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Role of gypsum in wheat production in rainfed areas

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Abstract

The success of wheat production in rainfed areas depends on conservation of rainfall received during monsoon season. Moisture conservation is generally done through deep ploughing and use of mulch. Some chemicals have also been tried with partial success but this practice could not become popular because of more expenses involved. An attempt has been made to assess the role of gypsum in this regard. The gypsum was applied @ 0, 1.25, 2.5, and 5.0 t ha^{-1} before monsoon after deep ploughing with moldboard plough and the experiments were conducted for 3 years i.e. 2001-2002 to 2003-2004 at SAWCRI farm Chakwal. Application of gypsum resulted in increase in grain yield of wheat during three years. The impact of gypsum was most conspicuous during 2001-2002 with 98.5mm rainfall during wheat season. There was 46% increase in wheat yield with gypsum @ 2.5 t ha^{-1}. But during the next year, the same dose of gypsum could cause only 19% increase in wheat yield with the rainfall of 235 mm. In 2003-2004, the rainfall was 120 mm during growth period of wheat and the effect of gypsum was like the year 2001-2002. It can be inferred from the results that gypsum improved the wheat during all the years but the improvement was more conspicuous during years of less rainfall. Application of gypsum resulted in increased moisture contents in soil profile at sowing of wheat.

Key words: *Gypsum, wheat, rainfed, moisture, Pakistan*

Introduction

Wheat is grown over an area of about 8.2 million hectares in Pakistan. In the Punjab province, the area under this crop is over 6 million hectares out of which 10 percent is rainfed. The average annual rainfall in the Pothwar rainfed areas (latitude 32^{o} 10’ to 34^{o} 9’ N; longitude 71^{o} 10’ to 73^{o} 55’ E) ranges from 500 to 900 mm with northern parts of the area receiving comparatively more rainfall. The national average yield of this crop is around 2.5 t ha^{-1} but average in rainfed areas is much lower and depends on the intensity, time and spread of rainfall. It ranges from 0.6 to 1.5 t ha^{-1} (Anonymous, 2004). The behavior of rainfall is highly variable but generally two third of it is received in the form of high intensity rainstorms during monsoon season from July to September. The wheat crop is sown in the months of October and November; therefore the success of this crop is directly related to the success in conservation of moisture received during monsoon months.

Moisture conservation mainly depends on soil type, soil organic matter and management practices like mulch and tillage operations. There are many chemicals, which can lead to increased soil moisture through improvement of soil conditions which include gypsum, polyacrylamide etc. Various researchers have conducted work on soil properties as a result of application of gypsum. Yu *et al.* (2003) studied the effect of Polyacrylamide (10 and 20 kg ha^{-1}) and gypsum (2 and 4 t ha^{-1}) on seal formation and infiltration rate. He observed that spreading gypsum at the soil surface doubled the final water infiltration rate compared to that of control. This study was, therefore, carried out to see the impact of gypsum application on the yield of succeeding wheat crop and see its efficacy for conservation of rainfall moisture.

Materials and Methods

The experiment was conducted from 2001-02 to 2003-04 at SAWCRI research farm in sandy loam soil. The soil was free from any salinity / sodicity problem. Deep ploughing of soil was done with Mould board plough after first rainfall of monsoon in first week of July. Gypsum @ 1.25, 2.5, 3.75 and 5.0 t ha^{-1} was applied and mixed with shallow cultivation. Cultivations were given to the field when needed to conserve moisture and control weeds. *Inqilab 91* variety of wheat was sown in end of October. Sowing was done with automatic Rabi drill using 125 kg ha^{-1} seed rate. Fertilizer was placed @ 120-80-60 kg of N-P_2O_5-K_2O kg ha^{-1} with drill 5.0 cm below the seed depth. Harvesting of wheat was carried out in mid of April and yield data were recorded. Whole plot was harvested with mini-reaper for taking the yield data. Experiment was conducted at new site each year with plot size of 12m x 12m in randomized complete block design. After having encouraging results, during third year, aluminum tubes were installed in the field in third week of July 2003 to monitor the moisture in the soil. Moisture readings were

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taken with Hydroprobe model CPN 503DR at five depths i.e. 0-25, 25-50, 50-75, 75-100 and 100-125 cm referred here as D1 to D5.

