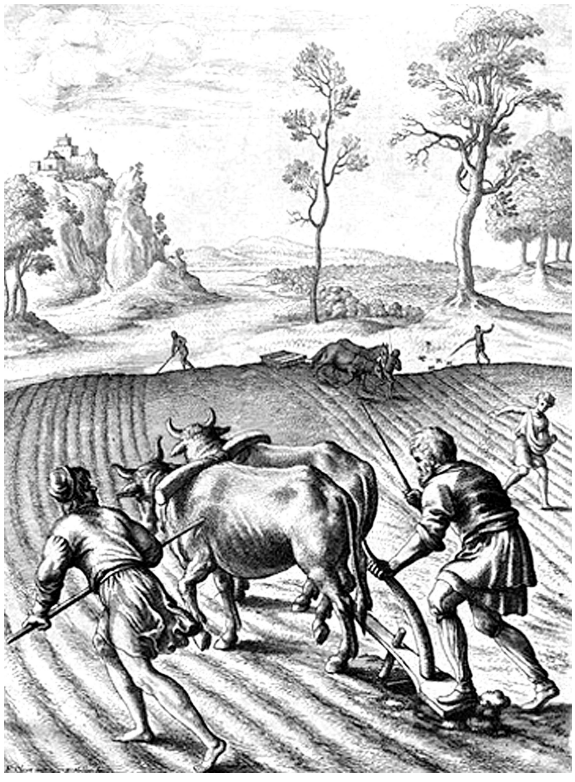
ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY



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Journal of Agronomy 4 (4): 329-332, 2005
ISSN 1812-5379

Tillage Parameters and Economic Analysis of Direct Seeding, Minimum and Conventional Tillage in Wheat

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Abstract: The objective of this study was to examine the three main soil tillage operations: conventional tillage, minimum tillage and direct seeding in wheat production. For conventional tillage operations, main tillage tool was moldboard plough. For minimum tillage, two tillage alternatives were applied; in first alternative, the plough were replaced with heavy-duty disk harrow. In second alternative, soil was prepared for seeding with only one pass of soil tillage combination of chisel, rotary tiller and spiral roller. Direct seeding was applied with no-tillage after herbicide use. For each applications, travel speed, slip and fuel consumption were measured. After the operations, soil properties such as soil moisture, bulk density and porosity were measured from soil samples and cone index were measured from the penetrometer resistance of the soils. Finally, fuel consumption and the tillage efficiency were calculated for each application from the measured data and from that, the economic analysis was made. According to the results, all tillage parameters were found statistically significant. The direct seeding gives the best results for fuel consumption and the tillage efficiency 8.9 L ha^{-1} and 1.25 ha h^{-1}, respectively. On the contrary, conventional tillage has the highest fuel consumptions and the lowest tillage efficiency 58.4 L ha^{-1} and 0.27 ha h^{-1}, respectively. Although the conventional tillage method gives the good preparation of the seed-bed with weed free condition and high yield, direct seeding saves almost 6 times of fuel and 4 times time save. The highest yield was found as 7400 kg ha^{-1} in the minimum tillage method. I in which heavy-duty disk harrow with tillage combination used. Direct seeding has the lowest yield with 6800 kg ha^{-1}. This was due to the fact that weed manifestation was high in direct seeding comparing the other methods. The yield for conventional method was 7200 kg ha^{-1}.

Key words: Tillage systems, direct seeding, wheat, economic analysis

INTRODUCTION

Effective energy use is gaining more importance in the farm applications to increase the gain and to reduce expenditure. Since the tillage takes most of the energy and the cost in farming comparing the other applications, some other applications such as minimum tillage and direct seeding is practiced recently to reduce the time spent and the cost.

Minimum tillage and no-till planting reduces the erosion, conserves the soil and reduces the fuel consumption that allows the fuel save. But there are some problems regarding the soil type and the location of application of no-till planting in some plants. More researches are needed to solve the problems associated with minimum tillage and no-till planting and increase the application of these methods.

For susceptible and erodible and light sandy soils no-till planting should be practiced to decrease great soil loss due to wind and water erosion occurring during heavy tillage. Leaving the crop residue and application of no-till planting techniques will be widely used when the problems with no-till are solved and sustainable agriculture are well known in the world for reducing the erosion potential.

