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Effect of Gypsum Application on Rice Yield Under Wheat Rice System

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ABSTRACT

A field experiment was conducted during 2004 - 05 on wheat and rice to study the response of gypsum application in wheat-rice system. Two levels of gypsum viz 1.0 and 2.0 tons ha^{-1} with check were studied with the basal dose of N, $P_2 O_5$, $K_2 O$, as 120 - 90 - 60 kg ha^{-1} in the form of urea, TSP and SOP and Calcium Sulphate during both the crops. Wheat variety Naseer 2000 and rice variety IRRI 6 were planted in randomized complete block design (RCBD) with three replications. Gypsum application significantly affected the wheat grain yield over control, ranged from 2.68 – 3.29 t ha^{-1} giving an increase of 22.6% over control by the application of 1.0 t gypsum ha^{-1}. The number of tillers m^{-2}, number of spikes m^{-2}, plant height and spike length of wheat were also significantly affected over control except 1000 grain weight, which were non-significant. The paddy yield was also significantly affected by gypsum application that ranged from 3.60 - 5.45 t ha^{-1}. The highest paddy yield was recorded by the application of 2.0 t gypsum ha^{-1}. Similarly all the yield components like number of spike m^{-2}, number of spikes $plant^{-1}$, spike length, plant height and 1000 grain weight were also significantly affected by gypsum application. Gypsum decreased the pH but electrical conductivity was slightly increased. The Ca^{+2} + Mg^{+2}, P and K contents were increased with the application of gypsum after the harvest of wheat and rice. The cumulative, residual and direct application of 2.0 t gypsum ha^{-1} gave an increase of 51.5, 35.0 and 46.4%, respectively while cumulative application of 1.0 t gypsum ha^{-1} increased the paddy yield by 46.4% over control. It can be concluded that direct application of 2.0 t gypsum. ha^{-1} or cumulative application of 1.0 t gypsum ha^{-1} gave the same increase in yield of paddy.

Key Words: Gypsum; Rice; Yield; Wheat-rice system

INTRODUCTION

Crop yield can not be increased without proper judicious use and management of nutrients in soil. Most of our soils are calcarious with fairly high pH value thus rendering the availability of P and all micro nutrients except Mo. Any method that helps to normalize the soil pH will certainly improve the nutrients availability and crop productivity. Gypsum is one of the most commonly used amendments for reclamation of sodic soils, because of its low cost, easy availability and ease of handling. Many published results demonstrate the effectiveness of reducing soil pH and electrical conductivity. Gypsum is used effectively for amelioration of saline sodic/sodic soils (Ghafoor *et al.,* 2001). There are, however, some reports, where application of gypsum on normal soils has shown improved crop yields, which may be possibly due to supplementation of soil with sulphur and calcium. It has also been reported that gypsum acts as plant nutrient source and supplies P for plants absorption. The application of gypsum decreased the pH and HCO3 contents of the soil but increased Ca^{+2} + Mg^{+2} contents. A slight increase in Electrical conductivity was also noted due to gypsum application. ESP and SAR were decreased with increasing rates of gypsum. Higher levels of gypsum did not stimulate grain yield as compared to control (0, 1.2, 2.5, 3.7 & 5.10 t ha^{-1}) of applied gypsum during 1985 - 86 and 1986 – 87, respectively. It was concluded that gypsum applied at lower rates may increase crop yields on normal soils due to supplementation of plant nutrients (Hussain *et al*., 1992). Use of gypsum in combination with FYM was significantly better in improving the physical and chemical properties of soil and crops yield (Chaudhry, 2001). Maximum fodder yield (34583 kg ha^{-1}) was recorded with gypsum application, while 20625 kg ha^{-1} yield of fodder was recorded from control. Soil parameters such as pH, Electrical conductivity were also decreased (Haq *et al.,* 2001). The use of gypsum ($CaSO_4$) also increases the soil sulphur (S) levels (Jimmy & Kidder, 1997). Application of calcium improved all growth characteristics like tillering capacity, etc. Seed setting was also improved in rice cultivars (Aslam *et al.,* 2001).

MATERIALS AND METHODS

A field experiment was conducted during 2004 - 05 on wheat to study the response of applied gypsum on wheat and its residual/cumulative effect on rice crop. The

