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INVESTIGATION OF DIFFERENT TILLAGE AND SEEDING METHODS IN SAFFLOWER (*Carthamus tinctorius* L.) CULTIVATION

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Abstract

The aim of this study is to determine the effects of different tillage and seeding method on some soil physical properties and some plant growth parameters in safflower (Carthamus tinctorius L.). In the study, conventional tillage (CT), reduced tillage (RT) and direct seeding (DS) method were used.
According to results, the highest bulk density at 0-20 cm soil depth was found in CT method, followed by RT and DS method respectively. The highest porosity at 0-20 cm soil depth was determined in the DS method followed by RT and CT methods respectively. Soil penetration resistances for 0-25 soil depth were found to be 1.50, 1.96 and 2.37 MPa for CT, RT and DS methods, respectively. Weed growth for CT, RT and DS methods were found to be 26.3%, 31.3% and 42.5% respectively. Grain yields for CT, RT and DS treatments were 1340, 1160 and 1070 kg ha^{-1} were found, respectively. The highest seedling emergence rate was obtained at CT treatment and the lowest at DS treatment. The least seedling emergence time was obtained at the DS treatment and the longest at the CT treatment.

Key words*: tillage systems, safflower, direct seeding, reduced tillage.*

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) seed is an important source of oil also its flowers are an important source of spice. Safflower flowers can be in red, orange, yellow and rarely white colors (Erbas and Baydar, 2017). Safflower oil in the semi-drying oil group is also evaluated in the construction of paints, varnishes, polishes and soaps (Ogut and Oguz, 2006). In our country, as of 2016, there are 39,500 ha plantation area, 58,000 tonnes total production and 147 kg da^{-1} seed yield (Anonymous, 2017). Safflower plant can be grown in different climates, as well as the use of all the equipment used in wheat-barley farming in the cultivation of this plant is an important advantage (Coskun, 2014). Although there are studies on different tillage methods for many plants, no studies have been done for safflower plants. In a study conducted by Kucukalbay and Akbolat (2015) on different tillage methods in chickpea cultivation, the highest yield was found in the conventional tillage, the highest weed growth was in direct seeding, the lowest penetration resistance was in the conventional tillage method, and the highest grain yield was obtained in the direct seeding method. Barut et al. (2010), in a four-year study of traditional, reduced and direct sowing methods in wheat farming; the highest penetration resistance were found in the reduced tillage and direct seeding methods, and the highest soil bulk density was found in the direct seeding method. Martinez et al. (2008) reported that for many years, in the study of conventional tillage and no-till method in wheat production, while the no-till method increased the stability of aggregate positively for many years, it affected other physical properties of soil negatively. Bayhan (2016) evaluated the different tillage and direct seeding methods of sunflower cultivation in terms of energy use efficiency. According to the results, the lowest energy output / input ratio is determined in reduced tillage method while the highest energy output / input ratio is determined in direct seeding method. Bayhan (2015) reported that in a study using disc harrow, rotary tiller, disc harrow + combined harrow and direct seeding methods as the

[1]The data of this study were taken from the master's thesis titled "Investigations of tillage and seeding methods at safflower cultivation".

tillage methods, the highest crop yield was obtained in the rotary tiller and the lowest crop yield was found in the method using disc harrow. Lopez-Garrido et al. (2014), in a study of conventional, reduced and non-till methods for sunflower cultivation, grain yield was lower in the no-till system, while penetration resistance was found to be higher than the other methods. Kasap and Dursun (2013) have tried five different tillage methods in their study to determine the different tillage methods used in the cultivation of chickpea and their effects on yield and yield component. According to the results obtained, the highest grain yield (260.6 kg da^{-1}) was obtained by the conventional tillage method whereas the least grain yield was obtained by direct seeding method (80 kg da^{-1}). Kaya et al. (2010) compared the yield and economic aspects of conventional tillage and direct seeding methods in dry climates of Chickpea-wheat planting. It has been reported that direct seeding methods on grain yields are ineffective and conventional tillage method is more profitable economically in chickpea cultivation. According to the results of many studies on soil tillage and direct seeding methods, the maximum weed growth was determined by direct seeding method while the least weed growth was determined by conventional tillage method (Cardina et al., 2002; Khattak, Khan 2005; Çakır et al. 2006; Celik, Altıkat, 2006; Jan et al., 2010).

