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Full Length Research Paper

Effects of different tillage applications on the seed yield of winter rapeseed (*Brassica napus* L.)

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Abstract

In this experimental study, the conventional tillage, reduced tillage and direct sowing were applied for rapeseed cultivation. The main objective of the present study was to evaluate the effects of different tillage systems on the crop yield and fuel consumption for winter rapeseed cultivation. The values of specific fuel consumption and seed production were calculated for winter rapeseed production. It was found that the seed yield for the conventional tillage, reduced tillage and direct sowing were determined as 2144.4 kg/ha, 1956.5 kg/ha and 1724.4 kg/ha, respectively. It was determined at the end of evaluation that tillage systems statistically (P<0.01) affected the yield. It was found that the seed yield for the conventional tillage, reduced tillage and direct sowing were determined as 2144.4 kg/ha, 1956.5 kg/ha and 1724.4 kg/ha, respectively. When compared to conventional tillage, while the seed yield reduced in 8.76% and 19.58%, the fuel consumption reduced in 40.3% and 63.2% in reduced tillage and direct sowing applications, respectively, The specific fuel consumption in winter rapeseed cultivation was 33.93 L/t, 22.20 L/t and 15.51 L/t, for the conventional tillage, reduced tillage and direct sowing applications, respectively. The specific seed production in winter rapeseed cultivation was 29.47 kg/L, 45.03 kg/L and 64.43 kg/L for the conventional tillage, reduced tillage and direct sowing applications, respectively.

Keywords: Fuel consumption, plant dry mass, rapeseed, tillage, yield.

INTRODUCTION

The agricultural machinery use is considered the main factor contributing to the total energy inputs in the agricultural system. Tillage represents half of the operations carried out annually in a field. Consequently, there is a potential to reduce energy inputs and production costs by reducing tillage (Cavalaris and Gemtos 2004). In addition, reduced tillage methods promote soil conservation. It is essential to prevent loss of the soil fertility while taking measures to increase the yield per area. One of the main factors in sustainable soil fertility is plant nutrients consisting after the organic matters being decomposed by micro organisms compose consistent nutrient resource in soil. The most natural way of returning the plant nutrients depleted from soil is to give organic matters formed by biological methods into the soil. Minimum tillage with residue improves soil quality and yield. Conservation tillage system that are low in labor, time, energy and production cost have been considered important as time goes by.

Some researches showed that conventional tillage and planting systems weren't economical because of high production cost in spite of reaching the highest yield. As operation number used tillage systems diminish, task time and fuel consumption reduces too. In this context, task time and fuel consumption in conventional tillage systems that have more operation number, is higher than in other tillage systems. Parsch *et. al.,* (2001) compared conservation tillage seedbed preparation vs. conventional tillage main plots with subplots of soybean, grain sorghum, corn and cotton. Except for cotton, conventional

tillage resulted in higher average net returns than conservation tillage. The study confirmed the increased variable costs and decreased equipment costs that accompany conservation tillage systems. Conservation tillage is an ecological approach including many different soil management systems. Single tillage system is not suitable for all soils and climatic conditions. Therefore, the choice of the best suited tillage system must be harmonious to the particular agro-ecological environment. Cavalaris and Gemtos (2004) evaluated the tillage efficiency and energy requirement for five methods of soil preparation in the sugar beet crop. The effect of different tillage systems on economically important pests (Gencsoylu and Yalcın 2004), weed flora (Bilalis *et al.* 2001), plant biomass (Sidiras *et. al.,* 1999), root growth (Sidiras and Kendristakis 1997; Sidiras *et. al.,* 1999; 2001; soil characteristics (Roth *et. al.,* 1986; Anurag Saxena *et. al.,* 1997; Sidiras and Kendristakis 1997; Battikhi and Suleiman 1999a; 199b; Karamanos *et. al.,* 2004), crop yield and quality parameters (Bhadoria 1986; Guhuman and Sur 2001; Karamanos *et. al.,* 2004; Patra *et. al.,* 2004; Casa and Cascio 2008; Qin *et. al.,*. 20010), fertilizer nitrogen rates (Olness 1992; Olness *et. al.,* 1995) and water use efficiency (Casa and Cascio 2008) for different crops have been investigated in the comprehensive studies.

