XVII[th] World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

TILLAGE EFFECTS ON SOIL AND PRODUCTION MANAGEMENT FOR WINTER WHEAT IN SOUTHWEST TURKEY

ZELIHA B. BARUT[1*], SAIT AYKANAT[1], M. MURAT TURGUT[1]

1 Z. B. BARUT, Çukurova University, Faculty of Agriculture, Department of Agricultural Machinery 01330 Adana/TURKEY, zbbarut@cu.edu.tr
1 S. Aykanat, saitaykanat@mynet.com
1 M. M. TURGUT mmturgut@cu.edu.tr

CSBE100514 – Presented at Section III: Equipment Engineering for Plant Production Conference

ABSTRACT The main concept of tillage should be to create the most appropriate soil conditions by taking into consideration ecological balance for sustainable agriculture. The proper soil conditions improve seedling emergence, plant growth and thus yield. In this study, different tillage systems were examined for sustainable wheat production. The tillage systems consisted of minimum tillage, two rows of the ridge tillage, three rows of the ridge tillage and direct seeding techniques. The systems were analyzed in terms of the soil moisture content, porosity, bulk density, working efficiency, the percentage of emergence, yield, biological yield, harvest index and fuel and time consumption. As a result, the highest yield (8587.4 kg ha^{-1}) was obtained from minimum tillage system while the lowest yield (6419.8 kg ha^{-1}) was in the two rows of the ridge tillage. The maximum efficiency (1.34 a h^{-1}) on wheat production was obtained from the direct seeding technique. The minimum fuel consumption (7.9 l ha^{-1}) and the minimum time consumption (0.75 h ha^{-1}) were in direct seeding. The direct seeding system saved time on fuel consumption and working efficiency at the rate of 81-86 %.

Keywords: Tillage systems, soil properties, yield, fuel consumption, time, wheat

INTRODUCTION Wheat is one of the essential crops which have the highest rate of the crop production in Turkey. Approximately 50% of the cropland in Turkey is for cereals and one third of this cropland is wheat production area. In the last 20 years, the cultivated area of the wheat is differs between 8.1-9.5 million ha and wheat production is differs between 17.6-21.5 million tones in Turkey. According to year 2008 data's Mediterranean Part is the third in wheat production of Turkey (Anonymous, 2008). Çukurova region is situated in the east part of the Mediterranean Part. Farmers generally burn stubble both for wheat production after harvesting the second crop or second crop production after harvesting the wheat. After burning the stubble, they first use a moldboard plough and discharrow to till the soil and than use a float to break the clods.

It becomes important problem burning stubble before soil tillage in wheat growing as conventional tillage method in Çukurova region. Unsuitable soil tillage methods minimize the sustainability of the agriculture canalized the researchers to apply the conservation tillage methods.

In this study conservation tillage systems were analyzed in terms of the soil moisture content, porosity, bulk density, working efficiency, the percentage of emergence, yield, biological yield, harvest index and fuel and time consumption for wheat production in Çukurova region.

MATERIALS AND METHODS The study was carried out on randomized blocks of 10 m x 2.8 m with four replications on lands of Çukurova Agricultural Research Institute Directorate Hacıali Undertaking between the years 2007-2008. For this research, a standard farm tractor that has 63 kW of drawbar power was used for tillage equipment. The technical properties of tillage equipment used in this study were given in Table 1. Ceyhan-99 variety as wheat seed was used in the study.

Table 1. The technical properties of the tillage machines used in the study

Equipments and machines	Unit number	Working width (m)	Working depth (cm)	Working speed (km h^{-1})
Disc-harrow	20 discs	2.10	10-15	7.75
Lister plow	4 (70 cm) ridges	2.80	15-25	3.34
Ridge float	4 (70 cm) ridges	2.80	15-20	5.02
Ridge drill	4 (70 cm) ridges	2.80	-	
No-tillage drill	8 rows	1.40	-	
Drill	12 rows	2.20	-	4.55

In order to determine moisture content, bulk density and porosity in the soil depth of 0-30 cm, from different points selected randomly, the soil core sampler equipment such as density rings with 100 cm^3, soil cups, hammer, spatula etc., was used.