The aim of this research is to determine the effect of soil tillage methods on soil physical properties, grain yield and plant growth parameters of safflower in the province of Eskişehir.

MATERIALS AND METHODS

A field experiment was conducted in a farm belong to a farmer during the growing season of 2016 at the Seyitgazi district of Eskisehir province of Turkey. According to Eskişehir province of Seyitgazi district of meteorological data; minimum, average and maximum air temperatures are -2.6°C, 10.6°C and 35.5°C respectively. The average annual precipitation of the Seyitgazi district is 365.0 mm. The content of soil organic matter of test area is 2.66% and pH is 6.32. It has also acidic and clay loam soil texture type.

As a seed in the experiment, Dincer variety safflower seeds were used. Dinçer variety, 90 to 110 cm in height, flower colour is orange, grain colour is white and has a medium thorn structure. In the trial, a four-wheel drive tractor with 90 HP power was used to seedbed preparation. The methods and equipment used in the experiment are given below in Table 1.

Table 1. Details of the tillage and sowing methods used in the experiment

Treatment	Details
CT (Conventional tillage)	Tillage with moldboard plow in the autumn with a depth of 30 cm + tillage with the cultivator at 15 cm depth in the spring (1 time) + scrapper + seeding with seed drill.
RT (Reduced tillage)	Tillage with cultivator at depth of 15 cm in the spring + scrapper + seeding with seed drill.
DS (Direct seeding)	Seeding with direct seeding machine.

Soil sampling cylinders with a volume of 100 cm^3 were used to determine the soil bulk density and porosity.

The samples taken from trial plot were dried in oven at 105°C for 24 hours according to Blake and Hartge (1986). Eijkelkamp (Eijkelkamp Equipment, Model 06.15 Eijkelkamp, Giesbeck, The Netherlands) Penetrologger was used to determine the soil penetration resistance.

Penetrologger memory is 1500 measurements, force resolution 1 N, maximum penetration resistance 1000 N measurement depth 80 cm, depth resolution 1 cm.

The experiment was consisted of 9 plots, three treatments and three repetitions according to randomized plot design. The experiment was consisted of 9 plots, three treatments and three repetitions according to randomized plot design.

In the CT treatment, first tillage was performed in the autumn by a 30 cm depth with a mouldboard plow. In the spring, seedbed was prepared with the cultivator and the field was

made ready for seeding. Cultivator was used for soil preparation in RT treatment and seed drill was used for seeding.
In DS treatment, any soil tillage was not carried out for seed bed preparation.
Total herbicides were used in all treatments to control weeds before seeding.
Weeds were measured 20 days after seeding to determine the effect of soil tillage and seeding methods on weed growth.
For this purpose, weed quantities were determined by counting weeds remaining in a 1 m 2 frame at three points randomly determined in each parcel (Demirkan and Ark, 1991).
The average germination time (day) and emergence rate (%) of safflower seed were determined according to Mohanty and Painuli (2004). Also plant height (cm), head diameter (cm), number of branch (piece), first branch height and number of head per plant values were determined as plant growth parameters.
The yield was determined by the yield cycle method. In this method, circles with an internal area of 1 m^2 were used.
When the safflower was matured, the remaining plants in the circle which were dropped at three different location of each plot, were harvested by hand.
Then these plants were threshed and the safflower yield in the decare (kg/decare) was determined.
Data were analysed using analysis of variance (ANOVA). Means separation among the treatments was determined by LSD test at 5% significance.

RESULTS AND DISCUSSIONS

This study was conducted during the summer season of 2016. In the study, the conventional and reduced tillage methods applied by the farmer in the region where safflower was grown and direct seeding methods which could be alternative to this method were selected.
There was no statistically significant difference in terms of soil moisture content between the treatments.
In other words, the effect of the treatments on the soil moisture content was not significant (p=0.05).
The soil bulk density and porosity according to the treatments is given in Figure 1.