Soil analysis

Soil samples were collected from 0-15 and 15-30 cm depths from all the fields and brought to the laboratory. Electrical Conductivity (ECe) and pHs of soil were determined from saturated soil paste (Richard, 1954). These samples were analyzed for organic matter (Walkley and Black, 1934), available P (Watanabe and Olson, 1965), Extractable K (Rhoades, 1982) and texture by Bouyoucus method. Statistical analysis was carried out using “Mstatc” program by applying the methods of Steel and Torrie (1980). Duncan’s Multiple Range Test was employed for calculating least significance difference between means (Duncan, 1955). Meteorological data were recorded at meteorological observatory located at SAWCRI Chakwal about 500 m from the experimental sites.

Results and Discussion

Soil status

The soil of experimental fields during all the three years was found free of any salinity/sodicity problem having pHs in the range of 7.7 to 7.8 (Table 1). The soil fertility status of all the three fields was poor having organic matter content in the range of 0.36 to 0.61% and available phosphorus 5.9 to 7.1 mg kg^{-1}. The extractable K was also not in the satisfactory range i.e. less than 180 mg kg^{-1} in all the three fields. The soil texture was sandy loam.

Grain and straw yield

The data of grain and straw yield are presented in the table 2 and 3 and month wise rainfall data are given in table 4. During the year 2001-02, the grain yield of wheat was recorded in the range of 1.52 to 2.22 t ha^{-1}, which is the minimum among all the three years. During this year, the rainfall received during August to October was only 209 mm, for next three months i.e. November to January, the quantity of rainfall was 3.5 mm followed by 49 and 33mm during February and March, respectively. It is very clear from the distribution of rainfall over various months that during the peak period of tillering and growth of wheat plant i.e. Nov. to January, no rainfall was received and during the period of various stages of grain formation, the rainfall received was only 82 mm. Gypsum played its role in conserving the moisture received in the months of June to October and 46.1% increase in yield was observed with 2.5 t ha^{-1} gypsum application and this improvement was statistically significant. During the year 2002-03, the yield ranged from 3.27 to 4.36 t ha^{-1} which is comparable to the irrigated wheat by all means. The perusal of rainfall data during various months showed that the rainfall received from August to October was 445mm in comparison to 209 mm during previous year. Similarly, during the month of February, which is peak time for grain formation for this plant, the rainfall was three times higher than previous year i.e. 145 mm. No doubt, the moisture was enough at various stages of growth to meet the requirement of the plant but still gypsum dose of 2.5 t ha^{-1} showed 19 % increase in yield. During next year i.e. 2003-04, the rainfall received from August to October was 295 mm, which was less than the previous year but more than year 2001-02 and the yield during this year also followed the similar pattern and ranged from 2.51 to 3.67 t ha^{-1}. It appears that gypsum application played appreciable role to conserve the moisture during monsoon with application of 2.5 t ha^{-1} gypsum. It is very clear from these data that the efficiency of gypsum for improvement of wheat yield was more in the years of less rainfall during the growth period of this crop. Farina *et al* (2000) also observed the yield benefits of maize crop due to gypsum which were greatest in seasons of severe moisture stress. Straw yield also followed almost similar course of action.

Hamza and Anderson (2004) used 2.5 t ha^{-1} of gypsum as single dose in its work on two soils i.e. loamy sand and sandy clay loam in Western Australia with problem of compaction. A combination of deep ripping and gypsum treatment increased the soil water infiltration rate by about 90% on the loamy sand soil and by more than 130% on the sandy clay loam soil, four years after the application of the treatments. They also noticed that the summer rain stored in the soil prior to seeding was increased almost 3 times in both soils.

