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Effect of crop rotations on winter wild oat (*Avena sterilis* L.) populations in Osmaniye province wheat sown areas

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ABSTRACT

This study was carried out to determine the impact of three-year crop rotation in sampling fields on winter wild oat (Avena sterilis L.) populations in Osmaniye wheat sown areas. The study was conducted in Osmaniye province between the years 2013-2015. A total of 103 fields in 7 districts' wheat sown areas were determined; these sampling fields were visited every year during May-August and effects of different crops sown on winter wild oat populations were observed. Besides determining frequency of occurrence, randomly chosen general coverage in 1 decare and special coverage in 1 m2 in three points were specified. As a result of the study, it was determined that all of the crops except wheat decreased winter wild oat populations and it was found that the changes were related to the crop rotations. It was determined that corn, sunflower, soybean and peanut sown in 2nd and 3rd year instead of wheat decreased the frequency of winter wild oat at 2% and below. Moreover, when the three-year crop rotation system was analyzed, it was revealed that the maximum decrease in winter wild oat population general coverage occurred in 4 crop rotation period. It can be found that populations decrease can be up to more than 90% when compared to 2 and 3 crop rotation systems. It was concluded that crop rotations are sufficient in controlling winter wild oat that are problematic in wheat fields.

Introduction

The quality and yield of wheat (*Triticum* spp.), which is strategic crop of today's world, decrease if weeds are not taken under control. Winter wild oat (*Avena sterilis* L.), a member of *Poaceae* family, which consists of 650 varieties and almost 9000 species, is the main host of wheat in some regions (Uygur 1985; Uygur et al 1986). In the studies carried out in Turkey, it was observed that yield loss in wheat was approximately 30.00% in Aegean Region while it was 24.00% in Eastern

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Anatolia Region (Tepe, 1998). Also, Kadıoğlu et al. (1993) determined that when winter wild oat reaches 3-5 weed/m^2, it is necessary to start to manage as the economic loss threshold is reached. The recent use of licensed herbicides, which have common effect mechanism, winter wild oat has become resistant to ACCase (*Acetyl-CoA carboxylase*) and ALS (*Acetolactate synthase*) inhibitors; in addition to this, it has now become almost impossible to control with winter wild oat populations because of many reasons. Sowing same crop more than once, using same type of soil tillage, irritation and fertilization times, incorrect and unconscious use of herbicides, missing the right development period of weeds, are some of these reasons (Yücel, 2004; Ayata, 2014; Gürbüz, 2016; Torun, 2017). Changes in winter wild oat populations in sampling wheat fields were researched in order to determine different crop rotation effects. It was attempted to observe which crop rotation system affected mostly the problematic winter wild oat population. As a result of the sampling fields, Osmaniye province of winter wild oat population is determined for the first time and the relationship between winter wild oat population change-crop rotation systems is presented in this study.

Materials and Methods

Materials consist of the fields in Osmaniye province, Çukurova, Turkey. The determined fields were visited during May and August every year and sown crops and winter wild oat populations in the field were carefully recorded. The total distance from Osmaniye districts to the center was 206 km. By choosing sampling fields along the line, 103 wheat fields at every 2 km were determined. The sampling wheat fields to be sown in first year 2013 were determined and these fields were periodically visited in 2014 and 2015, crop rotation and winter wild oat population interactions among the crops were observed (Uygur et al 1991; Uygur, 1997) (Table 1).

Table 1. Determined of survey districts, distances to center and field survey numbers in 2013.

Survey districts	Distance from center point (km)	Field survey numbers
Kadirli	41	30
Sumbas	54	10
Center	-	26
Düziçi	30	23
Bahçe	40	4
Hasanbeyli	32	5
Toprakkale	9	5
Total	206	103

Winter wild oat frequency (%) (F), general coverage (GC) and special coverage (SC) were individually calculated (Uygur et al. 1984). Population of calculation model was modified according

to Odum (1971); 1 decare area was randomly chosen from every sampling field and also general coverage was determined. On the other hand, observations in three different points (1 m^2) were carried out in order to determine special coverage of winter wild oat populations. Estimations were conducted to determine the effect of winter wild oat coverage (Tagem, 2008). Population changes in 103 fields, which were determined in crop rotation system, had been carefully observed for three years. Below mentioned formula were used in determining winter wild oat populations.

