



# Kahramanmaraş Sütçü İmam University

## Journal of Engineering Sciences



Geliş Tarihi : 02.04.2020  
Kabul Tarihi : 07.05.2020

Received Date : 02.04.2020  
Accepted Date : 07.05.2020

### A RESEARCH ON THE EFFECTS OF PESTICIDES AND WOOD VINEGAR ON WEEDS AND CULTIVATED PLANTS IN WHEAT AGRO-ECOSYSTEM

#### PESTİSİTLER VE ODUN SİRKESİNİN BUĞDAY AGRO-EKOSİSTEMİNDEKİ YABANCIOTLAR VE KÜLTÜR BİTKİSİNE ETKİLERİ ÜZERİNE BİR ARAŞTIRMA

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#### ABSTRACT

This study was carried out to determine the effects of pesticides and wood vinegar that are used for the plant protection in wheat agro-ecosystems on weeds and cultivated plants in 2014-2015 and 2015-2016 production seasons in Muş Province ecological conditions. The field experiment was done in wheat field according to randomized block design with four repetition. Treatments in the experiment was based on the pesticides used by BERCE Alparslan agricultural enterprise and treatment schedule of the company. These treatments were: 1) Pesticide treatment (fungicide, herbicide), 2) 0.5% - 1% - 2% - 3% - 4% and 5% ml wood vinegar treatments that correspond to pesticide treatment, 3) Control treatment with tap water. It was observed that when compared to control group, pesticide treatment decreased weeds the number of, variety and the dry weight ( $P=0.002$ ), however, it significantly increased values such as grain size, number of seed per spica, grain yield per spica and harvest index (%) of cultivated plants ( $P\leq 0.05$ ). On the other hand, use of 1% ml wood vinegar had a significant effect on higher yield index ( $P\leq 0.05$ ).

**Keywords:** Agro-ecosystem, pesticides, weeds, wood vinegar, yield index

#### ÖZET

Bu çalışma, buğday agro-ekosisteminde bitki koruma amaçlı kullanılan pestisitlerin ve odun sirkesinin, yabancı ot ve kültür bitkisine etkilerini belirlemek amacıyla 2014-2015 ve 2015-2016 üretim sezonlarında Muş ili ekolojik şartlarında yapılmıştır. Tarla denemesi, tesadüf blokları deneme desenine göre ve dört tekerrürlü olarak yürütülmüştür. Denemede yapılan muameleler, BERCE Alparslan tarım işletmesinin kullandığı pestisitler ve uygulama takvimi takip edilerek yapılmıştır. Yapılan muameleler; 1) pestisit muamelesi (fungisit, herbisit), 2) pestisit uygulamasına tekabül eden %0.5 - %1 - %2 - %3 - %4 ve %5 ml odun sirkesi muameleleri ve 3) sadece şebeke suyu verilen kontrol muamelesi şeklinde yapılmıştır. Yapılan istatistiksel analizler sonucunda; kontrol grubuna göre pestisit muamelesinin yabancı ot sayısı, çeşitliliği ve kuru ağırlığını azalttığı ( $P=0.002$ ), kültür bitkisinin; başakta tane sayısı, başakta tane verimi ve hasat indeksi gibi değerleri önemli düzeylerde artırdığı görülmüştür ( $P\leq 0.05$ ). Buna karşın %1 ml odun sirkesinin hasat indeksinin daha yüksek olmasında önemli bir etkiye sahip olduğu görülmüştür ( $P\leq 0.05$ ).

**Anahtar Kelimeler:** Agro-ekosistem, pestisitler, yabancı ot, odun sirkesi, hasat indeksi

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**ToCite:** KOÇ, İ., YILDIZ, Ş., & YARDIM, E. N., (2020). A RESEARCH ON THE EFFECTS OF PESTICIDES AND WOOD VINEGAR ON WEEDS AND CULTIVATED PLANTS IN WHEAT AGRO-ECOSYSTEM. *Kahramanmaraş Sütçü İmam Üniversitesi Mühendislik Bilimleri Dergisi*, 23(2), 94-106.

