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Research Article

Effects of Traditional Tillage, Conserved Tillage and No Tillage Methods and Some Allelopathic Practices on Weed Growth in Organic Vineyards

Koray KAÇAN[*1], **Fadime ATEŞ**[2], **Engin ÇAKIR**[3], **İkbal AYGÜN**[4]

[1]Muğla Sıtkı Koçman University, Research and Application Center, 48000, Muğla, Turkey
[2] Viticulture Research Institute, Atatürk Neighbourhood, Horozköy, 45125, Manisa, Turkey
[3,4]Ege University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering, 35040, İzmir, Turkey

[1]https://orcid.org/0000-0003-3316-9286, [2]https://orcid.org/0000-0003-4466-4573, [3]https://orcid.org/0000-0003-4573-4991
[4]https://orcid.org/0000-0003-1144-913X

*Corresponding author's e-mail: koray099@hotmail.com

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Abstract: This study was carried out to determine the effects of some tillage methods; it included conventional tillage and conservation tillage with some weed control applications on weed manifestation in organic vineyards. The organic vineyard experiment area was designed as main and sub-plots. The effects of some methods of conventional tillage, no-tillage, and conservation tillage on weed coverage, densities, fresh weight, and dry weight were determined in the organic vineyard experiment area. These tillage methods were applied in the main plots. A chisel and heavy-duty disk harrow were used for conservation tillage methods. The plough and disc harrow were also applied as conventional methods. Other allelopathic methods (olive mill wastewater, radish (*Raphanus sativus* L.), and broccoli (*Brassica oleracea* L.) were applied as sub-plots in the experiment area. As a result of the statistical analysis of the values obtained in the study, the most effective method, the application of the plough and disc harrow, was determined for weed coverage and fresh and dry weight weeds in the main plots. The olive mill wastewater was also determined as the most effective application in the sub-plots. In terms of grape yield, the most effective method in the main plots was the plough + disc harrow application (6.8068 kg vinestock^{-1}). The planting of broccoli (6.4485 kg vinestock^{-1}) was determined as the most effective sub-plot application for grape yield.

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1. Introduction

Equivalent to the increasing use of pesticides in agricultural areas, it is inevitable that the practice of sustainable agriculture will be disturbed as a result of improper practices. In addition, the negative effects of intensive pesticide use on the environment and human health cause increasing health concerns. Therefore, the conscious use of agricultural land to meet the adequate nutritional needs of the world's population (İlter et al., 1998, Aksoy and Altındişli 1999) and alternative methods to conventional agriculture and their integrated management should be investigated. The loss of crops caused by diseases, pests, and weeds is approximately 67.15% in some important crops such as wheat, corn, paddy, cotton, and soybeans in the world. This loss is caused by 13.78% from disease, 21.75% from pests, and 32% from weeds (Oerke and Dehne 2004).

In Turkey, depending on the type and density of weeds, the average yield loss varies between 10%–50% (Tepe, 1998); however, the yield loss is known to occur in even larger amounts depending on crops. The amount of pesticides used to eliminate these losses is increasing. Besides the many damaging effects of weeds, the most important damage is that they cause a decrease in crops; this decrease amounts to an average loss of 10% in worldwide production (Oerke, 2006). Pesticide use is increasing the cost of production exponentially and causes the irreversible destruction of agricultural systems, as resistance to harmful organisms is caused by intensive pesticide use. According to FAO (Food and Agriculture Organization), the worlds' pesticide use has reached 4 122 334 tons (FAOSTAT, 2018), meaning 41.5% of the pesticide market is used by herbicides, plant growth regulators, and growth inhibitors, 27.1% is used by insecticides, 21.5% by fungicides and 9.9% by other chemicals (FAOSTAT 2017). Using the amount of pesticides is 60 020 tons in Turkey. This amount consists of 20 450 tons of fungicide, 12450 tons of insecticides, herbicides 10025 tons, rodenticides 259 tons, and 6 835 tons of other pesticides (FAOSTAT, 2018). It is known that 0.015%–6% of pesticides used in agriculture reach target organisms. The remaining use of the 94.0%–99.9% of pesticides is mixed with the ecosystem (Yıldız et al., 2005).

