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Use of Gypsum to Increase Fertilizer Efficiency on Normal Soils

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Abstract: Field experiments were conducted on maize and wheat under normal soil conditions at Qalla, Charsadda and Tarnab, Peshawar irrigated with canal water to evaluate the effect of gypsum application on the efficiency of NPK fertilizers. Gypsum was applied @ 0, 500 and 1000 kg ha^{-1} with two levels of fertilizers i.e. recommended dose of NPK (120,90, 60 kg ha^{-1}) and half dose (60, 45 and 30 kg ha^{-1}) respectively. Maximum grain (3605 kg ha^{-1}) and stalk (9922 kg ha^{-1}) yield of maize was recorded at Qalla by the application of recommended dose of NPK with 1000 kg gypsum ha^{-1}. The NPK with 500 kg gypsum ha^{-1} ranked second in this respect. Half dose of the NPK without any gypsum gave minimum grain (2248 kg ha^{-1}) and stalk (3435 kg ha^{-1}) yield. The yields were non- significantly different at Tarnab under the same treatment compared with that of Qalla. During the second year, the soil conditions improved and yield of grain (2883 kg ha^{-1}) as well as stalk (15833 kg ha^{-1}) was better at both sites. Wheat yield was non-significantly different at Tarnab. Uptake of different ions was variable. Uptake of P, K, Zn and Cu decreased while that of Mn and Fe increased during the second year. Maximum yield of maize grain (2883 kg ha^{-1}) and stalk (15833 kg ha^{-1}) with half dose and wheat grain (3605 kg ha^{-1}) and stalk (12910 kg ha^{-1}) was obtained by application of 1000 kg ha^{-1} gypsum with full dose of NPK.

Key words: Maize, wheat, micronutrients, nutrient status, gypsum

Introduction

Cultivation of high yielding crops, use of high analysis sulphur (S) free fertilizers and decreased use of organic and crop residues have resulted in a wide spread sulphur deficiency and low crop yields. Therefore sulphur application along with NPK has been found important in increasing crop yields of various crops (Saleem and Rahmatullah, 1986). Plants require sulphur in amounts slightly less than P (Dillon and Dev, 1980). The nutritive value of cereals is determined by the proportion of S containing amino acids, this S not only increase yield but also improve crop quality (Biswas and Tewatia, 1992). It has also been reported that S and N have broadly similar functions in the plants. Sulphur occurs in protein, especially in the amino acids, cysteine and methionine. Adequate S supply is essential to obtain maximum crop responses to N application in terms of yield (Schung, 1988) and grain quality (Schung *et al*., 1993). Bapat (1989) observed 32.4% increases in wheat yield with 20 kg S ha^{-1} ammonium sulphate as a source of sulphur. Singh and Saha (1995) revealed that the magnitude of grain yield response in maize to 20 kg S ha^{-1} was 730 kg ha^{-1}. Dangarwala *et al*. (1995) and Subbaiah *et al*. (1992) in separate experiments determined that application of 30 kg S ha^{-1} had significant residual effect on the subsequent maize-groundnut and groundnut wheat cropping systems. The economic benefits derived were higher in maize-groundnut system with a benefit-cost ratio of Rs. 30:1 as compared to benefits obtained from groundnut-wheat system as Rs. 8:1. Studies on sulphur nutrition of plants have not received enough attention in Pakistan. Hence very little is known about the sulphur status of its soils and sulphur requirements of its crops (Saleem and David, 1987; Saleem and Rahmatullah, 1986). Gypsum being abundant and a cheaper source of sulphur. It has been used for the reclamation of saline sodic soils at various places in the country for reclamation of sodic soils and under brackish waters (Hussain *et al*., 2000). The normal soil has showed favorable response compared to salt affected soils (Ahmad *et al*., 2001). Therefore, it was contemplated to study its effects on the efficiency of NPK fertilizers under normal soil conditions.

Materials and Methods

The studies were conducted on normal soil and water conditions to observe the effect of gypsum on fertilizer use efficiency during Kharif 1996 and Rabi 1996-97 at two locations i.e. ARI, Tarnab and Qalla, district Charsada. The design of the experiment was randomized complete block with six treatments and three replications. The treatments were as follows:

T_1 NPK (120, 90, 60 kg ha^{-1}) with 0 kg ha^{-1} gypsum.
T_2 NPK (60, 45, 30 kg ha^{-1}) with 0 kg ha^{-1} gypsum.

