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Research Article

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Reduced Tillage and No-Till Effect on Characteristics of Second Crop Silage Corn

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Abstract: This experiment will examine the characteristics of second crop silage corn impact of reduced tillage and no-till. Field studies were established in 2023 at the village of Inanlı, Muratlı District, Tekirdag Province. Two reduced tillage systems and no-till were used in the research and one is reduced tillage which is power harrow (RD-1) and the secondary is a heavy-duty disc harrow (RD-2) and the other is a no-till (NT) systems of tillage. In this study, plant leaf number, stub weight, stem diameter, plant height and yield values were investigated from the characteristic features of silage corn. The RED-2 method had the highest percentage of emerged seedlings 92,69%, followed by the RED-1 at 87,09%. The RED-2 tillage methods achieved the highest yield (4763 Kg da^{-1}), while the RED-1 achieved the lowest (3050 Kg da^{-1}). Although power harrow (vertical) method gives good preparation of the seedbed and high yield, direct seeding is recommended because it reduces field traffic and plant production cost and also prevents the soil erosion. It is confirmed that power harrow (reduced tillage) and no-till methods can be used in second crop silage corn in the region for a long term, more economic and erosion free sustainable agriculture.

Keywords: Corn, Soil tillage, Secondary crop, Yield

1. Introduction

One of the sectors most impacted by global climate change and population growth worldwide is agriculture. Among the challenges facing agriculture, drought emerges as one of the most critical issues. Defined as a natural phenomenon, drought occurs when precipitation significantly declines below the recorded average levels, adversely affecting land and water resources and disrupting the hydrological balance.

The growing emphasis on agricultural sustainability stems from various challenges associated with intensive farming practices, including excessive fertilizer use, environmental pollution risks, and the degradation of soil and water resources. Conservation tillage systems, as an alternative to plow-based seedbed preparation methods, offer significant potential for the sustainable management of soil resources [1]. Cultivation practices influence soil's physical, chemical, and biological properties, which in turn affect plant growth, development, and yield [2; 3; 1]. Numerous examples illustrate how improper agricultural management practices have led to a decline in soil quality [4; 1]. Research has extensively documented the impact of management techniques, such as tillage and crop rotation, on soil structural properties, particularly the stability and size distribution of soil aggregates [5; 6; 1]. For instance, [7] observed that residue cover in no-till systems enhanced soil aggregation and increased organic carbon content ([1] Hajabbasi and Hemmat, 2000).

Alternative agriculture seeks to promote healthier and more secure production systems compared to traditional agriculture, emphasizing the protection of natural resources and the environment. Achieving this objective necessitates the adoption of alternative methods capable of ensuring both efficient and profitable production. Among these methods, practices aimed at environmental protection and cost reduction are most commonly employed during soil preparation processes. The most notable of these practices are reduced tillage and no-till farming techniques. This study focuses on the use of reduced tillage combined with direct sowing to achieve several goals: enhancing soil organic matter levels, increasing soil nitrogen content, stimulating the activity of beneficial microorganisms, sequestering soil carbon, improving infiltration rates, and mitigating soil compaction, water erosion, and wind erosion.

2. Materials and Method

Materials

Site description

This experiment was conducted in 2023 in a village within the Muratlı District of Tekirdağ Province (41°18'N latitude, 27°46'E longitude) and involved satellite observations. Tekirdağ experiences a Mediterranean climate characterized by mild, rainy winters and hot, dry summers along the coast, while inland areas exhibit a more continental climate. Over a 64-year period (1939–2022), the region's average annual temperature was recorded as 13.88°C, with a relative humidity of 75% and annual precipitation averaging 580.8 mm.

The soil composition of the study area consists of 34.10% clay, 34.75% silt, and 31.15% sand, classifying it as clay-loam. The soil in the testing field was well-drained and capable of retaining approximately 0.18 m of water within a 1.20 m soil profile [8]. Laboratory analyses confirmed the clay-loam structure of the soil in the trial area.