Pesticide residue damages the soil, flora, and fauna, which play an important role in the soil. They also pass from the soil to the crops and from there to humans and animals causing harmful effects on the food chain. Pesticides enter groundwater and the atmosphere through evaporation, adversely affecting the reproductive ability of fish and bird populations, along with many other organisms, thereby causing the destruction of organisms (Kortekamp, 2011). However, in organic agriculture, which alternates conventional agriculture with chemicals, one of the most important problems in organic production is weed growth (Reddiex et al., 2001).

Climate change is also emerging as a serious growing threat, largely due to its negative impacts on agricultural production and global food security. (FAO, 2009, Wheeler and Von Braun, 2013). In the last 50-100 years, an increase of approximately 0.5 °C in annual average surface temperature has been observed in different parts of the world (IPCC, 2014). Furthermore, climate change affects the ability of ecosystems to effectively capture carbon and maintain balance in the nitrogen cycle (Fu et al., 2020, Succarrie et al., 2020). There is evidence that conservation tillage (reduced tillage and no tillage) increases yields (Naab et al., 2017) and reduces soil degradation in conserved tillage practices, as well as the addition of plant waste to soil is one mechanism supporting the positive effects of these practices on soil health, soil organic carbon, and yield. The high nitrogen and phosphorus content in (cutting cover crops and incorporating them into the soil before planting the target crop) has been explained as the reason behind their ability to improve yields and soil health (Nziguheba et al., 2000).

Three long-term experiments were conducted with a combination of reduced and conventional plow tillage and stubble tillage to determine weed infestation levels in organic farming. As a result of the treatment, tillage by chisel plough resulted in significantly highest annual weed density compared to all other treatments. The natural *C. arvense* infestation showed the highest shoot density in the plough/chisel treatment (Gruber and Claupein 2009). In another study; showed that zero tillage application increased grain yield by 49% and 18%, gross yield by 43% and 14%, and reduced the total amount of weeds for four years in tillage applications (Sasode et al., 2020). Compared to conventional tillage with zero tillage systems, some It has been observed that perennial weeds have decreased. (Thomas et al., 2004). Therefore, a tillage reduction can be expected in Long-term organic crop systems. Using cover crop mulches for weed control can also lead to a change in the weed community. It can cause an increase in perennial weeds (Ryan et al., 2009). Fewer weeds and lower weed biomass in reduced tillage plots were also observed compared with tilled plots and no-till plots (Vaisman et al., 2011). Besides the amount of cover crop residue, other factors such as field history, cultural practices, and the weed seed bank can also determine the weed type. Species present in the year following the cover crop should b. evaluated in the context of weed competition.

Turkey has the most favorable conditions for grape production and is one of the country. Thus, it ranks sixth in the world in terms of grape production. Furthermore, Turkey has the highest rate of organic grape exports. According to statistics in 2017, 4 200 000 tons of grapes are produced in an area of 416.907 ha (FAOSTAT, 2017). These production figures include 50.2% fresh grapes, 38.1% drying grapes, and 11.6% wine grapes (TUIK, 2019). The yield for grape production in Turkey is 10 074 kg ha^{-1}. Moreover, organic grapes are produced in 116.283 tons on 403,047 ha^{-1}.

In organic farming applications, the highest costs refer to the expenditures related to the control of weeds (Uygur and Lanini 2006). Therefore, in order to produce successful organic production, weeds must be effectively controlled. The 'organic agriculture' system refers to controlled and certified agricultural production at every stage, from production to consumption, without using chemical input. It is recommended to apply the appropriate soil tillage methods in the control of weeds. However, excessive tillage applications that may cause soil erosion are not allowed (TMOARA, 2005). The most important reasons for tillage are the elimination of crop competition with weeds and supporting the early growth of the crop (Triplett and Dick 2008).

The success of weed control can be measured by crop yield. Chemical weed control is widely used in conventional agriculture. Production costs decrease according to the intensity of the weeds' pressure. Herbicide application rates can be reduced if weeds remain below the economic damage threshold in the crop. Therefore, alternative weed control methods are important for sustainable agriculture. However, perennial weeds with longer life spans and deep root systems cannot be reduced by herbicides. The seed reserve in the soil and weed infestation tends to increase under conservation tillage and no-tillage (Légère et al., 2011).

