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Tillage effects and energy efficiencies of subsoiling and direct seeding in light soil on yield of second crop corn for silage in Western Turkey

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Abstract

The objective of this study was to examine tillage effects and energy efficiencies of subsoiling and direct seeding on yield of second crop corn (*Zea mays* L.) for silage in light soil of Odemis located in the western part of Turkey. In this research, tillage and direct seeding were applied in dry and wet soil conditions after winter wheat (*Triticum aestivum* L.) harvesting in the years 2002 and 2003. The effects of conventional tillage method, reduced tillage methods that include one and cross pass subsoiling, and direct seeding applications on corn yield were examined. In the experiment, a regular four-row corn planter was used. Tillage speed, slip, fuel consumptions, seedling emergence, plant height, and yield were measured. From the data, total energy requirement and effectiveness of each method were calculated.

The highest fuel consumption was measured in conventional method (PLG) whereas the lowest value was found in direct seeding method (DIR) as 60.5 l ha^{-1} and 7.5 l ha^{-1} in 2002, respectively. The conventional method required seven times more fuel than the direct seeding method. For field efficiencies, as parallel to the finding in fuel consumption, the highest value was 1.34 ha h^{-1} in DIR and 0.40 ha h^{-1} in one pass subsoiling method (SUB I). DIR method had nine times more field efficiencies as compared to the conventional method. The highest yield was found in cross pass subsoiling method (SUB II) as 72.6 Mg ha^{-1} and 61.6 Mg ha^{-1} in the first and second year, respectively. Although DIR has minimum fuel consumption and maximum field efficiency, this method gave the lowest yield as 64.7 Mg ha^{-1} in the first year and 37.2 Mg ha^{-1} in the second year.

Keywords: Direct seeding; Subsoiling; Second crop corn

1. Introduction

Sustainable farming and increasing the cost of fuel in tillage operations force farmers to change the farming methods. Minimum tillage and direct seeding are some of the methods that farmers apply recently for a long-term erosion free farming at lower fuel cost. Considering the negative effect of intensive farming in the field, direct seeding becomes more vital for farmers for establishing the nature of the soil and flora allowing natural plant growth with less plant protection problems.

Weed manifestations and difficulties in seeding due to residues are the problems for the application of direct seeding, especially in a short-term. Although, most of these problems disappear in a long-run, but some insecticide problems remain. Observing the negative short-term effect of direct seeding, it seems the application of this technique requires regional adaptation regarding the soil type and plant production.

Subsoiling is vital especially for solving the hardpan problems due to the plough use. Subsoiling can also

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be used as an alternative to the plough in conservation tillage in light soils.

Subsoiling in severely compacted soils reduce the soil resistance and provides an increased root depth that helps the plants withstand short-term drought conditions (Cooper et al., 1969; Raper et al., 1998).

Velykis (2000) experiments showed that the effect of subsoiling depended on the method of loosening, and on the species of crops grown. He found that a higher amount of productive moisture accumulated in the soil loosened deeply, especially in the subsoil. But after subsoiling, subsoil bulk density decreased only when long-rooting crops were grown.

Adawi and Reeder (1996), in a study of compaction and subsoiling effects on corn and soybean yields and on soil physical properties, reported that subsoiling improved yields in compacted plots, but those yields were still lower than yields of the control plots. They also found that soil cone index, bulk density and total porosity were affected by compaction.

Raper et al. (1998) examined the four cotton tillage systems along with two traffic applications, including a conservation tillage practice of in-row subsoiling and planting into wheat residue stubble. They found that the best soil condition resulted from the conservation tillage practice of in-row subsoiling and planting. This practice produced the lowest cone index and the deepest hardpan depth.

Aykas and Önal (1999) studied the effect of different tillage methods on yield and weeding for wheat. They obtained the better grain and straw yield from reduced tillage (rotary-tiller) as 350 kg da^{-1} and 347 kg da^{-1} as compared to conventional and zero tillage system, respectively. They recommend that proper tillage system should be carefully selected in order to achieve a better weed control.

Yalcin (1998) studied the suitable tillage methods in second crop corn for silage. The experiment was a long-term base with main plant wheat. He found that the wheat yields were 2.40 Mg ha^{-1} and 3.35 Mg ha^{-1} for no-till planter and conventional system, respectively. The yield for second crop silage corn was 41 Mg ha^{-1} for conventional system and 42.88 Mg ha^{-1} for no-till planter.

Applying no-till and reduced tillage systems cause an increase in the soil moisture content (Hajabbasi, 2003). This helps conserving water in the soil. Soil conservation practices including residue management and no-till/reduced tillage, management may help constructing or improving soil structure.

According to the research findings, fuel consumptions of different tillage methods were found as 49.4 l ha^{-1} (100%), 31.2 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 direct seeding, respectively. Direct seeding saved 73% of fuel energy comparing the conventional method (Köller, 2003).

From the results of long-term research conducted by Megyes et al. (2003), it was found that crop production technologies based on reduced/conservation tillage methods may replace conventional ploughing systems and are applicable under the environmental conditions of Hungary.

The no-till planting method should be considered for highly erodible soils to reduce erosion by water and wind. For non-irrigated farms or farms that have irrigation problems, these techniques become important to keep the moisture in the soil. Leaving the residue on the soil surface prevents moisture loss. Since it is easy to work on and cut through the soil, direct seeding or at least reduced tillage methods should be practiced on light sandy soils.

Hence, this study was conducted to examine tillage effects and energy efficiencies of subsoiling and direct seeding on yield of second crop corn (*Zea. mays* L.) for silage in light soil of Odemis, located in the western part of Turkey. Reduced tillage methods (one and two pass subsoiling) and direct seeding were compared with the conventional tillage system.

2. Materials and methods

The experiments were conducted in the field of Odemis Vocational Training School, 38°19′S latitude and 28°06′S longitude, located 110 km away from city of Izmir which is the western part of Turkey, in the years of 2002 and 2003. The altitude is 123 m a.s.l.

The soils are classified as Typic Xerfluvent in the US Soil Taxonomy. The average annual temperatures of air and soil, relative humidity, and rainfall are given in Table 1.

For preparation of the experiment field, the baler was used to pick up the hay to cover 30% of the soil surface with residue in the field after wheat harvesting. The mean stubble height was measured as 25 cm. The field was divided into two zones. The first zone was kept dry and the other one was irrigated to obtain the planting conditions. Planting was achieved in dry and wet soil conditions. Dry soil was irrigated after planting. Each plot was 50 m long and 6 m wide with sandy soil having a texture of 0.2% clay, 14% silt, and 85.80% sand. Each tillage method was applied in the