THE degradation of soil has become an environmental problem which limits the sustainability of agriculture and decreases soil productivity. The most effective cause of degradation is either over cultivation or the utilization of improper tillage methods. In Turkey, sesame production is done as a second crop in dry or wet conditions after wheat harvest. Farmers generally burn the stubble after harvesting wheat and till the soil under excessive machine traffic. In this study, conventional and conservation tillages was compared in terms of some agricultural mechanization inputs, yield and some physical effects on the soil for second crop sesame after wheat harvesting. The systems consisted of conventional tillage (CT), reduced tillage with unstubble (RT) and reduced tillage with stubble (RTS). As a result, the lowest machine usage was determined as 12.99 h ha⁻¹ in reduced with unstubble tillage method. The most machine usage was 16.1 h ha⁻¹ in conventional tillage method. The lowest and highest fuel consumption were 26.4 l h⁻¹ and 35.2 l h⁻¹ with unstubble tillage and conventional tillage methods respectively. The lowest hydraulic conductivity in 5-10 cm, 15-20 cm and 25-30 cm was determined in reduced tillage with unstubble method. The highest porosity 5-10 cm, 15-20 cm and 25-30 cm was in conventional tillage method. There was no significantly statistical difference regarding yields for both methods.

Keywords: Sesame, tillage systems, soil properties, hydraulic conductivity, crop yield, time and fuel consumption.

INTRODUCTION Sesame (*Sesamum indicum* L. Pedaliaceae) is one of the oldest crops known to humans. There are archeological remnants of sesame dating to 5,500 BP in the Harappa valley in the Indian subcontinent (Langham and Wiemers, 2002). Sesame holds a special importance in the world’s oil production due to high quality 40-60% of sesame seed of composed of soil (Doğan et al, 2005).

According to FAO, in 2007, the reserved area for sesame seeding in the world was 7725706 ha, with the production rate of 3.38 billion tones year⁻¹ (Anonymous, 2009a). In Turkey reserved area for sesame planting was 28781 ha, the production rate was 20 million tones year⁻¹ in 2007 (Anonymous, 2009b).

In Turkey, sesame is produced as a second crop in dry or wet conditions after wheat harvest. There is no machine usage in sesame cultivation except soil preparing. Farmers generally burn the stubble after harvesting the crop wheat. They first use a moldboard plough and discharrow to till the soil and than use a float to break the clods. After an irrigation and treatment of discharrow and float twice, soil becomes ready for seeding. This intensive
method needs more energy combustion and more machine use and also burning the stubble is
harmful for soil structure and micro organisms.
Şelli et al. (2001), were conducted a three year study to determine the alternative soil tillage
methods instead of conventional tillage for second crop sesame in Harran plain conditions.
Four tillage methods and seeding methods were compared technically and economically.
They found that cultivator + float + seeding and rotary tiller + cylinder + seeding were the
best in yield. Though, the fuel consumption and labor were the lowest in these tillage systems.
Çıkman et al. (2006), compared the cotton sowing machine with stubble sowing ridge
machine, special stubble sowing machine, local sesame cultivator foot sowing machine,
cotton sowing machine with direct stubble sowing machine, local sesame sowing machine
with soil cultivated sowing (control) systems in terms of input. According to study, the
highest yield was 908.8 kg ha⁻¹ sowing machine with stubble sowing ridge machine and the
lowest yield was 809.4 kg ha⁻¹ local sesame cultivator foot sowing machine. The highest fuel
consumption was 56.9 l ha⁻¹ at control subject and the lowest fuel consumption was 7.31 l ha⁻¹
at local sesame cultivator foot sowing machine.
Polat et al. (2006), studied for determination of the best soil tillage method in sesame
production. In this study, four different tillage systems were compared in terms of their effects
on some physical properties of soil (bulk density, penetrometer resistance and porosity), fuel
consumptions, labor and time efficiency and crop yield. In the research, second crop sesame
was planted as rotational crop with four different tillage applications. The results of this
research were indicated that the rotarytiller and roller method had the highest bulk density
results and the highest crop yield (473.84 kg ha⁻¹). On the other hand, the plough, rotarytiller
and roller method had the highest porosity values. The penetrometer resistance values of soils
were decreased by all tillage applications from average 3.7 to 2.0 MPa. It was suggested that
rotarytiller and roller method can be used in sesame farming for the proper soil physical
properties and the highest crop yield.
In this sense, it will be helpful to determine the suitable soil tillage methods for a good soil
quality and fuel and time saving instead of conventional tillage systems.
In this study, conventional tillage system and two conservation tillage systems were compared
in second crop sesame cultivation for mechanization management and effects on soil physical
properties.