## INTRODUCTION

It is estimated that the yearly pesticide use is 2.5 million tones worldwide and only less than 0.1% of this amount reaches the target bio during disinfestation (Pimentel, 1995). Besides the fact that pesticides have significant benefits in protecting the products, they have serious negative effects on the environment (Mahmood, Imadi, Shazadi, Gul & Hakeem, 2016). Problems caused by the use of synthetic pesticides necessitated the use of natural pesticides (Erdoğan & Toros, 2005). Wood vinegar products with the potential of bio-pesticides are liquids produced as side products of carbonization processes (pyrolysis liquids) that have been found in archeologic studies that had been used in Neanderthal ages (Tiilikkala, Fagnäs & Tiilikkala, 2010). Referring to Jang, Kim, Seo, Lee & Lee (2008), stated in their study that 80-90% of WV is water while 10-20% of WV is made of more than 200 organic compounds (the main part is made of acetic acid); they also mentioned that recent yearly production of WV is approximately 14.000 tones. Literature reviews on herbicides reveal that they are efficient on weeds (Curaoğlu, 2008; Kıvılcım-Kılınc, 2015; Sönmez, 1993; Şanlı, Kaya & Kara, 2009; Tepe & Nemli, 1993) and they increase yield (Khan, Khan, Khan, Imran, Idrees & Bibi, 2013; Şanlı, Kaya & Kara, 2009). On the other hand, the literature reviews about fungicide showed that the use of them increased yield (Blandino, Minelli & Reyneri, 2006; Rodrigo, Cuello-Hormigo, Gomes, Santamaria, Costa & Poblaciones, 2015). As a result of the researches about WV, it was observed that there are studies in the literature about the use of it on agricultural lands as fertilizer, insect repellent and organic fungicide (Jothityangkoon, Koolachart, Wanapat, Wongkaew & Jogloy, 2008; Baimark & Niamsa, 2009; Rakmai, 2009). In addition, it was reported that WV has been used as a fruitful resource in organic agriculture and widely used in Japan both in agricultural procedures and in daily life (Mu, Uehara & Furuno, 2003). Baimark & Niamsa (2009) reported that WV prevented the growth of fungi (*Penicillium griseofulvum*) in the PDA medium because of its phenolic content. Wood vinegar is effective against *A. niger* and *P. digitatum* and it is thought to may be useful against disease (Koç, Yardım & Yıldız, 2017; Koç, Yardım, Çelik, Mendes, Mirtagioglu & Namli, 2018). In their study, Yoshimura, Washio, Yoshida, Seino, Otaka, Matsubara & Matsubara (1995) determined that raw WV increased product yield by 0.1-6% and mass of fruit by 21-42%. Nurhayati, Roliadi & Bermawie (2005) produced WV from *A. mangium* and determined that 3-5% concentration of it caused significantly positive improvement in plant height, leaf length and shoot growth when compared to control group. Mungkunkamchao, Kesmala, Pimratch, Toomsan & Jothityangkoon (2013) produced bio-extracts from plant and animal residues through fermentation (FB) and treated them separately and in combination on an experiment group. At the end of the process, they found that the treatment slightly increased plant total dry weight, number of fruits, weight of fresh fruit and weight of dry fruit. Pangnakorn, Watanasorn, Kuntha & Chuenhooklin (2009) produced fermented organic liquid fertilizer by using WV and weeds and carried out six different treatments by using this fertilizer. Koc, Namli, Mendes, Pinar, Cig & Yardim (2019) were found that the 4% mL WV had positive effects on cultivated plant height and 1% mL WV had positive effects on thousand kernel weight and seed per spike. At the end of the process, in contrast with the other positive findings in the literature, they found that there was not a significant relation between treatments and yield. In line with the findings Namli, Akça, Turgay & Soba (2014) obtained under in-vitro conditions, they concluded that using WV in-vivo conditions may give positive results. In this study, it was attempted to research the effects of pesticides on weeds and cultivated plants in comparison with wood vinegar as an alternative used for the plant protection.

## MATERIAL AND METHODS

This study was carried out in a wheat field of Krasunia odeska variety, on BERCE Alparslan agricultural enterprise (1276 m, lat.: 38°47'33.1577", long.: 41°32'45.8119") in Muş province (in Turkey). Seeds were planted with No-Till method. Interrow distances were arranged as 20 cm and cultivation norm was 500 plant/m<sup>2</sup>. Trial was carried out in 2014-2015 and 2015-2016 production seasons according to randomized block design and was repeated four times. Each parcel size was 5m×5m=25 m<sup>2</sup>, with minimum distances of 2 m between blocks and parcels.

Wood vinegar (WV) was bought from a company producing it Broiler chicken breeding waste through carbonization technique (Namli, Akça, Turgay & Soba, 2014). Pesticide, fertilizer and treatment calendar was based on BERCE's treatment calendar about the use of pesticides on wheat diseases and weeds. Treatments were made by means of 16 L backpack sprayer (Anadolu Power APW-16).

The climatic data of the study area for the last ten years, for the first season (2014-2015), and the last season (2015-2016) were as such (respectively): Total rainfalls were 740.5 mm, 740.4 mm and 790.1 mm; average temperatures were 10.62 °C, 11.55 °C and 11.48 °C and average relative humidity values were (60.79%, 55.02% and 54.00%) (Muş meteorological provincial directorate records).

These treatments were carried out in the study; 1) pesticide treatment, 2) 0.5% - 1% - 2% -3% -4% and 5% ml wood vinegar (WV) treatments that correspond to pesticide treatment, 3) control treatment with water in which no pesticides and WV were used. During the trial period, one-time treatment was carried out in 2014-2015 and four time treatments had been carried out in 2015-2016 (Pesticide treatment calendar was based on BERCE's treatment calendar about the use of pesticides on wheat diseases and weeds).

In 2014-2015 treatment period, Weed killer D<sup>®</sup> (herbicide, active ingredient: 2,4-D Acid Dimethylamin, 1000 ml/ha, Koruma, Koruma Tarım) and Duett super<sup>®</sup> (fungicide, active ingredient: 84 g lt Epoxiconazole and 250 g lt Fenpropimorph, 1000 ml ha, Basf, BASF Agricultural Solutions Turkey), and in 2015-2016 treatment period Input<sup>®</sup> (fungicide, active ingredient: 160 g lt Prothioconazole + 300 g lt Spiroxamine, EC, 1000 ml ha, Bayer, Bayer Crop Science), Harmony platinum<sup>®</sup> (herbicide, active ingredient: 37.5% Thifensulfuron methyl + 37.5% Tribenuron methyl, DF, 20 g ha, Bayer, Bayer Crop Science), Duett super<sup>®</sup> (fungicide, active ingredient: 84 g lt Epoxiconazole and 250 g lt Fenpropimorph, 1000 ml ha, Basf, BASF Agricultural Solutions Turkey), Attribut super WG 20<sup>®</sup> (herbicide, active ingredient: 6.75% Propoxy carbazone-sodium + 4.5% Mesosulfuron-methyl, WG, 200 g ha, Bayer, Bayer Crop Science) and Biopower<sup>®</sup>(1000 ml ha, Bayer, Bayer Crop Science) mixtures were prepared and treated on the parcels on which pesticides are used. On the other hand, 0.5%, 1%, 2%, 3%, 4%, and 5% ml WV were used on WV parcels and only water was used on control group parcels.

