WHEAT RESPONSE TO TILLAGE AND IRRIGATION

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A field experiment was conducted during *Rabi* 2003-04 to compare the effect of various tillage and irrigation treatments on yield of wheat grown under cotton-wheat cropping system. The experiment was arranged in a split plot design with four tillage treatments (T_1: one pass of rotavator, T_2: one pass of rotavator + one pass of cultivator, T_3: one pass of rotavator + two pass of cultivator, and T_4: one pass of rotavator + three pass of cultivator) in the main plots and four irrigation levels (I_1: irrigation at 35%, 50%, 65% and 80% depletion levels) in subplots with three replications. Phosphorus in the form of DAP @ 125 kg ha^{-1} was incorporated during seedbed preparation. Nitrogen in the form of Urea was applied @ 125 kg ha^{-1} in two splits: one-half at first and the other half at second irrigation. Grain yield data were statistically analyzed by analysis of variance technique and treatments were compared and ranked with LSD.
The results showed that wheat yield was affected significantly in all treatments. However, effect of tillage on grain yield was non-significant at more number of tillage operations. Maximum yield of 3.60 t ha^{-1} was obtained from plot irrigated at 65% depletion level under T_2 treatment consisting of one pass of rotavator plus one pass of cultivator. The lowest yield of 1.72 t ha^{-1} was obtained with irrigation at 80% depletion level under T_1 tillage treatment. The yield was the lowest because of moisture stress as the result of delaying irrigation till 80% depletion. Based on the result of this study, it may be concluded that increased tillage not necessarily increases grain yield of irrigated wheat under cotton-wheat cropping system in the study area.
Keywords: Wheat, tillage, irrigation, treatment, yield

INTRODUCTION

Wheat is Pakistan's major and staple food crop. It is grown on about 8.35 million ha, producing about 21.6 million tons with an average yield of 2.58 t ha^{-1} (GOP, 2006). But the yield is far less than the potential of soil and climate. The reasons behind low yield include late sowing, poor seed quality, and inappropriate tillage and irrigation practices. Among these tillage and irrigation are important factors affecting crop yield.
Cotton-wheat is the most dominant cropping system in southern Punjab where wheat is often sown in the month of December after harvesting cotton. Tine cultivator is commonly used for primary and secondary tillage operations to prepare seedbed for wheat sowing. Due to limited depth (Rafiq, 1990 and Razzaq *et al.*, 1993) and less pulverization by tine cultivator (Sial, 2005), farmers use more number of cultivation in order to get good seed bed. Farmers on average make six (Sharif *et al.*, 2004) to eight passes with a tine cultivator to prepare the land for wheat (Hobbs *et al.*, 1997). This multiple plowing contributes greatly to the labor and fuel cost in any crop production system resulting in lower economic returns to farmers (Labios *et al.*, 1997 and Jat *et al.*, 2005). Moreover, excessive tillage results in a loss of organic matter (Sabir and Mrabet, 2002, Stewart, 2003) and consequently loss of plant nutrients. Goss, *et al.* (1993) reported that tillage also increased loss of nitrate through leaching by 21% as compared with direct drilling in drained plots.
Canal water supplies decrease during *Rabi* season due to lower reservoir levels and canal closure that force the farmers to use tube well water (where available) to irrigate wheat crop. But, majority of the tube wells pump marginal to poor quality groundwater (Jahangir, *et al.*, 2004 and PCRWR, 2004). In addition, irrigation water is applied without considering the optimum water requirements for good yield. Most of the time farmers over irrigate their fields due to uncertain water supplies during *Rabi* season. Moreover, consistent increase in diesel and electricity rates has further aggravated the farmers' income from agriculture.
On the other hand, underirrigation and inappropriate tillage practices lead to cause lower yield and lower economic returns to farmers. Considering tillage and irrigation water major contributors to production cost to most of the farmers, the present study was undertaken to compare the effects of tillage and irrigation practices on yield of wheat in cotton-wheat farming system.

MATERIALS AND METHODS

An experiment was conducted on a farmer's field in D.G. Khan area during the *Rabi* season of 2003-04. The field was previously planted with cotton. The texture of the soil was silty clay loam which was slightly alkaline in nature (pH: 8-9). Some of the chemical and physical properties of the experimental field soil are shown in Table-1 and Table-2.

Table 1. Some chemical characteristics of the soil at the experimental site

Soil depth cm	Ex. K ppm	Av. P ppm	N %	O.M %	Ex. Na me/100g	pH (1:2.5)	EC(1:2.5) dS m^{-1}
0-20	216	3	0.041	0.65	1.7	8.2	0.66
20-40	116	2	0.039	0.63	1.7	8.2	0.66

Table 2. Some physical characteristics of the soil at the experimental site

Soil depth cm	Bulk density g cm^{-3}	Field capacity % wt. basis	Wilting point % wt. basis	Available water mm/30 cm
0-30	1.44	27.0	16.2	46.6
30-60	1.50	29.0	15.8	49.4
60-90	1.53	33.0	19.0	64.2

The volumetric soil water contents were calculated from dry gravimetric soil water content multiplied by bulk density. The available water content was calculated as the difference between volumetric soil water content at field capacity and permanent wilting point (USDA-SCS, 1991); which was found to be approximately 160 mm within the 0.90 m soil profile.

