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Evaluation of wild oat (*Avena ludoviciana*) resistance to diclofop methyl herbicide in Southern Iran

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Abstract

Herbicide resistance is a growing problem in weed management in different region of the world including Iran. In order to evaluate the resistance of wild oat population from southern Iran to diclofop methyl (Ilooxan) herbicide, five population of wild oat from different region of Fars province collected and sprayed by Illoxan with recommended dose at 3 leaved stage. For evaluate dose response of populations concentration of 0, 0.5, 1, 1.5, 2, 3 and 4 folds of recommended dose also evaluated in each population. The results showed that by application of Illoxan wild oat dry weight and survival reduced significantly, but was not completely controlled by recommended dose which mean these biotypes shows tolerance to this herbicide. There was also considerable difference between populations collected from different regions. So, required dose for 50% reduction in wild oat biomass (ED_{50}) was higher in populations from Marvdasht than other regions. In general these results showed that more précised management such as herbicide rotation need for avoidance from herbicide resistance in wild oat.

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Introduction

Among most harmful weeds of the word (which include 18 weed species) 10 species belong to poaceae family and wild oat (*Avena ludoviciana*) is one of the most important weed of poaceae family in more than 20 important crops and in the 55 countries in the world (Heap, 2008). Wild oat is one of the most important weeds in irrigated and rain-fed cereal fields, pulse and important crops (Dezfoli, 1997). Two species of wild oat are spring wild oat (*A. fatua*) and winter wild oat (*A. ludoviciana*) which, occurrence of winter species is dominant in Iran (Dezfoli, 1997). In a 5 years evaluation done by Weed Research Institute of Iran, wild oat is the most important grass weed in Iran wheat fields with average of 20 plants per square meter (Minbashi *et al.*, 2007).

Diclofop methyl (Since 1978) and other ACCase inhibitor herbicides have the highest effect and application in controlling wild oat. Extensive use of ACCase herbicides for selective control of wild oat in different main crops causing to evolution of herbicide resistance population of wild oat in main area of crop growth in the different regions of the world (Owen *et al.*, 2007; Heap, 2008). In a field evaluation in Canada showed the level of wild oat resistance to ACCase and ALS inhibitors varied in different regions (Beckie *et al.*, 2008). Broster *et al* (1998) also reported the occurrence of resistance biotypes in eastern Australia. According to International Survey of Herbicide Resistance Weed (2013) more than 44 reports of resistance of wild oat biotypes to different herbicide group are exist up today.

Chemical control is the prevalent methods of wild management in Iran. Based on Iran Crop Protection Organization phenoxypropionate herbicides family are used to control wheat grass weeds specially wild oat for many years (Zand *et al.*, 2009). During past decade herbicides such as diclofop methyl, clodinofop propargyl and phenoxyprop-p-ethyl are among the most applied herbicides in Iran (Deihimfard and Zand, 2004). Constant and permanent use of ACCase inhibitors herbicides caused that wild oat resistance to these herbicides for the first time in 2004 and after 24 years of introducing diclofop methyl, after 12 years of introducing phenoxyprop-p-ethyl and after 10 year of intrucing of clodinofop propargyl from some region of Iran (Banakashi *et al.*, 2006; Zand, 2004).

There are several reports of unsuccessful control of wild oat from southern Iran with ACCase herbicides. For example Zand *et al.* (2008) reported that diclofop methyl cannot completely control wild oat from Khozestan province and Banakashi *et al.* (2004) reported the resistance to clodinafop propargil in genotypes from Fars and Khozestan Province. Because of extensive spread of wild oat and extensive use of diclofop methyl in Fars province there is a need for evaluate the resistance to this herbicide. Since the objective of this experiment was to evaluating the resistance of wild oat biotypes from different area of Fars province.

Material and methods

Location of experiment

The pot experiment was conducted in Arsanjan Islamic Azad University in Fars province with 1690m altitude, latitude of 29° 55´ and longitude of 53 ° 19´. Soil texture was silty sand with 1 % organic matter and pH= 7.9 and EC= 0.59 mmohs/cm.

Plant materials

Wild oat seed were collected from different region of Fars province included, Marvdasht, Arsanjan, Saadat Shahr, Eqlid and Beyza. For this purpose infested area was determined and seeds from fields which wild oat were not control completely with herbicide application were collected. After collecting, seed hulls removed and seed were sunjected to chilling for reducing seed dormancy and improving germination.