Density of weeds was calculated by observing 1 m<sup>2</sup> frame taken from three different parts of each parcel. Collected weeds were dried with herbarium technique and they have become herbarium materials after being enumerated and properly recorded. Works entitled "Flora of Turkey and the East Aegean Islands" (Davis, 1965-1985; Davis, Mill & Tan, 1988), (Güner, Özhatay, Ekim & Başer, 2000) were used in diagnosing the plants. Furthermore, samples in the Herbarium of Van Yüzüncü Yıl University (YYU), Faculty of Science, Department of Biology (VANF) were used and comparisons were made. The plants collected for this study are kept in the VANF. Author and plant names have been checked according to Güner, Aslan, Ekim, Vural & Babaç (2012). Weeds in one square meter frame area were cut from the surface of soil and dried for 48 hours at 70 °C in drying chamber. Weed biomass was determined at the end of this specific process (Kaydan, Tepe, Yağmur & Yergin, 2011). Ten cultivated plants that were randomly chosen from each parcel were evaluated in terms of plant height, harvest index (%), number of seed per spica, grain yield per spica, thousand kernel weight (Tuğay, 1999) and early earing (TAGEM).

Minitab (Ver. 17) and IBM SPSS (Ver. 24) statistics package programs were used for statistical analysis Analyses of categorical data with non-normal distribution was carried out using simple correspondence analysis method. Variance analysis technique was used in repeated measurement ANOVA in order to determine the effect of treatments on weed dry weight, cultivated plant yield and growth parameters (Winer, Brown & Michels, 1971).

## RESULTS AND DISCUSSION

Weeds under 16 different family were determined during the study; 4 of them are genus while 32 of them were in species level (Table 1).

**Table 1.** Weeds Identified in the Test Field

Line no	Name
1	<i>Vicia anatolica</i> Turrill (Fabaceae)
2	<i>Trifolium echinatum</i> M.Bieb (Fabaceae)
3	<i>Lathyrus inconspicuus</i> L. var. (Fabaceae)
4	<i>Trifolium</i> sp. (Fabaceae)
5	<i>Lathyrus gloeospermus</i> Warb.& Eig (Fabaceae)
6	<i>Lathyrus aphaca</i> L. var modesta P. H. Davis (Fabaceae)
7	<i>Glycyrrhiza glabra</i> L. var. glandulifera (Waldst. & Kit.) Boiss (Fabaceae)
8	<i>Cichorium glandulosum</i> Boiss. & A.Huet (Asteraceae)
9	<i>Tripleurospermum disciforme</i> (C.A.Mey) Sch. Bip. (Asteraceae)
10	<i>Tragopogon bupthalmoides</i> (D.C.) Boiss. var. bupthalmoides (Asteraceae)
11	<i>Lactuca serriola</i> L. (Asteraceae)
12	<i>Lapsana communis</i> L. (Asteraceae)
13	<i>Senecio vernalis</i> Waldst. & Kit. (Asteraceae)
14	<i>Centaurea depressa</i> (Asteraceae)

15	<i>Centaurea balsamita</i> (Asteraceae)
16	<i>Sedum nanum</i> Boiss. (Crassulaceae)
17	<i>Erodium absinthoides</i> Willd. subsp. <i>armenum</i> (Trautv.) P. H. Davis (Geraniaceae)
18	<i>Galium verum</i> L. subsp. <i>verum</i> (Rubiaceae)
19	<i>Convolvulus arvensis</i> L. (Convolvulaceae)
20	<i>Thlaspi perfoliatum</i> L. (Brassicaceae)
21	<i>Polygonum bellardii</i> All. (Polygonaceae)
22	<i>Polygonum</i> sp. (Polygonaceae)
23	<i>Cerastium longifolium</i> Willd. (Caryophyllaceae)
24	<i>Cerastium dichotomum</i> L. subsp. <i>dichotomum</i> (Caryophyllaceae)
25	<i>Ornithogalum narbonense</i> L. (Asparagaceae)
26	<i>Papaver dubium</i> L. (Papaveraceae)
27	<i>Eromopoa songarica</i> (Schrenk) Rashev. (Poaceae)
28	<i>Alopecurus myosuroides</i> Hudson var. <i>myosuroides</i> (Poaceae)
29	<i>Cynodon dactylon</i> (L.) var. <i>villosus</i> Regel (Poaceae)
30	<i>Nigella segetalis</i> M. Bieb. (Ranunculaceae)
31	<i>Ranunculus arvensis</i> L. (Ranunculaceae)
32	<i>Adonis aestivalis</i> L. (Ranunculaceae)
33	<i>Consolida oliveriana</i> (DC.) Schrod. (Ranunculaceae)
34	<i>Orobanche alba</i> Stephan ex Willd. subsp. <i>alba</i> (Orobanchaceae)
35	<i>Veronica</i> sp. (Plantaginaceae)
36	<i>Euphorbia</i> sp. (Euphorbiaceae)

### Effect of Treatments on Weed Dry Weight

Statistical analysis revealed that the effect of the treatments on weed dry weight varied in the years ( $P=0.002$ ) (Table 2). The treatment in 2014-2015 season was not as efficient as the other pesticide treatments; it was believed that this might have resulted from the fact that herbicide treatment in that season was carried out late because of climate and field conditions (26 May, 2015).

