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WHEAT PRODUCTION USING DIRECT SEEDING, REDUCED TILLAGE AND CONVENTIONAL TILLAGE IN MIDDLE ANATOLIA

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Abstract

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The objective of this study was to examine wheat production using direct seeding, reduced tillage and conventional tillage in Middle Anatolia during the years of 2006-2007 and 2007-2008. In the experiment, two tillages and the direct seeding were used. All tillage methods and the direct seeding were applied in the dry farming conditions. The effect of treatments on mean emergence dates, percentage of emerged seedling, fuel consumptions and wheat yield were measured. From the data, power requirement and field efficiency of each method were calculated.

The highest fuel consumption was measured in the conventional method as 46.1 l ha^{-1} whereas the lowest value was found in the direct seeding method as 10.7 l ha^{-1}. Fuel consumption of the conventional method required four times more fuel than the direct seeding method. The best result for wheat yield was found in the direct seeding as 3388.9 kg ha^{-1} in 2008. The lowest wheat yield was found in the conventional method as 2290 kg ha^{-1} in 2007. The direct seeding gives the best result for fuel consumption, effective power requirement, field efficiency and wheat yield. In the dry farming condition, the direct seeding methods can be proposed for wheat production in the Middle Anatolia.

Key words: direct seeding; tillage system; wheat; fuel consumption

Introduction

Making the soil suitable for culture plant growing is possible with soil tillage. However, intensive soil tillage destroys nature of the soil. Intensive soil tillage and removing plant residues from the upper soil cause soil erosion and soil hardiness. Soil hardiness is increased by farm traffic especially in wet seasons and soil hardiness makes dry basis volume weight increased.

Energy use and costs are decreased with conservation tillage and with this method, enough plant residues is left in soil to protect field. The main purpose of direct planting is to decrease the water and wind soil erosion and to make plant production more profitable. Therefore, the target is protection of soil. In addition, soil moisture, energy consumption, labor and protection of machinery will be effective.

The direct seeding, like no-till, is a cropping system, which aims to improve soil and soil moisture conservation. The direct seeding has been shown to increase or improve Wildlife Habitat, Environmental Sustainability, Economic Viability and Energy Conservation. Direct Drilling greatly reduces soil erosion by 60-90%, increasing the quality of surface water by reducing sediment.

Emissions to the atmosphere from the conventional agriculture reduce the potential CO_2 sink effect of the soil, decreasing the organic matter content of the soil and contributing to global warming. Intensive tillage of agricultural soils has led to substantial losses of soil carbon (C), frequently over 50% in the 20-30 years of cultivation.

The conventional tillage needs more mechanical investment and labor when compared to conservation tillage, especially direct planting. Energy efficiency increases 25 to 100 % and consumption of energy decreases 15 to 50 % in direct planting. The direct seeding requires only 1/3 of field traffic compared to the conventional tillage.

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Aykas and Onal (1999) studied the effects of different tillage methods on yield and weeding for wheat. They obtained better grain and straw yield from reduced tillage (rotary-tiller) as 3500 kg ha $^{-1}$ and 3470 kg ha $^{-1}$ as compared to the conventional and zero tillage system, respectively. They recommend that proper tillage system should be carefully selected in order to achieve a better weed control.

Barut and Akbolat (2005) evaluated the conventional and conservation tillage systems. They concluded that tillage systems with crop residue improved physical properties of soil. They found the highest yield in the conventional system but the lowest time and fuel consumption were gathered 4 h ha^{-1} and 28.8 l ha^{-1} respectively on conservation tillage.

According to the research findings, fuel consumptions of different tillage methods were found as 49.4 l ha^{-1} (100%), 31.21 l ha^{-1} (63.2%), 28.3 l ha^{-1} (57.3%), 25.2 l ha^{-1} (50.9%), and 13.3 l ha^{-1} (27.08%) for plough, chisel, disk harrow, ridge-tillage, and the direct seeding, respectively. the direct seeding saved 73 % of fuel energy compared with the conventional method (Köller, 2003).

Yalcin and Cakir (2006) studied tillage effects and energy efficiencies of sub soiling and the direct seeding in light soil on yield of second crop corn for silage in Western Turkey. They found that the fuel consumptions were 60.5 l ha^{-1} and 7.5 l ha^{-1} for the conventional system and the direct seeding, respectively.

Carman and Marakoglu (2007) compared reduced tillage and direct planting applications in chickpea production. The biggest and least fuel consumptions were obtained in the conventional method (52.02 l ha^{-1}) and the direct seeding (9.72 l ha^{-1}), respectively.

