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Effect of Different Tillage Implements on Wheat Production in Rice-wheat Cropping System in Saline-sodic Soil

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Abstract: A field experiment was conducted to determine the effect of different tillage implements and rice stubbles as residue on the yield of wheat in saline-sodic soil. Rotavator proved the best among all the tillage implements producing maximum germination counts (35.5 m^{-2}). no. of tillers (289.49 m^{-2}); 1000 grains wt. (45.52 g), grain yield (3.409 t ha^{-1}) and straw yield (3.42 t ha^{-1}). Rice stubbles had better residual effect giving significantly higher values of these parameters than the rice stubbles removed from field before sowing the wheat crop. Incorporation of rice stubbles into soil proved also beneficial in improving health of saline-sodic soil.

Key words: Tillage, implements, rice stubbles, grain yield productivity

Introduction

Salt affected area of about 6.3 million hectares (Khan, 1993) signifies the importance of salinity problem in Pakistan. Approximately, sixty percent (3.78 million hectares) of salt affected soils are saline-sodic in nature (Muhammad, 1983). The hydraulic properties (infiltration rate, permeability to water and hydraulic conductivity) and aeration of saline sodic soils are deteriorated due to dispersion, translocation and redeposition of clay platelets, choking of macro and micro pores as the dominant mechanism. As a result, the roots of plants face resistance for proliferation, aeration, water absorption and nutrient uptake. Hence the growth of plants is restricted and yield is ultimately reduced. Maximum improvement in hydraulic conductivity is only possible with simulating subsoiling and gypsum-saturated solution (Shahid, 1993).

Sodium dominated soils have problems of poor aeration and low hydraulic conductivity, both of which are responsible for oxygen stress to plants due to ponding of water and leaching of salts cannot occur during reclamation. Moreover, dense or hard layers may develop in the subsoil due to the clay illuviation and accumulation of lime (Hassan *et al.*, 1990). The incorporation of rice husk and rice straw into sandy clay loam saline-sodic soil improved the physical properties (bulk density, porosity, hydraulic conductivity and clay dispersion) significantly. Soil EC (electrical conductivity), pH and SAR (Sodium adsorption ratio) also significantly decreased (Hussain *et al.*, 1998). Dobermann and Fairhust (2000) reported that incorporation of rice stubbles into the soil, returns most of the nutrients and helps to conserve soil nutrient reserves in the long term and its effect on grain yield is also significant.

Cultivation increases the mulchability and infiltration rate and helps in leaching the salts and reclaiming saline-sodic soils. Pratharpar and Qureshi (1999) evaluated the effect of pre-monsoon surface cultivation for reclamation of saline soils by using a numerical model SWAP-93. It was found that with a water table at one meter or below, abandoned saline soils could be reclaimed by pre-monsoon surface cultivation within few years. However, deep ploughing and chiselling alone are not helpful to reclaim saline sodic soils because the soil slumps again on wetting and becomes hard after drying (Qureshi and Barrett-Lennard, 1998). Comparison of sub-soiler, chisel plough and cultivator indicated that deep tillage produced 8-12% higher yield of Barani wheat during the first year (Khokhar and Nizami, 1987). Whereas, the differences in wheat yields from plots treated with sub-soiler, chisel plough and cultivator were non-significant in another study at Islamabad, Sukhamur, Daultala and Jatli (Khan *et al.*, 1986). The implements (chisel plough and vibro drainer) temporarily increased the percolation of water but after first irrigation, permeability reduced and the effect of these implements on wheat yield proved to be non-significant (Jamil *et al.*, 1995).

Being easily available and cheap source of calcium, gypsum is commonly used for reclamation of saline-sodic soils in Pakistan. The alternative approach for economic utilization of moderately salt affected lands is to grow salt tolerant crops coupled with cultivation practices and addition of organic materials (Biomelioration). To achieve the objective of economic utilization of moderately salt affected soils, the present study was conducted for investigating the effects of various field implements and incorporation of rice stubbles on the yield of wheat as well as gradual improvement of the health of saline-sodic soil.