Weeds can obstruct the early development of the crop both by reducing the nutrient content of the soil and by reducing the soil temperature in conservation tillage and no-tillage applications (Triplett and Dick, 2008; Boomsma et al., 2010). At the same time, they can also significantly reduce crop yield (Davis et al. 2005). Generally, the presence of weeds depends on soil conditions, cultivation treatments, thermal conditions, and weed seed reserves in the soil (Shahzad et al., 2016, Skuodiene et al., 2018).

Thanks to the ploughing system, more than 33% of weeds on the surface of the soil were carried to the deeper layers of the soil as a result of ploughing, which significantly decreases the emergence of weeds (Woźniak, 2007). On the other hand, opinions on crop infestation with weeds in the ploughing and no-till systems are inexplicit. Therefore, our primary objectives were to determine the control efficiency of different tillage systems and organic practices on weeds.

2. Materials and Methods

2.1. Experiment area

This study was conducted at the Viticulture Research Institute between 2015 and 2018 in Manisa 38° 38' 0,9.40" N, 27° 23' 59.43" E). The variety was seedless Royal which is planted at a range of 3 m - 2 m in the experiment area. Some organic weed control practices consisted of radish, broccoli, and mill olive waste water.

2.2. General features of the Manisa province

Manisa province is only 41 kilometers away from the Aegean Sea. It is located between 27 08' and 29 05' east longitudes and 38 04' and 39 58' north latitudes, with an area of 13,810 km2 (Figure 1). The prevailing climate in Manisa is also referred to as the Mediterranean land climate type. Temperatures rise in the summer, while rainfall intensifies in the winter. The months of summer are very hot, as the characteristics of the continental Mediterranean climate prevail in Manisa. The average annual temperature is 16.3ºC. The coldest months are January and February. The Western Anatolia region has the precipitation characteristics of the Mediterranean climate type (MMMID, 2019).

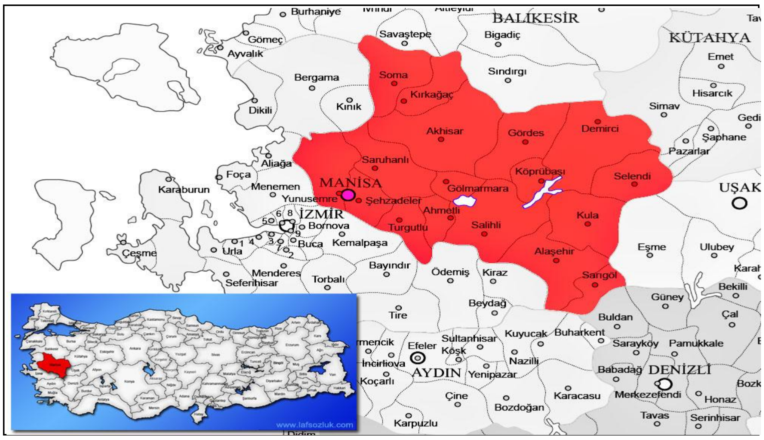

Figure 1. Map of the province of Manisa, Turkey.

2.3. Soil analysis

The soil samples were taken from 0–30 cm depth, and some physical and chemical analyses were performed to determine the initial soil properties. Cation exchange capacity (CEC) was determined by using sodium acetate (buffered at pH 8.2) and ammonium acetate (Sumner and Miller 1996). The Kjeldahl method was used to determine organic N (Bremner 1996), while plant-available P was determined by using the sodium bicarbonate method (Olsen et al., 1954).

Electrical conductivity (EC) was measured in saturation extracts according to Rhoades (Rhoadesö 1996). Soil pH was determined in 1:2 extracts, and calcium carbonate concentrations were determined according to McLean (McLean, 1982). Soil organic matter was determined using the Smith-Weldon method (Nelson and Sommers, 1982). Ammonium acetate was buffered at pH 7 (Thomas, 1982). was used to determine exchangeable cations. After extraction, the P, K, Ca, Mg, and Na contents were determined using an inductively coupled plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484- 4794, USA). The analysis results for soil physical and chemical properties are given in Table 1.

