	4.53	0.86	25.48	27.55
CD (0.05)	0.40	0.06	7.46	5.09
P_0Zn_0	4.16	0.75	35.81	22.77
P_0Zn_1	4.18	0.96	37.62	25.85
P_0Zn_2	4.11	0.78	51.62	19.40
P_0Zn_3	4.00	0.73	52.40	27.35
P_1Zn_0	5.02	0.87	60.24	21.01
P_1Zn_1	4.84	0.87	58.85	24.82
P_1Zn_2	4.79	0.85	53.15	24.84
P_1Zn_3	4.63	0.77	56.02	23.26
P_2Zn_0	5.28	1.08	76.24	32.70
P_2Zn_1	5.05	0.97	74.63	30.66
P_2Zn_2	4.83	0.82	62.16	26.02
P_2Zn_3	4.82	0.95	56.29	29.91
P_3Zn_0	5.40	1.16	90.61	38.10
P_3Zn_1	5.09	1.07	85.66	35.55
P_3Zn_2	4.81	0.98	56.60	29.68
P_3Zn_3	4.67	0.82	69.30	24.81
CD (0.05)	0.12	0.23	12.92	NS

and its uptake by the grain was also curtailed, while in the straw these parameters remained unaffected (Table 2 and 3). Our results supports the findings of previous workers who also reported positive effect of applied P on its concentration and uptake (Marok and Dev, 1980). Similarly, the observed adverse effect of P application on the Zn concentration is also in the affirmation with that reported by others (Burleson *et al.*, 1961; Safaya, 1976).

Zinc application at Zn_3 level increased its concentration by 77 and 64 per cent and its uptake upto 88 and 75 per cent by the grain and straw, respectively over that in Zn_0, while the concentration and uptake of P by grain were reduced by 32 and 17 per cent, respectively, over the respective values of these parameters under Zn_0. Though the concentration of P in the straw was diminished with progressive Zn levels, its uptake was increased upto 15 per cent under Zn_3 over that in Zn_0. These

TABLE 3

Mean and interaction effect of phosphorus and zinc on the concentration uptake of zinc wheat CV GW 120.

Treatment	ZN concentration ($mg\ g^{-1}$)		Zn uptake ($mg\ pot^{-1}$)		Ca concentration ($mg\ g^{-1}$)		Ca uptake ($mg\ pot^{-1}$)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
P_0	76.47	60.34	826	1465	1.12	3.22	12.05	78.21
P_1	71.70	59.34	834	1690	1.08	3.21	12.63	91.42
P_2	63.28	53.71	855	1680	1.07	3.19	12.48	99.78
P_3	63.29	50.71	975	1604	1.02	3.22	15.73	111.91
CD (0.05)	3.30	6.20	24	25	0.03	NS	0.56	NS
Zn_0	49.27	44.69	622	1240	1.05	3.13	1.26	86.85
Zn_1	63.32	53.54	816	1567	1.13	3.23	14.56	94.54
Zn_2	75.04	60.69	999	1761	1.04	3.26	13.85	94.63
Zn_3	87.11	73.17	1171	2168	1.06	3.21	14.25	95.11
CD (0.05)	3.30	6.20	24	25	0.03	0.03	0.56	NS
$P_0 Zn_0$	58.79	54.00	506	1186	1.03	3.20	9.21	70.33
$P_0 Zn_1$	74.17	61.25	667	1452	1.24	3.47	11.16	82.31
$P_0 Zn_2$	82.45	70.51	1035	1754	1.06	3.16	13.31	78.62
$P_0 Zn_3$	90.47	77.62	1185	2327	1.10	3.05	14.41	81.00
$P_1 Zn_0$	51.70	42.31	620	1097	0.97	3.15	11.64	81.73

1	2	3	4	5	6	7	8	9
$P_1 Zn_1$	66.06	55.37	803	1579	1.15	3.05	13.98	87.01
$P_1 Zn_2$	80.95	62.41	900	1825	1.12	3.35	12.45	97.92
$P_1 Zn_3$	88.09	77.21	1062	2332	1.07	3.27	12.95	98.78
$P_2 Zn_0$	47.82	43.90	708	1329	1.07	2.88	15.85	87.20
$P_2 Zn_1$	56.22	51.15	830	1616	1.15	3.39	16.99	107.16
$P_2 Zn_2$	65.11	58.24	837	1847	1.04	3.37	13.55	106.93
$P_2 Zn_3$	83.98	63.93	380	2013	1.03	3.11	12.03	97.93
$P_3 Zn_0$	38.78	38.55	650	1264	1.08	3.28	18.12	107.61
$P_3 Zn_1$	46.84	46.37	737	1540	1.00	3.01	16.81	100.02
$P_3 Zn_2$	71.65	53.57	844	1622	0.95	3.16	11.19	95.71
$P_3 Zn_3$	85.89	64.34	1284	1947	1.05	3.43	15.58	108.82
CD (0.05)	2.66	1.40	48	58	0.06	0.06	1.12	2.86

bservations are in direct line with those eported elsewhere (Brar and Sekhon, 978). Sakal *et al.* (1981) reported 61 and 9 per cent increased in Zn concentration lue to Zn application @ 10 kg Zn ha^{-1} in the rain and straw of wheat, respectively. Similar esults were also reported by other workers Khamparia *et al.*, 1984). Negative effect of Zn ertilization on the concentration and uptake of by the field crops was also reported by (Safaya, 1976).