Yalcin et al. (2005) studied tillage parameters and economic analysis of the direct seeding, minimum and the conventional tillage in wheat. They found that wheat yields were 6800 kg ha^{-1} and 7400 kg ha^{-1} for the direct seeding and minimum tillage, fuel consumption were 8.9 l ha^{-1} and58.4 l ha^{-1} for the direct seeding and the conventional tillage, respectively.

Bayhan et al. (2006) studied possibilities of direct drilling and reduced tillage in second crop silage corn. The direct seeding method gave the best result for mean of emergence dates and percentage of emerged seedling. The best result for silage yield was found in tillage combination. The lowest yield was found in the heavy-duty disc harrow tillage method. The direct seeding gives the best results for tillage efficiency parameters, such as fuel consumption, effective power requirement and field efficiency.

Barut and Celik (2008) evaluated the direct drill and conventional tillage system in the dry farming conditions. They found wheat yield in the conventional tillage system and direct drill as 3556.7 kg ha^{-1}, 3130.0 kg ha^{-1} and 3413.3 kg ha^{-1}, 2880.0 kg ha^{-1} in the first and second years, respectively.

In recent years, weather conditions in Middle Anatolia have been unstable. In autumn, the rainfall has generally been delayed until November. Hence, farmers did not accomplish the seedbed preparation at proper time. As a result, the drilling of cereals such as wheat and barley has been delayed so that there has been insufficient emergence after drilling and a large decrease in yield. Farmers have drilled wheat in early autumn into dry soil and then waited for rainfall to cause germination and emergence. However, the expected rainfalls have not occurred in recent years. The soil has been losing humidity due to soil tillage for preparing the field to the planting. The direct seeding can be an alternative production method in the region because of low annual precipitation. The aim of this research was to determine wheat production using direct seeding, reduced tillage and conventional tillage in Middle Anatolia.

Materials and Methods

The experiments were conducted in the field of Konuklar Agricultural farms of TIGEM in the years of 2006-2007 and 2007-2008. Located 65 km away from the city of Konya, which is located in the Middle Anatolia region of Turkey. (37°52´N latitude, 32°29´E longitude and altitude1016 m)

The soils are classified as Typic Xerfluent in the US Soil Taxonomy. Physical and mechanical properties of the soil in the experiment field are given in Table 1. The average annual temperatures and rainfall data in October – July during the years 2006-2008 are given in Table 2. The tillage methods are given as follows:

- Method 1: The conventional method: plough + disc harrow - float + drill.
- Method 2: Reduced tillage: Rotary tiller - roller + drill.
- Method 3: The direct drill.

For the conventional tillage method, the soil was first ploughed with three bottom moldboard plough. After

Table 1
Physical and mechanical properties of the soil in the experiment field

	Conventional methods		Reduced tillage		Direct seeding	
	2007	2008	2007	2008	2007	2008
Particle size distribution						
Sand, %			28.99			
Clay, %			34.18			
Silt, %			36.82			
Bulk density, g cm^{-3}	0.9	1.25	0.9	1.29	1.18	1.45
Penetration resistance (MPa) (0-20 cm)	0.78	1.37	1.37	1.61	2.02	2.11
pH	7.69	7.72	7.72	7.62	7.60	7.52
Lime, %	13.1	18.4	15.8	12.2	15.2	24.5
EC, micromos cm^{-1}	149	176.5	137	185	163	176
Phosphorus, mg kg^{-1}	15.94	15.41	15.09	13.61	14.5	13.1
Potassium, mg kg^{-1}	542.4	595	568.6	683.5	510	681

plowing, the field was harrowed with disc harrow and leveled with float. In the reduced tillage method, soil was prepared for seeding with only one pass of soil tillage, roller and drill. For the direct seeding application, seeding was made without tillage. The specifications of the tools used in the experiment are given Table 3. Ford 6600 (Engine Power 80 HP) tractor was used in the experiments. The wheat variety was Gerek 79, which is the most commonly used wheat in the Middle Anatolia.

The direct drill was home made. Row spacing was 13 cm, seeding rate was 200 kg ha^{-1} and there were 12 seeding units (Figure1). Diameter of press cylinder in direct drill is 490 mm; it has a width of 53 mm, height of 32 mm and has a pressing ability of 0.25 daN cm^{-2}

The numbers of emerged seedlings were measured in rows and mean emergence dates (MED) and percentage of emerged seedlings rates (PE) were calculated using formulae (1) and (2) (Bilbro and Wanjura, 1982):

$$MED = \frac{N_1 D_1 + N_2 D_2 + ... + N_n D_n}{N_1 + N_2 + ... + N_n} \quad (1)$$

$$PE = (\frac{Total\ emerged\ seedling\ per\ meter}{Number\ of\ seeds\ planted\ per\ meter}) x100 \quad (2)$$

MED, PE, fuel consumptions, effective power requirement, field efficiency and yield were determined to compare the methods. MED, PE, fuel consumptions, effective power requirement, field efficiency and yield were measured with three replications in plots of 100 m long and 6 m wide. Yields were measured from samples taken from an area of 3.5 m^2 at harvest time.