Table 1. Chemical and physical characteristics of the soil

Evaluated Characters	**Values**	**Evaluated Characters**	**Values**
pH (1 mol KCL dm^{-3})	**7.50**	K (mg kg^{-1})	593.3
Salt (dS m^{-1})	**0.015**	Ca (mg kg^{-1})	620
Lime (%)	**5.62**	Mg (mg kg^{-1})	463.5
Organic matter (%)	**1.41**	Fe (mg kg^{-1})	5.15
N (%)	**0.18**	Cu (mg kg^{-1})	2.84
P (mg kg^{-1})	**2.68**	Zn (mg kg^{-1})	0.78
Soil type	**Sandy-loamy**	Mn (mg kg^{-1})	6.58

2.4. Climate data

The climate values measured between 2015-1018 in the experimental area are given in Table 2-3.

Table 2. Weather data at the experimental station between 2015 and 2018

	Annual	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
^{0}**C**	16.1	6	8	10	15	20	24	27	26	23	17	12	8
Average High Temperature													
^{o0}**C**	22.0	10	8	15	21	26	31	34	33	30	23	17	12
Average Low Temperature													
^{o0}**C**	10.2	2	0	5	9	13	17	20	19	16	11	7	4
Average Precipitation													
mm	740	129	109	88	59	24	9	-	-	26	49	90	160
Average Length of Day													
Hours	12.7	10.3	11.2	12.4	13.7	14.8	15.3	15.1	14.1	12.9	11.6	10.5	10

Table 3. Precipitation data at the experimental station between 2015 and 2018

Date	**Liquid Precipitation (mm)**			**Number of Days**		
Elem	**> PRCP**	**EMXP**		**DP01**	**DP10**	**DP1X**
Year	**Total Liquid Content**	**Extrem Max Precip.**	**Max. Precip. Date of occurence**	**Precip >= 0.01**	**Precip >=0.10**	**Precip >= 1.00**
2015	725.4	50.8	Oct-25	77	50	9
2016	669.3	86.1	Jan-18	69	37	6
2017	693.7	74.9	Mar-08	82	49	8
2018	564.9	26.9	Dec-10	86	46	2

The number of days above 20 ℃ in 2017 was 68. It was 68 days in 2018. It was 41 ℃ in July 2017, 39 ℃ on the 19th of August 2018. 2017 average was 23.5 ℃, 2018 average was 24.1 ℃. (NOAA, 2021. NOAA's National Centers for Environmental Information).

2.4. Experiment details

Experiments were conducted in 2015 and 2018 in the experiment vineyards of the Viticulture Research Institute. The experiment contained four replicates and made use of a randomized complete block split-split plot design. A row of the vineyard was left as a space buffer between each main plot. Each main plot was divided into three subplots with the four vines in each subplot, and the two vines maintained as buffers. The first treatment (the main plots) split-plot used the conventional conservation and no-tillage methods. The conservation tillage methods included the use of a chisel and heavy duty disc harrow. Broccoli, radish, and olive mill wastewater were investigated as Organic allelopathic weed control applications. Experiments were undertaken with four replicates applications consisting of 12 vines per plot.

2.5. Soil tillage Applications

Conventional Tillage (CT): In this method, it was carried out as an intensive cultivation applied by farmers in the region. The conventional tillage with the use of a disc harrow and a plough were carried out twice a year. 1. Plough applications in Autumn with two passes of disc harrow application. 2. Weed count and plough application with two passes of disc harrow application in April.

Conservation Tillage (CST1): This method was applied in ways using a chisel. Conservation Tillage : 1. Soil tillage applications with chisel in Autumn 2. Weed count and chisel application in April

Conservation Tillage (CST2): This method was applied in ways using a heavy disk harrow. 1. Soil tillage applications with heavy duty disc harrow in Autumn. 2. Weed count and heavy duty disc harrow application in April.

No Tillage (NT): Grape production was carried out without soil tillage in the experiment plots. Weeds were count in April. (Figure 2).

Control (C): Weedy plots control.without any weed control.