**Table 2.** Weeds Dry Weight (g) In Terms Of Year and Treatment and Tukey Multiple Comparisons Test Results

Years	Treatments	$\bar{X} \pm S_x$	Minimum (g)	Maximum (g)
2014-2015	0.5% ml WV	8.65 ± 2.95 Ba	1.64	15.99
	1% ml WV	20.75 ± 8.43 Ba	5.77	43.07
	2% ml WV	10.62 ± 0.77 Ba	8.79	12.53
	3% ml WV	8.92 ± 2.89 Ba	1.47	15.28
	4% ml WV	18.14 ± 4.52 Ba	6.10	27.82
	5% ml WV	9.03 ± 2.49 Ba	2.08	13.84
	Pesticide	12.59 ± 3.24 Aa	3.41	18.47
	Control	12.81 ± 5.79 Ba	3.37	28.35
2015-2016	0.5% ml WV	173.60 ± 17.20 Aa	139.20	219.00
	1% ml WV	168.80 ± 46.10 Aab	44.30	260.60
	2% ml WV	190.60 ± 25.00 Aa	130.60	249.00
	3% ml WV	270.40 ± 12.70 Aa	245.60	305.80
	4% ml WV	173.10 ± 32.50 Aa	97.60	248.40
	5% ml WV	239.60 ± 27.80 Aa	205.60	321.80
	Pesticide	55.10 ± 19.10 Ab	5.40	87.00
	Control	182.20 ± 42.70 Aa	77.40	285.40

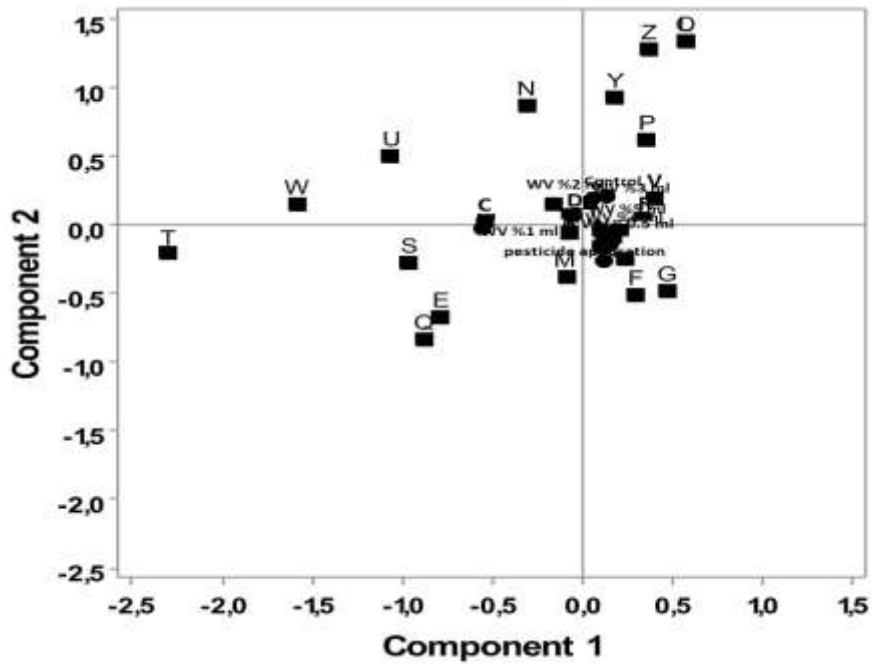
\*Differences treatment doses treated in the same year represented with different lower-case letters are important ( $P \leq 0.05$ ).

\*Differences between the years represented with different upper-case letters with the same treatment dose are important ( $P \leq 0.05$ ).

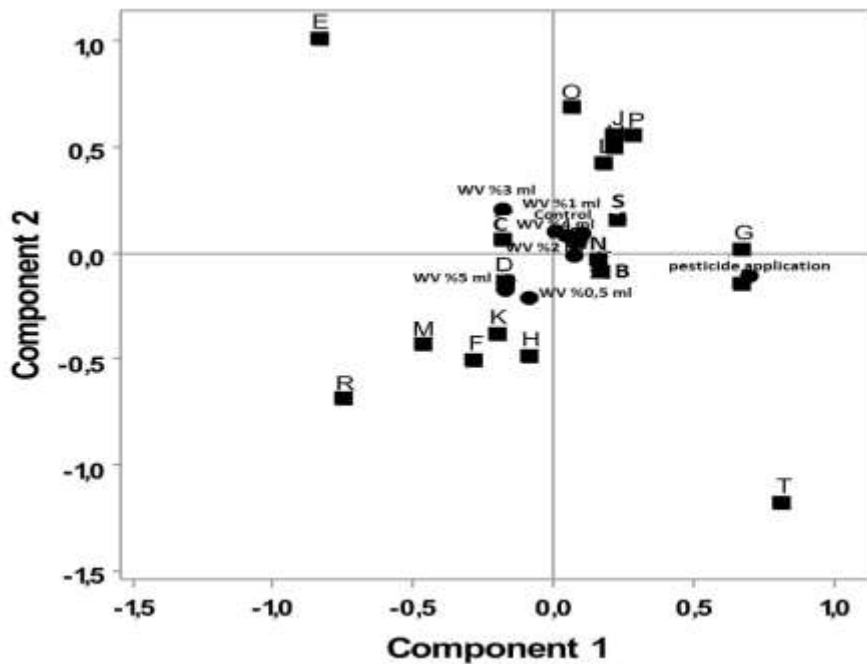
It was seen that a similar result has been obtained by Kılıncı-Kılınç (2015) in their study. It was determined that minimum average weed weight was in pesticide treatment (33.85 g), while maximum was in 3% ml WV treatment (139.66 g). Similar results were obtained in the studies by Curaoğlu (2008); Uysal (2012); Shehzad, Maqsood, Anwar-ul-Haq & Niaz (2012); Tepe & Nemli (1993) in terms of the effectiveness of pesticides on weed. On the other hand, there were similar results in the literature about the inefficiency of WV treatments (Rico, Mintah, Kim, Chung, Son & Lee, 2007). As mentioned before, weed dry weight in 2015-2016 (1453.40 g) was higher when compared to 2014-2015 (101.51 g); it was believed that insufficiency of WV in terms of preventing weed and climate conditions in 2015-2016 are the resources of this situation.