Soil moisture

In present experimentation, pre-monsoon addition of gypsum improved storage of water in soil profile. The changes in volumetric water content in soil profile from application of gypsum upto harvest of wheat are presented in figures 1 to 5. With the application of gypsum @ 2.5 t ha^{-1} or more, moisture contents increased appreciably at every depth in soil profile upto 125 cm. However, the moisture contents in surface layer were mostly related to the occurrence of rainfall. Maximum increase in moisture contents was recorded at the depths of 50 to 75 cm in treatments receiving gypsum.

Table 1. Initial soil analysis (0-15 cm depth) of all the three fields

Parameter/Year	2001-02	2002-03	2003-04
EC_e (dS m^{-1})	1.19	1.05	1.38
pHs	7.78	7.70	7.82
O.M. (%)	0.61	0.36	0.44
Extractable K (mg kg^{-1})	118.00	111.00	90.00
Available P (mg kg^{-1})	5.90	6.40	7.10
Textural Class	Sandy Loam	Sandy Loam	Sandy Loam

Table 2. Effect of gypsum on the grain yield (t ha^{-1}) of wheat

Gypsum t ha^{-1}	2001-02		2002-03		2003-04	
	Yield	% increase	Yield	% increase	Yield	% increase
0	1.52 b		3.27 b		2.51 b	
1.25	1.90 ab	25.0	3.59 b	9.8	3.44 a	37.1
2.50	2.22 a	46.1	3.89 ab	19.0	3.67 a	46.2
3.75	2.10 a	38.2	4.29 a	31.2	-	-
5.00	2.03 a	33.6	4.36 a	33.3	3.66 a	45.8
7.50	-		-		3.24 a	29.1
LSD (0.05)	0.416		0.640		0.734	
CV (%)	13.8		10.7		14.4	

Table 3. Effect of gypsum on the straw yield (t ha^{-1}) of wheat

Gypsum t ha^{-1}	2001-2002		2002-2003		2003-04	
	Yield	% increase	Yield	% increase	Yield	% increase
0	2.59 b		5.95		4.43	
1.25	3.44 a	32.8	6.00	0.8	5.16	16.5
2.50	3.94 a	52.1	6.01	1.0	5.00	12.9
3.75	3.92 a	51.4	6.76	13.6	-	-
5.00	3.84 a	48.3	6.78	13.9	4.33	-2.3
7.50	-	-	-		3.47	-21.7
LSD (0.05)	0.659		N S		N S	
CV(%)	12.06					

Table 4. Month wise rainfall (mm) data recorded at SAWCRI, Chakwal

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2001-02	26	98.5	196.5	124	39	45.7	3.5	0	0	49	33	13
2002-03	0	107	155.5	303	125.5	17.1	0.5	0.4	0.5	145	36	27.1
2003-04	25	0	106	187.8	71.4	35.6	13.2	13.4	65.1	19.4	9.2	62.3

Moisture reading were taken on 2, 9, 17, 24th Dec., 2003, 15th Jan, 26th Feb and 25th March, 2004 during the crop growth period (Figure 2) At surface depth (DI), the moisture contents here were also related to rainfall occurrence. At all other depths in soil profile water contents were higher in gypsum receiving treatments than control upto the maturity of crop. Chartres *et al.* (1985) studied the photographic images of thin sections of red duplex soils of Northern Victoria, Australia. Micromorphological observations indicated that in the presence of gypsum, crust formation was reduced because less clay was mobilized and redistributed in the surface soil layers. Moreover, in soils with higher proportion of randomly interstratified clay minerals, the area of macropores approximately doubled on the stubble cropped site and also considerably increased on the fallow cropped site. Shanmuganathan and Oades (1983) observed that the content of dispersible clay was related to both exchangeable sodium percentage (ESP) and electrical