Control application

Chisel application

Plough application

Disc harrow application

No tillage application

Figure 2. The soil tillage applications

2.6. Organic allelopathic weed control applications

Olive mill wastewater, radish, and broccoli were used to determine the effectiveness of weed control in organic viticulture. These plants were selected because of their allelopathic properties. In order to compensate for the missing nutrients in the vineyard, stable manure (1.5 tons da^{-1}) and green fertilizer (barley + vetch + fababean 2.5 + 3.5 + 7.5 kg da^{-1}) were applied.

2.7. Identification of weeds and measurements

While counting, the broadleaf weeds were counted by the whole plant in the plots, while the narrow-leaf weeds were counted by the shoot number. The recognized weed species were recorded, and the unrecognized species were numbered and brought to the laboratory. Afterwards, their diagnosis was made as a result of the comparison of plants in the flora of Turkey (Davis, 1965; Davis, 1988). In order to determine the effect of the applications on weeds, the type and number of weeds were determined by throwing a 50 x 50 cm^{-2} frame on each plot 28 and 56 days after the application (Figure 3). The effects of the applications were determined as a percentage by applying the following Abbott formula to weed coverage and weed density (Abbott, 1925).

$$\%\ EFFECT = \left(\frac{Weed\ Coverage-Density\ in\ Unapplied\ Control\ Parcels-Weed\ Coverage-Density\ in\ Applications\ Parcels}{Weed\ Coverage-Density\ in\ Unapplied\ Cotrol\ Parcels}\right) \times 100$$

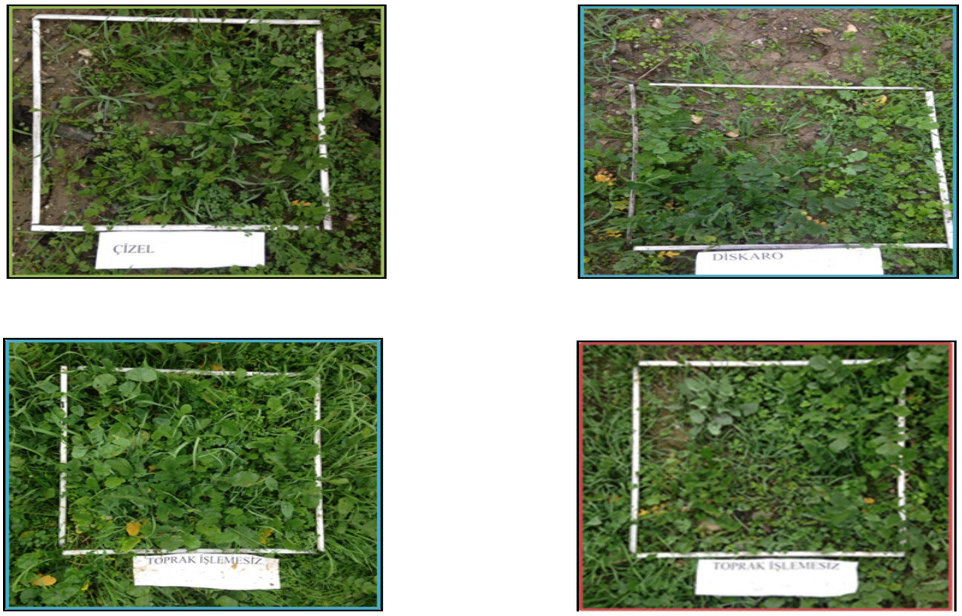

Figure 3. Images of weed counts from the experiment area.

Effects of the applications on grape yield: The number of grapes obtained from the vines in the application plots were weighed, and the yields were determined as grape kg vine^{-1}. Statistical Analysis: The values obtained in the counts performed in the plots in the experiment area were applied using one-way variance (ANOVA) analysis and the IBM SPSS v22 package program; the differences between the averages obtained from the measurements were subjected to variance analysis by Duncan Multiple Comparison.