Sowing and tillage systems

After harvesting wheat, the following six tillage methods were compared:

1. No-tillage; seeding by direct drill (NT);
2. Power harrow (vertical) + pneumatic precision drill (RED-1);
3. Heavy-duty disc harrow + pneumatic spacing drill (RED-2

Power harrows: The Drago DC is a power harrow specifically designed for small to medium-sized farms. Its robust construction, lightweight design, versatile range of accessories, and compatibility with Gaspardo seed drills make it an ideal choice for tractors with mid-range power. The Drago DC features an adjustable rotor speed, achieved by changing the gear pair within the gearbox, allowing users to easily fine-tune the equipment to meet specific operational requirements (Figure 2.5).

Penumatic sowing machine: The pneumatic sowing machine used in the experiment is designed with six rows, spaced 700 mm apart, with an inter-row spacing of 250 mm. This machine features a three-point attachment system, allowing it to be easily connected to a tractor. It is versatile and capable of planting a variety of seeds, including sunflower, corn, melon, watermelon, pumpkin, soybean, peanut, beet, cotton, cucumber, sesame, tomato, onion, carrot, and pea.

Disc harrow: The disc harrow is engineered for operations to a maximum working depth of 10 cm, making it suitable for seedbed preparation and crop residue management in minimum tillage applications. With working widths of up to 3 meters and an operational speed of up to 12 km/h, this implement offers high performance, catering to the needs of large-scale farmers and contractors. It is compatible with tractors up to 120 horsepower and features discs with a diameter of 520 mm.

Figure 1: Sowing unit of direct drill machine

No-till machine: The no-till machine is equipped with double-disc openers and is designed for planting crops such as corn, soybean, sunflower, sesame, cotton, peanut, and similar products. The machine features six rows with a row spacing of 700 mm. Its dimensions are 4300 mm in width and 2000 mm in height. The machine operates at a working speed of 4–8 km/h, with a PTO speed of 540 rpm (Figure 1).

Methods

Percentage of emerged seedlings

After planting, 10 meter long strips from six rows were determined in each plot. The plants that emerged from the first day of germination until the completion of germination were counted. Percentage of emerged seedlings was determined with the help of the equation below [9]; [10].

$$PE = \frac{Totalemergedseedlingpermeter}{Numberofseedsplantedpermeter} x100$$

Measurements of characteristics of plant

After harvesting, plant leaf number, stem diameter, stub weight and plant height were measured from 30 samples in each replication when dry matter was around 35% for each plot

Plant leaf number:

Stem diameter: The measurement of stem diameter in these harvested plants was conducted by employing a calliper to measure the diameter of one-third of the ground, as described.

Stub weight: The stub weight of each corn plant was determined by weighing the stub.

Plant height: The measurement was taken from the base of the corn silk to the bottom of the plant.

Yield

According to [11], it is commonly assumed that yields from the central area of a plot are more representative of real-world conditions compared to those from border areas. Therefore, measurements of plant height, stem diameter, and yield were conducted exclusively within the central area of the plot, which covered approximately 28 square meters. Corn was harvested when the dry matter content reached approximately 35% for each plot. The silage yield was determined by weighing all harvested plants within the plot.

Statistical analysis and experimental design

SPSS package program was used to determine whether there is a difference between the findings obtained in the study. Located parameters were compared statistically significant and variance analysis (ANOVA) using SPSS software (Version 12:00; Chicago, IL, USA) was made in statistical software program. Field trials were carried out in three replications according to random plots (Figure-2). The Duncan test (p≤0,05) was performed to investigate whether there are significant differences between the measured parameters caused by direct drill machine.[12].