Equation 1. $$F\ (\%) = \left(\frac{n}{m}\right) * 100$$

Equation 2. $$GC\ (\%) = \frac{Species\ Coverage\ Area}{m}$$

Equation 3. $$SC\ (\%) = \frac{Species\ Coverage\ Area}{n}$$

Frequency shows percentage (%) of weeds in surveyed fields. n = Total number of fields involving specific species. m = Total number of fields in which measurement is made (Equation 1). Species Coverage Area (%) is the total value of weed covering the surface of a field.

General Coverage (%) (GC) = Coverage of a weed species in surveyed fields/ number of total surveyed fields (Equation 2).

Special Coverage (%) (SC) = Coverage of a weed species where a species occurred / number of total surveyed fields (Equation 3).

Results and Discussion

It was observed that population frequencies between 2013 and 2015 in Osmaniye were 81.80% and 80.70%; the frequency decreased to 66.60% in 2014 (Table 2). There were various reasons behind this frequency decrease in 2014. Wheat crops could not develop because of lack rain and wheat fields were plowed. Another significant factor was changing crops that winter wild oat were not main host of these crops.

It was determined that the highest general coverage were in Sumbas and Düziçi in 2013, Düziçi and Hasanbeyli in 2014 and 2015, respectively. The highest general coverage average in three years was 24.44% in Düziçi while the lowest was 1.33% in Bahçe. General coverage of other districts was respectively: 23.77% in Hasanbeyli, 15.01% in Kadirli, 15.00% in Sumbas, 13.97% in Toprakkale and 6.31% in Center (Table 2). Doğan (1985) determined that the dominant *Avena* species in Western and Southern Anatolia was winter wild oat. He reported that the species is very common in Southern and Eastern Anatolia including Osmaniye, Adana, Urfa, Diyarbakır and Mardin. On the

other hand, Kadıoğlu et al (1993) made an analysis on the basis of wheat prices per decare and stated that economic loss of winter wild oat thresholds in Çukurova Region was 5 winter wild oats per m^2.

It was found that the highest special coverage was 32.18% in Düziçi. The other districts of special coverage were 21.96% Kadirli, 19.37% Sumbas, 8.96% Center, 22.25% Toprakkale, 1.47% Bahçe and 23.77% Hasanbeyli (Table 2). Kadıoğlu et al (1990) focused on winter wild oat which caused problem in Çukurova Region wheat sown areas. They carried out a research on the effect of winter wild oat on wheat development and yield and they reported that winter wild oat population especially increased in 2-4 leafed periods, and chemical control should be applied in winter wild oat development period.

It was stated that the highest frequency was observed between 2013 and 2015 in Sumbas, Bahçe; it was 100.00%. Frequency in three years for other districts were 70.00% in Kadirli, 76.67% in Sumbas, 67.95% in Center, 78.26% in Düziçi, 66.67% in Toprakkale, 75.00% in Bahçe and 100.00% in Hasanbeyli (Table 2). According to our data compared from studies, these species belonging to *Poaceae* family, which cause problem in wheat fields, decreased yield and quality loss; it was found that the species were 30.00% in Aegean Region and 24.00% in Eastern Anatolia Region (Tepe, 1998). Furthermore, it was ascertained that *Avena* species of *Poaceae* family affected wheat yield in Çukurova (Kadıoğlu and Uygur 1990; Boz et al. 1993; Kadıoğlu et al. 1993).

It was observed that there was a decrease in the values of winter wild oat populations with the change of different crops in determined fields. Population decreased in the second year because of sowing different crops, in that period winter wild oat were not the main pests of determined fields, so there was a change in the population and crop rotation was used for controlling weeds automatically (hoeing, allelopathic effect, etc.).

There was no effect on winter wild oat frequency in the determined fields of Bahçe and Hasanbeyli districts as wheat had been continued to sow for 3 years. Beside different crops were sown in other observed fields, there occurred winter wild oat frequency changes which was a decrease from 83.30% to 70.00% in Kadirli, 100.00% to 70.00% in Sumbas, 76.90% to 69.20% in Center and 80.00% to 60.00% in Toprakkale. There were decreases in winter wild oat frequencies according to different crop sown except wheat (Table 3). In Kadirli, it was evaluated that there was 30.47% decrease in winter wild oat frequency in wheat which was sown in the same field for 2 years; in the 3rd year the frequency was 24.43%. It was determined that winter wild oat frequency in corn and peanut sown for 2 years was below 1.00% while there was no wild oat population in soybean. It was found that in Sumbas district, in the same fields winter wild oat frequency was

40.00% in wheat for 2nd year, also it decreased to 16.34% in 3rd year and in peanut 1.00%. It was important increase seen in the number of different crops in the fields in Center; this kept winter wild oat frequency below 10.00%.