The study carried out on trial plots of 10 m x 2.8 m, was planned in completely randomised block design with four replications for one year. The main plot treatments were minimum tillage without stubble (MT), ridge tillage with two rows with stubble (RTS2) and ridge tillage with three rows with stubble (RTS3) and direct seeding with stubble (DS). The methods were:

1. MT : Burn stubble + Disc-harrow + Seeding
2. RTS2: Stubble + Disc-harrow (two times) + Lister + Ridge float + Seeding with two rows on ridge
3. RTS3 : Stubble + Disc-harrow (two times) + Lister + Ridge float + Seeding with three rows on ridge
4. DS : Stubble + Direct seeding

Stubble on MT plots was burned while that on RTS and DS plots was retained. Herbicide (480 g l^{-1} glyphosate) was applied at 5 l ha^{-1} to DS plots before sowing. Fertilizer was applied at rates of 350 kg ha^{-1} for wheat (20% N, 20% P) using a spinning disc distributor. Wheat was sown into dry soil in November and the seeding rate was 171 kg ha^{-1} for wheat After seeding, top dressing (26% N, 350 kg ha^{-1}) chemical weed control (herbicides with 40 g ha^{-1} clodinafop-propargyl for wheat) and plant protection treatments (fungicide with 1.25 kg ha^{-1} tebuconazole for wheat) were applied uniformly over the entire area at the same time and rate.

The soil physical parameters such as moisture content, bulk density and soil porosity were measured in order to determine effect of tillage systems on soil properties. For this reason, soil samples were taken from depths of 0-10cm, 10-20cm and 20-30cm. Soil samples were tested in the laboratory for bulk density and total porosity using methods described by Blake and Hartge (1986), and Danielson and Sutherland (1986), respectively. One part of soil samples taken from each plot was dried in the oven at 105 °C to determine soil gravimetric moisture content.

The plant numbers of the wheat were recorded about four weeks after sowing by counting the plants in 5 m rows per plot three times after the emergence period. From these counts, the percentage of emerged seedlings was calculated for each treatment to evaluate the effect of the tillage system, as reported by Bilbro and Wanjura (1982). The percentage of plant emergence is the ratio of number of germinated plant to number of seed sowed per meter. Winter wheat was harvested manually in late May to determine grain yield (at approximately 0.115 kg kg^{-1} grain moisture content). The yield was obtained from an area equivalent to 1 m^2 within each treatment with three replicates. Harvest index that is defined as grain yield divided by the biological yield (stalk+grain) was used to evaluate the effect of the tillage system on total yield of plant.

The task times for the tillage systems were measured by using a chronometer in order to obtain management data of farm machineries used seedbed preparation for wheat. Fuel tank of tractor at the beginning of each application was filled fully to determined fuel consumption. At the end of each application, the measured fuel was added up to fill in the fuel tank of the tractor. The added fuel was consumed fuel based on area for plots (Barut et al, 1996).

The experiment data was analyzed by SPSS statistics packet programme. The ANOVA procedure was used to evaluate the significance of each treatment on soil properties and yield in a randomized complete block design with three replications. Treatment means were separated by the least significance difference (LSD) test to prove statistical significance of the results. All significant differences were reported at the %1 and 5% level.

RESULTS AND DISCUSSION The results of the soil sample analyses measured in the stem elongation period according to soil depth for different tillage methods were presented in Table 2, 3 and 4.

Soil moisture Considering all samplings in the study, the tillage systems had a significant effect ($P < 0.05$) on moisture content of the soil (Table 2). The highest soil moisture contents were in RTS plots while the lowest in DS plots. The moisture contents of tillage systems varied between 16.88 % and 19.69 % based on soil depth.