Experimental design

Experimental design was completely randomized design with five wild oat populations and four replications. Fifteen seeds were planted in each pot and located in appropriated condition for growth. After irrigation and emergence of wild oat at 3-leaved stage diclofop methyl (Illoxan) were applied at dose of 2.5 L/ha. For comparing with control check one pot

not sprayed for each treatment. After tow months of wild oat growth number of alive remained plants in each pot, mean heights of 10 plants in pot and wild oat dry weight in pot were measured. Data were subjected to ANOVA using Genstat software and mean compared using least significant difference test at 5% level.

Dose response analysis

In order to evaluate and determinate the degree of resistance in wild oat populations, effects of different dose of herbicide evaluated in a dose response experiment. For this purpose herbicide concentration of 0, 0.5, 1, 1.5 2, 3 and 4 folds of recommended dose of Illoxan were applied on plant and number of alive plants and dry weight of each pot were measured. For acquiring dose response curve a logistic regression equation was used:

$$y = y_0 \frac{a}{1 + abs(\frac{X}{X_0})^b}$$

Which in this equation, Y is dependent variable (dry weight and percent of alive plants) in x dose, x is herbicide dose, Y_0 is the lowest response limit, a is the highest response limit, b is slope and x_0 is the herbicide dose require for reducing weed dry weight by 50%.

Results and discussion

Number of wild oat

The results showed that application of Illoxan herbicide at 3-leaved stage significantly reduced number of wild oat in all populations (Table 1). The percent of reduction in density was differed among population of wild oat from 51.4 to 80% (Table 2). The lowest reduction obtained in population from Marvdasht and Arsanjan but, the highest reduction obtained in Beyza population and after this population from Eqlid and Saadat Shahr showed lower degree of reduction (Table 2). These results shows that in none of evaluated populations Illoxan in recommended dose cannot control wild oat completely and although in all of these populations number of survived wild oat plants were less than 50% but, this showed a tolerance to Illoxan herbicide. Banakashi *et al.* (2004) evaluates the response of wild oat to Clodinofop herbicide and observed that populations from Fars and Markazi province showed the higher tolerance in to this herbicide.

Table 1. Effect of Illoxan herbicide on density (plant/m²), dry weight (g/m²) and height (cm) of different wild oat populations.

Population		density	dry weight	height
Eqlid	Untreated	108	972.0	83
	Treated	34	221.0	35
Marvdasht	Untreated	107	1005.8	79
	Treated	52	301.6	64
Arsanjan	Untreated	100	910.0	81
	Treated	47	253.8	49
Saadat Shahr	Untreated	102	948.6	85
	Treated	33	55.0	32
Beyza	Untreated	110	984.4	83
	Treated	22	11.2	48
LSD		8.14	10.71	8.51

Wild oat biomass

The means showed that wild oat dry weight significantly affected by Illoxan application (Table 1). In all populations application of Illoxan reduced dry weight in comparison with control check but in none of these population dry weight reached to zero (Table 1). Among different population the highest reduction (87.8% reduction compared to untreated) in dry

weight observed in populations from Beyza region while the lowest reduction (70%) observed in population from Marvdasht (Table 2). There were no significant differences among population from Eqlid, Marvdasht and Arsanjan. This results shows that wild oat populations from Marvdasht had the highest tolerance to Illoxan herbicide which only 70% reduction observed in dry weight of this population.

Table 2. Effect of Illoxan herbicide on percent of reduction (compare to control check) in density dry weight and height of different wild oat populations.

Population	density	dry weight	height
Eqlid	68.5	77.3	57.8
Marvdasht	51.4	70.0	19.0
Arsanjan	53.0	72.1	39.5
Saadat Shahr	67.6	80.9	62.4
Beyza	80.0	87.8	42.2
LSD	6.71	7.62	5.63

Wild oat height

Illoxan application in all wild oat population significantly reduced plant height (Table 1). Percent of reduction varied between 19 to 62.2% (Table 2). Mrvdasht and Saadat Shahr population showed the lowest and highest reduction in height respectively. Also height reduction in population of Eqlid and Beyza were reltively high.

Dose response curve

Dose response curve of wild oat dry weight and survival have been shown in Fugres 1 and 2. All population showed similar response to increasing dose of Illoxan. The estimate parameters for logistic equation showed that base on wild oat dry weight with application of the highest dose (4 fold of recommended dose) wild oat population from Eqlid, SaadatShahr and arsanjan were not completely controlled (Table 3). On the other hand ED_{50} for dry weight of wild oat showed that the required dose for 50% control of oat completely varied for different population. The highest ED_{50} (1.72 L/ha) was belonged to Marvdasht population while for population of Saadat Shahr the Illoxan required dose for 50% reduction in wild oat dry weight was 0.98 L/ha. There were also different parameter values for survived plants (Table 3). The highest ED_{50} for survival obtained for Marvdasht population (2.14 L/ha) while the lowest values obtained in Beyza populations (0.90 L/ha). These mean that population of wild oat from Mrvdasht have higher tolerance to Illoxan while population from Beyza and Saadat Shahr have lower tolerance.