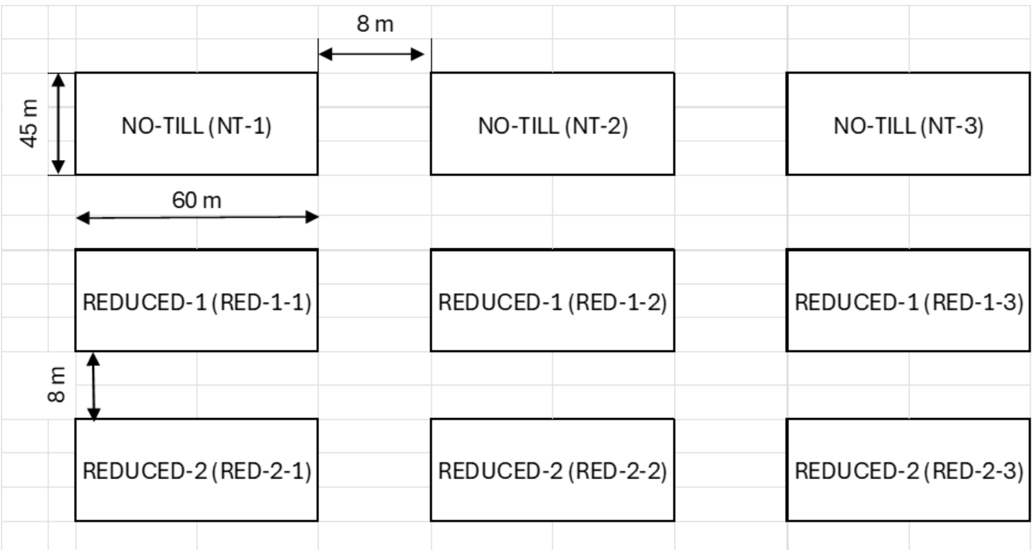

Figure 2: Experimental design for tillage systems

3. Results and Discussion

Percentage of emerged seedlings

According to Table 1, tillage methods had a significant impact on the percent emergence of silage corn (F = 12.495**). The lowest seedling emergence rate was observed in RED-1, with 87.09%, while the highest was recorded in RED-2, with 92.69% (Table 2 and Figure 3). Since the experimental field was irrigated after planting, it was evident that RED-1 exhibited higher water content at planting depth compared to other methods, contributing to its superior percent emergence (PE) results. Similar findings have been reported in [13; 14; 15; 16; 17; 18], which also highlighted that no-tillage and reduced tillage systems tend to retain higher soil water content, leading to improved emergence rates.

Table 1: Variance analysis table of emergence

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	48,074	2	24,037	12,495	0.07*
Within Groups	11.543	6	1,924		
Total	59,617	8			

** Significant at P<0,05

Table 2: Statistical data

Method	Average Emergence (%)
RED-1	87,09**B**
RED-2	92,69**A**
NT	90,63**A**

Tests were done by Duncan (%5)

Figure 3: Values of percentage emergence seedlings as affected tillage methods

Plant leaf number

A statistically significant difference was seen between tillage systems based on leaf number, as indicated in Table 3. The highest leaf number has RED-2 method and the smallest leaf number has RED-1 method (Tables 4).

Table 3: Variance analysis table of plant leaf number

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between groups	54,200	2	27,100	45,080	0,000**
Within groups	52,300	87	0,601		
Total	106,500	89			

** Significant at P<0,01

Table 4: Statistical data

Method	Average plant leaf number
RED-1	10,90**C**
RED-2	12,80**A**
NT	11,80**B**

Tests were done by Duncan (%5)

Stem diameter

The statistically significant difference in stem diameter between the two approaches was found in the experimental data (Table 5). Table 6 show that the steam diameter is greatest for RED-2 at 24,83 mm and smallest for RED-1 at 21,40 mm.

Table 5: Variance analysis table of stem diameters

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between groups	178,822	2	89,411	8,148	0,001**
Within groups	954,733	87	10,974		
Total	1133,556	89			

** Significant at P<0,01

Table 6: Statistical data

Method	Average Diameter (mm)
RED-1	21,40**B**
RED-2	24,83**A**
NT	23,43**A**

Tests were done by Duncan (%5)

Leaf of stub weight

The difference between the values related to the wet root weight according to the soil tillage methods applied was found to be significant as statistics (Table 7). Soil tillage methods were found in the same group and the maximum stub weight was in RED-2 with 349,59 grams, while the RED-1 was in a different group and the stub weight was found to be 209,23 grams (Table 8).

Table 7: Variance analysis table of leaf stub weight

Source	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	298652,147	2	149326,073	22,699	0,000**
Within groups	572329,429	87	6578,499		
Total	870981,576	89			

** Significant at P<0,01

Table 8: Statistical data

Method	Average leaf stub weight (g)
RED-1	209,23**C**
RED-2	349,59**A**
NT	291,91**B**

Tests were done by Duncan (%5)

Plant height

Statistically significant variations were found between the approaches with respect to plant height when the study's data were analysed (Table 9). According to Table 10, the RED-2 method achieves the highest plant height while the RED-1 method achieves the lowest.