**Effect of Treatments on the Amount and Species of Weed**

In 2014-2015, while the weed species T (*V. anatolica*), W (*Euphorbia* sp.), U (*T. echinatum*), N (*C. dactylon*), Y (*L. gloeospermus*), Z (*L. communis*), Q (*L. aphaca*), S (*C. glandulosum*), E (*E. songarica*), O (*S. nanum*), G (*L. inconspicuus*), F (*Trifolium* sp.) and P (*C. arvensis*) (Figure 1); In 2015-2016, E (*L. communis*), O (*L. gloeospermus*), P (*C. longifolium*), J (*A. myosuroides*), R (*L. inconspicuus*), M (*Veronica* sp.), H (*O. alba*), T (*Trifolium* sp.), F (*G. verum*), K (*A. aestivalis*), U (*T. echinatum*) and V (*A. myosuroides*) did not have relation with any of the treatments, it was seen that the other weeds had relations with other pesticide treatments (Figure 2, Table1).



**Figure 1.** Simple Correspondence For the Relations Between 2014-2015 Season’s Treatment and Sampling Dates In Terms Of the Number of Weeds



**Figure 2.** Simple Correspondence For the Relations Between 2015-2016 Season’s Treatment and Sampling Dates In Terms Of the Number of Weeds

It was determined that some of the weed types have no interactions with any of the treatments. It was believed that this may have resulted from the fact that there was no weed in some of the parcels (0). It is measured that minimum average number of weeds was seen in parcels treated with pesticides (598) while the maximum average number was seen with 2% ml WV (1511.5). It was seen that pesticides were efficient in weed control in general. It was observed that this result was in line with the study results obtained by Khan, Khan, Khan, Imran, Idrees & Bıbı (2013), Shehzad, Maqsood, Anwar-ul-Haq & Niaz (2012) and Ghulam, Ali, Raffaqt, Zafar, Muhammad & Muhammad (2010). Although timing of 2015-2016 (15869) season pesticide treatment was better than the timing of 2014-2015 (4812) season, the number of weeds was higher. It was believed that this may be resulted from the inefficiency of WV against weed and the higher amount of rainfall during that season.

### ***Effect of Treatments on Plant Height***

As a result of the variance analysis, the effect of Year  $\times$  Treatments interaction on cultivated plant height was not statistically significant ( $P=0.084$ ); on the other hand, when the effects of Year and Treatment were separately analyzed, it was seen that they were statistically significant ( $P=0.039$ ). It was found that minimum average plant height was in 1% ml WV treatment (57.98 cm), while maximum average plant height was found in 5% ml WV treatment (62.16 cm) (Table 3).

**Table 3.** Identification Statistics of Plant Height In Terms Of Treatments and Tukey Multiple Comparisons Test Results

Treatments	N	$\bar{X} \pm S_{\bar{x}}$	Minimum (cm)	Maximum (cm)
0.5% ml WV	80	60.34 $\pm$ 1.04 ab	35.40	79.00
1% ml WV	80	57.98 $\pm$ 0.93 b	39.40	82.00
2% ml WV	80	59.86 $\pm$ 1.14 ab	36.00	88.00
3% ml WV	80	59.42 $\pm$ 0.97 ab	37.00	82.00
4% ml WV	80	59.06 $\pm$ 0.97 ab	41.00	79.00
5% ml WV	80	62.16 $\pm$ 1.01 a	38.00	89.00
Pesticide	80	58.36 $\pm$ 1.25 ab	37.50	91.00
Control	80	60.12 $\pm$ 0.89 ab	45.00	83.00

\*Differences between the averages represented with different letters are statistically significant ( $P \leq 0.05$ ).

It was determined that when compared to 2014-2015 (64.08 cm), average plant height in 2015-2016 (55.24 cm) was smaller (Table 4). The specific efficiency of 5% WV (62.16 cm) when compared to control treatment may have resulted from the positive impact of components in WV. This result was in agreement with the findings obtained by Nurhayati, Roliadi & Bermawie (2005) and Saberi, Askary, Sarpeleh & Gharalari (2013).