T_3 NPK (120, 90, 60 kg ha^{-1}) with 500 kg ha^{-1} gypsum.
T_4 NPK (120, 90, 60 kg ha^{-1}) with 1000 kg ha^{-1} gypsum.
T_5 NPK (60, 45, 30 kg ha^{-1}) with 500 kg ha^{-1} gypsum.
T_6 NPK (60, 45, 30 kg ha^{-1}) with 1000 kg ha^{-1} gypsum.

Plot size at both the sites was 6 x 6.7 m^2 with row to row distance 30 cm for wheat and 75 cm for maize. Wheat variety inqalab 91 and maize variety kissan were sown. All fertilizers at both times and locations were applied at planting except N which was applied in two splits i.e. half at sowing time and the rest half at early growth stage.

Plant samples were taken from rows at the 50% silking stage for analysis. The leaves below the silk were taken for this purpose. Fifty to hundred leaves were from top four leaves of the wheat plants before tasseling. The leaf samples dried at 70°C to constant weight were ground by a Wiley Mills.

Soil samples collected before sowing and after harvest of the crop were analyzed for pH, EC_e and other physico-chemical characteristics (Richards, 1954). The data collected were subjected to statistical analysis according to Gomez and Gomez (1976).

Results and Discussion

A significant ($P < 0.01$) effect of gypsum application was observed on the efficiency of fertilizers used during the study at Qalla site. Effect of gypsum application on grain (3605 kg ha^{-1}) and stalk (9922 kg ha^{-1}) yield of maize showed that gypsum was effective enough to increase the efficiency of added full dose of fertilizers with 1000 kg ha^{-1} gypsum (Table 1). Addition of gypsum enhances the production of biomass and seeds in the saline sodic soils (Ramzan, 2001). However, in the present studies the normal soils also favored the plant growth compared to salt affected soil. The reason could be that the addition of gypsum had increased the availability of macro-nutrients and thus brought significant increase in straw and grain yield (Singh and Saha, 1995). Maximum grain (3605 kg ha^{-1}) and stalk (9922 kg ha^{-1}) yield were given by 100% recommended fertilizers and 1000 kg ha^{-1} gypsum application while minimum grain (2248 kg ha^{-1}) and stalk (7935 kg ha^{-1}) yield was given by 50% of the recommended fertilizer dose without the combination of gypsum (Table 1).

Application of gypsum on grain and stalk yield of maize at Tarnab was not effective enough to increase the efficiency of added fertilizers in the first year. It was because the experiment conducted at a field had already sufficient amount of major plant nutrients. So the addition of gypsum could not bring significant increase in the grain and straw (non-significant) yield (Table 2). However, maize grain yield decreased significantly ($P < 0.05$) for the

Table 1: Effect of gypsum application on maize yield at Qalla under normal soil conditions in 1996

	Yield kg ha^{-1}	
Treatments	Grain	Stalk
T_1	2685BC	9383AB
T_2	2248D	7935D
T_3	2808AB	99076BC
T_4	3065A	9922A
T_5	2425CD	8290CD
T_6	2563BC	8762BC

Treatment means for grain and stalk yield are significantly different among them ($P < 0.01$).

Table 2: Effect of gypsum application on maize yield at Tarnab under normal soil conditions in 1996

	Yield kg ha^{-1}	
Treatments	Grain	Stalk
T_1	3699	7960
T_2	3110	7297
T_3	4263	8292
T_4	3947	8955
T_5	3767	8789
T_6	3383	8955

Treatment means for grain and stalk yield are not significantly different among them ($P < 0.01$ and 0.05).

Table 3: Effect of gypsum application on maize yield at Tarnab under normal soil conditions in 1997

	Yield kg ha^{-1}	
Treatments	Grain	Stalk
T_1	2650a	15167
T_2	1767b	11333
T_3	2883a	15833
T_4	2767a	14167
T_5	1833b	12833
T_6	1850b	14000

Treatment means for stalk yield are not significantly different among them ($P < 0.01$).