Table 9: Variance analysis table of plant height

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between groups	23989,434	2	11994,717	14,979	0,000**
Within groups	69665,626	87	800,754		
Total	93655,060	89			

** Significant at P<0,01

Table 10: Statistical data

Method	Average plant height (cm)
RED-1	203,430**B**
RED-2	242,270**A**
NT	214,600**B**

Tests were done by Duncan (%5)

Yield

A statistically significant difference was observed between tillage treatments in terms of yield, as shown in Table 11. The RED-1 treatment resulted in the lowest yield, measuring 3.050,00 Kg da^{-1}, while the power harrow (vertical) tillage system produced the highest yield at 4.763,33 Kg da^{-1}. The no-till method yielded an intermediate result, with a yield of 3.300,00 Mg ha^{-1} (Table 12 and Figure 4).

Table 11: Variance analysis table of yield

Source	Sum of Squares	DF	Mean Square	F	Sig.
Between groups	5139355,556	2	2569677,778	167.831	0,000**
Within groups	91866,667	6	15311,111		
Total	5231222,222	8			

** Significant at P<0,01

Table 12: Statistical data

Method	Average Yield (Mg ha^{-1})
RED-1	3050**C**
RED-2	4763**A**
NT	3300**B**

Tests were done by Duncan (%0,05)

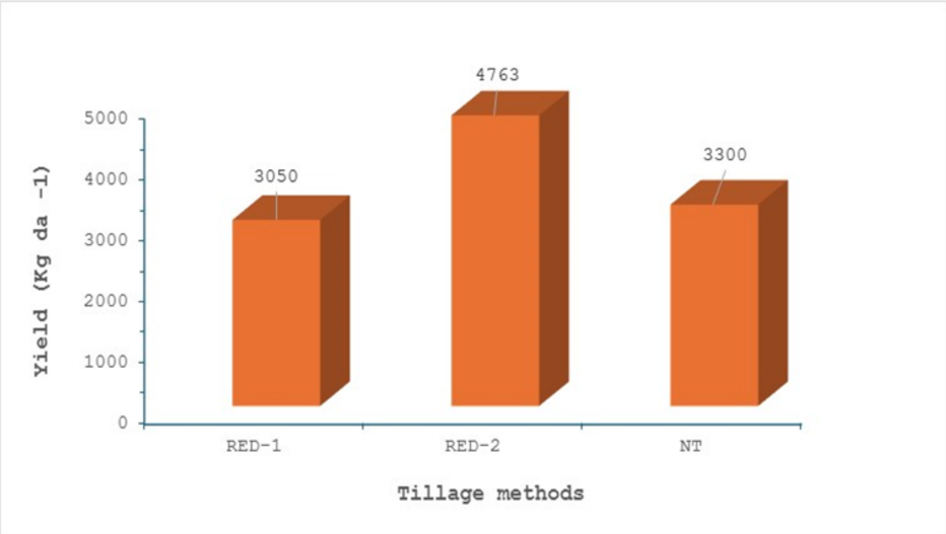

Figure 4: Values of yield as affected tillage methods

The low crop yield in this method was attributed to the reduced percentage of emergence. The results indicate that the percentage of emergence has a significant impact on crop yield. This finding aligns with [19], which reported that maize yields were higher in fields where deep tillage was performed compared to shallow tillage. Similarly, [20] highlighted that deep tillage and controlled field traffic significantly improved plant root depth, root density, and water use efficiency. Moreover, studies by [21; 19; 1; 17] emphasized that crop yields were consistently higher following deep tillage operations than after shallow tillage.

4. Conclusion

This study investigated the effects of reduced tillage and no-tillage methods on plant characteristics and yield of silage corn. The results revealed that plant leaf number, stem diameter, stub weight, plant height, and yield were statistically significant. The RED-2 method exhibited the highest percentage of seedling emergence at 92.69%, followed by RED-1 at 87.09%. In terms of yield, RED-2 achieved the highest value (4763 Kg da^{-1}), while RED-1 recorded the lowest (3050 Kg da^{-1}). Although the power harrow (vertical tillage) method demonstrated excellent seedbed preparation and high yield, direct seeding is recommended due to its ability to reduce field traffic, lower production costs, and prevent soil erosion. It was concluded that both the power harrow (reduced tillage) and no-till methods are viable options for long-term, economical, and erosion-free sustainable agriculture in second-crop silage corn production in the region.

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