experiment was laid out at Arid Zone Research farm, D.I. Khan in Randomized Complete block design with five treatments replicated three times. The treatments comprised of No gypsum (control T1), Nil to wheat and 2.0 t gypsum ha^{-1} to rice (T2), 2 t gypsum ha^{-1} to wheat and nil to rice (T3), 2 t gypsum ha^{-1} to wheat and rice (cumulative T4), 1.0 t gypsum ha^{-1} to wheat and rice (cumulative T5). The basal dose of 120 – 90 - 60 kg ha^{-1} of N, P_2O5 and K_2O along with gypsum rates were applied in the form of urea, TSP, SOP and $CaSO_4$, respectively to both the crops. All P, K, gypsum and half N was applied at sowing, while the remaining half N was applied at 2nd irrigation in wheat and at panicle initiation in rice. The variety sown for wheat was Naseer 2000, while IRRI 6 variety was planted for rice. The wheat was planted during the 2nd week of November, while rice was planted during the 1st week of June. The treatment plot size of 2.40 m x 6.00 m was kept for both the crops as the rice was planted in the same plots of wheat. All the other cultural practices were followed uniformly throughout the growing period of each crop. A composite soil sample was collected before sowing of the wheat and was analyzed for various physico chemical characteristics. The results have been summarized (Table I). The soil samples from individual treatments have been collected after harvesting of wheat and rice to study some the physico chemical properties of soil and the results have been summarized (Table III). The post-harvest data i.e. number of tillers m^{-2}, number of spikes m^{-2}, number of spike/plot, spike length and plant height in wheat and rice were recorded at proper time. The net plot of 0.60 m x 5.0 m was harvested manually for 1000 grain weight and grain yield of both wheat and rice. All the relevant data was statistically analyzed using MSTATC computer program.

RESULTS AND DISCUSSION

Effect of gypsum application on the chemical properties of soil after wheat harvest. The gypsum application affected significantly the chemical properties of the soil over control after wheat (Table II). The pH of the soil was decreased with gypsum application that ranged from 8.34 to 7.94. Electrical conductivity of the soil was slightly increased with gypsum application, ranged from 0.328 to 0.510 dsm^{-1}. The gypsum application also increased the Ca^{++} + Mg^{++} (soluble cations) that ranged from 3.5 to 5.0 meq l^{-1}. The P content of the soil were also increased with gypsum application that ranged from 4.00 to 7.22 mg kg^{-1}, similarly K contents of the soil were increased with gypsum application but the differences was non significant.

Effect of gypsum application on the chemical properties of soil after rice harvest. The gypsum application affected significantly the chemical properties of the soil after rice (Table III). The pH was decreased with gypsum application that ranged from 8.54 to 7.54. Electrical conductivity of the soil was also slightly increased with gypsum application that ranged from 0.380 to 0.600 dS m^{-1}. The soluble cations like Ca^{++} + Mg^{++} were also increased with gypsum application, ranged from 4.0 to 5.5 meq L^{-1}. The P contents of the soil were increased with gypsum application ranged from 4.5 to 7.5 mg kg^{-1}, similarly the K contents of the soil were also increased with gypsum application but the effect was non-significant. These results are in agreement with Hussain *et al*. (1992).

Table I. Physico-Chemical Properties of Soil

Soil properties	Value
pH	8.0
E.C dsm^{-1}	0.60
CaCo3 Eq.(%)	11.0
Organic matter (%)	0.76
Nitrogen %	0.038
Sod Bicarbonate Extractable P (mg kg^{-1})	04
Amm.Acetate Extractable K (mg kg^{-1})	85
Sand (%)	20
Silt (%)	44
Clay (%)	36
Textural class	Silty clay

Effect of gypsum application on wheat. The gypsum application significantly affected the wheat grain yield (Table IV) and ranged from 2682 to 3289 kg ha^{-1}. The highest grain yield was achieved from 1.0 t gypsum ha^{-1} followed by 3214 and 3190 kg ha^{-1} obtained from the treatments receiving 2.0 t gypsum ha^{-1}, which were statistically at par with each other. The lowest yield of 2682 and 3109 kg ha^{-1} was obtained from check plots. Gypsum rates could not significantly affect the 1000 grain weight. The plant height was significantly affected and ranged from 98.4 to 103.6 cm. The highest plants (103.6 cm) and (103.0 cm) were recorded by the application 1.0 and 2.0 t gypsum ha^{-1}, respectively but they were statistically at par with each other. The lowest height of 98.4 and 100.1 cm was achieved from control plots. The number of tillers m^{-2} were also significantly affected over control and ranged from 444 to 686. The number of tillers m^{-2} was not affected significantly by the rates of gypsum application. The lowest numbers of 444 and 475 tillers m^{-2} were recorded from check. The number of spikes m^{-2} were also significantly affected over control and ranged from 265 to 419. The lowest nos. of spike m^{-2} were achieved from control plots and highest were recorded 1.0 and 2.0 to gypsum ha^{-1} but statistically non-significant. The spike length was not affected significantly by the rates of gypsum, rather it was significant over control plots and ranged from 10.0 to 11.5 cm. The highest grain yield of 19.8 and 22.6% were recorded from 2 and 1.0 t gypsum ha^{-1} (Fig. 1). These results were in agreement with (Hussain *et al*., 1992), who concluded that there was significant increase in grain yield over control up to 2.5 t ha^{-1} of applied gypsum.