A punch planter for corn was designed, prototyped and evaluated for no-till conditions using commercial seed metering unit[1]. Field tests were conducted with several residue covers for testing the residue effect at a speed of 2 m sec^{-1}. No significant difference was observed in the planter performance.

McGarry *et al.*[2] stated that removing tillage is attractive for many reasons: reduced tractor hours, increased tractor life, reduced fuel use (attractive economically and environmentally), minimizing compaction risk and increasing both organic matter and diversity of beneficial soil fauna.

Barut and Akbolat[3] evaluated the conventional and conservation tillage systems. They concluded that tillage systems with crop residue improved physical properties

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of soil. They found the highest yield in conventional systems but the lowest time and fuel consumption were gathered 4.0 h ha^{-1} and 28.8 L ha^{-1} respectively on conservation tillage.

Barzegar *et al.*[4] studied conventional, minimum and no-tillage systems on wheat root growth in semiarid region. Their results suggested that the inhibition of root growth by possibly mechanical impedance of soil could be declined in later stage of wheat growth and the reduced tillage system produced wheat root length density equivalent or even higher than the conventional tillage in semiarid region.

According the results of the research of Ozpinar[5] on the influence of tillage systems on wheat yields and economics in clay loam soil, the highest weed manifestation was found in heavy duty disk harrow application as 61 weeds m^{-2}. She recommends rototiller to be adopted for economic and higher crop production.

Van Doren and Allmaras[6] discussed the usefulness of crop residues on the soil surface but they also concluded that there were some difficulties in residue management such as weed manifestations, insect problems and planting problems in the residue.

Yalcin[7] found that the wheat yields were 2200 and 3200 kg ha^{-1} for no-till planter and conventional system respectively. The yield for conventional system in second crop silage maize was 41 t ha^{-1}, but this reduced down 37 t ha^{-1} for no-till planter.

The objective of this study was to examine the three main soil tillage operations: Conventional tillage, minimum tillage and direct seeding in wheat production. For conventional tillage operations, main tillage tool was moldboard plough. For minimum tillage, two tillage alternatives were applied; in first alternative the plough were replaced with heavy-duty disk harrow. In second alternative, soil was prepared for seeding with only one pass of soil tillage combination of chisel, rotary tiller and spiral roller. Direct seeding was applied with no-tillage after herbicide use.

MATERIALS AND METHODS

The study was carried out on trial plots of 500 m^2 with 22% clay, 50% silt and 28% sand on experimental field of Ege University's research farm in Izmir (38°26' latitude N, 26°40' longitude E, 10 m above sea level). The soil was Aquic Xerofluvent according to soil taxonomy. After harvesting second crop maize for silage, the field was divided into four sections each of which representing different tillage method:

- Method 1: Conventional tillage method with moldboard plough,
- Method 2: First alternative for minimum tillage: Heavy-duty disk harrow and tillage combination of spring tine harrow and spiral roller,
- Method 3: Second alternative for minimum tillage: Soil was prepared for seeding with only one pass of soil tillage combination of chisel, rotary tiller and spiral roller,
- Method 4: Direct seeding.

After autumn rains, tillage operations were made when the desirable soil moisture of 12.5% was found. The soil was ploughed with three furrow general purposed plough then disk harrowed and finally leveled with float for conventional tillage. In the first alternative to the plough, heavy-duty disk harrow was used. The clods in this alternative was crushed and soil surface was leveled with soil tillage combination of spring tine harrow and spiral roller. In second alternative, soil was prepared for seeding with only one pass of soil tillage combination of chisel, rotary tiller and spiral roller. Direct seeding was applied with Amazone NT 250 with row spacing of 19.23 cm and seeding rate of 160 kg ha^{-1} after herbicide use. The wheat variety was Cumhuriyet 75 which is the most common used wheat in the region. Some technical specifications of the tillage tools were given in Table 1. Fiat 60-56 (44.1 KW) tractor was used to operate the whole tillage operations. Before and after tillage, penetrometer measurements were taken from the soil. Soil samples were taken from 0 to 20 cm depths with 5 cm intervals just before harvesting to calculate the bulk density and porosity of the soil (Table 2). In the field tests, forward speed and fuel consumption were measured and from the data, slip, tillage efficiency and fuel consumptions per area were calculated.

