INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2001/03–3–323–325
http://www.ijab.org

Effect of Horizontal Flushing on the Reclamation of Sodic Soils and Yield of Fodder Crops after Gypsum Application

IZHAR-UL-HAQ, HABIB-UR-RAHMAN, B.H. NIAZI† AND M. SALIM†
Agricultural Research Institute, Tarnab, Peshawar–Pakistan
†Land Resources Research Institute, NARC, Islamabad–Pakistan

ABSTRACT

A set of field experiments was conducted at three sites (Prang and Dosehra, District Charsadda and Aman Kot, District Peshawar) to study the effect of flushing the irrigation water after gypsum application to reclaim the sodic soils. Gypsum @ 100% of gypsum requirement (GR) was applied at Prang and Dosehra. The irrigation water was flushed out after 12, 24 and 48 h. There was no flushing in the plots to represent the control (conventional) treatment. Two gypsum treatments were applied @ 100 and 50% GR at Aman Kot with the same flushing time. Maize was cultivated at Prang, berseem at Dosehra and dhancha at Aman Kot. The crops were harvested at maturity. Yield of fodder was recorded at the harvest time. Fodder yield increased significantly at 5% level of probability with 24 and 48 h with 100% gypsum application at Prang. Maximum fodder yield recorded at Prang Charsadda was 34583 kg ha^{-1} while minimum fodder yield i.e. 20625 kg ha^{-1} with control. Similar results were also obtained at Dosehra and Aman Kot. At Aman Kot, 50% GR with 24 h flushing time gave best results. Soil parameters such as pH, EC_e and GR decreased as the flushing time increased. The study showed that relatively greater amount of water is required for enhancing reclamation of sodic soil when higher rates of gypsum are applied.

Key Words: Gypsum; Flushing; Fodder crops; Sodic soils

INTRODUCTION

Soil salinity inhibits plant growth through numerous complex interactions including osmotic effect, specific ion toxicity and nutritional imbalances (Wyn Jones, 1981). Gypsum ($CaSO_4$ $2H_20$) is widely used on saline sodic and sodic soils to displace the sodium in order to reclaim the soil (Mian & Ali, 1980; Keren & Shainberg, 1981; Bahri & Amami, 1986; Hussain *et al*., 1986). Leaching with water invariably follows the application of gypsum to dissolve this applied amendment and to remove the soluble reaction products from the root zone. For this purpose, the addition of 90-120 cm irrigation water has been recommended for an application of 9.9 to 12.4 t ha^{-1} of the agriculture grade gypsum of 100 mesh fineness (Richards, 1954). Dutt (I 994) and Dutt *et al*. (I972) predicted that 52 to 72 cm of water was required to dissolve 16.5 to 23.9 t of gypsum ha^{-1}, when applied to the soil surface.

Ramzan *et al*. (I982) reclaimed saline sodic non gypsiferous soil with gypsum within three years by adopting the rice-berseem, rice-wheat crop rotation. Hussain and Hussain (1989) reclaimed saline sodic soil with surface drainage of water after standing over night. In this way salinity of the soil was reclaimed but sodicity persisted. Due to hard pan at certain depth, leaching of salts is a problem in heavy sodic soils. Thus application with simple leaching becomes less effective (Ghafoor & Muhammad, 1981). One method to get rid of excessive soluble salts in the solution is to flush out the surface water after the completion of reaction of gypsum with soil particles (Ahmad *et al*., 1992). The present study was carried out to assess the effectiveness of flushing the sodic soil after gypsum application for its amelioration.

MATERIALS AND METHODS

This experiment was conducted at three sites i.e. Prang (Charsadda), Aman Kot (Peshawar) and Dosehra (Charsadda) under sodic soil and normal water conditions during Kharif 1996 and Rabi 1996-97. Design used for the study at Prang, Dosehra (Charsadda) was Randomized Complete Block while at Aman Kot the design was factorial combination and two levels of gypsum application in order to assess the length of flushing at 50% gypsum application of the soil requirement. Three replications were kept at all the sites. The number of treatments at Prang and Dosehra were four while at Aman Kot there were six treatments. The land was thoroughly leveled and gypsum was applied according to the requirement of respective fields and mixed with the soil with shallow ploughing. Treatments at Prang and Dosehra (Charsadda) were as follows:

T_1= Gypsum applied @ I00% and flushing of irrigation water after 12 h; T_2= Gypsum applied @ 100% and flushing of irrigation water after 24 h; T_3= Gypsum applied @ I00% and flushing of irrigation water after 48 h; T_4= Gypsum applied @ I00% and no flushing (conventional).