Effect of gypsum application on rice. After the harvest of wheat rice was planted on the same plots. The paddy grain yield was significantly affected by gypsum application (Table V) and ranged from 3601 to 5456 kg ha^{-1}. The

Table II. Effect of Gypsum Application on Chemical Properties of Soil after Wheat Harvest

Treatments	Gypsum t ha^{-1}		pH	Electrical conductivity	$Ca^{+2} + Mg^{+2}$ (mg L^{-1})	P (mg kg^{-1})	K (mg kg^{-1})
	Wheat	Rice					
1	0	0	8.34 a	0.328 d	3.5 b	4.00 b	80
2	0	2	8.27 a	0.378 cd	3.8 b	4.50 b	85
3	2	0	7.94 b	0.465 ab	4.8 a	7.03 a	105
4	2	2	7.80 b	0.510 a	5.0 a	7.22 a	110
5	1	1	8.05 ab	0.410 bc	4.6 a	6.80 a	100
LSD ≤ 0.05			0.32	0.059	0.59	0.67	N.S

Means followed by same letter(s) do not differ significantly at P≤ 0.05

Table III. Effect of Gypsum Application on Chemical Properties of Soil after Rice Harvest

Treatments	Gypsum t ha-^{1}		pH	Electrical conductivity	$Ca^{+2} + Mg^{+2}$ (mg L^{-1})	P (mg kg^{-1})	K (mg kg^{-1})
	Wheat	Rice					
1	0	0	8.54 a	0.380 c	4.0 c	4.50 c	70
2	0	2	8.00 ab	0.465 b	4.8 b	6.00 b	90
3	2	0	8.10 ab	0.485 b	4.5 bc	5.00 c	85
4	2	2	7.54 b	0.600 a	5.5 a	7.50 a	110
5	1	1	7.92 b	0.585 a	5.0 ab	6.00 b	105
LSD ≤ 0.05			0.58	0.059	0.545	0.548	N.S

Means followed by same letter(s) do not differ significantly at P≤ 0.05

Table IV. Wheat Response to Gypsum Application under Wheat Rice System

Treat-ments	Gypsum t ha^{-1} to crop		Number of tillers m^{-2}	Number of spike m^{-2}	Spike length (cm)	Plant height (cm)	1000 grain weight (g)	Grain yield (kg ha^{-1})	Increase over control %
	Wheat	Rice							
1	0	0	444 b	265 b	10.0 b	98.4 b	32.54 b	2682 b	-
2	0	2	475 b	309 b	10.4 b	100.1 ab	34.17 a	2660 b	-
3	2	0	686 a	415 a	11.5 a	101.4 ab	34.77 a	32.14 ab	19.8
4	2	2	593 a	34.3 ab	11.3 a	103.0 a	35.02 a	3190 ab	18.9
5	1	1	678 a	419 a	11.3 a	103.6 a	35.14 a	3289 a	22.6
LSD≤0.05			98.28	86.72	0.6892	4.596	1.576	132.4	

Means followed by same letter(s) do not differ significantly at P< 0.05

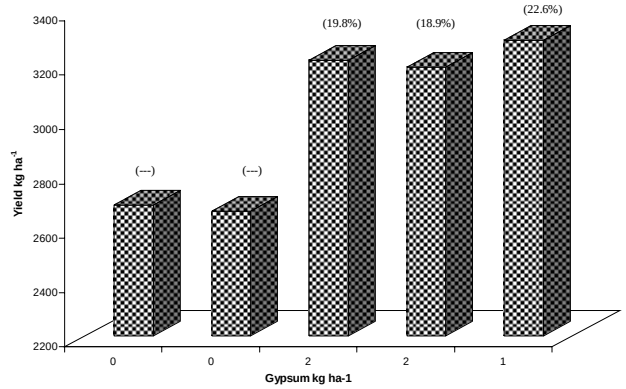
Table V. Rice Response to Gypsum Application under Wheat Rice System

Treat-ments	Gypsum kg ha^{-1} to crop		Number of spikes m^{-2}	Number of spike plant^{-1}	Spike length (cm)	Plant height (cm)	1000 grain weight (g)	Grain yield (kg ha^{-1})	Increase over control %
	Wheat	Rice							
1	0	0	329 d	18.87 d	21.5 c	101.2 d	21.60 c	3601 d	-
2	0	2	365 bc	22.80 b	24.0 b	108.8 c	22.12 b	5272 b	46.4
3	2	0	361c	21.53 c	23.6 b	107.8 c	22.36 b	4863 c	35.0
4	2	2	373 b	24.33 a	26.0 a	114.3 a	22.81 a	5456 a	51.5
5	1	1	394	24.47 a	25.5 a	112.0 b	22.05 b	5273 b	46.4
LSD .05			11.22	1.012	1.083	1.317	0.32	117.3	