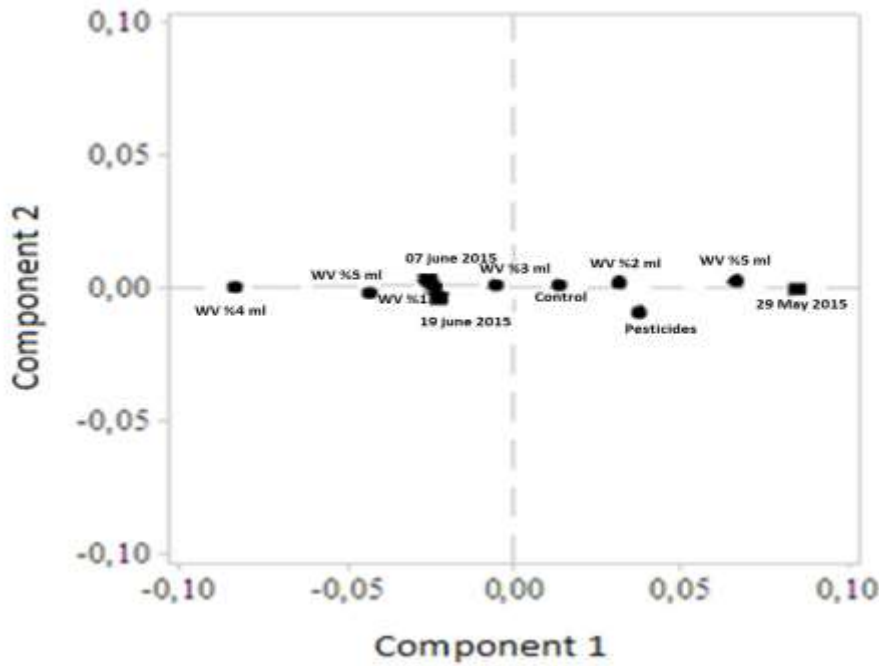
**Table 4.** Identification Statistics of Plant Height In Terms Of Treatments During 2014-2015 and 2015-2016 Seasons

Years	N	$\bar{X} \pm S_{\bar{x}}$	Minimum (cm)	Maximum (cm)
2014-2015	320	64.08 $\pm$ 0.50	37.00	91.00
2015-2016	320	55.24 $\pm$ 0.41	35.40	73.50

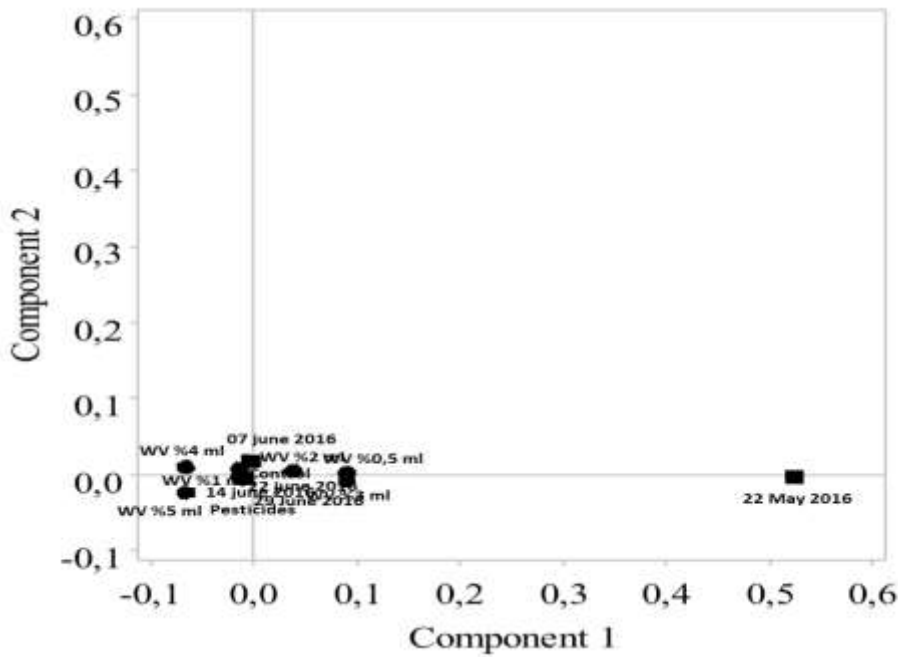
\*Difference between 2014-2015 and 2015-2016 seasons' averages is statistically significant ( $P \leq 0.05$ ).

### ***Effect of Treatments on Earing Period***

It is determined that May 29, 2015 treatment was related with 5% ml WV while June 7, 2015 and June 19, 2015 treatments were both inter-relational and related with 1%, 3% and 0.5% ml WV samplings (Figure 3). It was seen that there was no distinct relation between treatments and samples except from May 22, 2016. It was found that effects of all of the treatments on the number of earing were similar (Figure 4).



**Figure 3.** Simple Correspondence Analysis Graphic For the Relations Between 2014-2015 Season's Treatment and Sampling Dates In Terms the Number of Earing



**Figure 4.** Simple Correspondence Analysis Graphic For the Relations Between 2015-2016 Season's Treatment and Sampling Dates In Terms the Number of Earing

Although there was not a significant difference between treatments, it was also seen that there is a relative bigger effect of 5% ml WV on earing period. It was concluded that this may be resulted from the positive impacts of WV components.

**Effect of Treatments on the Number of Seed Per Spica**

Variance analysis on the effect of Year × Treatment interaction was not statistically significant in any of the features ( $P=0.428$ ). On the other hand, separate Year and Treatment dose effects were found to be statistically significant ( $P=0.000$ ). Minimum average number of seed per spica was found in 2% ml WV treatment (24.35), while maximum

was determined in pesticide (46.51) (Table 5). Average number of seed per spica in 2015-2016 (32.78) was higher than the number in 2014-2015 (26.64) (Table 6).

**Table 5.** Identification Statistics of Number of Seed Per Spica In Terms Of Treatments and Tukey Multiple Comparisons Test Results

Treatments	N	$\bar{X} \pm S_{\bar{X}}$	Minimum	Maximum
0.5% ml WV	8	25.91 $\pm$ 1.37 b	17.70	29.20
1% ml WV	8	29.34 $\pm$ 2.17 b	22.40	40.10
2% ml WV	8	24.35 $\pm$ 1.37 b	19.60	30.40
3% ml WV	8	28.57 $\pm$ 1.71 b	22.20	36.10
4% ml WV	8	28.09 $\pm$ 1.82 b	20.90	36.10
5% ml WV	8	29.35 $\pm$ 2.84 b	20.60	45.80
Pesticide	8	46.51 $\pm$ 1.89 a	40.10	54.10
Control	8	25.54 $\pm$ 1.56 b	16.50	31.80

\*Differences between averages represented with different letters are statistically significant ( $P \leq 0.05$ ).