Interaction effect of phosphorus and zinc

The P x Zn interaction was significant in case of the earhead length, test weight and grain and straw yield (Table 1). At a particular level of P, the earhead length was increased with the advancing levels of Zn upto P_2Zn_2 beyond which it was decreased. Similarly, test weight was found to be curtailed under P_2Zn_2, P_2Zn_3, P_3Zn_2 over that in their respective preceeding levels. Grain yield showed somewhat ambiguous trend. It was increased with Zn levels under P_0 and P_1 except P_1 Zn_2. Contrary to expectation, it was decreased with progressive levels of Zn under P_3, the reduction being 21 per cent in P_2Zn_3 over P_2Zn_0. Similarly, the grain yield was further reduced by P_3Zn_2 but it was raised slightly under P_3Zn_3. While it increased with Zn levels except P_2Zn_3, P_3Zn_2 and P_3Zn_3 whereby it was curtailed when compared with the preceeding Zn level. Safaya (1976) also reported antagonistic effect of P x Zn on the yield attributes and yield.

Phosphorus % zinc interaction was significant in case of the concentration of P, Zn and Ca and their respective uptake by the grain and straw except the P uptake by the straw (Table 2 and 3). The concentration and uptake of P by the grain and straw were gradually diminished with increasing levels of Zn under each level of P except the P uptake by straw which was erratic. Effect of Zn was more severe on the P concentration in the straw, particularly under P_2 and P_3.

The interaction of P x Zn significantly affected the concentration and uptake of Zn and Ca by the grain and straw. Though the Zn concentration and uptake were raised with increasing level of Zn, its magnitude was found to decreased with progressive levels of P and this was more so in case of the Zn concentration in the straw. The calcium concentration varied inconsistently with the levels of P and Zn, so also its uptake by the grain and straw.

Negative interaction between P and Zn has been widely reported (Takkar and Randhawa, 1978). The common observation is that one reduces the other's concentration and uptake in the plant (Loneragan, 1951; Burleson *et al.*, 1961). In most case, P induced Zn deficiency results from the dilution effect when the rate of plant growth exceeds that of uptake of Zn as also reported by Loneragan (1951). There are cases where P decreased the Zn concentration but its uptake remained same (Boawn and Brown, 1968). The reason of this P induced Zn deficiency has been suggested to be due to interference by P with the uptake, uneven distribution of Zn in the plant (Burleson *et al.*, 1961) and physiological immobilization of Zn by P (Boawn and Brown 1968).

REFERENCES

Boawn, L. C. and Brown, J. C. (1968). Further evidence for a P-Zn imbalance in plants. *Proc. Soil. Sci. Soc. Am.*, **32** : 94-97.

Brar, M. S. and Sakhon, G. S. (1978). Effect of Zn and Cu application on the yield and micronutrient content of wheat. *J. Indian Soc. Soil. Sci.*, **26** : 84-86.

Burleson, L. A., Dacus, A. D. and Gerard, C. J. (1961). The effect of phosphorus fertilization. *Proc. Soil Sci. Soc. Am.* **25** : 365-368.

Jackson, M. L. (1958). *Soil Chemical Analysis.* Prentice Hall Inc. Englewood, Chiffs.

Jackson, M. L. and Ulrich, A. (1969). Analytical methods for use in plant analysis. *California Agric. Exp. Stn. Bull.* 766.

Khamparia, R. S., Rathore, G. S., Gupta, G. P. and Gajendragadkar, G. R. (1984). Zinc deficiency in some alluvial (Entisols) of Gird Region and response of wheat to zinc application. *J. Indian Soc. Soil Sci.*, **32** : 313-317.

Loneragan, J. F. (1951). The effect of applied phosphate o the uptake of zinc by flax. *Aust. J. Sci. Re* **134** : 108-114.

Marok, A. S. and Dev, G. (1980). Phosphorus and sulphu interrelationship in wheat. *J. Indian Soc. So Sci.*, **28** : 184-188.

Rajput, R. L. Bhadouria, S. S. and Jain, V. K. (1987 Response of wheat to fertilizers in norther Madhya Pradesh. *Indian J. Agron.*, **32** : 175-17

Randhawa, N. S. and Tandon, M. L. S. (1982). Advance in soil fertility and fertilizer use research in Indi *Fertil. News*, **27** : 11-26.

Safaya, N. M. (1976). Phosphorus zinc interaction i relation to absorption rates of phosphorus, zinc copper, managanese and iron in corn. *Proc. So Sci. Soc. Am.*, **40** : 719-722.

Sakal, R., Singh, A. P., Thakur, K. N. and Sinha, R. P (1980). Response of wheat, lentil to zinc, iro and boron application in calcareous soil. *Madra agric. J.*, **67** : 131-133.

Takkar, P. N. and Randhawa, N. S. (1979). Micronutrient in Indian Agriculture. *Fertil. News*, **23** : 3-26.