Even though a lot of work is done with concerning the effects of soil properties (Gutierrez Boem *et al.* 1994; 1997), crop rotations (Christen and Sieling 1995), temperature and light quality (Slauenwhite and Qaderi 2013), herbicides (Ibrahim *et. al.,* 1987), irrigation applications (Gutierrez Boem 1997), progressive drought (Ilami *et al.* 1997), some biochemical parameters (Iori *et al.* 1991), plant density (Shrief *et. al.,* 1990; Hühn 1993; Momoh and Zhou 2001) and fertilizer applications (Pattl *et. al.,* 1996; Ahmad *et. al.,* 1998; 1999; Kappen *et. al.,* 1998; Cheema *et. al.,* 2001; Barłóg and Grzebisz 2004) on seed yield and quality characteristics of rapeseed, the research concerning the adaptation to reduced tillage for winter rapeseed is limited. Therefore, in this experimental study, the conventional tillage, reduced tillage and direct sowing methods were applied for winter rapeseed cultivation**.** The main objectives of the present study were: (1) to investigate the fuel consumption with the adoption of reduced tillage and the probable effect in crop yield; (2) to determine the specific fuel consumption and seed production for the different tillage systems and (3) to evaluate the effects of different tillage systems on the crop yield and fuel consumption for cultivation.

MATERIALS AND METHODS

Study Area Description

The experiments were carried out in the field of Cukurova University, Faculty of Agriculture, the Department of Agricultural Machinery, Research and Applications Farm in Adana province of Turkey between the years 2011–2013. Adana province located between 35–38° northern latitudes and 34–46° east longitude in the Mediterranean region. Adana has the features of the Mediterranean climate. Summers are hot and dry, winters are mild and rainy. The average rainfall is 625 mm. The city has 74 rainy days per year in average. The chance of precipitation is usually 51% in winter, 26% in spring, 18% in autumn, 5% in fall. In general, summers are humid, but some years there is no rain falls can be seen. Although the average relative humidity is around 66%, it can be over 90% on summers. The average annual temperature has been 18.7 ˚C for the last 37 years. The coldest month is January, with an average temperature of 9.5 ˚C and the warmest month is August, with an average temperature of 28˚C. Adana has 195.6 days of summer in a year. 134.4 of these days are designated as tropical day. Clay content of the soil ranged from 44 % to 63% in the profile. The organic matter content in the surface horizons is 1.5%. The pH of the soil is between 7.29 and 7.37.

Tillage applications

Three different tillage methods for the winter rapeseed cultivation were tested:

1) *Conventional tillage* includes tillage with a plough at a depth of 25 cm, tillage with a disk harrow at a depth of 7–8 cm, and final preparation with a roller in two times in the P1 parcel.

2) *Reduced tillage* includes tillage with a disk harrow at a depth of 7–8 cm, and final preparation with a roller in twice in the P2 parcel.

3) *Direct sowing* includes preparation with a roller in twice in the P3 parcel.

The tillage applications, sowing and cultivation operations were performed with the standard tractor of 50 kW. The tools-machineries that used for process of rapeseed cultivation and their specifications, task time and fuel consumption are given in Table 1

Cultivation Practices

For rapeseed cultivation, 5 kg of seed was sowed per unit area (ha). 140.5 kg of pure nitrogen (N) and 115.0 kg of pure phosphorus (P_2O_5) was used per unit area (ha). There was no irrigation process performed on these parcels of land. After plant emergence, the operations such as cultivation (2 times) and fertilization were performed at the same time and same dose on all plots with regard to trial. Cultivation practices were the same for all the treatments according to the needs of the highest yield.

Fuel Consumption

The amount of fuel that consumed by the tractor during the process of rapeseed cultivation, which were carried

Table 1. Tools and machineries that used for the processes of rapeseed cultivation.

Tools/machineries	Working width (m)	Mass (kg)	Task time (h/ha)	Fuel consumption (L/ha)
Conventional Tillage			*72.76*	*15.48*
Tractor (50 kW)				7.74
Plow	1.10	1220	29.32	2.78
Disc harrow	2.10	2220	12.83	1.16
Harrow	3.50	1300	3.85	0.40
Grain sowing machine	2.50	1490	4.62	0.65
Roller	1.70	1260	7.92	0.78
Centrifugal fertilizer machine	12.00	140	1.92	0.28
Drum mower machine	1.65	370	12.30	1.69
Reduced Tillage			*43.44*	*9.92*
Tractor (50 kW)				4.96
Disc harrow	2.10	2220	12.83	1.16
Harrow	3.50	1300	3.85	0.40
Grain sowing machine	2.50	1490	4.62	0.65
Roller	1.70	1260	7.92	0.78
Centrifugal fertilizer machine	12.00	140	1.92	0.28
Drum mower machine	1.65	370	12.30	1.69
Direct Sowing			*26.76*	*6.80*
Tractor (50 kW)				3.40
Grain sowing machine	2.50	1490	4.62	0.65
Roller	1.70	1260	7.92	0.78
Centrifugal fertilizer machine	12.00	140	1.92	0.28
Drum mower machine	1.65	370	12.30	6.80