The conventional method, reduced tillage and the direct seeding were conducted in three different plots. Each tillage method and the direct seeding were applied in the same plots for 2 years.

The data were analyzed using MSTAT statistical software for analysis of variance. LSD Test $P \leq 0.05$

Table 2
Monthly averages of air temperatures and rainfall at Konuklar measured in 2006 and 2008

Months	Air temperature, °C		Rainfall, mm	
	2006-2007	2007-2008	2006-2007	2007-2008
October	3.8	12.8	46	10
November	2	7.8	16	67.5
December	-0.7	1	-	37
January	-2.2	-3.8	32	6
February	-0.2	-3.2	23	20
March	5.4	9	18	22
April	7.7	12.9	14	11.5
May	18.3	14.5	2	17.5
June	21.1	20.9	3	9
July	24.3	23.2	-	-

Table 3
The specifications of the tools used in experiment

Tool	Average speed, km h^{-1}	Working depth, cm	Working width, m
Plough	5.5	30	1.20
Disc harrow	6.5	15	2.20
Rotary tiller combination	2.8	20	2.30
Drill	6.3	4-5	1.82
Direct drill	5.6	4-5	1.62

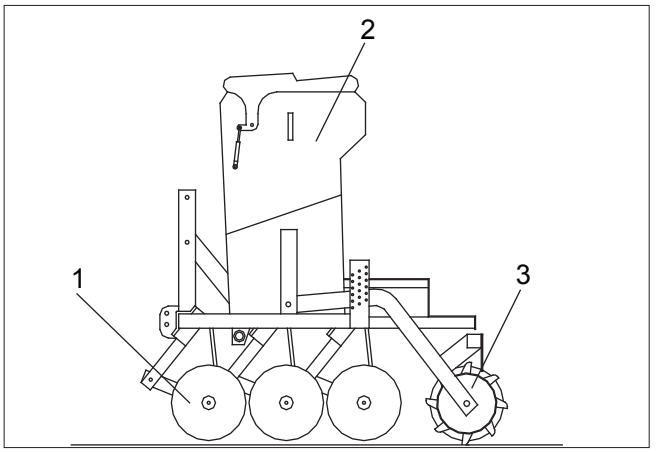

Fig. 1. Direct drill
(1. Disc coulter, 2. Seeding unit, 3. Roller)

was used to compare the means of the obtained results in this research.

Results

Mean emergence dates and percentage of emerged seedlings rates

Mean emergence dates and percentage of emerged seedlings rates of tillage methods calculated are given in Figures 2 and 3. The lowest averages of mean emergence dates were found for the conventional method in both years, and the highest mean emergence dates were found for reduced tillage with 24.75 days and the direct seeding with 16.72 days in the first and second year, respectively.

According to the methods, the highest seedling emergence rates were obtained for the conventional method as 78.53%, and for the direct seeding as 93.56% in the first and second year, respectively. The lowest seedling emergence rates were obtained for the direct seeding as 62.80%, and for the conventional method as 92.22% in the first and second years, respectively. As seen in Figures 2 and 3, no significant differences were found for tillage methods regarding mean emergence dates in both of years. However, percentage of emerged seedlings rates of tillage methods were found statistically significant ($P < 0.01$) in 2007. Results showed that the percentage of emergence had an important effect on wheat yield.

Wheat yield

According to the wheat yield results given in Table 4, the first year results were found lowest as compared to the second year. The highest yield was found in the direct seeding as 3007.5 kg ha^{-1} and 3388.9 kg ha^{-1}, the lowest yield was found in the conventional method as 2290 kg ha^{-1} and 2373.6 kg ha^{-1} in the first and second years, respectively. As seen in Table 4, tillage methods were found statistically significant ($P < 0.01$) for wheat yield in both years. Total annual precipitations were calculated as 154 mm and 200.5 mm for the first and second years. Therefore, the second year wheat yield is higher than the first year. Barut and Celik (2008) found a similar result in the same direct drill machine.