Means followed by same letter(s) do not differ significantly at P≤ 0.05

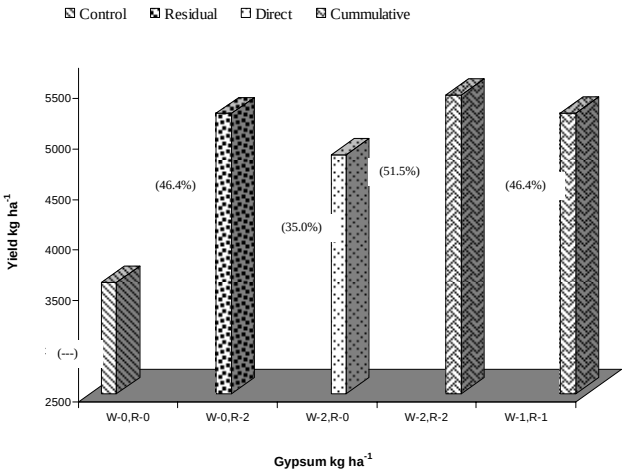
highest yield was recorded from the cumulative application of 2.0 t gypsum ha^{-1} to both crops and lowest yield from control. The cumulative application of 1.0 t gypsum ha^{-1} gave the same yield 5272 kg ha^{-1} as recorded by the direct application of 2 t gypsum ha^{-1}. The yield recorded by residual application of 2.0 t gypsum ha^{-1} gave the yield of 4863 kg ha^{-1}, which was statistically different from the other treatments. Rice plants also responded significantly to gypsum application and ranged from 101.2 to 114.3 cm. The maximum height was attained from cumulative application of 2.0 t gypsum ha^{-1} to both the crops while minimum from control. The plant height recorded from the direct/residual application of 2.0 t gypsum ha^{-1} was non-significant; 1000 grain weight was significantly affected over control and ranged from 21.60 to 22.81 g. The highest weight was recorded from the cumulative application of 2.0 t gypsum ha^{-1}, while lowest from control. The weight recorded from direct/residual application of 2.0 t gypsum ha^{-1} and cumulative application of 1.0 t gypsum ha^{-1} was non-significant with each other. The number of spike m^{-2} was significantly affected by rates of gypsum applied and ranged from 329 to 394. The highest number was recorded from cumulative application of 1.0 t gypsum ha^{-1}, while lowest from control. The number of spike m^{-2} from other treatments was non-significant. The number of spike/plant was also significantly affected by various rates of gypsum application and ranged from 18.87 to 24.47. The highest number 24.47 and 24.33 were recorded from cumulative application of 1.0 and 2.0 t. gypsum ha^{-1}, respectively were non-significant but these differ significantly from direct and residual application of 2.0 t gypsum ha^{-1}. The spike length was also significantly affected by gypsum application and

Fig. 1. Wheat response to Gypsum under Wheat-Rice System



Note: Figures in parenthesis refer to percent yield increase over control

Fig. 2. Rice response to Gypsum under Wheat-Rice System



Note: Figures in parenthesis refer to percent yield increase over control

ranged from 21.5 to 26.0 cm. The highest spike length of 26.0 and 25.5 cm were recorded by the cumulative application of 2.0 and 1.0 t gypsum ha^{-1}, respectively and were also non-significant with each other. The residual/direct application of 2.0 t gypsum ha^{-1} produced statistically same length and lowest length was obtained from control. The cumulative, residual and direct application of 2.0 t gypsum ha^{-1} increased the yield of paddy over control by 51.5, 35.0 and 46.4%, respectively while the cumulative application of 1 t gypsum ha^{-1} gave an increase of 46.4% over control (Fig. 2).

CONCLUSION

Gypsum application significantly affected the wheat grain yield over control, giving an increase of 22.6% over control by the application of 1.0 t gypsum ha^{-1}. In wheat all the yield components like number of spike m^{-2}, number of spikes $plant^{-1}$, spike length, plant height except 1000 grain weight significantly affected with 1.0 t ha^{-1} gypsum, while in rice the yield components showed significant influence at 2.0 t gypsum ha^{-1} in rice, respectively. Gypsum decreased the pH but electrical conductivity was slightly increased. The Ca^{+2} + Mg^{+2}, P and K contents were increased with the application of gypsum after the harvest of wheat and rice. The cumulative, residual and direct application of 2.0 t gypsum ha^{-1} gave an increase of 51.5, 35.0 and 46.4%, respectively; while cumulative application of 1.0 t gypsum ha^{-1} increased the paddy yield by 46.4% over control. It can be concluded that direct application of 2.0 t gypsum ha^{-1} or cumulative application of 1.0 t gypsum ha^{-1} gave the same increase in yield of paddy.

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