Table 1: Some technical specifications of the tillage tools

Technical specifications	Plough	Heavy duty disk Harrow	Harrow Roller Combination	Rotary Tiller Combination	Direct Seeding Machine
Working width (mm)	1010	2600	2850	1900	2500
Working depth (mm)	250	200	150	150	30
No. of legs or disks	4	24	21	21	19

Table 2: Moisture, bulk volume of weight and porosity of soil as influenced by tillage method

Methods	Bulk density (g cm^{-3})	Moisture (%)	Porosity (%)
1	1.34	23.0	41
2	1.19	22.0	48
3	1.28	24.4	44
4	1.34	23.6	42

RESULTS AND DISCUSSION

The soil conditions naturally changes with different tillage methods. Minimum cone index was found in Rotary Tiller tillage combination for tillage depth of 15 cm. Tillage with plough gives the second good preparation of the soil with low cone index value. The highest penetration resistance was found in direct seeding. After 22.5 cm depth, penetration resistance reaches to the untilled conditions (Fig. 1).

Tillage parameters of each tillage operations of each method are given in Table 3. The number of pass and the fuel consumptions are very high in conventional tillage comparing the minimum tillage methods and direct seeding.

When we compare the tillage methods, it was found that all values for tillage parameters were statistically significant. It is obvious that direct seeding gives the best results for fuel consumption and the tillage efficiency 8.9 L ha^{-1} and 1.25 ha h^{-1}, respectively (Fig. 2 and 3.). On the contrary, conventional tillage has the highest fuel consumptions and the lowest tillage efficiency 58.4 L ha^{-1}

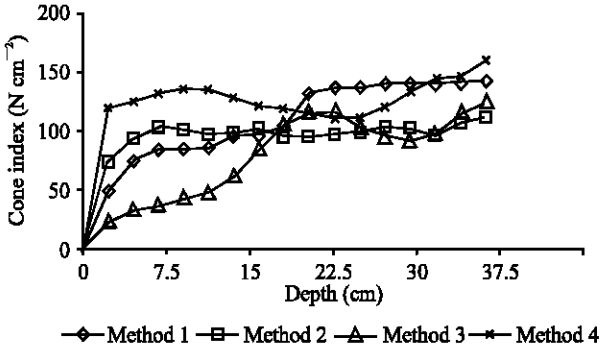

Fig. 1: Penetration resistances of tillage methods just before planting

Table 3: Tillage parameters of applications

Methods	Tillage type	Fuel consumption (L ha^{-1})	Slip (%)	Forward speed (km h^{-1})	Field efficiency (ha h^{-1})
	Plough	19.6	21.57	6.17	0.62
	Disk Harrow-1 Pass	7.0	13.88	5.33	1.33
1	Disk Harrow-2 Passes	6.9	8.50	6.82	1.71
	Float	16.0	12.16	5.45	1.39
	Planting	8.9	8.50	5.00	1.25
	Heavy-Duty Disk Harrow	11.5	17.13	5.83	1.52
2	Soil Combination	15.3	12.16	5.30	1.51
	Planting	8.9	8.50	5.00	1.25
3	Rotary Tiller	26.0	4.52	2.71	0.51
	Planting	8.9	8.50	5.00	1.25
4	Direct Seeding	8.9	8.50	5.00	1.25