**Table 6.** General Identification Statistics For 2014-2015 and 2015-2016 Seasons' Number of Seed Per Spica In Terms Of Treatments

Years	N	$\bar{X} \pm S_{\bar{X}}$	Minimum	Maximum
2014-2015	32	26.64 $\pm$ 1.25	16.50	44.90
2015-2016	32	32.78 $\pm$ 1.50	23.60	54.10

\*Difference between 2014-2015 and 2015-2016 seasons' averages is statistically significant ( $P \leq 0.05$ ).

Although only pesticide treatment seems to be statistically significant, it was seen that other averages are slightly higher except for 2% ml WV treatment. It was believed that this statistically significant difference between the parcels treated with pesticide results from the efficiency of pesticides that were used for controlling weed and diseases. There were studies in the related literature involving similar results (Rodrigo, Cuello-Hormigo, Gomes, Santamaria, Costa & Poblaciones, 2015; Blandino, Minelli & Reyneri, 2006; Khan, Khan, Khan, Imran, Idrees & Bibi, 2013; Shehzad, Maqsood, Anwar-ul-Haq & Niaz, 2012). Although they were not statistically significant, most of the WV treatments increased average number of seed per spica when compared to control. The study by Mungkunkamchao, Kesmla, Pimratch, Toomsan & Jothityangkoon (2013) supports this finding.

### Effect of Treatments on Grain Yield Per Spica

Variance analysis on the effect of Year  $\times$  Treatment interaction on grain yield per spica was not statistically significant ( $P=0.417$ ). On the other hand, separate Year and Treatment dose effects were found to be statistically significant ( $P=0.000$ ). Minimum average grain yield per spica is found in 2% ml WV treatment (0.80 g), while maximum is determined in pesticide (1.67 g) (Table 7). Average grain yield per spica in 2015-2016 (1.09 g) was higher than the grain yield per spica in 2014-2015 (0.96 g) (Table 8).

**Table 7.** Identification Statistics of Grain Yield Per Spica In Terms Of Treatments and Tukey Multiple Comparisons Test Results

Treatments	N	$\bar{X} \pm S_{\bar{X}}$	Minimum (g)	Maximum (g)
0.5% ml WV	8	0.85 $\pm$ 0.06 b	0.58	1.04
1% ml WV	8	1.04 $\pm$ 0.08 b	0.82	1.54
2% ml WV	8	0.80 $\pm$ 0.03 b	0.70	0.92
3% ml WV	8	1.02 $\pm$ 0.07 b	0.80	1.39
4% ml WV	8	1.00 $\pm$ 0.08 b	0.73	1.34
5% ml WV	8	0.96 $\pm$ 0.12 b	0.47	1.58
Pesticide	8	1.67 $\pm$ 0.08 a	1.36	2.01
Control	8	0.87 $\pm$ 0.06 b	0.56	1.01

\* Differences between averages represented with different letters are statistically significant ( $P \leq 0.05$ ).

**Table 8.** Identification Statistics For 2014-2015 and 2015-2016 Seasons' Thousand Kernel Weight

Years	N	$\bar{X} \pm S_{\bar{X}}$	Minimum (g)	Maximum (g)
2014-2015	32	0.96 $\pm$ 0.04	0.56	1.57
2015-2016	32	1.09 $\pm$ 0.07	0.47	2.01

\*Difference between 2014-2015 and 2015-2016 seasons' averages is statistically significant ( $P \leq 0.05$ ).



Pesticide treatment's positive effect on grain yield per spica was in line with the results obtained by Blandino, Minelli & Reyneri (2006), Shehzad, Maqsood, Anwar-ul-Haq & Niaz (2012), Khan, Khan, Khan, Imran, Idrees & Bibi (2013), Rodrigo, Cuello-Hormigo, Gomes, Santamaria, Costa & Poblaciones (2015). On the other hand, it was observed that grain yield per spica was higher in all of the WV treatments except for 0.5% and 2% ml WV treatments when compared to the control. It is thought that difference between treatments may result from the pesticide, different weed population density, the number of pests and predators. Positive effect of WV in the study was in line with the findings of Yoshimura, Washio, Yoshida, Seino, Otaka, Matsubara & Matsubara (1995) and Jothityangkoon, Koolachart, Wanapat, Wongkaew & Jogloy (2008).

### *Effect of Treatments on Thousand Kernel Weight*

At the end of the variance analysis, it was observed that the effect of Year  $\times$  Treatment dose interaction on thousand kernel weight was not statistically significant ( $P=0.163$ ). On the other hand, separate Year and Treatment dose effects were found to be statistically significant ( $P=0.005$ ). Minimum average thousand kernel weight is found in 2% ml WV treatment (34.23 g), while maximum was determined in pesticide (37.85 g) (Table 9).