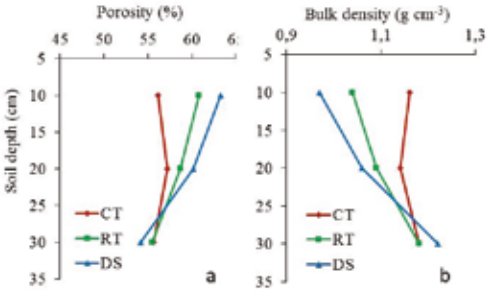

Figure 1. Soil porosity (a) and bulk density (b)

Soil porosity was decreased with depth increasing in all treatments. While the highest soil porosity was obtained in 0-10 cm soil depth at DS treatment (59.2%), the lowest soil porosity was obtained in 0-10 cm soil depth at CT treatment (56.3%). The difference between the treatments was found statistically significant in terms of soil porosity at 0-10 cm soil depth (p=0.05). While the treatments in 10-20 cm soil profile depth were different from each other, the differences between the treatments were not significant at 20-30 cm soil profile depth.
The highest soil bulk density was determined at CT treatment with a depth of 0-10 cm as 1.22 g cm^{-3} while the lowest soil bulk density was determined as 0.97 g cm^{-3} at a depth of 0-10 cm at DS treatment. The bulk density and porosity values obtained in the study are the opposite of the results obtained by Akbolat et al. (2009) and Kucukalbay and Akbolat (2015) for similar treatments. This may be because the first tillage in the CT and RT treatments have already been tilled at the autumn and the soil may be compacted in the time until the seeding. The soil penetration resistance results according to the treatments are given in Figure 2.

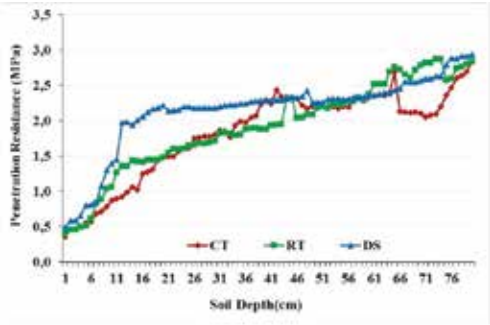

Figure 2. Soil penetration resistance results

The difference in the penetration resistance between the treatment was more evident in the soil depth of 0-25 cm. The penetration resistance difference in the profiles with a depth of 25 cm or more was declined gradually. The penetration resistance averages at 0-25 cm soil depth were determined as 1.50, 1.96 and 2.37 MPa for CT, RT and DS treatments, respectively. The mean penetration resistances at 0-80 cm soil depth were 2.13, 2.28 and 2.48 MPa for CT, RT and DS treatments, respectively. As a result, the difference between treatments in terms of penetration resistance was found to be significant for 0-25 cm soil depth (p=0.05). Küçükbay and Akbolat (2014) reported that they found penetration resistances at soil depths of 0-25 cm for CT, RT and DS treatments as 1.50, 1.96 and 2.37 MPa, respectively.

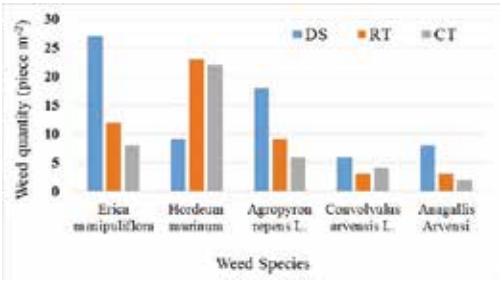

Figure 3. Weed species and amounts according to treatments

Our results are consistent with the findings of Kucukalbay and Akbolat (2015) for similar treatments.

In the study conducted to determine the effects of tillage and seeding methods on weed growth, the most weed growth was determined at DS treatment and the least weed growth at CT treatment. Among the weed species, the highest number of broom (*Erica manipuliflora*) was detected in the DS method while wild barley (*Hordeum murinum*) was detected in the RT and CT methods (Figure 3).

These varieties were followed by couch-grass (*Agropyron repens* L.), bindweed (*Convolvulus arvensis* L.) and scarlet pimpernel (*Anagallis arvensi*), respectively. According to the treatments, weed growth percentages for CT, RT and DS were 26.3%, 31.3%, 42.5% respectively. The difference between the treatments in terms of weed growth was found to be statistically significant (p=0.05). Ozpinar (2005) found to be the least weed growth in the CT method, Kucukalbay and Akbolat (2015) found to be the most weed growth in the RT method. Shresta et al (2002) found to be insignificant the effects of the soil tillage methods on weed growth. Plant growth parameters is given below Table 2.