Table 2. General coverage, special coverage and frequency changes in winter wild oat populations of between 2013 and 2015 (%).

Survey	2013			2014			2015			Averages		
Districts	GC	SC	Frequency	GC	SC	Frequency	GC	SC	Frequency	GC	SC	Frequency
Kadirli	17.2	20.6	83.3	16.3	28.7	56.7	11.6	16.6	70.0	15.0	22.0	70.0
Sumbas	23.4	23.4	100.0	16.1	26.8	60.0	5.6	7.9	70.0	15.0	19.4	76.7
Merkez	10.9	14.2	76.9	3.7	6.5	57.7	4.3	6.3	69.2	6.3	9.0	67.9
Düziçi	24.0	29.1	82.6	22.0	38.9	56.5	27.3	28.5	95.7	24.4	32.2	78.3
Toprakkale	7.4	9.3	80.0	17.1	28.5	60.0	17.4	29.0	60.0	14.0	22.3	66.7
Bahçe	0.3	0.5	50.0	0.5	0.7	75.0	3.3	3.3	100.0	1.3	1.5	75.0
Hasanbeyli	18.7	18.7	100.0	24.3	24.3	100.0	28.3	28.3	100.0	23.8	23.8	100.0
Averages	14.5	16.5	81.8	14.3	22.1	66.6	14.0	17.1	80.7	14.3	18.6	76.4

The frequency was below 1.50% in sunflower and barley. There were less wheat fields in Düziçi district in the second year; because of this, winter wild oat frequency decreased to 29.76%. Continuing an increase in the number of wheat fields in the third year, this caused frequency up to 31.58%. Frequency in barley was 8.50%, while it was 2.00% in the fallow. It was evaluated that in Toprakkale, winter wild oat population frequency in wheat fields were 28.50% and 21.75% respectively. It was observed that, there was no winter wild oat population in both years in the fields that were seen in rotation system (wheat and corn) (Table 3). After indicating winter wild oat populations in the fields in May, the fields were revisited in August and crops were carefully recorded. It was observed that it was a decrease in winter wild oat coverage, which became problem in winter because of the changing the number of crop sown. It was also determined that at the end of the three-year crop rotation, there was no winter wild oat population seen in some crop rotation systems (Table 4). Thus, it was ascertained that increase in the number and variety of crops can be used for controlling winter wild oat populations; and it was detected that corn as the first preferred crop in fields and alternative crops such as sunflower are efficient in decreasing winter wild oat populations.

Table 3- Crop sorts and the field numbers of crop sown in Osmaniye province between 2013 and 2015 and the effect of crops on winter wild oat frequency (%).

Survey Districts	May 2013			May 2014				May 2015			
	A.sterilis Frequency (%)	Crop	Field Numbers	*A.sterilis* Frequency (%)	Crop	Field Numbers	Crops Effect on *A.sterilis* Frequency (%)	*A.sterilis* Frequency (%)	Crop	Field Numbers	Crops Effect on *A.sterilis* Frequency (%)
Kadirli	83.3	Wheat	30	56.7	Wheat	16	30.47	70.0	Wheat	14	24.43
					Corn	13	0.12		Corn	12	0.34
					Soybean	1	-		Peanut	4	0.38
Sumbas	100.0	Wheat	10	60.0	Wheat	4	40.00	70.0	Wheat	3	16.34
					Corn	6	0.17		Corn	5	0.90
									Peanut	2	1.00
Center	76.9	Wheat	26	57.7	Wheat	14	6.36	69.2	Wheat	10	9.75
					Sunflower	6	1.17		Sunflower	9	1.39
					Corn	5	0.10		Corn	6	0.17
					Soybean	1	0.50		Barley	1	1.50
Düziçi	82.6	Wheat	23	56.5	Wheat	17	29.76	95.7	Wheat	19	31.58
					Fallow	4	-		Barley	3	8.50
					Corn	1	-		Fallow	1	2.00
					Peanut	1	-				
Bahçe	50.0	Wheat	4	75.0	Wheat	4	100.00	100.0	Wheat	4	100.00
Hasanbeyli	100.0	Wheat	5	100.0	Wheat	5	100.00	100.0	Wheat	5	100.00
Toprakkale	80.0	Wheat	5	60.0	Wheat	3	28.50	60.0	Wheat	4	21.75
					Corn	2	-		Corn	1	-
Averages	81.8	Wheat	103	66.6	Wheat	63	47.87	80.7	Wheat	59	43.41
					Corn	27	0.08		Corn	24	0.35
					Sunflower	6	1.17		Sunflower	9	1.39
					Fallow	4	-		Peanut	6	0.69
					Soybean	2	0.25		Barley	4	1.50
					Peanut	1	-		Fallow	1	2.00