Table 2. Soil moisture (%) according to soil depth for tillage methods; RT: Ridge Tillage, MT: Minimum Tillage, DE: Direct Seeding

Soil Depth	Tillage Methods					
	RTS [b]		MT		DS	
0-10 [a]	**19,69 a**	**A**	17,02 c	B	16,88 c	B
10-20	**19,87 a**	**A**	18,20 b	B	17,92 b	C
20-30	19,24 a	A	**18,78 a**	AB	**18,92 a**	AB
Average	**19.60**		**18.00**		**17.90**	
CV (%)	2,3		1,74		1,84	

a: Means with different upper case letters in each line are significantly different at **0.05 level.
b: Means with different lower case letters in each column are significantly different at **0.05 level

There were no statistical differences between soil moisture contents in RTS based on soil depth. Means of moisture contents of tillage systems were 19.60%, 18.00% and 17.90% for RTS, MT and DS, respectively.

Soil bulk density The tillage systems had a significant effect ($P<0.05$) on bulk density (Table 3). Soil bulk density of 0-10 cm layer was significantly lower (1.32 g cm^{-3}) in DS than in the other plots. But, there was no statistical difference among tillage systems in the 20-30 cm soil layers as is seen in the Table. Crop residue has been reported to improve soil bulk density and cause lower bulk density (Valzano et al, 1997; Arshad et al, 1999; Ghuman and Sur, 2001).

Table 3. Soil bulk density (g cm^{-3}) according to soil depth for tillage methods; RT: Ridge Tillage, MT: Minimum Tillage, DE: Direct Seeding

Soil Depth	Tillage Methods					
	RTS [b]		MT		DS	
0-10 [a]	1.36 c	AB	1.37 b	A	1.32 b	B
10-20	1.48 b	AB	1.49 a	AB	**1.56 a**	A
20-30	1.64 a	A	1.53 a	A	**1.55 a**	A
Average	**1.49**		**1.46**		**1.47**	
CV (%)	4.19		4.82		2.83	

[a]: Means with different upper case letters in each line are significantly different at * 0.05 level.
[b]: Means with different lower case letters in each column are significantly different at * 0.05 level.

Soil porosity Total porosity in 0-10 cm soil layer was significantly affected by tillage systems as is seen in Table 4 ($P<0.05$). DS had higher porosity (50.70%) than other tillage systems. Total porosity in the same tillage system was significantly higher in the 0-10 cm depth than other both depths. The highest means of soil porosity of tillage systems was 45.43% in MT. However a study performed by Azooz and Arshad (1996) indicated that total porosity was not affected by no-tillage compared with conventional tillage in the silt loam, distribution of pore sizes was affected (Arshad et al., 1999).

Table 4. Soil porosity (%) according to soil depth for tillage methods; RT: Ridge Tillage, MT: Minimum Tillage, DE: Direct Seeding

Soil Depth	Tillage Methods					
	RTS [b]		MT		DS	
0-10 [a]	**49.28 a**	AB	**48.94 a**	AB	**50.70 a**	A
10-20	**44.62 b**	**A**	44.33 b	AB	41.73 b	B
20-30	38.92 c	A	43.03 b	A	42.25 b	A
Average	**44.27**		**45.43**		**44.89**	
CV (%)	5.16		5.79		3.38	

a: Means with different upper case letters in each line are significantly different at * 0.05 level.
b: Means with different lower case letters in each column are significantly different at * 0.05 level

Grain yield The average grain yield for tillage systems was given in Table 5.

Table 5. Average plant density and grain yield for tillage systems; RT: Ridge Tillage, MT: Minimum Tillage, DE: Direct Seeding

Tillage systems	Plant density (plants m^{-2})	Grain yield (kg ha^{-1})
RTS2	384	6419.8 d
RTS3	398	7197.0 c
MT	418	8587.4 a
DS	406	8103.9 b
CV (%)	-	3.51
$LSD_{0.01}$	-	42.62

Means with different letters in each column are significantly different at 0.01 level.