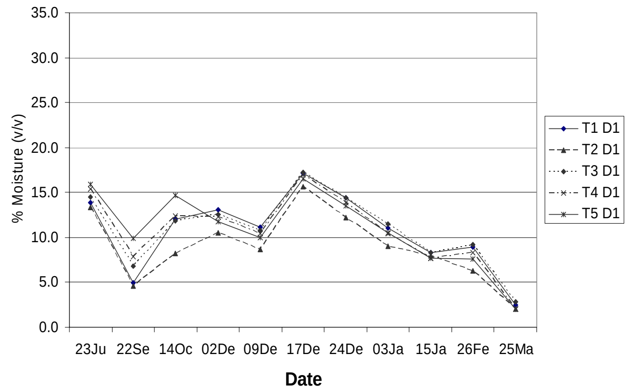

Figure 1. Moisture content in soil profile at 0 to 25 cm depth

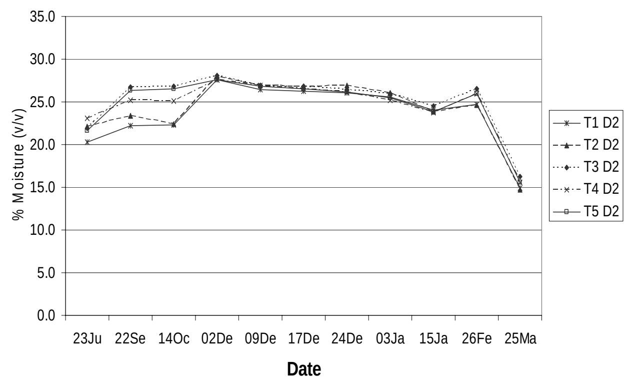

Figure 2. Moisture content in soil profile at 25 to 50 cm depth

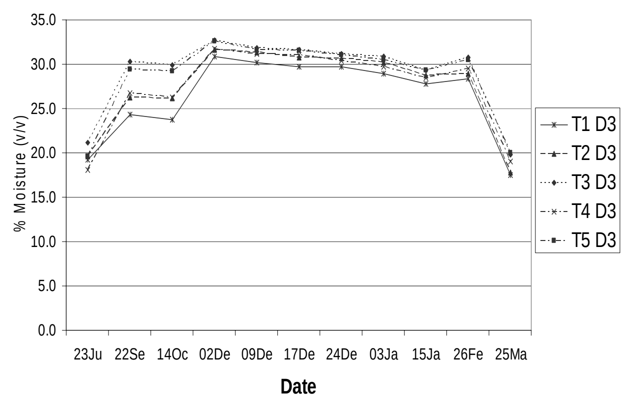

Figure 3. Moisture content in soil profile at 50 to 75 cm depth

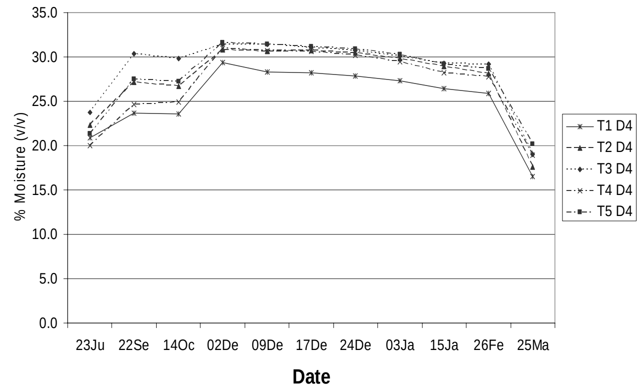

Figure 4. Moisture content in soil profile at 75 to 100 cm depth

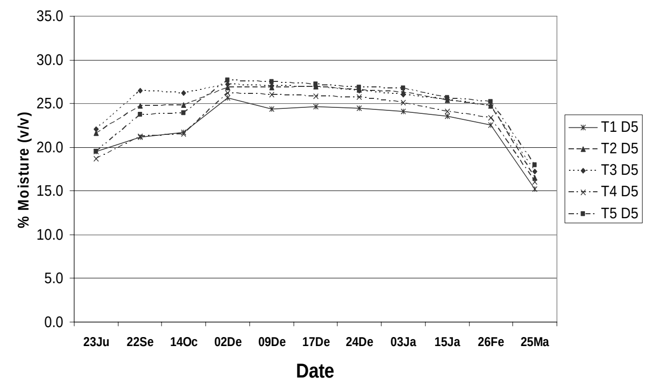

Figure 5. Moisture content in soil profile at 100 to 125 cm depth

conductivity (EC). He observed that small amount of gypsum (0.2% w/w) coagulated most of the clay by lowering the ESP and raising the electrolyte concentration.

