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Effect of Tillage Methods on Productivity of Winter Wheat in the Aral Sea Basin of Uzbekistan

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Abstract: Since achieving independence, Uzbekistan has made efforts towards developing its own market economy and put a major emphasis on agricultural growth. During this transition, large and inefficient shirkat (cooperative) farms were dismantled and much smaller private farms were established. For development of this new type of farms, there are constraints associated with limited potential and abilities in crop, tillage methods, soil fertility improvement and on-farm water management. There is an urgent need to pilot changes in agricultural practices in the region in order to improve winter wheat productivity in the salt and drought-affected region of Aral Sea Basin of Uzbekistan. A four-year experiment was conducted, to identify best options of different tillage methods in winter wheat cultivation, at farmers' field in Chimbay district, of Uzbekistan (N 42°57.091', E 059°45.798', 69 m above sea level). Data analysis was performed using GenStat program. The highest yield was recorded in 2007 and yield ranged between 2.23-2.87 t ha^{-1}. It should be mentioned here that weather conditions in 2007 were favorable for winter wheat growth and development. The absolute highest yield was recorded in the no till treatment (2.87 t ha^{-1}) in farmer 2 and 2.81 t ha^{-1} in farmer 1. Statistical analysis shows that winter wheat yield was significantly affected by years (<0.001). The conventional tillage could be replaced by no-tillage systems that increase yield and will likely improve soil properties in the long term.

Keywords: Conservation agriculture, No-till, Soil salinity, Tillage methods, Winter wheat

1. Introduction

Since achieving independence, Uzbekistan has made efforts towards developing its own market economy and put a major emphasis on agricultural growth. During this transition, large and inefficient shirkat (cooperative) farms were dismantled and much smaller private farms were established. For development of this new type of farms, there are constraints associated with limited potential and abilities in crop, tillage methods, soil fertility improvement and on-farm water management. There is an urgent need to pilot changes in agricultural practices in the region in order to improve winter wheat productivity in the salt and drought-affected region of Aral Sea Basin of Uzbekistan. Degradation of soil resources in the region is widespread and it is a direct threat to the sustainability of agricultural production. Dramatic changes in soil management concepts are needed to counter the threat. Conservation agriculture proposes options for such positive changes through addressing a very broad variety of issues related to soil management concepts, water resources management and erosion control, mechanization and tillage, mulching, etc.

Tillage is one of the important agronomic techniques in most agricultural crops while no-till is the most modern tillage technique which is a part of conservation agriculture. No-till controls soil erosion because the plant material protects the soil surface from high winds and rainfall and prevents loosening and carrying away of soil elements. Thus, plant nutrients and soil organic matter remain in the field where they are very useful for crop production. Leaving at least some crop residues in place can slow evaporation of precious soil moisture. This effect is increased in a dry climate because residues are slower to degrade. No-tilling also conserves soil moisture, so more organic matter is produced, outweighing the initial loss of feed or of income from its sale. The objectives of this experiment were to see effect of different tillage methods on productivity of winter wheat growth and development in the region of Aral Sea Basin of Uzbekistan.

Touchton and Jonson (1982) conducted an experiment on the effect of 3 different methods of tillage and plantation on the yield of wheat and soybean. The 3 tillage methods included chisel, Moldboard plow and no tillage. The results were that the yield of soybean in the 2 mentioned tillage methods didn't differ, but yield of wheat in case of Plow with Chisel Plow was less than Moldboard plow.

Cox (1986) studied the effect of different methods of preparation of soil and 2 different types of wheat seed on the

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amount of yield. In that study, different methods of soil preparation included the conventional method of the region with keeping the vegetative remains in the field with plowing and tillage and without plowing or tillage. From the view point of the amount of yield no significant difference was observed between treatments.

2. Materials and Methods

This experiment was conducted at the two demonstrations farms of Chimbay district, Autonomus Republic of Karakalpakistan, Uzbekistan. High-sensitivity GPS receiver eTrex Vista®HCx used to obtain GPS coordinates of the research site and the coordinates are 42°58'19.71'' N and 59°50'38.30''. The soil type is medium-loamy, low in organic matter (<0.612-0.617%). The method of Mishustin, *et al.* (1968) was used to assess soil fertility and to determine the soil biological activity. The soil of experimental site is rather dense with the bulk density fluctuating between 1.4 and 1.6 g/cm³. The highest bulk density was noted in the depth of 20-40 cm. The soil of experimental site is rather dense with the bulk density fluctuating between 1.4 and 1.6 g/cm³. The highest bulk density was noted in the depth of 20-40 cm. The irrigated areas of the experimental site are considered to be of slightly saline soil and the value of soil salinity fluctuates from 0.199% to 0.637%. The content of Cl ranges from 0.03 to 0.065%, which is close to maximum allowable concentration (0.04%) for these conditions. All soil parameters were analyzed by the method developed in Uzbek Research Institute of Cotton (UzRIC, 1973).