The experiment was arranged in a split-plot design with four tillage treatments in the main plots and four irrigation regimes in subplots with three replications. The area of each subplot was 50 m^2 (5m x 10 m). The treatments were as follows:

Tillage: (i) one pass of rotavator (T_1), (ii) one pass of rotavator + one pass of cultivator (T_2), (iii) one pass of rotavator + two pass of cultivator (T_3) and (iv) one pass of rotavator + three pass of cultivator (T_4).

Irrigation: (i) irrigation at 35% depletion (I_1), (ii) irrigation at 50% depletion (I_2), (iii) irrigation at 65% depletion (I_3) and (iv) irrigation at 80% depletion (I_4).

After harvesting cotton sticks, the soil was prepared with a rotavator and nine-tine cultivator according to the tillage treatments. Phosphorus fertilizer in the form of DAP was incorporated at the rate of 125 kg ha^{-1} at the time of seedbed preparation. Wheat variety Inqlab-91 using seed rate of 150 kg ha^{-1} was sown on December 14, 2003 with a *Rabi* drill. The crop was kept free from weeds by weedicide spray.

The soil moisture content of the top 0.30 m was measured by the gravimetric method (Evett *et al.*, 1993). The amount of soil water in the 0.60 m top layer was used to initiate irrigation to bring the soil profile to field capacity. The source of irrigation remained tube well water throughout the growing season. Chemical analysis of tube well water is shown in Table-3.

Table 3. Chemical analysis of tube well water

EC, dS m^{-1}	TSS, me L^{-1}	RSC, me L^{-1}	SAR	pH
1.5	15	Nil	2.1	7.8

A cut throat flume of size 10 cm x 75 cm was installed in the main channel to measure tube well discharge. Initially, irrigation water was applied to the non-experimental field to get a constant flow rate. When the upstream and downstream water levels in the flume's stilling wells became stable, water was diverted to the experimental plots according to irrigation treatments.

Irrigation depths were considered equal to the soil moisture deficiencies at the time of irrigation according to irrigation treatments. Assuming an application efficiency of 75%, irrigation water to the experimental plots was applied for the duration necessary to bring the soil profile to field capacity. The duration of irrigation was calculated with the following formula:

$$t = \frac{60AD}{E_a Q}$$

where,

t = duration of irrigation, min

A = plot area, m^2

D = irrigation depth, mm

Q = flow rate from flume, L s^{-1}

E_a = application efficiency, fraction (i.e., 0.75)

Nitrogen in the form of urea @ 125 kg ha^{-1} was applied in two splits: half at the time of first and the other half during second irrigation. During February-March, lodging was observed, particularly in plots less tilled and at lower moisture depletion levels. All the plots were harvested and thrashed manually, and grain yield for each treatment was recorded. The results were statistically analyzed by analysis of variance technique. The Least Significance Difference Test (LSD) was used to compare and rank treatments (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Table-4 presents the result of ANOVA for grain yield which shows that the effect of all treatments and their interaction was significant. However, effect of tillage treatments on yield remained relatively less significant

Table 4. Analysis of variance (ANOVA) for grain yield

Source of Variation	Degree of Freedom	Sum of squares	Mean Square	F Value	Probability
Replications, R	2	0.00125	0.000625	0.07003	
Tillage, T	3	1.46661	0.488869	54.7752	0.0001
Error, E_1	6	0.05355	0.008925		
Irrigation, I	3	17.9556	5.985191	806.690	0.0000
T x I	9	0.79724	0.088582	11.9391	0.0000
Error, E_2	24	0.17807	0.007419		
Total	47	20.4523	0.435155		

Table 5. Wheat grain yield as affected by tillage and irrigation, t ha^{-1}

Treatments	Soil Moisture Depletion				
	35%, I_1	50%, I_2	65%, I_3	80%, I_4	Mean
T_1	2.46 h	2.97 g	3.25 ef	1.76 j	2.61 B
T_2	2.99 g	3.44 bcd	3.60 a	1.94 i	2.99 A
T_3	3.18 f	3.49 abc	3.54 ab	1.98 i	3.04 A
T_4	3.37 cde	3.45 bc	3.30 def	1.88 ij	3.00 A
Mean	3.00 γ	3.34 β	3.42 α	1.89 δ	

Values followed by the same letters do not differ significantly at $P \leq 0.05$.

than that of combined effect (interaction) of tillage and irrigation and of irrigation alone. Table-5 shows the grain yield obtained under various tillage and irrigation treatments. Four tillage treatments (T_1, T_2, T_3 and T_4) resulted in mean grain yield of 2.61, 2.99, 3.04 and 3.00 t ha^{-1}, respectively. But the differences among T_2, T_3 and T_4 were not significant that indicate increased tillage does not necessarily increase yield of irrigated wheat in cotton-wheat cropping system.