Financial benefits

Simple benefit of gypsum application (Income from additional yield minus cost of gypsum) is presented in Table 5.

Gypsum application @ 2.5 t ha^{-1} was found to be the best dose keeping in view the net benefit (Table 5) on the basis of one year impact of gypsum. Increasing the dose of gypsum resulted only in increasing the cost. It is also visible that the benefit of gypsum was more in years of less rainfall i.e. 2001-02 and 2003-04 as compared to year 2002-03 with gypsum @ 2.5 t ha^{-1}.

Table 5. Simple benefit with use of gypsum for wheat crop

Gypsum dose t ha^{-1}	Gypsum cost Rs	Simple Benefit (Rs ha^{-1})		
		2001-02	2002-03	2003-04
1.25	988	3501	2316	8845
2.50	1976	6107	3309	10038
3.75	2964	3916	7712	-
5.00	3952	2167	7627	7359
7.50	5928	-	-	520

Note: Grain @ Rs 10 kg^{-1}, straw @ Rs 0.88 kg^{-1}, and Gypsum @ Rs 0.80 kg^{-1}

Effect on soil properties

Soil samples were analyzed after harvest of wheat crop every year. No appreciable change in soil chemical parameters was observed with the application of gypsum except EC_e which increased from 0.73 to 1.35 dS m^{-1} with application of 5 t ha^{-1} of gypsum during 2001-02 at sowing of wheat. In year 2003-04, the EC_e increased with application of gypsum from 0.73 to more than 1.40 dS m^{-1} with various doses of gypsum which was obviously within safe limits for wheat crop.

References

Anonymous. 2004. Punjab Statistics, Beaureau of Statistics, Government of the Punjab, Lahore

Chartres, C.J., R.S.B. Greene, G.W. Ford and P. Rengasamy. 1985. The effects of gypsum on macroporosity and crusting of two red duplex soils. *Australian Journal of Soil Research* 23(4): 467-479.

Duncan, D.B. 1955. Multiple range and multiple F-Test. *Biometerics* 11: 1-42.

Farina, M.P.W., P. Channon and G.R. Thibaud. 2000. A comparison of strategies for ameliorating subsoil acidity. Long term growth effects. *Soil Science Society of America Journal* 64: 646-651.

Hamza, M.A. and W.K. Anderson. 2004. Responses of soil properties and grain yields to deep ripping and gypsum application in a compacted loamy sand soil contrasted with a sandy clay loam soil in Western Australia. *Australian Journal of Agricultural Research* 54(3): 273 - 282.

Richard, L.A. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handbook 60.

Rhoades, J.D. 1982. Cation exchange capacity. p. 149-158 In: Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. A.L. Page (ed.). American Society of Agronomy, Madison, Wisconsin, USA.

Shanmuganathan, R.T. and J.M. Oades. 1983. Modification of soil physical properties by addition of calcium compounds. *Australian Journal of Soil Research* 21(3): 285-300.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. Mc Graw Hill Co. Inc. New York.

Walkley, A. and C.A. Black. 1934. An examination of Degtjareff methods for determining soil organic matter and a proposed modifications of the chromic acid titration method. *Soil Science* 37: 29-38

Watanabe, F.S. and S.O. Olsen. 1965. Method for determination of phosphorus in water and $NaHCO_3$ extracts from soil. *Soil Science Society America Proceedings* 29: 677-678.

Yu, J., T. Lei, I. Shainberg, A.I. Mamedov and G.J. Levy. 2003. Infiltration and erosion in soils treated with dry PAM and gypsum. *Soil Science Society of America Journal* 67: 630-636.