Table 2: Seed yield ([a]), plant dry mass ([b]) and fuel consumption ([c]) for tillage systems.

Methods	Seed yield[a] (kg/ha)	Plant dry mass[b] (kg/ha)	Fuel consumption[c] (L/ha)	Specific seed production (kg_{seed}/L_{fuel})	Specific fuel consumption (L_{fuel}/t_{seed})
Conventional tillage	2144.4	1154.6	72.76	29.47	33.93
Reduced tillage	1956.5	1053.5	43.44	45.03	22.20
Direct sowing	1724.4	928.6	26.76	64.43	15.51

[a,b,c] Significant at P<0.01

out with agricultural tools and machineries is defined and measured with a measuring system (a flow meter). The amount of fuel which was read in flow meters (as L) after tractor reached the distance of 20 m further ahead on the land and effective working width values (m) of farm tools/machineries and fuel consumption values were calculated per the unit area as L/ha for the conditions.

Statistical Analyses

The study carried out on trial plots of 10 m (with) × 25 m (length), was planned in completely random block design with four replications for two years. The cultivation practices took two years. Standard analysis of variance was used to evaluate single factor effects on the seed yield and plant dry mass. Univariate analyses were performed to investigate the effect of the tillage applications on the seed yield and plant dry mass. Duncan's multiple range tests was used to compare the means. Data were analyzed using the Proc Mixed of SAS®. Means were compared for significant level (P<0.01).

RESULTS AND DISCUSSION

It was found that the seed yield for the conventional tillage, reduced tillage and direct sowing were determined as 2144.4 kg/ha, 1956.5 kg/ha and 1724.4 kg/ha, respectively (Table 2). The seed yield was the greatest (2144.4 kg/ha) in the conventional tillage compared to other tillage treatments. The lowest seed yield was 1724.4 kg/ha in the direct sowing application. This result is pertinent to plant density. As the plant density increased, so did grain yield. When compared to

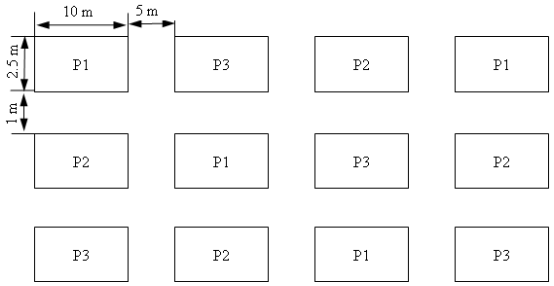


Figure 1: The practice pattern of rapeseed cultivation (P: Parcel of land)

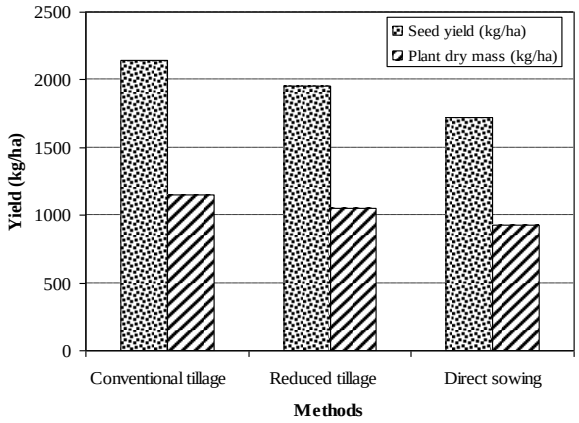


Figure 2: Effect of tillage methods on the seed yield and plant mass for rapeseed cultivation