As far effect of irrigation at various soil moisture depletion levels is concerned, yield was statistically different in all cases. Maximum yield of 3.42 t ha^{-1} was obtained when irrigated at 65% soil moisture depletion level. The yield (1.89 t ha^{-1}) at 80% soil moisture depletion level was low mainly due to moisture stress caused by delayed irrigation.

Overall maximum yield of 3.60 t ha^{-1} was observed from a plot irrigated at 65% depletion level under T_2 tillage treatment. The lowest yield (1.76 t ha^{-1}) was obtained at 80% depletion level under T_1 tillage treatment. Yield was low at lower depletion levels due to more lodging caused perhaps by less tillage coupled with frequent irrigation. Yield at higher depletion level was low because of moisture stress which reduced the yield. In general, it seems that minimum/reduced tillage coupled with irrigation at ≥ 50% soil moisture depletion level an appropriate practice for the study area. However, more trials may be conducted to study the effect of irrigation and tillage on irrigated wheat and its economic analysis in cotton-wheat cropping system.

REFERENCES

Evett, S.R., T.A. Howell, J.L. Steiner and J.L. Cresap. 1993. Evapotranspiration by soil water balance using TDR and neutron scattering. In R.G. Allen and C.M.U. Neale (eds.) Management of Irrigation and Drainage Systems, Integrated perspectives. Am. Soc. Civil Engr., New York, NY. Proc. National Conference on Irrigation and Drainage, Park City, UT, July 21-23, 1993: 914-921.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedure for agricultural research. 2nd Ed. John Wiley and Sons, Inc., New York, USA.

GOP. 2006. Pakistan statistical year book 2006. Federal Bureau of Statistics, Ministry of Economic Affairs and Statistics, Govt. of Pakistan.

Goss, M.J., K.R. Howse, P.W. Lane, D.G. Christian and G. Harris. 1993. Losses of nitrate-nitrogen in water draining from under autumn-sown crops established by direct drilling or mouldboard ploughing. J. of Soil Sci. 44(1):35-48.

Hobbs, P.R., G.S. Giri and P. Grace. 1997. Reduced and zero tillage options for the establishment of wheat after rice in South Asia. Consortium Paper Series 2. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India. pp18.

Jehangir, W.A., H. Turral and S. Khan. 2004. Net gains from conjunctive use of surface and ground water. A paper presented at the 19th Annual General Meeting of the Pakistan Society of Development Economists (PSDE) held on Jan.13-15, 2004, Islamabad.

Jat, M.L., A. Srivastava, S.K. Sharma, R.K. Gupta, P.H. Zaidi, H.K. Rai and G. Srinivasan. 2005. Evaluation of maize-wheat cropping system under double no-till practice in Indo-Gangetic Plains of India. In: Proc. 9th Asian Regional Maize Workshop, September 5-9, 2005, Beijing China. pp. 25-26.

Labios, R.V., V.T. Villancio, J.D. Labios, A.M. Salazar and R.E. Delos Sanos. 1997. Development of alternative cropping pattern in rainfed lowland areas with small farm reservoirs. *The Philippine Agriculturist* 80 (3 & 4): 187-199.

PCRWR. 2004. Water quality report 2003-04. Pakistan Council of Research in Water Resources, Islamabad.

Rafiq, M. 1990. Soil variability in agronomic research. Pakistan J. of Soil Science 5:9-14.

Razzaq, A., A. Karim and B.A. Sabir. 1993. Appropriate tillage package for wheat production after rice in rice tract. Agricultural Mechanization in Asia, Africa and Latin America, 24:23-34

Saber, N. and R. Mrabet. 2002. Impact of no tillage and crop sequence on selected soil quality attributes of a vertic calcixeroll soil in Morocco. Agronomie 22:451–459.

Sharif, M., H. Shah, N.A. Shah and N. Akmal. 2004. Factors affecting low wheat yield in Central Punjab, 2002-03. Annual Report of Social Sciences Institute, NARC, Islamabad.

Sial, J.K. 2005. Tillage practices for wheat fields. European J. of Scientific Research 12(1):106-112.

Stewart, B.A. 2003. Fire in the soil. ENABLE-Newsletter of the Association for Better Land Husbandry, UK, No. 17(w)

USDA-SCS. 1991. Soil-plant-water relationships. Chapter 1 of Section 15, National Engineering Handbook, Washington, D.C., USA.