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Strip tillage width effects on sunflower seed emergence and yield

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ABSTRACT

Strip tillage is a conservation practice in which narrow strips, generally totaling less than 50% of the field area, are tilled. We hypothesized that strip tillage would be beneficial for long-term soil quality improvement, erosion control, and environmental protection because it also protects crop residues so they can cover and continuously protect the soil surface. A two-year field experiment with three replicates was conducted to quantify effects of three strip widths on selected soil physical properties, seed emergence and yield of sunflower (*Helianthus annuus*). A powered row crop rotary hoe which is a group of narrow rotary tillers spaced evenly along the width of the toolbar and powered by the tractor power take-off was used to till soil in strips. The rotary hoe was equipped with C-type blades and was used to till strip widths of 37.5, 30 and 22.5 cm by changing the blade position and number of flanges on each row of the rotary hoe. A constant rotor rotational speed (370 rpm), forward tractor speed (5.4 km h^{-1}) and tillage depth (10 cm) were used to create the three strip widths that corresponded to tilled zones encompassing 50, 40, and 30% of the field area, respectively. A pneumatic seeder with 75 cm row intervals was used for planting. The results show that as strip width increased, soil temperature increased but soil moisture content decreased due to evaporation loss from the tilled surface of the strips. Sunflower seed emergence ranged from 67 to 93%, with the lowest levels occurring with 22.5 cm strips. Plant length and stalk diameter also increased as strip width increased. Seed yields for the two years also increased with strip width, averaging 4.4, 4.1, and 3.9 Mg ha^{-1} for the 37.5, 30 and 22.5 cm strip widths, respectively. Based on these results, although seed yield was least for the 22.5 cm strip width, tractor fuel efficiency was greatest for that width and the soil tended to retain more moisture for that width, compared to the 30 and 37.5 cm widths, so the 22.5 cm strip width is recommended to the eastern Turkey.

1. Introduction

Conservation tillage is a generic term defined as any tillage and planting system that after planting maintains a minimum of 30% crop residue cover on the soil surface to reduce soil and water loss (ASAE Standards, 2006). Specific examples include minimum tillage, no-till, strip till, ridge till and mulch till. Soil and water protection is achieved by maintaining crop residues, to partially cover and protect the soil surface. The net results include improving soil moisture status, yield or productivity (Fortin, 1993) and soil water quality (Baker and Laflen, 1983; Kettler et al., 2000). It can also reduce input costs and labor needs (Tebrugge and During, 1999). The effectiveness of conservation tillage on water-use efficiency and grain yield depends on several factors including soil type, crop requirements, rainfall probability, and soil water-storage capacity (Boone, 1988; Lampurlanes et al., 2002).

Global adoption of conservation tillage has been gradually increasing in response to concerns regarding the impact of agricultural production on the environment. Use of conservation tillage practices frequently reduces the negative impacts associated with conventional tillage systems which include energy use, soil erosion, leaching and runoff of agricultural chemicals, and carbon emissions (Uri, 1999).

Subtle differences in the various forms of conservation tillage can be summarized as follows. Minimum-tillage simply embraces fewer passes and minimal soil disturbance in comparison to traditional tillage. No-till systems create only a very narrow slit in the soil for planting and fertilizer application (Morrison, 2002). Strip tillage is relatively new, having been first evaluated in the early 1990s. It offers a unique opportunity to apply nutrients and prepare a narrow tilled seedbed in one operation. Strip tillage thus offers a potential solution to several problems associated with no-tillage, especially late seed emergence due to cool and wet soil

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conditions. The tilled zone enhances evaporation of water from soil and warming of the seedbed while minimizing total soil disturbance (Licht and Al-Kaisi, 2005).

Strip tillage for row crops can be beneficial for long-term soil quality improvement, erosion control, and environmental protection (Morrison, 2002; Luna and Staben, 2003). It combines the benefits of no-till and full-width tillage by creating narrow tilled areas that provide a good seedbed condition while leaving the inter-row space undisturbed and covered with crop residue. The tilled zones generally encompass less than 50% of the total field area, especially when they are only 15–30 cm wide (Luna and Staben, 2003; Licht and Al-Kaisi, 2005). By preserving crop residues to partly cover and continuously protect the soil surface, soil and plant-available water are increased, infiltration is enhanced, soil compaction is reduced, and machinery, fuel and labor costs are lowered (Luna and Staben, 2003; Anon., 2004).

In recent studies, Opoku et al. (1997) found that corn grain yield with strip tillage was higher than with no-till, and similar to conventional tillage which included moldboard plowing + disc harrowing. Wysocki (1986) reported crop yields were about 3% lower with strip tillage than conventional tillage. Lowther et al. (1996) suggested that strip tillage was the ideal method for pasture renewal, while Cruse (2002) found that slight corn production increases with conventional tillage were not sufficient to offset differences in total production costs, which were lower with strip tillage. Similarly, Mullins et al. (1998) determined that strip tillage increased corn silage and grain yield by 14 and 30%, respectively, when compared to conventional tillage, while Lamm and Aiken (2007) reported that conventional tillage increased corn yield by 5 and 3% compared to strip tillage and no-till, respectively.