Winter wheat variety Dostlik was sown in the experiment. The experiment was initiated in the autumn of 2004 and winter wheat was planted in the first year in the beginning of November and harvested at the end of June, and following years the winter wheat planted in mid of October. No-till sowing had not been practiced at any of the sites prior to the experiment. Seed was placed with 4 cm of soil cover in all treatments. Fertilizer rate was held constant for all treatments each year.

Tillage treatments include conventional tillage or plough (CT), minimum tillage with chiseling (MTC), minimum tillage with disking (MTD), and no-till (NT) respectively. Winter wheat seeding rate was 200 kg ha^{-1} for each treatment through the experimental years.

The experiment was laid out in randomized complete block design. Plot size was 200 m^2 (25×8 m). Field observations were recorded on plant height, TKW, grains per spike and yield. Biometrical analysis of winter wheat was done according to the methods developed by State Variety Testing Commission of Agricultural Crops (SVTCAC, 1970). The data was statistically analyzed using GenStat program 11 edition.

The climate of experimental site is severe continental with hot summers and cold winters. The average summer temperature is 30ºC often surpassing 45°C; the average winter temperature in January is about -5°C, with absolute minimum as low as -40°C. According to the long term data of the Chimbay Meteo Station, located in Chimbay district of Uzbekistan, the mean long-term precipitation is 110 mm, distributed as 18 mm in fall (September- November), 60 mm in winter (December-March), 24 mm in spring (April-May), and 8 mm in summer (June-August).

3. Results and Discussion

Humus content was higher with no-till wheat in the 0-10 cm depth, but lower at the 10-15 cm depth in **Table 1**. This is explained by well known fact of differentiation of soil fertility as a result of conservation tillage when soil is not turned up. Overall, the no-till treatment had significantly more organic matter.

There was a small, but significantly lower pH in the top 10 cm of the no-till system (Table 1). This is to be expected since all the nitrogen is placed on the soil surface and the nitrogen acidifies the soil. The tilled plots mixed and diluted this effect. Various research experiments also investigated the impact of different tillage systems on soil organic matter. Mohanty *et al.* (2007) reported that regression analyses between crop yield and soil organic matter values for tillage and crop residues in rice-wheat systems revealed that both crops showed a positive yield response to increased levels of organic matter. There is general agreement that reduced tillage can increase soil organic matter. There are three kinds of organic matter in soil: the visible root system, the partly decomposed remains of plants, and the well decomposed organic matter, commonly called humus (Mirzajanov 1971). Humus is usually well mixed with the soil and adds structural stability.

ANOVA (analysis of variance) shows that winter wheat yield was significantly affected by years (<0.001). There was

Table 1. Soil chemical parametres in the different tillage systems (2004-2008).

	2004				2008			
Soil characteristics	CT	MTC	MTD	NT	CT	MTC	MTD	NT
Humus content (%)	0.612	0.612	0.612	0.612	0.612	0.613	0.613	0.617
Nitrogen (%)	0.045	0.045	0.045	0.045	0.045	0.046	0.046	0.049
Phosphorus (%)	0.141	0.141	0.141	0.141	0.141	0.142	0.142	0.151
N-NO3, mg/kg	12.87	12.87	12.87	12.87	12.87	12.87	12.88	12.93
P2O3, mg/kg	27.87	27.87	27.87	27.87	27.87	27.85	27.85	28.14
K2O, mg/kg	291	291	291	291	291	292	293	299
pH	7	7	7	7	7	7.1	7.1	7.2

Table 2. Analysis of variance.

Source of variation	d.f.	m.s.	v.r.	F
Year	3	1369979	10.16	<.001
T	3	697389	5.17	0.002
Year.Farm	4	154692	1.15	0.339
Year.T	9	115662	0.86	0.566
Year.Farm.T	12	71690	0.53	0.889
Residual	96	134858		
Total	127			

Remarks: d.f - Degree of freedom; m.s – means square; v.r – variance ratio; F – F-test statistic.

not significant effect on yield between the treatments, year with farm and treatments (**Table 2**). Our findings are in line with Silvio Košutić *et al.* (2005) reports where grain yield of winter wheat among conventional, conservation and no-till treatments did not significantly differ.

