The Effect of Different Tillage Methods on Plant Emergence Parameters for Wheat

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Abstract. Conventional tillage; it is an application where most of the plant residues are buried or burned under the ground, and the plant residues on the soil surface are less than 15% after planting. With the environmental awareness that developed after the 1970s, alternative methods have been developed that minimize the field traffic and soil tillage without overturning it. In this method, which is defined as conservation tillage, the main criterion is that the field surface is covered with at least 30% plant residue. Reduced tillage forms the subgroup of conservation tillage. In this system, chisel or disc tools are generally used for primary tillage, harrow disc or cultivators are used for secondary tillage and seedbed preparation. In tillage application, no-tillage is done before planting after the previous crop harvest. Sowing is done directly on the previous crop stubble without seedbed preparation. In this research; no-tillage (direct seeder), reduced tillage (rototiller) and conventional (moldboard plow + disc harrow + roller) tillage methods were tested in terms of plant distribution and plant emergence uniformity. The mean emergence date, emergence rate index and percentage of emergence values were calculated for that. In the research, the best mean emergence time value was determined in the reduced tillage method with 15.18 days, the highest emergence rate index and percentage of emergence value were determined in the conventional tillage method with 20.7 plants/day m^2 and 70.4%, respectively.

Keywords: Conventional tillage · Conservation tillage · Sustainable agriculture · No-tillage

1 Introduction

From past to present, the losses and problems of soil and water resources caused by human factors based on agriculture have led researchers to new searches all over the world. Many studies have been carried out by researchers for many years to protect and ensure the sustainability of these resources, which are of vital importance for future generations. [1–3]. Although there are different classifications in the world today, tillage methods are generally evaluated under two main headings: conventional tillage and conservation tillage, according to the previous crop plant residues left on the soil surface.

Conventional tillage: it is the soil tillage method with the highest field traffic. It is a tillage method in which a large part of the plant residues are buried underground

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and the plow is often used (Fig. 1). Processing the soil by conventional methods by creating intense field traffic greatly triggers soil compaction and erosion [4]. Our soils are damaged by significant degradation in the short and long term. It is of great importance to develop and disseminate a conventional method instead of this unsustainable method, which consumes more time, labor and energy. Methods that minimize field traffic and tillage the soil without turning it over have been developed in this application [5–7]. The conservation tillage method is examined under five headings; strip tillage, plant-tillage, mulch-tillage, reduce-tillage and no-tillage are the methods.



Fig. 1. Conventional tillage application (all plant residues on the soil surface after sowing are buried)

Reduced tillage, which is a subgroup of conservation tillage; in this method, chisel or disc tools are generally used for primary tillage and disc tools or cultivators are used for secondary tilalge and seed bed preparation. It provides significant fuel and energy savings compared to conventional tillage due to less machine traffic (Fig. 2).



Fig. 2. Reduce tillage application (superficial is processed and the stubble remains on the soil surface)

No-tillage method, which will be compared as an alternative to conventional tillage in the research; In planting, after the harvest of the previous crop, no soil tillage is

done before planting. In other words, planting is done directly on the previous crop stubble without any seed bed preparation. No-tillage improves the structure of the soil and maintains soil moisture (Fig. 3). Plant residues on the soil surface are of great importance in terms of soil protection [8]. It largely prevents wind and water erosion even if there are very few plant residues on the soil surface.



Fig. 3. No-tillage application (plant residues on the soil surface after sowing are more than 80%)

Research was conducted to compare technically and economically the conservation tillage and planting systems applied in wheat agriculture in the Çukurova Region. As a result of the evaluations, the highest wheat yield was obtained in the reduced tillage method, while the lowest yield was obtained in the two-row sowing method. The lowest value in terms of time and fuel consumption among the methods; Additionally, the highest value in terms of work efficiency was obtained in the no-tillage method. The no-tillage method provides savings of approximately 81–86% compared to other methods in terms of time consumption, fuel consumption and work efficiency [9].

A study was conducted to compare the technical and economic aspects of conventional tillage and conservation tillage and planting practices for second crop silage corn in the Çukurova Region. In this research, the fuel consumption and work efficiency of the machines, percentage of emerge, emergence rate index and mean emerge date were tested. The best results in terms of emergence rate index (1.63 day/m^2) were observed with conventional tillage. The best results in terms of percentage of emerge (%100) were observed with conventional tillage. As a result, the highest corn green grass yield was obtained in the stubble tillage method. Among the applications, the lowest fuel consumption and highest work efficiency were obtained in the no-tillage method. The no-tillage method provides savings of approximately 85–92% in terms of fuel consumption and work efficiency compared to other methods [10].