3. Results

3.1. Effects of different soil tillage methods on weed coverage

The results of the Duncan Multiple Comparison Test on the different tillage methods between 2015 and 2018 for weed coverage are shown in Table 4. As a result of the statistical analysis of weed coverage, differences between the main plot and sub-plot applications and the weed coverage obtained between the years were found to be statistically significant for $p \leq 0.05$. At the same time, applications–years and the interaction of the main plot applications between the sub-plot applications are statistically significant for $p \leq 0.05$.

Statistical analysis was carried out by taking the average of the weed covering values obtained at the time of both counts of tillage applications. The weed coverage obtained at the second count time shows similar information to the data in the first count time but was increased by 8%–30% with the development of weeds (Table 4). Compared to the control plots (C), the plow and disc harrow (CT) were the most effective application by reducing the coverage of weeds by 70.39%. The least effective application was the NT method, with 33.34%.

The main plot applications on weed fresh weights were found to be statistically as significan in terms of the applications and interactions of the main applications with years in organic experiment plots. The CT applications were the most effective application by reducing the fresh weight of weeds by 68.31%. Other applications were found to be effective at rates of CST1 32.47%, CST2 29.64%, NT 16.84%, respectively. The most effective application was the plough and disc harrow method CT (53.37%) in terms of dry weights of weeds. In plots of no-tillage (7.42%) was the least effective application. Other applications had an efficiency of 28% to 31.07%.

Table 4. Effects of main plot applications on weeds (2015–2018)

Treatment	CT	CST1	CST2	NT	C	SE	ANOVA
Weed coverage (%)	24.97d	51.94c	54.44bc	56.22b	84.34a	5,357	***
Fresh Weed Weight (g m^{-2})	225.14d	479.72c	499.84c	590.73b	710.40a	12.846	***
Dry Weed Weight (g m^{-2})	57.58c	88.95b	85.57b	114.92a	124.14a	3.642	***

ns, not significant. ANOVA: ***P <0.001, **P <0.01, *P <0.05. The Standart Error = SE, CT: Conventional, CST1: Conservational, CST2: Conservational, NT: No-Tillage, C: Control.

3.2. The effects of Organic allelopathic weed control applications on weed coverage in the experiment

All the Organic allelopathic weed control applications were reduced to between 40.12% and 50.34% of the weed coverage compared to the control plots. According to the control plots, the olive mill wastewater application (50.34%) was the most effective application, while broccoli (44.94%), radish (42.20%), and the control plots were listed (Table 5).

The effects of the Organic allelopathic weed control applications on fresh weed weights and year interactions were found to be statistically important ($p \leq 0.05$). Olive mill wastewater, the most effective application, had an efficiency rate of 48.57% for weed fresh weights. The least impact was obtained from the application of radish (%35.20).

As for the weed dry weight, the effects on weed dry weights were found to be important in the sub-plot's applications. Nevertheless, the weight differences in their interactions between the sub-plots *year and sub-plots* main plot applications were insignificant. The olive mill wastewater had the highest effective rate (46.87%) for the dry weight of weeds. The least impact was obtained from the application of radish (30.10%).

Table 5. Effects of Organic allelopathic weed control applicationss on weeds (2015–2018)

Treatment	OW	B	R	SC	C	SE	ANOVA
Weed coverage (%)	41.88d	46.44c	48.75b	50.50b	84.34a	1.668	***
Fresh Weed Weight (g m^{-2})	365.34c	425.12b	460.27b	544.94a	710.40a	16.349	***
Dry Weed Weight (g m^{-2})	65.95d	85.13c	85.66c	110.28b	124.14a	5.460	**

ns, not significant. ANOVA: ***P <0.001, **P <0.01, *P <0.05. The Standart Error = SE OW: Olive mill wastewater, B: Broccoli, R: Radish, SC: Sub-plots control, C: Control.

The effects of the applications in the weed coverage in 2015 were 20.39% higher than the effects in 2017, which were the least impactful. The effects in other years have followed to 2015 effect (Table 6). According to the statistical analysis of fresh weed weight, differences in the fresh weight of weeds obtained from applications over the years were found to be important. In 2017 and 2018, with the decrease in the amount of precipitation, the increase in the average temperature, especially the hot months of July and August, had a negative effect on the fresh and dry weight of weeds. Accordingly, the lowest weed fresh weight was determined in 2017, while the highest weed fresh weight was attained in 2016. Moreover, differences in the distribution of dry weed weights were obtained from applications between the years and were found to be important. Accordingly, the lowest weed dry weight was achieved in 2017, while the highest dry weights were achieved in 2016 (Table 6).