Fuel consumption, effective power requirement and field efficiency

Averages of tillage efficiency parameters for different tillage methods (Table 5) were found statistically significant for fuel consumption in both years. In the conventional method, fuel consumption and effective power requirement with 46.1 l ha^{-1} and 35.84 kW m^{-1} were the highest. The lowest fuel consumption and effective power requirement were found in the direct seeding with 10.7 l ha^{-1} and 7.32 kW m^{-1}, respectively. The direct seeding has also the highest field efficiency

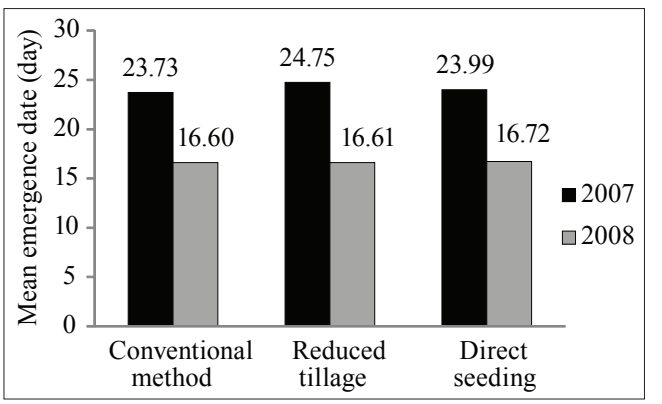

Fig. 2. Effect of different tillage methods on mean emergence date

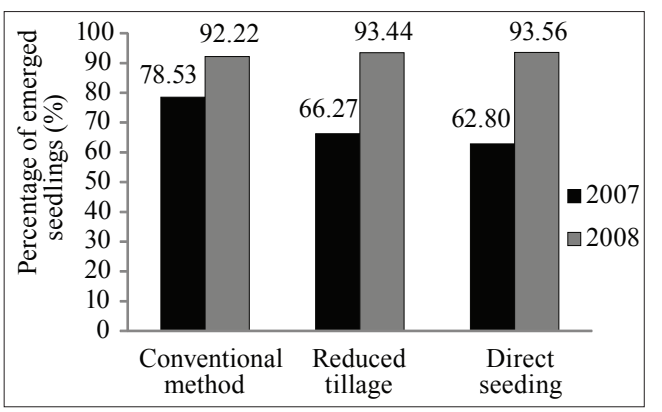

Fig. 3. Effect of different tillage methods on percentage of emerged seedlings rate

with 0.82 ha h^{-1} whereas the lowest field efficiency was found in the conventional method with 0.32 ha h^{-1}. There are contrary relations between fuel consumption and field efficiency. It is obvious that the direct seeding gives the best results for all parameters.

Discussion

The conventional tillage method had highest fuel consumption and the lowest field efficiency as compared to the other tillage methods and the direct seeding. The direct seeding method had the lowest fuel consumption with the highest field efficiency. The conventional method required four times more fuel compared to the direct seeding method. The direct seeding method had 2.5 times more field efficiency compared to the the conventional tillage method. The direct seeding method had the highest wheat yield in comparison to all the other tillage methods. Similar results were found by Borin and Sartori (1995), Cakir et al. (2003), Carman and Marakoglu (2007) and Bayhan et al. (2006).

Conclusions

The highest seedling emergence rates were obtained for the conventional method as 78.53%, and for the direct seeding as 93.56% in the first and second year, respectiv-ely. The highest yield was found in the direct seeding as 3007.5 kg ha^{-1} and 3388.9 kg ha^{-1}, the lowest yield was found in the conventional method as 2290 kg ha^{-1} and 2373.6 kg ha^{-1} in the first and second years, respectively. The highest fuel consumption was measured in the conventional method as 46.1 l ha^{-1} whereas the lowest value was found in the direct seeding method as 10.7 l ha^{-1}. The direct seeding gives the best result for fuel consumption, effective power requirement, field efficiency and wheat yield.

From the results, it can be concluded that the direct seeding can be easily applied in wheat production in the Middle Anatolia region.

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Table 4
Wheat yield, kg ha^{-1}

Methods	Year 2007	Year 2008
Conventional method	2290.0 b	2373.6 b
Reduced tillage	2336.2 b	2789.1b
Direct seeding	3007.5 a	3388.9 a
LSD (P < 0.05)	520.4	460.1

Table 5
Average of tillage efficiency parameters for different tillage methods

Methods	Fuel consumption, l ha^{-1}	Effective power requirement, kW m^{-1}	Field efficiency, ha h^{-1}
Conventional method	46.1 a	35.84	0.32
Reduced tillage	26.1 b	16.16	0.40
Direct seeding	10.7 c	7.32	0.82
LSD (P < 0.05)	11.42		

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