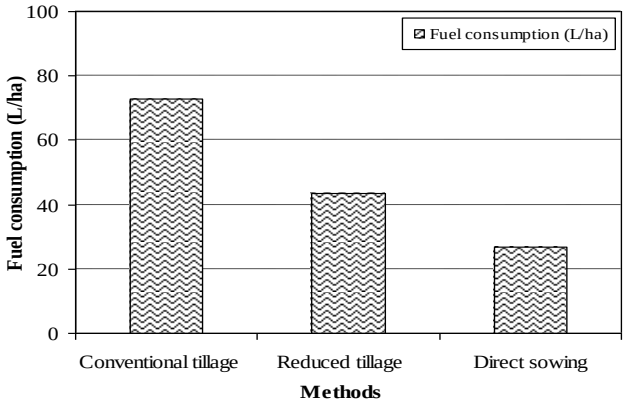


Figure 3: Comparison of the fuel consumption for tillage applications in rapeseed cultivation

conventional tillage, seed yield reduced in 8.76% and 19.58% proportions in reduced tillage and direct sowing applications, respectively. As expected, the highest plant dry mass was obtained as 1154.6 kg per cultivated area (ha) in the conventional tillage application. When compared to conventional tillage treatments, the plant dry mass were 101.1 kg and 226 kg less in reduced tillage and direct sowing applications, respectively. According to the results of statistical analyses, tillage systems have statistically ($P<0.01$) affected the seed yield and plant dry mass.

As can be seen from Table 1, for field operation, the lowest time spent was found 6.80 h/ha in the direct sowing application, whereas the highest time spent was found 15.48 h/ha in the conventional tillage. This situation shows that task time for field tillage increases due to increasing the pass number. Similar findings were observed for fuel consumption (Table 2). Owing to less the field traffic, the lowest fuel was consumed as 26.76 L/ha in the direct sowing. On contrary to this, the highest fuel consumption was measured as 72.76 L/ha in the conventional tillage because of increment of pass number on the field. When compared to conventional tillage treatments, the fuel consumption were 29.32 L and 46 L less per hectares in reduced tillage and direct sowing applications, respectively. When compared to conventional tillage, while the seed yield reduced in 8.76% and 19.58%, the fuel consumption reduced in 40.3% and 63.2% in reduced tillage and direct sowing applications, respectively, Generally, tillage systems with disc harrow had less task time and fuel consumption in comparison with other tillage systems with plough due to less pass number. According to the results of Least Significance Difference (LSD), tillage systems have statistically ($P<0.01$) affected the fuel consumption.

The values of specific fuel consumption and seed production were calculated for winter rapeseed production and given in Table 2. The specific fuel consumption for tillage methods can be calculated based on dividing fuel consumption (L) by its seed yield (tone=1000 kg). The specific fuel consumption (L/t), defined as the ratio of the total amount fuel (L) consumed in the production process to the total amount of harvested product (t). The value of the specific fuel consumption indicates the amount of fuel consumed (L) to produce the unit quantity (t) of seed product. The specific fuel consumption in winter rapeseed cultivation was 33.93 L/t, 22.20 L/t and 15.51 L/t, for the conventional tillage, reduced tillage and direct sowing applications, respectively. The lower value of the specific fuel consumption means the energy efficiency of production is higher. Taking into account, the values of specific fuel consumption, while 33.93 L fuel (diesel) was consumed to produce 1 tone rapeseed for the conventional tillage, 22.20 L fuel was consumed per tone rapeseed production for the direct sowing application.

The specific seed production (kg/L), as the inverse of the specific fuel consumption value, was defined as the ratio of the total amount of harvested seed product (kg) to the total amount of fuel (L) used in the production process. The value of the specific seed production indicates the total amount of harvested product (kg) from the unit production area (ha) corresponds to the unit amount of fuel (L) consumed for the production from the unit production area (ha). The specific seed production in winter rapeseed cultivation was 29.47 kg/L, 45.03 kg/L

and 64.43 kg/L for the conventional tillage, reduced tillage and direct sowing applications, respectively. The higher value of the specific seed production means the energy efficiency of production is higher. Considering the values of specific seed production, while 1 L fuel was consumed to produce 29.47 kg rapeseed for the conventional tillage, 64.43 kg rapeseed was obtained per liter (L) of fuel consumption for the direct sowing application.

CONCLUSIONS

In this experimental research, the effect of different tillage systems on seed yield and fuel consumption was performed for the winter rapeseed production. Taking into account the significant environmental advantages that can be obtained with the adoption of a reduced tillage system; reduced tillage appears the best method for the substitution of the mouldboard plough. Different tillage treatments have proved to be statistically important on seed yield of rapeseed production. 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.

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