It was seen that preferring different crops which do not have host is significant in decreasing winter wild oat population in wheat and practicing different methods and control techniques have direct impact on the populations. It was found that cultivating a different crop after wheat

decreased the populations of winter wild oat. It was observed that, cultivating sunflower or corn as the first crop in wheat fields instead of wheat decreased winter wild oat populations.

Harker et al. (2009) completed a study on barley weed species in Canada. They focused on and analyzed herbicide regime used on soil cultivation and on rotation of barley-canola-barley-pea; they also observed population density and frequency of wild oat (*Avena fatua* L.) in specific locations and changes in seed production. It was reported that herbicides used in barley fields can be decreased by the use of crop rotation. They reported that density, frequency and seed production of wild oat population in canola-pea rotation fields decreased. They stated that this rotation decreased the population from 91.00% (2001) to 97.00% (2005). According to Gonzalez-Diaz et al (2012), it is possible to keep under economic loss of thresholds by using three-year crop rotation system without any needs to practice chemical control on wild oat populations.

Filizadeh et al (2007) focused on changes in populations on only rice and rice + soybean + rice combinations. They observed the highest density in *Echinochloa crus-galli* (L.) P.B., *Sagittaria sagittifolia* L. and *Alisma plantago-aquatica* L. species in only rice fields; on the other hand there was 62.50% decrease in *Echinochloa crus-galli* (L.) P.B., *Sagittaria sagittifolia* L. and *Alisma plantago-aquatica* L. population density in rice+soybean+ rice crop rotation on fields. Also, species population density in fields with no soil cultivation was lower, and crop rotation increased rice yield about 17.00 and 21.00%. Norsworthy et al (2012) indicated lack of crop rotation results in the rise of weed populations with less crop rotations and deduced that continuous herbicide applications in less rotations for controlling weeds cause herbicide resistance. There were decreases in winter wild oat populations as crops cultivated after wheat was different between 2013 and 2015 in Osmaniye. It was determined that among the determined crop rotation systems, there was 100.00% change in winter wild oat populations in wheat + corn + wheat, wheat/corn + peanut/corn + wheat, wheat/soybean + corn/soybean + corn and wheat/peanut + corn/peanut + peanut crop rotation systems. It was determined that there were almost 90.00% - 99.00% changes in weed coverage in the other preferred crop rotation systems (Table 4). It was observed that it is possible to decrease populations in time by changing crops that are not main hosts of winter wild oat. In scope of three-year crop rotation systems in Osmaniye, it was determined that; in two-crop rotation system, there was 95.20% decrease in winter wild oat populations, in three-crop rotation system, there was 98.40% decrease and in four-crop rotation system, there was almost 100,00% decrease in populations.

Table 4. Some crop rotation systems of winter wild oat general coverages and their highest changes (%)between 2013 and 2015.