Winter wheat productivity was higher in the treatment with no till method compared to the other treatments (**Table 3**). The results obtained by Abbas Hemmat and Iraj Eskandari (2004) are in line with the findings of the recent study. The highest yield was recorded in 2007 and yield ranged between 2.23-2.87 t ha^{-1} over the treatments and farms. Weather conditions in 2007 were favorable for winter wheat growth and development. The absolute highest yield was recorded in the no till treatment (2.87 t ha^{-1}) in farmer 2 and 2.81 t ha^{-1} in farmer 1. The reason for slightly higher yields of no-till winter grown is not clear at this time. There are a number of changes which take place in the soil with a true no-tillage system. It can be explained that these increased yield results from improved soil water management in the no-till system, which limits evaporative water loss and improves water infiltration during the fallow period. This shows that winter wheat yield increased with tillage methods and across the years. It should also be mentioned here that winter wheat grain productivity with no-till method was steady increased across the years except 2008 where severe cold winter observed.

Table 2. Effect of different tillage methods on grain yield of winter wheat, t ha^{-1}.

TM/F	Year, t ha^{-1}							
	2005		2006		2007		2008	
	F1	F2	F1	F2	F1	F2	F1	F2
CT	2.37	2.57	2.77	2.27	2.83	2.50	1.95	2.25
MTC	1.88	2.12	2.37	2.37	2.23	2.44	1.93	2.15
MTD	1.91	2.17	2.42	2.37	2.25	2.41	2.10	2.13
NT	2.12	2.24	2.57	2.59	2.81	2.88	2.34	2.32
Year	<.001							

These findings can showed that if we use no-till practices in winter wheat cultivation it allows us to get stable yield across the years and it also give us a buffer zone climate change issues in the Aral Sea Basin.

4. Discussion

The winter of 2008 was unfavorable to the winter wheat growth and development and coldest than usual and with heavily snow cover during the season and daily temperature felt down up to -45°C. It negatively affected the productivity of winter wheat entire experiment and, as a result, yield productivity was less compared to the observed in previous year. In other years, yield productivity was high in all tillage methods across the years and farms (see Table 3).

Tanaka's findings (1989) on the comparison of the yield of pea while using different tillage treatments including no tillage, reduced tillage and conventional tillage (Moldboard Plow) support the obtained results in the present study as it was indicated in their study that the yield difference for the mentioned tillage treatments was not significant and even no tillage showed a better yield trend.

Grain yields under direct drilling were similar to those obtained using the reduced-tillage system and superior to yields obtained by conventional tillage system (Abbas and Iraj, 2004).

Hossein (2008) reported that grain yield of wheat was not affected by seed density and types of tillage machine.

On the basis of primary findings of this research it can be concluded that the year is one of the factor that has been implicated as critical in determining winter wheat productivity in the region.

Finally, our results emphasize the necessity of taking into account the NT method in the cultivation of winter wheat in the drought and salt-affected region to stabilize wheat production in the region. Otherwise CT will be substantially reduced wheat yield and also soil fertility in the Aral Sea Basin. Further investigations of the effect of NT are needed to assess its effects in the longer term, specifically to monitor long-term effect of conservation agriculture.

5. Conclusions

In view of these results, specific conclusions for different tillage methods on winter wheat cultivation in the Aral Sea Basin are as follows:

Taking into account the slow decomposition of organic manure and crop residue, it is too early to make general conclusions but nevertheless the results obtained are encouraging. The humus content increased remarkably but the effect of organic manure and crop residue on the soil fertility

should be further tested in the future.

Winter wheat yield was higher in the treatment involving the no-till method compared to the other treatments. The highest yield was recorded in 2007 and this yield ranged between 2.23-2.87 t ha^{-1}. Statistical analysis shows that winter wheat yield was significantly affected by year-specific effects (<0.001).

The reason for slightly higher yields of no-till winter grown is not clear at this time. There are a number of changes which take place in the soil with a true no-tillage system.

No-till method tested in the Aral Sea Basin proved to be suitable for local conditions and can provide similar or higher crop yields but saving considerable resources including fuel and labour.

It is the first step towards Conservation Agriculture adoption and successful implementation. There are many efforts ahead needed to ensure further success of Conservation Agriculture, including training of farmers and specialists, providing support to supply of necessary equipment and resources.

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