Table 3. Parameters estimated from fitted logistic equation for biomass and survival of wild oat after spraying with different dose of Illoxan.

Wild oat populations	Biomass (g/m^2)			Percent of survived plants		
	Highest control (a)	Slope (b)	ED_{50}	Highest control (a)	Slope (b)	ED_{50}
Eqlid	970.4(23.9)*	1.94(0.10)	1.21(0.08)	105.7(7.24)	1.59(0.34)	1.45(0.15)
Marvdasht	1032.0(28.0)	2.27(0.17)	1.72(0.06)	108.1(0.13)	1.59(0.44)	2.14(0.39)
Arsanjan	908.0(46.8)	1.65(0.16)	1.20(0.06)	99.8(6.02)	1.27(0.53)	1.40(0.79)
Saadat Shahr	947.7(34.6)	1.81(0.09)	0.98(0.07)	102.6(2.02)	1.79(0.14)	1.21(0.39)
Beyza	1023.0(12.6)	2.51(0.15)	1.71(0.02)	102.3(2.84)	1.76(0.28)	0.90(0.06)

* Values in parenthesis shows standard error.

The results showed that application of Illoxan at recommended dose reduced dry weight and survival of wild oat in all population but none of which were not completely controlled by this herbicide at recommended dose. By increasing Illoxan dose almost all population controlled. Although application of higher dose of herbicide can removed higher percent of weed and economically efficient, but this accompany with harmful effects including contaminant of under ground water (Cibagelgy, 1992;

Zimdahl, 1995), accumulation of toxin in food chain other and environmental harmful effects (Zimdahl, 1995).

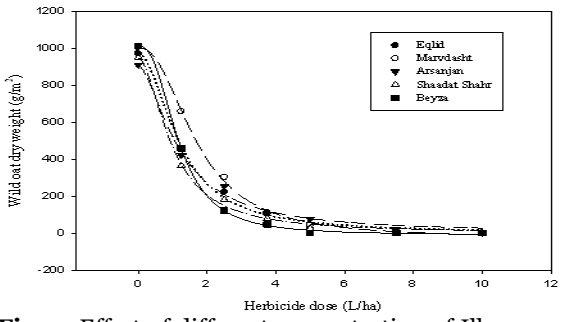

Fig. 1. Effect of different concentration of Illoxan on wild oat biomass.

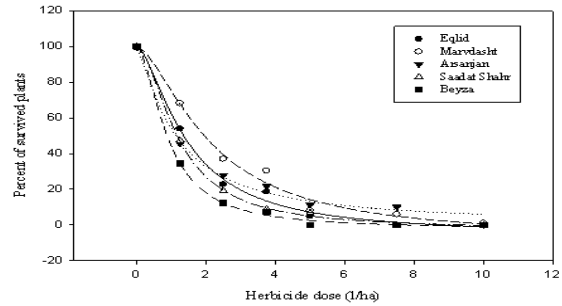

Fig. 2. Effect of different concentration of Illoxan on survival of wild oat.

The degree of herbicide tolerance was varied in different population as, population of Marvdasht showed the higher tolerance and Beyza and Eqlid showed the lower tolerance to Illoxan. Wild oat resistance to other herbicide also reported in other studies in different parts of Iran. Zand *el al.* (2006) evaluated the resistance of different wild oat population of Iran and reported that one of the populations obtained from Khuzestan province was resistant to clodinafop-propargyl in a field experiments and showed resistance to both fenoxaprop-p-ethyl and clodinafoppropargyl herbicides in greenhouse. Also among populations collected from Fars province one FR4 was resistant only to fenoxaprop-p-ethyl in greenhouse experiments. Banakashi *et al,.* (2004) reported that three wild oat population from Khuzestan province have resistance to clodifop- propargyl herbicide which was not control by recommended dose. Zand *et al.* (2003) also reported the wild oat resistance to some ALS inhibitor herbicide in different region of Iran.

Conclusion

The results showed that Illoxan herbicide at recommended dose can not control wild oat population obtained from different region of Fars province which mean these biotype shows tolerance or resistance to this herbicide. The degree of tolerance varied in different population so Marvdasht population shoed higher tolerance and Beyza and Eqlid population showed lower tolerance. This herbicide tolerance may be due to constant application of this Illoxan without any herbicide rotations which must be consider in herbicide management.

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