May-August 2013	May-August 2014	May 2015	Different Crop Sown	A. sterilis GC (%)		Change (Decrease%)
				2013	2015	
Wheat	Corn	Corn	2 crop	30.00	<0.01	100.0
Wheat + Corn	Corn	Corn		3.33	0.33	90.1
Wheat + Corn	Wheat	Corn		20.00	2.00	90.0
Wheat + Corn	Wheat + Corn	Corn		5.00	0.50	90.0
Wheat	Sunflower	Arpa	3 crop	50.00	1.50	97.0
Wheat + Corn	Corn	Peanut		<0.01	<0.01	-
Wheat + Soybean	Corn	Corn		45.00	0.75	98.3
Wheat + Corn	Wheat + Corn	Peanut		45.00	2.00	95.6
Wheat + Corn	Wheat + Peanut	Corn		50.00	0.50	99.0
Wheat + Corn	Corn + Peanut	Wheat		<0.01	<0.01	-
Wheat + Corn	Peanut + Corn	Wheat		70.00	<0.01	100.0
Wheat + Soybean	Corn + Soybean	Corn		5.00	<0.01	100.0
Wheat + Peanut	Corn + Peanut	Peanut		70.00	<0.01	100.0
Wheat	Wheat + Sesame	Sunflower		32.50	1.00	96.9
Wheat + Corn	Soybean + Peanut	Corn	4 crop	60	<0.01	100.0
	2 crop rotation system			14.60	0.70	95.2
	3 crop rotation system		Averages	36.75	0.58	98.4
	4 crop rotation system			60.00	<0.01	100.0

Anderson et al. (2007) focused on crops that can be alternatives for winter wheat and observed changes in weed populations. They stated combinations of eight different crops used in a period of eight years on crop rotation system and they followed 17 weed species. At the end of the study, they determined that *Bromus tectorum* L., *Kochia scoparia* (L.) Schrad., *Conyza canadensis* (L.) Cronquist and *Eragrostis cilianensis* (All) Vign. Lut.ex Janchen species made 87,00 % of population density during crop rotations. On the other hand, they determined that minimum weed populations were in wheat + fallow and wheat + corn + sunflower crop rotations. In wide and semi-arid agricultural areas, during cold and warm seasons, it is necessary to practice minimum four-crop rotation system in order to repress weed population density. Pop et al (2009) observed the effects of different crop interactions in fields with two-year (corn + wheat), three-year (soybean + corn + wheat) and four-year (soybean + corn + wheat + sunflower) crop rotations. They determined that weed density in two-year product rotation was 213-236 weed/m^2, which means decrease in population. They

compared two-crop, three-crop and four-crop rotations and they emphasized that four-year crop rotation decreased weed population the most and found that crop rotation is highly significant in decreasing weed population. Blackshaw et al. (2001) determined that there was 98 weed/ m^2 in fields with only wheat, 15 weed/m^2 in wheat + canola rotation fields, 5 weed/ m^2 in wheat + flax rotation fields and 6 weed/m^2 in wheat+fallow fields. Davis et al (2012) compared 2-year rotation (maize-soybean) that used fertilizers and applied herbicides to 3-year rotation (maize-soybean-small grain + red clover) and 4-year rotation (maize-soybean-small grain + alfalfa-alfalfa) conventionally. Weeds were affected because of sowing different crops by using small amounts of synthetic agricultural chemical inputs.

Conclusion

According to the studies, weed numbers, coverage and frequencies decrease with crop rotation and the method is highly important in weed management. It is mentioned that weed flora, which causes problems in agricultural areas, changes when different crops enter rotation; it is determined that different crops are almost sufficient in controlling weed populations (Forcella et al. 1993; Buhler, 2002; O'Donovan et al. 2007; Vencill et al. 2012). Shortly, different study results in world, it can be said that different types of crops are used for weed control as a part of crop rotation system, it has become possible to minimize herbicide use and there has been increase yield. On the other hand, there have been different crop sown in fields, it has been possible to automatically control weed populations and there has been a decrease in the dominance of weeds in fields (Liebman and Dyck, 1993; Blackshaw et al. 2001; Anderson et al. 2007). There is no study in Turkey about the relationship between crop rotation and weed population; this is why, it is highly important to carry out these researches and studies for detecting the effects of crop rotation on weed population. It was observed that alternative crop sown except wheat decreased the frequency and coverage areas of winter wild oat in 3 and 4 year crop rotations. In this study, it was revealed that only crop rotation is sufficient in the control of winter wild oat management that is the main host of wheat fields. It shows that crop rotation plays a significant role in changing weed flora, harvest of crops, weed phenologies, competitive capacity and in periodical changes in the relationship between crops and weed species.

Conflict of Interest

No conflicts of interest have been declared.

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