Table 6. Effects of the applications on weeds according to years (2015–2018)

Years	2015	2016	2017	2018	ANOVA
Weed coverage (%)	48.00c	54.15b	60.30a	55.07b	*
Fresh Weed Weight (g m^{-2})	752.07b	831.03a	159.79d	261.76c	***
Dry Weed Weight (g m^{-2})	82.07b	124.75a	78.45b	86.71b	**

ns, not significant. ANOVA: ***P <0.001, **P <0.01, *P < 0.05.

3.3. Effects of different tillage methods on grape yield

Statistically, compared to the effects of grape yields of the applications, the obtained yield differences were statistically important in the tillage methods. The results of the yield were important in the interactions between the year and the applications. The yields obtained from the conventional plots were about 2.65 times the yield of the control plots. The no-till application had nearly 2.62 times the yield of the control plots. While the third efficiency was obtained from the disc harrow application (CST2), the lower yield was obtained from the chisel application (CST1). (Table 7).

Table 7. Effects of the applications on grape yield (kg Vinestock^{-1}) (2015–2018)

Treatments	**CT**	**CST1**	**CST2**	**NT**	**C**	**SE**	**ANOVA**
Yield	6.80d	4.40c	5.29b	6.71d	2.56a	0.213	***

ns, not significant. ANOVA: ***P <0.001, **P <0.01, *P <0.05. The Standart Error = SE, CT: Conventional, CST1: Conservational, CST2: Conservational, NT: No-Tillage, C: Control.

The grape yield differences obtained from the sub-plots were found to be statistically important. Except for the control plots, all other sub-plot applications were included in the same statistical group (b). While the highest efficiency was obtained from broccoli, olive mill wastewater and Radish applications were also followed this application (Table 8).

Table 8. Effects of the sub-plot applications on grape yield (kg Vinestock^{-1}) (2015–2018)

Treatments	**OW**	**B**	**R**	**SC**	**C**	**SE**	**ANOVA**
Yield	6.17b	6.45b	6.13b	3.51a	2.54a	0.347	***

ns, not significant. ANOVA: ***P <0.001, **P <0.01, *P <0.05, The Standart Error = SE, OW: Olive mill wastewater, B: Broccoli, R: Radish, SC: Sub-plots control, C: Control.

4. Discussion

In general, weed seeds tend to come to the surface in no-tillage soil while also preventing the proliferation of weeds in well-tillaged soil. The seeds of weeds remained in the first 10 cm layer of soil before soil tillage, while the seeds were spread across 20 cm of the soils' surface by the tillage of the soil (Buhler et al., 2001). More than 50% of the total weed seeds are located at a depth of 0 to 5 cm, and this percentage decreases as soil depth increases (Buhler et al. 1997, Chauhan et al., 2006). Moreover, it is stated that the plough buries weeds in the soil and prevents them from germinating, and destroys their existing shoots (Boström, 1999). Plough tillage ensures that germination conditions are limited by spreading weed seeds deeper into the soil so that seed dormancy lasts longer (Børresen and Njos, 1994). However, weeds are effectively controlled by conventional tillage in the early season (Steckel et al., 2007); therefore, weed infestations may occur with this tillage system in the late season.

For many years, it is inevitable that the weeds adapt to conventional tillage systems in the same way for many years. Thus, new alternative systems are needed to compensate for crop losses (Harker and Clayton, 2004).

Conservation tillage systems not only improve the physical properties of soil, but they also enhance soil water availability (Unger 1994, Drury et al., 1999). At the same time, it may facilitate root growth (Martino and Shaykewich, 1994). Conservation tillage may be more productive than conventional tillage because it improves the soil quality and water use efficiency of crops (Samarajeewa et al., 2006).