**Table 9.** Identification Statistics of Thousand Kernel Weight In Terms Of Treatments and Tukey Multiple Comparisons Test Results

Treatments	N	$\bar{X} \pm S_{\bar{x}}$	Minimum (g)	Maximum (g)
0.5% ml WV	8	34.39 $\pm$ 1.16 b	30.40	39.40
1% ml WV	8	36.06 $\pm$ 0.86 ab	31.40	38.90
2% ml WV	8	34.23 $\pm$ 0.65 b	31.30	36.30
3% ml WV	8	36.33 $\pm$ 0.47 ab	34.10	38.80
4% ml WV	8	35.21 $\pm$ 1.11 ab	30.20	39.00
5% ml WV	8	35.09 $\pm$ 0.98 ab	29.60	38.80
Pesticide	8	37.85 $\pm$ 0.32 a	36.70	39.80
Control	8	34.99 $\pm$ 1.02 ab	32.00	38.90

\*Differences between averages represented with different letters are statistically significant ( $P \leq 0.05$ ).

Average grain yield per spica in 2015-2016 (33.98 g) was lower than the grain yield per spica in 2014-2015 (37.06 g) (Table 10). It was thought that pesticide treatment's statistical significance when compared to the other treatments results from the positive impact of pesticides that were used (Şanlı, Kaya & Kara, 2009; Bari, 2010; Balaž, Solarov, Vučković & Bagi, 2011; Khan, Khan, Khan, Imran, Idrees & Bibi, 2013). It was determined that the data about WV were similar with the findings obtained by Yoshimura, Washio, Yoshida, Seino, Otaka, Matsubara & Matsubara (1995), Mungkumkamchao, Kesmala, Pimratch, Toomsan & Jothityangkoon (2013), Jothityangkoon, Koolachart, Wanapat, Wongkaew & Jogloy (2008).

**Table 10.** Identification Statistics For 2014-2015 and 2015-2016 Seasons' Thousand Kernel Weight In Terms Of Treatments

Years	N	$\bar{X} \pm S_{\bar{x}}$	Minimum (g)	Maximum (g)
2014-2015	32	37.06 $\pm$ 0.31	33.50	39.80
2015-2016	32	33.98 $\pm$ 0.42	29.60	38.00

\*Difference between 2014-2015 and 2015-2016 seasons' averages is statistically significant ( $P \leq 0.05$ ).

### *Effect of Treatments on Harvest Index (%)*

At the end of the variance analysis, it was seen that the effect of Year  $\times$  Treatment dose interaction weight was not statistically significant ( $P=0.053$ ). On the other hand, separate Year and Treatment dose effects were found to be statistically significant ( $P=0.002$ ). Minimum average harvest index was found in control (37.34%), while maximum was determined in pesticide (46.65%) (Table 11). Average harvest index in 2015-2016 (45.47%) was higher than the harvest index in 2014-2015 (38.56%) (Table 12). It was observed that when compared to the control (37.34%), pesticide (46.65%) and 1% ml and WV (45.09%) treatments were significantly different. It was believed that high harvest index in pesticide was resulted from the positive results of disease and weed control.

**Table 11.** Identification Statistics of Harvest Index (%) In Terms Of Treatments and Tukey Multiple Comparisons Test Results

Treatments	N	$\bar{X} \pm S_{\bar{x}}$	Minimum	Maximum
0.5% ml WV	8	41.11 $\pm$ 2.54 abc	32.69	56.63
1% ml WV	8	45.09 $\pm$ 3.81 ab	35.22	62.97
2% ml WV	8	39.96 $\pm$ 2.31 abc	34.71	50.29
3% ml WV	8	43.60 $\pm$ 2.75 abc	35.35	60.36
4% ml WV	8	43.55 $\pm$ 2.69 abc	35.73	55.87
5% ml WV	8	38.80 $\pm$ 1.78 bc	31.13	49.19
Pesticide	8	46.65 $\pm$ 0.94 a	43.12	50.86
Control	8	37.34 $\pm$ 1.65 c	30.89	44.18

\*Differences between averages represented with different letters are statistically significant ( $P \leq 0.05$ ).

**Table 12.** Identification Statistics For 2014-2015 and 2015-2016 Seasons' Harvest Index (%) In Terms Of Treatments

Years	N	$\bar{X} \pm S_{\bar{x}}$	Minimum	Maximum
2014-2015	32	38.56 $\pm$ 0.61	32.53	42.03
2015-2016	32	45.47 $\pm$ 1.46	30.89	62.97

\*Difference between 2014-2015 and 2015-2016 seasons' averages is statistically significant ( $P \leq 0.05$ ).

## CONCLUSION

Chemical control method is one of the most commonly used techniques for controlling organisms that cause harm to the agricultural products. But these chemicals might threaten all of the living organisms that are not their target, including human beings besides polluting soil, air and water; there are various other negative impacts of these chemicals which are impossible to summarize. Therefore, it is highly important for us to prefer natural and safe products that can be used instead of these chemicals; today's world and the world in the future needs this replacement. It was observed that when compared to control group, pesticide treatment decreased weed in terms of variety and dry weight, it significantly increased values such as grain size, number of seeds per spica, grain yield per spica and harvest index of cultivated plants. On the other hand, it is determined that 1% ml vinegar had a significant effect on higher yield index.

## ACKNOWLEDGEMENT

The authors would like to thank Prof. Dr. Mehmet MENDEŞ, Assoc. Prof. Dr. Fatih ÇİĞ, and Assoc. Prof. Dr. Süleyman Mesut PINAR for the help, and BERCE Alparslan Agricultural Administration for providing place/opportunity for this study. This study constitutes a part of a PhD thesis (A Research on Determination of Some Effects of Wood Vinegar and Pesticides on Wheat Agro-ecosystems). Further, this study has been presented in IGAP2018-1ST International GAP Agriculture and Livestock Congress 2018 (25-27 April, 2018/Şanlıurfa, Turkey) and EJONS International Congress on Mathematic, Engineering and Natural Sciences - III (21-22 April, 2018/Mardin, Turkey) as an oral presentation.

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