No-tillage and conventional tillage methods have been investigated in second crop sunflower agriculture. As a result of the research, the shortest average germination time was 6.55 days in no-tillage, while the longest germination time was 7.87 days in the conventional method. While germination was lowest in the conventional method with 88.63%, it was highest in no-tillage with 96.29% [11].

In a study comparing reduced tillage and direct sowing techniques with conventional tillage methods in wheat (Tritucum aestivum L.) production. In order to determine the

effect of tillage systems on the soil, their effects on bulk denstiy, penetration resistance and organic matter were also determined. The results found that the effects of tillage methods on soil bulk weight, penetration resistance and organic matter content were significant [12].

In a study, three different applications were used in wheat production. These are conventional tillage, reduced tillage and no-tillage practice. The effects of the applications on the penetration resistance of the soil, total fuel consumption, plant output values and yield were evaluated. The highest total fuel consumption (5.15 l/da) was obtained in the conventional tillage application and the lowest (0.91 l/da) was obtained in the no-tillage application [13].

Six different tillage systems, including conventional tillage and conservation tillage, were tested in this research. Bulk density, aggregate stability, organic matter content and soil penetration resistance were evaluated as indicators of soil quality in this study. Accord¬ing to the results of the research, conservation tillage systems (no-tillage) improved soil organic carbon content and aggregation stability. Different tillage systems showed a significant effect on the amount of organic matter and aggregate stability in the soil. Organic matter values were lower (49–60%) in conventional applications and residue burning accelerated the loss of organic carbon content. The highest aggregate stability values were found for no-tillage (38%). Penetration resistance and bulk density of plowed soils were lower than that of uncultivated plots, while heap density was 1.26–1.32 g at all soil depths in conventional tillage. As a result of their experiments, it has been shown that conservation tillage practices can provide better soil characteristic values than conventional practices in soils of the Adana region [14].

In the studies reviewed, the advantages of reduced tillage and no-tillage compared to conventional tillage can be listed as follows;

- Prevents wind and water erosion
- Protects and increases the amount of organic matter
- Reduces moisture loss in the soil
- Field traffic is minimized
- Sustainable yield
- It saves time
- Less fuel consumption occurs and saves energy
- Better plant emergence parameters
- It prevents the fatal damage caused by burning stubble to living things [15].

The studies examined show that; global warming, which means the continuous increase in the Earth's temperature due to the greenhouse effect, has disrupted the agricultural ecosystem and caused unexpected changes in agricultural climate elements such as drought, temperature, precipitation, weather events and sunlight. In terms of agricultural production, these negative changes lead to a decrease in product yield and quality, a decrease in soil fertility, an increase in soil erosion due to heavy rainfall, and an increase in diseases and pests. It is an important known problem of today that climate change increases the fluctuation in agricultural production and harms agricultural production in general. Therefore, considering the food security of the ever-increasing world population, it is extremely important to create sustainable agricultural production systems that will reduce greenhouse gas emissions, are resistant and sensitive to climate change,

and develop technological and innovative agricultural production methods. The advantages of conservation tillage methods are quite obvious. Conservation tillage methods are essential to maintain sustainability.

In this research, the conventional tillage method, reduced tillage and no-tillage methods applied in wheat agriculture were compared in terms of emergence uniformity parameters.

2 Methods

A field study was performed at the Çukurova üniversity, in the Mediterranean coastal plain of Turkey between 2019 and 2020. The site is located near Adana. The Mediterranean region has hot and arid summers and mild, rainy winters. The average annual rainfall was 625 mm; average annual temperature, 19 °C and average annual humidity, 67% (from 46% in October to 80% in August). The experiment was carried out on a clay soil, which was classified as a Typic Haploxerert. The soil consisted of 47% clay, 30% silt and 23% sand. Winter wheat (Triticum aestivum L.) were planted in 12 × 40 m trial plots using a completely randomized block design with three replications. In the study, three different tillage methods consisting of conventional tillage, reduce tillage, no-tillage (Fig. 4). Equipment used in conventional tillage; moldboard plow, disc harrow (two times), roller (two times) and seeder. Equipment used in reduce tillage; rotatiller with roller and seeder. Equipment used in no-tillage; direct seeder.