Zero tillage (ZT) is one of the effective practices of conservation tillage, which reduces costs for land preparation, fuel consumption, equipment use, labor cost and increases crop yield by protecting soil and water (Farooq et al., 2011, Jabran and Mehmood 2015). Nevertheless, it also restricts the growth of the main root axis in the early stages of plant development. It also restricts the growth of the main root axis in the early stages of plant development (Lampurlanes et al., 2001). Many researchers draw attention to the change in weed flora after the application of the conservation tillage system. Moreover, while perennial weeds can be controlled in conventional tillage systems, they can become a major problem in conservation tillage applications (Nyagumbo, 2008; Mashingaidze et al., 2012). Therefore, conservation tillage contains high weed densities as opposed to conventional systems during the initial years of adoption (Cardina et al., 2002, Sosnoskie et al., 2006). The conservation tillage system also encourages weed seed banks and germination of higher weed emergence (Barberi and Lo Cascio, 2001). Therefore, this is needed to control new weed practices, which help control or reduce weed populations in conservation tillage methods. Allelopathy is a viable tool for weed management in conservation tillage (Jabran and Farooq, 2013, Jabran et al., 2015). Alternatively, allelopathy can also be used due to resource competition and non-chemicals in the weed control system.

According to the statistical consequences of the effects of the applications on weed fresh weights, the plough and disc harrow method (225.15 g m^{-2}) was found to at least the fresh weight of weed, and it also had 68.30% effectiveness when compared to the control plots in the organic vineyard. This application has been followed by chisel, disc harrow and no-tillage applications. As for the effectiveness of sub-plot applications, in terms of weed fresh weight, the effective applications of the olive mill wastewater, broccoli and radish applications are listed respectively.

The most effective application for the dry weights applications in the experiment area was the plough and disc harrow method (53.62%). In the sub-plot applications, olive mill wastewater (46.87%) was the most effective application. Studies with olive mill wastewater investigated the possibility of solid and liquid forms as fertilizers and herbicides. The effectiveness of different doses was evaluated in olive mill wastewater in wheat fields, while the solid form of olive mill wastewater was tested in the fields of sunflower and maize (Boz et al., 2003). According to the results obtained, it was determined that the olive mill wastewater was 90% effective against little hogweeds (Portulaca oleracea) in the wheat fields. Some doses of olive mill wastewater prevented the total weed density at rates ranging from 39%–100%. In another study for the control of weeds in fig nurseries, olive mill wastewater was applied before planting of the fig seedlings and was successful in the control of annual weeds, especially Portulaca oleracea, etc. This effectiveness also continued for three months (Öğüt, 2007).

In this study, the plough and disc harrow method showed the highest effect (70.39%) in terms of weed coverage in the experiment field. This application was followed by the chisel (38.41%) and no-tillage (33.34%) methods. Tillage has been shown to reduce weed populations in perennial agro-ecosystems such as vineyards (Kazakou et al., 2016, Hall et al., 2020). In different studies, the most effective application was the plough tillage for weed coverage in winter wheat fields (Kende et al., 2017). The plough and rotavator disc harrow tillage method as a similar example, as well as the wheat mulch application, were the most effective for weed biomass in maize fields (Din et al. 2013).

It has been determined that the application of no-tillage and clipped weeds increased crop yields. Other cover crops also increased yield by increasing the water content and the amount of carbon in the soil (Kaçan and Boz, 2014, Hashimi et al., 2019). In this study, the highest yield per vinestock was obtained from the plough and disc harrow method (6.80 kg $Vinestock^{-1}$) in the main plots. Moreover, the highest yield was harvested from broccoli (6.45 kg $Vinestock^{-1}$) in the sub-plots. In the same way, the applied mulch textile without soil tillage was determined as the most effective application in terms of grape yield in organic vineyards (Kaçan and Boz, 2014).

Conclusion

The plough and disc harrow method had the most effective application in terms of weed control in the main plots. Olive mill wastewater was determined as the most effective of the applications as subjects in sub-plots for the 2015–2018 period in the organic vineyard. The plough and disc harrow method also achieved the highest yield, while the yields of no-tillage application were very close to this yield. Accordingly, there was no tillage application evaluated in terms of workforce and energy, and it was revealed that allelopathic plants and organic waste should be included in the weed management system for sustainable agriculture.

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