Temesgen et al. (2007) compared strip tillage, with and without subsoiling, to a traditional system involving a Maresha plow. Using total evaporation data, they found that strip tillage, followed by subsoiling, resulted in the least surface runoff, highest transpiration, highest grain yield and highest water productivity. However, according to Morrison (2002), there is no need for deep tillage in a strip tillage system because shallow tillage is sufficient to increase corn yield just as much as deep tillage.

Celik and Altikat (2010) compared effects of various strip tillage widths on seedling emergence, plant growth and yield of silage corn. They determined that greater strip width increased soil temperature, seedling emergence, plant height and the silage yield, but also increased evaporation from the soil, resulting in lower soil moisture content. Bosch et al. (2005) reported that runoff with conventional tillage was 81% greater than with strip tillage. With regard to selected soil quality indicators, Bilen et al. (2010) found that increasing strip width in strip tillage increased soil CO_2–C fluxes and bacteria population, but decreased fungi population and soil bulk density.

Licht and Al-Kaisi (2005) reported that strip tillage accelerated the soil moisture loss a little more than no-till, but the primary difference was that it increased soil temperature by as much as 1 to 1.4 °C in the top 5 cm. Increases in soil temperature, particularly in poorly drained soils, can be beneficial when soil moisture conditions remain relatively near field capacity, although increases in soil temperature can be limited by excessively wet weather conditions. Overall, strip tillage appears to be best suited to poorly drained, wet, cold soils where seed germination is delayed. Strip tillage helps dry and warm the soils in the spring, easing planter operations and promoting seed germination (Al-Kaisi and Hanna, 2002). Strip-tillage thus has the potential to increase soil temperatures in-row while using inter-row residue cover to conserve soil moisture for plant growth and development.

Strip tillage is still a fairly a new tillage technique in Turkey, but is a simple, practical and effective form of conservation tillage that can be easily applied to various crops including sunflower. It has the potential to increase soil temperature in tilled strips which is important for seed emergence and plant growth in Eastern Turkey. Strip tillage also uses inter-row residue cover to conserve soil moisture for plant growth and development and reduces input costs. Strip width can be varied mechanically with specialized equipment, but little research has been done to determine optimum strip width for sunflower seed emergence and growth.

Sunflower has become one of the most important oilseed crops in Turkey during the past 30 years (Kaya et al., 2007) and is also important in many other locations around the world. This crop offers advantages in crop rotation, is highly adaptable to dry conditions, suitable for mechanization and generally has low labor input. Recognizing the increasing importance of sunflower, our objectives were to investigate effects of various strip tillage widths on selected soil physical properties, seed emergence, yield and yield components of this crop.

2. Materials and methods

Field experiments were conducted in 2008 and 2009 on a loam soil at the Agricultural Research Center of the Ataturk University at Erzurum, Turkey. The experimental site is 1800 m above sea level with nearly level topography. Precipitation, which occurs mostly during the winter and spring months, totaled 318 and 438 mm in 2008 and 2009, respectively (Anon., 2011). Mean annual temperature (1975–2010) is 5.4 °C, with monthly temperature ranging from −9.9 °C in January to 19.4 °C in August (Fig. 1). Some important pre-planting physical properties in the top 10 cm of soil at the experiment site are presented in Table 1.

The treatments consisted of three strip widths [37.5 cm (ST1), 30 cm (ST2) and 22.5 cm (ST3)], creating tilled zones that covered 50, 40 and 30% of the field area, respectively. A powered row crop rotary hoe, equipped with C-type blades (so named because they appear to be shaped like the letter "C" when viewed from the side) and powered by the tractor power take-off, was used to till soil and create the various strip widths by changing both blade position on the flanges and the number of flanges on each row. The rotary hoe was used with a constant rotor rotational speed (370 rpm), tractor forward speed (5.4 km h^{-1}) and tillage depth (10 cm). The experiment was designed as a randomized complete block with three replicates. Each plot was 3 m by 30 m, separated by a 1.5 m by 30 m buffer.

A two-wheel drive Ford 5000 S tractor with a maximum power of 49.4 kW at a rated engine speed of 2100 rpm, was used for this study. The forward speed of the tillage operation was maintained constant by using a DICKEY-john RVS II type speed radar sensor (Dickey-John Corp., Auburn, IL, USA) on the tractor.

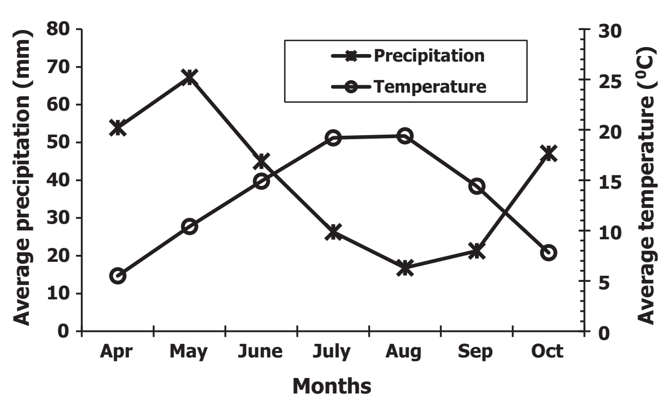

Fig. 1. Mean monthly rainfall and air temperature of growing season for 36-year average (1975–2010) at the experiment site (Anon., 2011).