Materials and Methods

A field experiment was conducted for three years at Agricultural Research Farm of Soil Salinity Research Institute, Pindi Bhattian during Rabi 1997-98 to 1999-2000 in sandy loam saline sodic soil. The experiment was laid out according to split plot design with three replications. Tillage implements were kept in main plots and rice stubbles treatments were assigned to sub-plots. The plot size was 12 X 6.75 m^2. Wheat variety Inqulab-91 was sown as test crop with seed rate of 100 kg ha^{-1} using single row hand drill.

The soil status of the field before the start of study and after harvest of wheat crop for all the three years were recorded (Table 1) through laboratory analysis of the soil samples collected from the field. Following tillage implements and rice stubbles treatments were studied in the experiment.

A: Tillage implements
- Cultivator
- Disc plough
- Chisel plough
- Rotavator

B: Rice stubbles
- R1 Rice stubbles incorporated into the soil.
- R2 Rice stubbles removed from the soil before sowing wheat crop.

Fertilizer was used @ 150, 100 and 50 kg. NPK ha^{-1} respectively. All PK and 1/3 N were applied at sowing time and remaining 2/3 N was applied at tillering and booting stage. All other agronomic practices were kept uniform for all treatments. Crop was harvested in the month of April during all the years and data regarding grain yield and yield components were recorded. Pooled data of three years were analyzed statistically by employing the analysis of variance technique and treatment means were compared by using LSD test at 5% level of probability (Steel and Torrie 1984).

Results and Discussion

The results (Table 2) indicated that the effect of tillage implements on germination of wheat crop was statistically significant. The plots that were prepared with rotavator gave the maximum germination counts (35.5 m^{-2}) among all other tillage implement used. It was followed by cultivator (31.15 m^{-2}), chisel plough (28.5 m^{-2}) and disc plough (27.5 m^{-2}) respectively. It may be due to the reason that rotavator pulverized very well the compacted upper layer of soil as compared to other tillage implements. It could have also increased the water permeability and air circulation into salt affected sandy loam soil. Tyagi and Minhas (1998) also observed that ploughing at excessive or low moisture content can

Table 1: Soil status before and after the start of study

		After wheat 1997-98		After wheat 1998-99		After wheat 1999-2000	
Parameters	Before the Start of study	Rice stubbles remove	Rice stubbles incorporated	Rice stubbles remove	Rice stubbles incorporated	Rice stubbles remove	Ricestubbles incorporated
ECe (dSm^{-1})	7.3	6.9	6.6	6.5	6.1	6.3	5.2
pH	9.16	9.05	8.96	8.98	8.90	8.91	8.84
SAR(mmol $l^{-1})^{½}$	24.8	23.7	22.9	22.9	22.1	22.2	20.7
O.M (%)	0.14	0.17	0.20	0.22	0.28	0.26	0.33
Texture(Sand 70%, Silt 18% & Clay 12 %).	Sandy loam	Sandy loam		Sandy loam		Sandy loam	

$_{ECe}$= Electrical conductivity of saturated extract, SAR= Sodium adsorption ratio, O.M.= Organic matter

Table 2: Effect of different tillage implements and incorporation of rice stubbles as residue on yield and yield parameter of wheat in saline sodic soil
(Data average of three years)

	Cultivator	Disc plough	Chisel plough	Rotavator	Means
Germination counts (m^{-2})					
R1	33.000	29.00	30.33	38.00	32.58A
R2	30.67	26.00	27.67	33.00	29.33B
Mean	31.15B	27.5D	28.5C	35.5A	
LSD for stubbles = 3.22 and LSD for implements = 0.95					
No. of tillers (m^{-2})					
R1	291.00	290.00	291.00	291.66	290.83A
R2	287.00	286.00	287.00	287.00	286.83B
Mean	289.00^{NS}	288.00	289.00	289.00	
LSD for stubbles = 3.95					
1000 grains weight (g)					
R1	47.69	48.00	47.25	48.01	47.99A
R2	42.80	42.58	32.20	43.03	42.90B
Mean	45.24^{NS}	45.29	45.23	45.52	
LSD for stubbles = 3.50					
Grain yield (t ha^{-1})					
R1	3.457	3.361	3.500	3.720	3.509A
R2	3.150	3.200	3.130	3.098	3.144B
Mean	3.303^{NS}	3.281	3.315	3.409	
LSD for stubbles = 0.294					
Straw yield (t ha^{-1})					
R1	3.56	3.54	3.58	3.60	3.57A
R2	3.24	3.28	3.21	3.23	3.24B
Mean	3.40^{NS}	3.41	3.40	3.42	
LSD for stubbles = 0.30					