The different tillage systems had a statistical ($P<0.01$) effect on grain yield of the wheat. The grain yield was the greatest (8587.4 kg ha^{-1}) in MT compared to other tillage treatments. The lowest grain yield was 6419.8 kg ha^{-1} in RTS2. This result is pertinent to plant density. As the plant density increased, so did grain yield. While plant number per area on stubble plots was lower, weed population was higher. Even though expected that the yield on plots with stubble would be higher, this result had not materialized. Due to the fact that weeds share water, nutrients and light by competing with crops, weeds and low plant density on stubble plots can be considered a factor which has decreased grain yield (Akbolat and Barut, 2001).

The harvest index It was determined there is not any statistical difference ($P<0.01$) between the different tillage systems on harvest index. The average harvest index values are seen in Table 6.

Table 6. The average harvest index values of the methods; RT: Ridge Tillage, MT: Minimum Tillage, DE: Direct Seeding

Methods	Harvest index (%)
RTS2	30.35
RTS3	31.18
MT	29.95
DS	30.32
CV (%)	12.88
LSD	6.28

As is seen in the table, the lowest harvest index was 29.95 % in MT, whereas the highest harvest index was 31.18 h ha^{-1} in RTS3. The high biological yield caused to low harvest index in spite of the greatest grain yield in MT.

The task time and fuel consumption The lowest time consumption was found 0.75 h ha^{-1} in DS, whereas the highest time consumption was found 3.94 h ha^{-1} in RTS (Table 7). Similar findings were observed for fuel consumption. This situation shows that task time for field tillage increases due to increasing the pass number. Owing to less the field traffic, the lowest fuel was consumed as 7.90 l ha^{-1} in DS. On contrary to this, the highest fuel consumption was detected as 62.50 l ha^{-1} in RTS because of increment of pass number on the field as it was observed by Korucu and Kirişci, 2001.

Table 7. The task time and fuel consumption for tillage equipments

Methods	Equipment	Task Time (h ha^{-1})	Total Task Time (h ha^{-1})	Fuel Consumption (l ha^{-1})	Total Fuel Consumption (l ha^{-1})
MT	Goble	0.94	1.40	14.60	18.90
	Driller	0.46		4.30	
RTS	2 Goble	1.88	**3.94**	29.20	**62.50**
	Lister (70 cm)	0.85		10.50	
	Ridge Float (70 cm)	0.30		8.00	
	Ridge Seeder (70 cm)	0.92		14.80	
DS	No-tillage drill	0.75	0.75	7.90	7.90

Working efficiency The working efficiency (ha h^{-1}) determined by rating the measured total time consumption for soil tillage, preparing the seed bad and seeding with the working area in all blocks. The values are given in Table 8.

Table 8. The average working efficiency values of the tillage methods

Methods	ha h^{-1}
MT	0.72
RTS	0.26
DS	1.34

Among the tillage treatments, the highest average working efficiency value (1.34 ha h^{-1}) was obtained in DS. The MT (0.72 ha h^{-1}) and RT (0.26 ha h^{-1}) followed DS respectively. These values showed an inverse ratio between the time and efficiency of the methods. It was determined while the working time increased, working efficiency decreased.

CONCLUSION The study has been performed to compare effects of different tillage and sowing systems on the plant growth, and to make technical analysis that is used for growing the wheat in 2007. The study has been carried out on the lands of Çukurova Agricultural Research Institute Directorate Haciali Undertaking.

The soil moisture content was increased in all the tillage systems except the ridge sowing in all soil depth. The ridge tillage method (RTS) has proved to be statistically unimportant on the soil moisture content according to soil depth. The highest soil moisture content in 0-10, 10-20 and 20-30 cm depths and the highest average value of the soil moisture content (19.60 %) were determined in the ridge tillage method (RTS).