Treatments at Aman Kot (Peshawar) were as follows:

T_1= Gypsum applied @ I00% and flushing of irrigation water after 12 h; T_2= Gypsum applied @ I00% and flushing of irrigation water after 24 h; T_3= Gypsum applied @ 100% and flushing of irrigation water after 48 h; T_4= Gypsum applied @ 50% and flushing of irrigation water after 12 h; T_5= Gypsum applied @ 50% and flushing of irrigation water after 24 h; T_6= Gypsum applied @ 50% and flushing of irrigation water after 48 h.

The size of each experimental plot was 25 x 13 m^2. The crops were sown at field capacity conditions. The maize

variety Gul Abadi was cultivated at Prang (Charsadda). Test crops at Aman Kot and Dosehra were dhancha and berseem, respectively. All the fertilizers were applied at planting stage except N, which was applied in two splits i.e. half dose during sowing time while the remaining half at early growth stage. Soil samples were collected before sowing and after the harvest of the crop and were analyzed in the laboratory for pH, EC_e and GR and other physico-chemical characteristics. Yield data were collected at the field.

RESULTS AND DISCUSSION

Effect on fodder yield. Yield data of the trials conducted are presented in Table I. Fodder yield results, at all the three locations are significant at both levels of probability. At Prang, Charsadda maximum maize fodder yield (34.58 t ha^{-1}) was obtained with 48 h flushing time while minimum fodder yield was observed in conventional method of water application. Significant yield increase was observed at both levels of probability with all the flushing duration compared to that of conventional method. However, there was no significant difference in the means of different flushing time. The reason could be that the soil at Prang, Charsadda was sandy loam, where the rate of water percolation was rapid and thus the hazardous soluble salts obtained due to the reaction of gypsum with the absorbed cations were leached down having no harmful effects on the crop yield.

In another study at Dosehra (Charsadda), maximum berseem fodder yield of 32.85 t ha^{-1} was found with 48 h flushing while minimum yield was obtained with 12 h flushing. The berseem fodder yield increased significantly with 48 h horizontal flushing while the other three treatments showed no significant difference among each other. At Aman Kot (Peshawar), maximum dhancha yield of 20.67 t ha^{-1} was recorded with treatments of 48 h flushing and I00% gypsum, whereas minimum dhancha yield was found with 12 h flushing time.

Table I. Effect of horizontal flushing on the fodder yield after gypsum application (yield of fodder crops (t ha^{-1}) at various sites)

Flushing Time (hours)	Yield of fodder crops (t ha^{-1}) at various sites		
	Prang, Charsadda Maize crop Kharif 1996	Dosehra, Charsadda Berseem crop Rabi 1996-97	Amankot, Peshawar Dhancha crop Kharif 1996
Conventional	20.63 B	27.02 B	-
12	28.75 A	24.87 B	12.33 C
24	33.13 A	28.38 B	15.33 B
48	34.58 A	32.85 A	20.67 A

Moreover, 48 h flushing treatment was found effective at 100% gypsum application. When gypsum application rate was reduced by 50%, the 24 h flushing treatment was found better in terms of yield increase (Table II). This indicates greater demand of water at higher rates of gypsum application. The reason could be that the more gypsum is kept in the saturated condition, the more it is effective in the reclamation of the soil. These results are in confirmation to that reported by Richards (1954), Dutt (1994) and Dutt *et al*. (1972).

Table II. Effect of horizontal flushing along with gypsum application on the yield (t ha^{-1}) of berseem fodder at Aman Kot, Peshawar Rabi 1996-97.

Flushing time (hours)	Gypsum @ I00 GR	Gypsum @ 50% GR
12	12.33 C	8.33 C
24	15.33 B	16.00 A
48	20.67 A	13.33 B

Effect on soil reclamation. The soil analysis presented in Table III shows that the pH, EC_e and gypsum requirements (t ha^{-1}) of the soil after gypsum application decreased at all the three sites where more water was ponded and allowed to dissolve gypsum and expedite reclamation reaction, which shows an improvement in the soil properties. However, the reclamation of the soil at Prang, Charsadda was more rapid where the soil was of sandy loam nature as compared to Dosehra, Charsadda and Amankot, Peshawar where the soils were clay loam.