Table 2. Average results for plant growth parameters and yields

Treatments	Seedling emergence rate (%)	Seedling emergence time (Day)	Plant height (cm)	Head diameter (cm)	Number of branch	First branch height (cm)	Grain yield (kg ha^{-1})	Head number per plant
CT	75^{a}	22^{a}	65.9	2.06	5.2	42.8	1340	10.53^{a}
RT	49^{b}	21^{ab}	65.9	2.06	5.3	46.2	1163	8.86^{b}
DS	51^{b}	17^{b}	66.5	2.21	5.3	43.1	1070	13.20^{c}

Means that do not share a letter are significantly different.

The effect of treatment on seedling emergence time and seedling emergence rate according to Fisher Pairwise Comparison test was found to be statistically significant (p=0.05). The average plant emergence times of the treatments varied between 17-22 days. The earliest seedling emergence was found in DS treatment with 17 days, and the latest plant emergence was found in CT treatment with 22 days. Kucukalbay and Akbolat (2015) stated that seedling emergence time for CT, RT and DS treatment were found to be 22.4, 23.5 and 23.1 day in chickpea cultivation. They also reported that there was no difference between the methods in terms of seedling emergence time. Their results are compatible with our results. Soil tillage and seeding methods were found statistically significant on seedling emergence rate. While the highest seedling emergence rate was obtained at CT treatment with 75%, the lowest seedling emergence rate was obtained at RT method with 49% (Table 2).

The highest plant height was obtained at DS method with 66.5 cm and the lowest plant height at RT method with 65.9 cm. However,

this difference was found statistically insignificant (p=0.05).

In the study conducted to determine the effect of tillage and seeding methods on yield of safflower, it was determined that the treatment was statistically insignificant on grain yield. The grain yields for CT, RT and DS treatments are obtained 1340 kg ha^{-1}, 1163, kg ha^{-1} and 1070 kg ha^{-1}, respectively.

While the lowest grain yield was obtained at DS treatment with 1070 kg ha^{-1}, the highest grain yield was obtained at CT treatment with 1340 hg da^{-1}. In a study conducted by Ozturk et al (2008), yield of safflower was found to be 1143 and 1140 kg ha^{-1} for irrigated and non-irrigated highland in 2002 growing season. These results are lower than the results we found for CT treatment that the method of commonly applied.

Head diameter development, which is the criterion for plant development, was found to be statistically insignificant among the treatments (p=0.05).

According to the treatments, mean head diameters were 2.06, 2.06 and 2.21 cm for CT, RT and DS, respectively. The highest head diameter was determined at DS treatment with 2.21 cm and the lowest head diameter with 2.06 cm at RT and DS treatments.

Tillage and seeding methods have been determined to be statistically significant on the number of head per plant.

The Tukey test was used to check the difference among the treatments. Head number per plant was determined as 10.5, 8.9 and 13.2 for CT, RT and DS treatments, respectively.

The effect of the methods used on the number of branches per plant was found statistically insignificant.

The average number of branches per plant varied between 5.33 and 5.20; The highest number of branches per plant was determined at RT treatment with 5.33, and the lowest number of branches was determined at CT treatment with 5.20.

The effect of the treatment on the first plant height was found statistically insignificant. The first branch heights of the plants for CT, RT and DS treatment were found to be 42.85, 46.20 and 43.11 cm, respectively.

CONCLUSIONS

There was no significant difference between the grain yields of treatments, even if the yield was relatively low in direct seeding treatment. The highest seedling emergence rate was obtained at CT treatment and the lowest at DS treatment. The least seedling emergence time was obtained at the DS treatment and the longest at the CT treatment. While the least number of heads per plant was determined at the RT treatment, the most heads per plant was determined at the DS treatment. while the most weed growth was obtained at DS treatment, the least weed growth was obtained at CT treatment. The highest penetration resistance (1.50 Mpa) was measured for 0-25 cm soil depth at DS treatment whereas the lowest penetration resistance (2.37 Mpa) was measured at CT treatment. While the bulk density in CT treatment was the highest, the bulk density in DS treatment was least.

It is a fact that the grain yield in the first years in reduced tillage method and direct seeding methods is lower than in the conventional tillage method. However, according to previous studies that increasing in soil productivity in the conservational tillage method will increase the yield in the next years. This research results present that, in terms of sustainability, safflower plant could be cultivated by applying conservational tillage methods as it is in other crops cultivation.

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