Table 4: Effect of gypsum application on wheat yield at Qalla under normal soil conditions in 1996 -1997

	Yield kg ha^{-1}	
Treatments	Grain	Stalk
T_1	3238ab	11340ab
T_2	2704c	8732b
T_3	3353ab	10980ab
T_4	3605a	12910a
T_5	3047bc	10700ab
T_6	3105b	11100ab

Treatment means for grain yield is significantly different ($P < 0.01$) while straw yield is significantly different at ($P < 0.05$).

Table 5: Effect of gypsum application on wheat yield at Tarnab under normal soil conditions in 1996-97

	Yield kg ha^{-1}	
Treatments	Grain	Stalk
T_1	3151	7463
T_2	3110	7670
T_3	3192	7173
T_4	2902	7214
T_5	2446	6260
T_6	2861	7090

Treatment means for grain and stalk yield are not significantly different among them ($P < 0.01$ and 0.05).

Table 6: Plant nutrient status of experimental field at Qalla and Tarnab after wheat 1996-97

	----------%---------		----------mg kg^{-1}----------				----------%---------		----------mg kg^{-1}----------			
Treatments	P	K	Zn	Cu	Mn	Fe	P	K	Zn	Cu	Mn	Fe
T_1	0.42	3	39	15	138	343	0.20	3	69	20	33	316
T_2	0.48	3.1	41	18	124	244	0.23	3	49	7	56	270
T_3	0.47	3.2	48	13	126	208	0.23	2.5	30	8	50	222
T_4	0.43	3.3	31	12	115	164	0.14	3.1	45	19	57	340
T_5	.48	3.6	34	14	148	172	0.20	2.8	74	21	35	331
T_6	.34	3.5	23	13	120	209	0.15	2.4	60	18	37	319

Treatment means are not significantly different ($P < 0.01$ and 0.05).

Table 7: Plant nutrient status of experimental field at Tarnab 1996-97

	----------%---------		----------mg kg^{-1}----------			
Treatments	P	K	Zn	Cu	Mn	Fe
T_1	0.20	2.7	49	15	87	477
T_2	0.23	3.1	45	15	88	482
T_3	0.23	3.5	18	15	74	556
T_4	0.14	3.4	18	14	66	791
T_5	0.20	2.8	25	14	85	780
T_6	0.15	2.6	17	14	83	541

Treatment means are not significantly different at both (1 and 5%) levels of significance.

year 1997 (Table 3). The decreased effect of gypsum may be due to decreased availability of plant nutrients. Higher grain yield of maize during the first year of gypsum application might be due to enhanced available supply of Ca^{2+} and S in the soil. The low solubility of gypsum may be another reason (Richards, 1954). In the second year availability of gypsum enhanced and had a significant effect on the crop yield. Haq (2001) has observed a non-significant increase in the yield of maize (grain and stalk) during the reclamation of a saline sodic soil. In the present experiment an increase in the yield may be related to the addition of gypsum as a fertilizer.

There was a significant ($P < 0.05$) effect of various rates of gypsum application on the efficiency of fertilizers used under wheat cultivation at Qalla (Table 4). The response of the wheat crop to fertilizers at both the sites was similar to that of maize crop. The response at Tarnab was not significant in this case also (Table 5). The experimental site has effect on the productivity of crop which is mostly due to different resources available (fertilizers, nutrients) to the crop plant. The same has been observed in the present study. Therefore different results at different sites have been recorded.

Nutrient uptake: Effect of fertilizers and gypsum application on the uptake of P and K was not prominent. However, there were non significant differences observed on both sites. Uptake of P was suppressed in the presence of higher doses of gypsum and half dose of NPK at Qalla site, but it was unaffected at Tarnab (Table 6). Uptake of Zn by the plant was higher at Tarnab (69 mg kg^{-1}) compared to Qalla (39 mg kg^{-1}). Uptake of Cu was not affected by the treatment at both the sites. Uptake of Mn (138 mg kg^{-1}) at Qalla site is higher than that of Tarnab (33 mg kg^{-1}). But concentration of Fe at both the sites shows a reverse order. The concentration of both these ions increased during the second year., which reveals that gypsum has positively affected the release of micronutrients. There is a clear cut antagonistic effect shown by the Mn and Fe during 1997 at Tarnab in this study (Table 7).

Gypsum has effectively been used for the reclamation of salt affected (sodic) soils. Its use on the normal soils has also been explored in the present studies. A significant increase in the dry matter and grain yield has been recorded and release of micronutrient specifically Mn and Fe is an added advantage of gypsum use in normal fields.

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