Table III. Soil analysis before and after harvest of crop

Location	Soil properties	Before sowing	Flushing time (Hours), at 100% gypsum Application			
			Conve.	12	24	48
Prang, Charsadda	pH	8.9	8.70	8.33	8.21	8.1
	EC (dS m^{-1})	0.9	0.88	0.86	0.86	0.79
	GR (t $acre^{-1}$)	10.0	2.30	2.50	2.00	0.20
Dosehra, Charsadda	pH	9.7	8.4	8.2	8.1	8.0
	EC (dS m^{-1})	0.35	0.35	0.27	0.23	0.22
	GR (t $acre^{-1}$)	8.0	2.50	2.50	2.30	1.90
Aman Kot, Peshawar	pH	10.0	9.1	9.0	8.8	8.6
	EC (dS m^{-1})	2.4	2.1	1.8	1.8	1.5
	GR (t $acre^{-1}$)	14.0	8.5	6.7	4.6	3.7

Conve.= Conventional

Experimental data at the site of Aman Kot presented in Table IV show that the trend of soil reclamation with flushing of water at various times was similar to that of other sites. However, that of reclamation was slower in case of gypsum application @ 50% compared to that of 100%.

CONCLUSIONS

1. Horizontal flushing of water after of the reaction of gypsum with soil particles is an effective practice in the reclamation of saline sodic and sodic soil.
2. Of all the treatments flushing of water after 48 h of flooding after gypsum application is more effective as compared to other treatments.
3. Flushing of water after 24 h of flooding after gypsum application at half rate may also prove successful in the reclamation of saline sodic soils.

Table IV. Soil analysis before sowing and after harvest of crop for flushing experiment at Aman Kot (Peshawar) 1996

Soil properties	Before sowing	Gypsum applied @ 100 %			Gypsum applied @ 50 %		
		Flushing time (hours)					
		12	24	48	12	24	48
pH	10.0	9.0	8.8	8.6	9.1	9.0	8.8
EC (dS m^{-1})	1.4	1.8	1.8	1.5	2.1	1.2	1.6
GR (t $acre^{-1}$)	14.0	6.7	4.6	3.7	8.5	6.5	4.3

ACKNOWLEDGEMENT

The authors are thankful to PARC, Islamabad for providing financial support, which made possible to conduct this study on farmers' fields.

REFERENCES

Ahmed, N., R.H. Qureshi, M. Aslam, M. Qadir and Z. Sawar, 1992. Efficiency of vertical leaching vs. flushing for the reclamation of a dense saline sodic soil. *Proc. 3rd Natl. Soil Sci. Cong.,* Lahore, p 177.

Bahri, A. and S.E. Amami, I 986. Utilization of saline sodic waters and soils in Tunisia. *Results and research prospects. Pak./UNESCO Seminar Proc. Prospects of Biosaline Res.* Karachi, Pakistan.

Dutt, G.R., 1994. Effect of small amount of gypsum in soils on the solutes in effluent. *Soil Sci. Soc. Am. Proc.,* 28: 754–7.

Dutt, G.R., R.W. Terkertoub and R.S. Ranschkolb, 1972. Prediction of gypsum and leaching requirement for sodium affected soils. *Soil Sci.,* 114: 93–103.

Ghafoor, A. and S. Muhammad, 1981. Comparison of H_2SO_4, HCl, HNO_3 and gypsum for reclaiming calcareous saline sodic soil and for plant growth. *Bull. Irrig. Drain. and Flood Control Res. Council of Pakistan,* 2: 69–75.

Hussain, G.A.H., Ihsanullah and D.G. Wastfall, 1986. Reclamation of saline sodic non-gypsiferous soil. *Arid Soil Res. and Rehab.,* 2: 29–47.

Hussain, M.A. and Z. Hussain, 1989. *Non reclaimable lands made to surrender.* Publication Directorate of Land Reclamation, Punjab, Lahore.

Keren, R. and Shainberg, 1981. Effect of dissolution rate on the efficiency of industrial and mixed gypsum in improving infiltration of a sodic soil. *Soil Sci. Soc. Am. J.,* 45: 103–07.

Mian, M.A. and M.A. Ali, 1980. Land Resources in the irrigated plains of Pakistan. *Pakistan Soil Bull.,* No.13. Soil Survey of Pakistan.

Ramzan, M., Ihsanullah, A. Hamid, and M.A. Javed, 1982. Role of inorganic and organic amendments in the reclamation of saline sodic soils. *Mona Reclamation Experimental Project, WAPDA Pub.* No. 124.

Richards, L.A., 1954. *Diagnosis and Improvement of Saline and Alkali Soils.* Agri. Handbook No. 60, US Dept. Agric., Washington, D.C. pp 160.

Wyn, J.R.G., 1981. Salt tolerance. *In:* Johnson, C.B., *Physiological Process Limiting Plant Productivity,* pp. 271–92. Butter Worth Press Ltd, London.

(Received 25 April 2001; Accepted 06 June 2001)