MATERIALS AND METHODS A field experiment was conducted during two growing
periods, in Mediterranean Region of Turkey. The Mediterranean region has hot and arid
summers and mild, rainy winters. The study field had a clay–loam texture in the 0–20 cm
surface layer (399 g kg⁻¹ sand, 298 g kg⁻¹ silt, and 304 g kg⁻¹ clay) with pH of 7.69, organic
carbon content of 7.3 g kg⁻¹, and bulk density of 1.31 Mg m⁻³. The soil consisted of 47% clay,
30% silt and 23% sand.
The agriculture equipments and machines used in this study were tractor, moldboard plough,
rotary tiller, float, discharrow and driller. The technical properties of tillage equipment used in
this study were given in Table 1.Muganlı-57 type sesame seed which is suitable for
Mediterranean Region was used in the study.
Table 1. The characteristics of the tillage and sowing equipment used in the research

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Type</th>
<th>Working width (m)</th>
<th>Working depth (m)</th>
<th>Working speed(^a) (km h(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plough</td>
<td>Four furrows</td>
<td>1.20</td>
<td>0.30</td>
<td>5.16</td>
</tr>
<tr>
<td>Disc harrow</td>
<td>32 discs</td>
<td>3.15</td>
<td>0.12</td>
<td>9.72</td>
</tr>
<tr>
<td>Rotary tiller</td>
<td>16 knifes</td>
<td>2.10</td>
<td>0.15</td>
<td>2.65</td>
</tr>
<tr>
<td>Float</td>
<td>1 unit</td>
<td>3.50</td>
<td>-</td>
<td>8.76</td>
</tr>
<tr>
<td>Drill</td>
<td>2 rows</td>
<td>1.14</td>
<td>0.04</td>
<td>8.75</td>
</tr>
</tbody>
</table>

\(^a\) Average working seed of the equipment used in the experiment

In the study three different methods were carried out on randomized plots of 650 m\(^2\) (13m x 50m) with three replications. The plot treatments were reduced tillage with stubble (RTS), reduced tillage without stubble (RT) and conventional tillage without stubble (CT). The methods were:

1. CT: Stubble burning + plough + float + irrigation + discharrow (2 passes) + float (2 passes) + drill
2. RTS: Stubble + irrigation + rotarytiller + float (2 passes) + drill
3. RT: Stubble burning + irrigation + rotarytiller + float (2 passes) + drill

The fuel consumption was determined by equipment which is mounted between the fuel tank and injection pomp. In order to determine the effects of soil tillage on the soil physical properties, bulk density, porosity, organic matter and hydraulic conductivity were determined on the soil sample which is taken by 100 cm\(^3\) cylinder. A sensible chronometer was used to measure the time for determining the rate of work.

The second crop sesame study was started in June with soil preparation after the wheat harvest and ended with harvest in October. It was used 300 kg ha\(^{-1}\) of 20.20.0 compose fertilizer. The row spacing was 55 cm. The seeding rate was 8.4 kg ha\(^{-1}\). There was no irrigation during growing periods after seeding.

To determine the emergence percentage, plants were counted randomly after 30 days from seeding. The average row spacing was determined by counting the plants in 2 m distance. At the end, the plant per hectare was calculated with these data.

In order to determine the effects of soil tillage on the soil physical properties, soil samples were taken from 3 different points in 3 different depths with 3 replications. The soil samples were analyzed in the laboratory and the bulk density, porosity, organic matter content and hydraulic conductivity under constant load were determined with the equations below (Klute and Dirksen, 1986):

\[
BD = \frac{Dw}{V} \tag{1}
\]

\[
P = \left(1 - \frac{BD}{SW}\right) \times 100 \tag{2}
\]
\[ HC = \frac{Q \times L}{A \times \Delta H \times t} \]  
\[ OM = 10 \left( 1 - \left( \frac{AFS}{T} \right) \right) \times 1.34 \]  

Where is BD bulk density (g cm\(^{-3}\)), Dw dry weight of the soil (g), V cylinder volume (cm\(^3\)), P porosity (%), SW specific weight (2.65 g cm\(^{-3}\)), HC hydraulic conductivity (cm h\(^{-1}\)), Q water content in soil (cm\(^3\)), L soil height (cm), A soil cross section (cm\(^2\)), \( \Delta H \) water height in soil (cm), t time (h), OM Organic matter (%), AFS Ammonium Ferro Sulfate for titration (ml) and T Ammonium Ferro Sulfate for sample (ml).

The basic management parameters as the efficiency of the equipment and the machines, the fuel consumption and the yield were calculated with the general equations in agricultural mechanization. All experiment data were analyzed by using the MSTAT-C statistics packet program for analysis of variance (Anonymous, 1988). The means were compared by LSD (Least Significance Difference) test at \( P \leq 0.05 \) to emphasize statistically significance of the results.