Fig. 4. Trial plots

In field trials, daily plant emergence after wheat planting and the distance between successive plants in the same row were measured when emergence was fixed. Emergence uniformity was determined using a 1m2 iron circle in measurements made on random sample rows after planting (Fig. 5).

Plant counts started with the first plant emergence and continued at the same time every day until plant emergence stabilized. With these counts, mean emerge date (MED), emergence rate index (ERI) and percentage of emerge (PE) values were calculated. Mean emerge date is the average emergence time of emerging plants until plant emergence stabilizes. Emergence rate index is the number of plants emerging per day per unit length. Percentage of emerge is the ratio of the number of plants germinating per day per unit

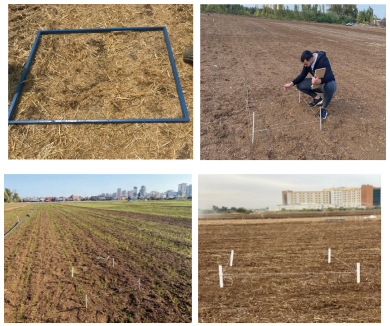

Fig. 5. Taking samples for emergence uniformity

length to the number of seeds planted per unit length. These parameters were calculated with the following equations [16].

$$MED = \frac{G_1B_1 + G_2B_2 + \cdots + G_nB_n}{B_1 + B_2 + \ldots + B_n}, \quad PE = \frac{\text{Nb}}{\text{N}}, \quad E\dot{R}\dot{I} = \frac{\text{Nb}}{MED}$$

MED: Mean emerge date (day)
ERI: Emergence rate index (plant/day)
PE: Percentage of emerge (%)
B: Number of young plants emerging since the previous census.
G: Number of days after planting
Nb: Number of plants per unit length (plant/m^2)
N: Number of seeds planted per unit length (seed/m^2).

3 Results

In the field trials of the research, the best mean emerge date (15.18 day) was observed in reduced tillage. The longest mean emerge date (16.53 day) was determined in the conventional tillage method with (Fig. 6). Since conservation tillage methods have more plant residue on the field surface than conventional tillage methods, they provide higher soil moisture and plant emergence is observed in a better time. These results agreed with those obtained by Bayhan [11].

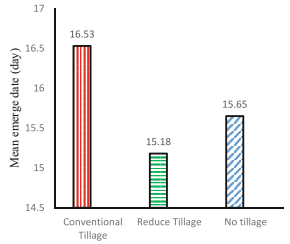

Fig. 6. Mean emerge date values (day)

The best results in terms of emergence rate index (20.7 day/m^2) were observed with conventional tillage (Fig. 7). Similar results were obtained with the research conducted by Karaağaç and Barut [10].

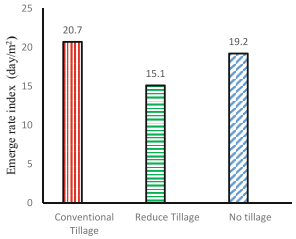

Fig. 7. Emerge rate index values (day/m^2)

When the percentage of emerge (70.4%) were examined in the research, the best results were determined in conventional tillage (Fig. 8). In conventional tillage, the field is tilled many times to prepare a good seed bed. This provides better plant emergence.

In the conservation tillage method, field traffic is minimal. Therefore, lower short-term outputs are achieved. In addition, intensive field traffic in conventional tillage increases input costs significantly, so the conservation tillage method is thought to be a more profitable application. Similar results were obtained with the research conducted by Karaağaç and Barut [10].

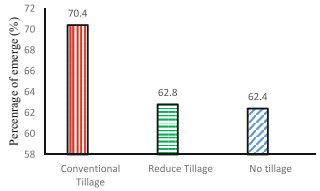

Fig. 8. Percentage of emerge values (%)

4 Conclusion

In this research, conventional tillage method, no-tillage and reduced tillage were tested in terms of emergence uniformity parameters. As a result of this trial, different tillage methods were compared by calculating the mean emerge date, emergence rate index and percentage of emerge values. In the research, the best mean emerge date was determined in the reduced tillage method, while the highest emergence rate index and percentage of emerge value were determined in the conventional tillage method. Soils damaged by intensive tillage applied in conventional tillage, reduce tillage can be an alternative treatment method compared to other tillage methods in wheat production, in terms of uniformity parameters and input costs. It is recommended to develop and investigate an efficient method that can be applied in reduced tillage method.

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