The highest bulk density in 0-10, 10-20 and 20-30 cm depths and the highest average value of the bulk density (1.49 g cm^{-3}) were determined in the ridge tillage method (RTS). The highest bulk density (1.44 g cm^{-3}) was in minimum tillage method (MT).

The highest porosity in 0-10, 10-20 and 20-30 cm depths and the highest average value of the porosity (45.43%) were determined in the minimum tillage method (MT). The lowest porosity (44.27%) was in ridge tillage method (RTS).

The highest yield (8587.4 kg ha^{-1}) was obtained from minimum tillage system (MT) while the lowest yield (6419.8 kg ha^{-1}) was in the two rows of the ridge tillage (RTS2). The maximum efficiency (1.34 ha h^{-1}) on wheat production was obtained from the direct seeding (DS) technique. The minimum fuel consumption (7.9 l ha^{-1}) and the minimum time consumption (0.75 h ha^{-1}) were in direct seeding (DS). The direct seeding system (DS) saved time on fuel consumption and working efficiency at the rate of 81-86 %.

It is essential that conservation tillage systems be used to preserve natural life and sustaining soil fertility. In this context selected tillage systems should be improved and new tillage systems functioning by mixing previous crop residue into soil should be investigated. So, further research is needed to overcome this problem in the tillage systems with residue. Improved soil properties, higher yield, and an economical tillage system indicate the MT and DS is an acceptable alternative practice for winter wheat production in this region.

REFERENCES

Akbolat, D., Barut, Z.B., 2001. Effects of Soil Tillage with Stubble and without Stubble on Weed. 20 th National Agricultural Machinery Congress Full Text Book, 13-15 September, p: 85-90. Şanlıurfa.

Anonymous, 2008. Wheat Production in Turkey, Grain Report of year 2008, p:63, Ankara.

Arshad, M.A., Franzluebber, AJ, Azooz, R.H. 1999. Components of Surface Soil Structure Under Conventional and No-Tillage in Northwestern Canada. Soil & Tillage Research 53:41-47

Azooz, R.H., Arshad, M.A., 1996. Soil infiltration and hydrolic conductivity under long term no-tillage and conventional tillage systems. Canadian Journal of Soil Science 76:143-152

Barut, Z.B., Okursoy, R., Özmerzi, A., 1996. Physical Effects Of Cotton Seed Bed Preparation On Silty Sand. Proc. 6^{th} International Congress on Mechanization and Energy in Agriculture. I; 455-461, Ankara, Türkiye

Bilbro, J.D., Wanjura, D.F., 1982. Soil Crusts and Cotton Emergence Relationships. Transaction of the ASAE. Vol. 25; 1484-1487.

Blake GR, Hartge KH. 1986. Bulk density. In: Klute, A. (Ed.), Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods, 2nd ed. Agron. Monogr. 9. ASA-SSA, Madison, WI, pp. 363-375.

Danielson, R.E., Sutherland, P.L., 1986. Porosity. Methods of Soil Analysis. Part 1, Physical and Mineralogical Methods, ed:Klute, A., 2.nd Edition, Agronomy Monograph No.9, ASA and SSSA, Madison, WI, p:443-461.

Ghuman, B. S., Sur, H. S., 2001. Tillage and Residue Management Effects on Soil Properties and Yields of Rainfed Maize and Wheat in a Subhumid Subtropical Climate. Soil & Tillage Res., 58; 1-10.

Korucu, T., Kirişci, V., 2001. Technical Comparison of Different Soil Tillage Systems in Second Crop Maize Production in Çukurova Region, Part I. 20 th National Agricultural Machinery Congress Full Text Book, 13-15 September, p: 102-108. Şanlıurfa.

Valzano, F.P., Grene, R.S.B., Murphy, B.W., 1997. Direct Effects of Stubble Burning on Soil Hydraulic and Physical Properties in a Direct Drill Tillage System. Soil & Tillage Res., 42. 209-219.