RESULTS and DISCUSSION

The basic management parameters of the methods in this study are given in Table 2. As seen, the lowest fuel combustion is 74.84 l ha\(^{-1}\) and 26.36 l h\(^{-1}\) in RT. The highest fuel consumption is 87.18 l ha\(^{-1}\) and 35.22 l h\(^{-1}\) in CT.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Time (h ha(^{-1}))</th>
<th>Fuel Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Machine</td>
<td>Labor</td>
</tr>
<tr>
<td>CT</td>
<td>16.10</td>
<td>24.44</td>
</tr>
<tr>
<td>RTS</td>
<td>13.07</td>
<td>21.38</td>
</tr>
<tr>
<td>RT</td>
<td>12.99</td>
<td>21.30</td>
</tr>
</tbody>
</table>

P<0.05

To determine the effects of soil tillage on the soil physical properties; the bulk density, porosity and hydraulic conductivity were investigated in 5-10 cm, 15-20 cm and 25-30 cm depths. The parameters were calculated before the tillage and after the tillage. As seen in Table 3, the porosity and hydraulic conductivity values before the tillage are lower than values after the tillage. In all treatments bulk density increases and the porosity and hydraulic conductivity decreases while the depth of the soil increases. The hydraulic conductivity value in conservation tillage with stubble is higher than the conservation tillage with unstubble and lower than the conventional tillage with stubble.
Table 3. Hydraulic conductivity (cm h⁻¹), porosity (%) and bulk density (g cm⁻³) according to soil depth for tillage methods

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hydraulic conductivity (cm h⁻¹)</th>
<th>Porosity (%)</th>
<th>Bulk Density (g cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>05-10 15-20 25-30</td>
<td>05-10 15-20 25-30</td>
<td>05-10 15-20 25-30</td>
</tr>
<tr>
<td>BST</td>
<td>0.71 0.39 0.19</td>
<td>50.95 43.21 41.13</td>
<td>1.30 1.51 1.56</td>
</tr>
<tr>
<td>BUST</td>
<td>0.30 0.11 0.01</td>
<td>47.55 43.21 40.38</td>
<td>1.39 1.51 1.58</td>
</tr>
<tr>
<td>CT</td>
<td>5.33 3.16 1.69</td>
<td>57.74 53.78 51.89</td>
<td>1.12 1.23 1.28</td>
</tr>
<tr>
<td>RTS</td>
<td>1.91 0.31 0.31</td>
<td>54.63 46.23 45.29</td>
<td>1.21 1.37 1.45</td>
</tr>
<tr>
<td>RT</td>
<td>0.42 0.14 0.06</td>
<td>52.41 48.40 44.86</td>
<td>1.27 1.43 1.47</td>
</tr>
</tbody>
</table>

BST: Before stubble tillage
BUST: Before unstubble tillage

The porosity in conservation tillage with stubble is higher than the conservation tillage with unstubble in 5-10 cm and 25-30 cm depth but lower than the conventional tillage with unstubble in all depths. The bulk density of the soil samples in conservation tillage with stubble is lower than the conservation tillage with unstubble but higher than the conventional tillage with unstubble. On the other hand, the bulk density in stubble area before tillage is lower than the unstubble area before tillage, the porosity and the hydraulic conductivity are higher before tillage than the unstubble area. The organic matter in stubble soil was 2.20% and the organic matter in unstubble soil was 1.98%.

As average of two years, effect of the tillage systems on plant number per area is shown in Table 4. Plant stand was affected statistically by soil tillage methods. The highest plant number was in RT with 881.64 plants per hectare. The lowest yield was calculated 324.90 kg ha⁻¹ in RTS and the highest yield was 342.87 kg ha⁻¹ in RT. The yield values were compatible with the results of plant density.

Table 4. The effects of the tillage systems on plant stand (plant ha⁻¹) and yield (kg ha⁻¹)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>CT</th>
<th>RTS</th>
<th>RT</th>
<th>LSD 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>plant ha⁻¹</td>
<td>790.318 c</td>
<td>747.273 b</td>
<td>881.637 a</td>
<td>10340</td>
</tr>
<tr>
<td>kg ha⁻¹</td>
<td>337.30 abc</td>
<td>324.90 bc</td>
<td>342.87 abc</td>
<td>62.38</td>
</tr>
</tbody>
</table>

CONCLUSIONS In the following there is a summary of this study which has done to determine the suitable soil tillage method for second crop sesame.

The lowest fuel and time combustion was 74.84 l ha⁻¹ and 12.99 h ha⁻¹ in RT. The time and fuel consumption were more in conventional tillage than conservation tillage. The highest yield was 342.87 kg ha⁻¹ in unstubble conservation tillage.

The porosity in conservation tillage with stubble is higher than the conservation tillage with unstubble in 5-10 cm and 25-30 cm depth but lower than the conventional tillage with unstubble in all depths.

The bulk density of the soil samples in conservation tillage with stubble is lower than the conservation tillage with unstubble but higher than the conventional tillage with unstubble.
As a result; to get the highest yield while protecting the soil efficiency will be possible by conservation tillage treatments and without burning the stubble but only burying the stubble to the top layers of the soil for sesame.

REFERENCES