R1 = Rice stubbles incorporated in the soil.
R2 = Rice stubbles removed from soil before sowing of wheat.
Means with different letters differ significantly at 5% level of significance.

produce soil compaction in the first case and a cloddy in the later. Whereas a good seed bed preparation is necessary when wheat follows rice.

It was also observed that all the tillage implements remained at par statistically when parameters like no. of tillers, 1000 grains weight, grain and straw yields were considered (Table 2). However, rotavator produced the maximum no. of tillers (289.49 m^{-2}), 1000 grains weight (45.52 g), yield of grain (3.409 t ha^{-1}) and straw (3.42 t ha^{-1}) among all other tillage implements. These results indicated that there has been no significant improvement of soil merely by using different implements. Qureshi and Barrett-Lennard (1998) also observed that deep ploughing and chiselling alone are not helpful to improve saline-sodic soils because the soil slumps again on wetting and becomes hard after drying. Similarly, Khokhar and Nizami (1978) recorded only 8-12% more wheat during first year. Khan *et al.* (1986) has reported that soil prepared with sub soiler, chisel plough and cultivator remained non significant in producing wheat at different sites. Moreover the effect of chisel plough and vibro drainer was recorded as temporary by Jamil *et al.* (1995) and differences in wheat yield were found to be non-significant.

The data regarding incorporation of rice stubbles into soil showed statistically significant values for more no. of germination counts (32.58 m^{-2}), no. of tillers(290.83 m^{-2}), 1000 grains weight (47.99 g), grain (3.509 t ha^{-1}) and straw yield (3.57 t ha^{-1}) than the plots from which rice stubbles were removed before sowing wheat crop (Table 2). The incorporation of rice stubbles into the soil returned the residual organic matter and nutrients into the soil which helped to increase soil nutrient reserves and organic matter contents of soil (Table 1). Thus, the physical conditions of the soil was improved resulting in more yield (Dobermann and Fairhust, 2000) Moreover, the soil analysis leads to conclusion that salinity/sodicity level of the field reduced in stubbles incorporated plots compared with stubbles removed plots (Table 1). The field had ECE = 7.3 dSm^{-1}, pH = 9.16, SAR = 24.8 (m mol $l^{-1})^{½}$ and organic matter = 0.14% before starting of the study. After three years on completion of the study, the soil status of incorporated rice stubbles were as ECE = 5.2 dSm^{-1}, pH = 8.84, SAR = 20.7 (m mol $l^{-1})^{½}$ and organic matter = 0.33%.It may be inferred that salinity (EC) reduced by 29% while sodicity (SAR) decreased by 16.5%. There was a reduction of 3.5% in pH and an increase of 57% in organic matter. Thus, rice stubbles incorporation enhanced the organic matter contents of soil and reduced salinity/sodicity level of soil by chemical reactions resulting into improved productivity of soil due to which yield increased. Hussain *et al.* (1998) also reported that incorporation of rice husk and rice straw into sandy clay loam saline-sodic soil improved the physical properties significantly. Resultantly, soil EC, pH and SAR also significantly decreased.

Whereas, low germination and less grain yield were recorded in stubbles removed plots (Table 2). It may be due to more salinity/sodicity of the plots as compared to incorporated rice stubbles plots (Table 1). Similar findings regarding effect of high salinity/sodicity on growth parameters of wheat crop were reported by Rashid (1986). The interaction of field implements and rice stubbles was found non-significant statistically.

It may be concluded from the results that deep ploughing had not significant effect on the yield components and yield of wheat in saline sodic soil but incorporation of rice stubbles proved beneficial in improving soil health and increasing wheat yield in saline sodic soil significantly.

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