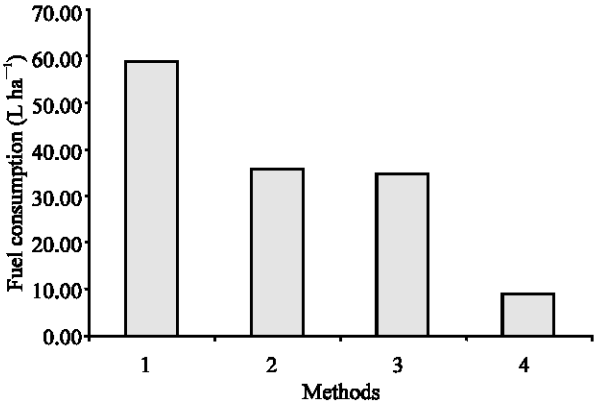

Fig. 2: Fuel consumptions of tillage methods

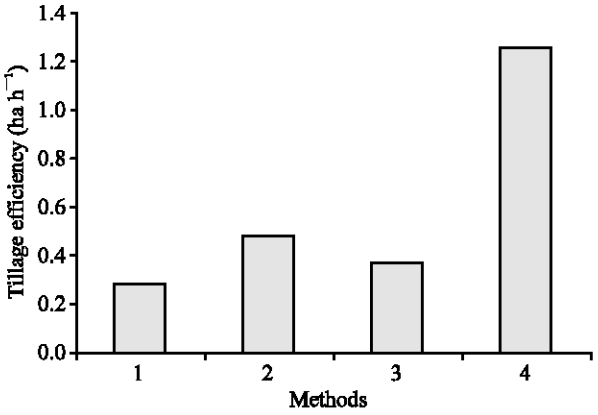

Fig. 3: Field efficiencies of tillage methods

and 0.27 ha h^{-1}, respectively. Comparing the minimum tillage methods 2 and 3, soil tillage combinations with heavy-duty disk harrow has higher tillage efficiency of 0.47 ha h^{-1} with statistically not significant fuel consumption difference of 0.8 L ha^{-1}. This was due to the low tillage speed of rotary tiller tillage combination comparing to the other minimum soil tillage operations.

There was found no statistical difference for seedling emergency of the methods. The average seedling emergency was found 82% (Fig. 4). But the yield among the tillage methods was found statistically significant. Although the seedling emergency was similar among the methods, the yield was found important. The highest yield was found in the minimum tillage method I in which heavy-duty disk harrow with tillage combination as 7400 kg ha^{-1} (Fig. 5). Direct seeding has the lowest yield with 6800 kg ha^{-1}. This was due to the fact that weed manifestation was high in direct seeding comparing the other methods.

As it is seen from the results, direct seeding can give the best of fuel and time save comparing the other tillage

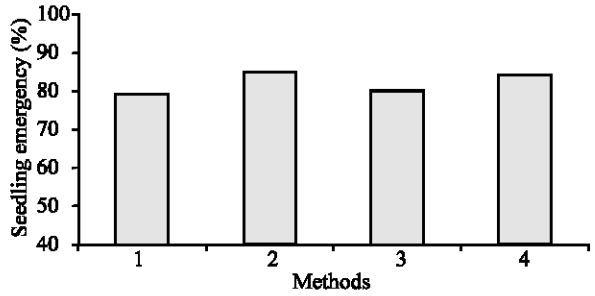

Fig. 4: Seedling emergency values of tillage methods

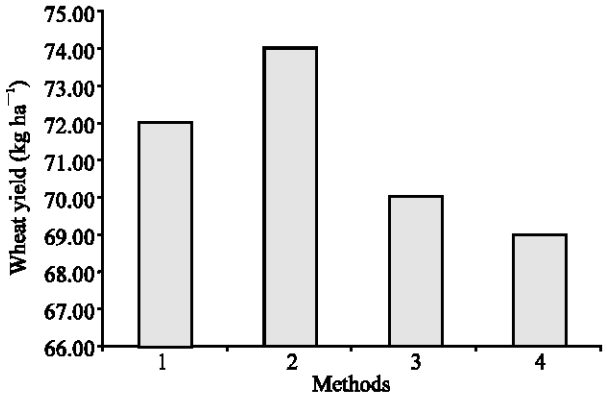

Fig. 5: Wheat Yields of tillage methods

methods. Although the conventional tillage method gives the good preparation of the seed-bed with weed free condition and high yield, direct seeding saves almost 6 times of fuel and 4 times time save. The experiences show that direct seeding gets the high yield in long run not to mention of allowing sustainable agriculture but also creating natural soil environment. This natural environment will not only give a chance to farmers to save money and time but also keep their field from heavy erosion with long time productive soil. The authors of this study intend to continue the same experiment in the same field to compare the direct seeding effect for a long time and measure the erosion control in the field.

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