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Effect of Clodinafop-Propargyl and Mesosulfuron-Methyl Herbicides on Wild Oat (*Avena ludoviciana*) Control under Moisture Stress Condition

Mahdi Aghabeigi[1*] and Mohsen Khodadadi[1]

[1]*Vegetable Research Center/ Horticultural Science Research Institute, Agricultural Research, Education & Extension Organization, Iran.*

Authors' contributions

This work was carried out in collaboration between both authors. Author MA designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author MK managed measuring horticultural traits of the study, read and approved the final manuscript.

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ABSTRACT

In order to investigate the effects of drought stress on the effect of herbicides of Clodinafop-Propargyl (Topic) and Mesosulfuron-methyl (Chevalier) in greenhouse conditions, a split factorial experiment was conducted in 4 replications in a completely randomized design. The main plot consisted of three levels of irrigation (no stress, moderate stress and severe stress) and subplots in a factorial arrangement including 6 doses (0, 25%, 50%, 75%, 100% and 125% of the recommended dose) herbicides Clodinafop-Propargyl (Topic) and Mesosulfuron-methyl (chevalier) in pot. The results of analysis of variance showed that the type of herbicide had no significant difference in the amount of wild oat dry matter and in fact both herbicides had the same effect. However, drought stress had a significant effect on dry weight of oat (P = .05). The mean dry matter of wild oat in treatments without stress, moderate stress and severe stress was 0.50, 0.46 and 0.41 g/plant, respectively. The highest amount of wild oat dry weight was related to control without herbicide treatment or zero dose with mean of 0.96 g/plant, and the lowest was 125% with 0.07

**Corresponding author: E-mail: maghabeygi@yahoo.com;*

grams per plant. Drought stress reduces the efficiency of herbicides and, by increasing the dose of herbicide from the recommended amount, this defect can be eliminated. In this experiment, with a 25% increase in dosage of herbicides, their efficacy was similar to that in the recommended dosage in non-stress conditions.

Keywords: Drought stress; herbicide; herbicide efficiency.

1. INTRODUCTION

Drought is a multidimensional tension that occurs on different plant organs at different levels [1]. The process of dehydration of plants in drought causes fundamental changes in water relations, biochemical and physiological processes, the structure of the membrane and the inner and outer cells of the plant [2]. Drought does not only affect the water relationship, causing the plant to close the stomach, it reduces the rate of photosynthesis and grows. The closure of the stomach reduces the diffusion of carbon dioxide into the mesophilic cell of leaf, As a result, NADPH accumulates [3]. Soil drying and leaf water depletion, cause pressure on the photosynthesis process and disrupt carbon and nitrogen assimilation [1]. Reducing the amount of photosynthesis is the result of stomatal and non-stomatal Biochemical restrictions [2]. With drought, the plant closes its stomats to lose less water through transpiration. As a result, the diffusion of carbon dioxide into the leaf is limited and the rate of photosynthesis comes down. Although the dual-photosystem is highly resistant to drought, the electron transfer is limited under dry conditions [2]. In conditions of lack of moisture, increasing transpiration of the plant prevents the increase of leaf area. Therefore, it is clear that the higher the allotment of dry matter to the leaf surface has the advantages of growth, but it also causes more water loss from the leaves [4].

The yield loss due to weed competition is one of the reasons for reducing production in many crops. The damage caused by weeds in cereals in Canada alone is $ 639 million. It has also been predicted that wild oat competition in oat, wheat, and barley has led to a loss in yields of 11%, 10%, and 8% respectively [5]. This is due to the fact that Canada is a member of developed and industrialized countries. In Iran, if we consider the loss of yield by 20%, we will suffer losses of about $ 450 million from the loss of yield of wheat.

Despite the availability of different herbicides for wild oat control, this weed is still considered as one of the main challenges in the production of crops, especially cereals. Despite the availability of different herbicides for wild oat control, this weed is still considered as one of the main challenges in the production of crops, especially cereals. The use of herbicides in the 1950s is one of the most important agricultural advances in controlling weeds. Only in North America, herbicides use 20-30% of the inputs [6]. Such reports indicate that the major part of the cost of weed management is related to the use of herbicides.

Mushtagh et al., Compared the treatments with six herbicide treatments, including clodinafop, isoprostane, isoprothron+carfentrazone, fenoxaprop, metribuzin and isoproturon + diflufenican on wheat weeds. The average of three years of experiment showed that the population of Fallaris and wild oats decreased significantly. They concluded that isoprothron+carfentrazone and isoproturon + diflufenican with an average mortality of 87% and 82%, respectively, were the most effective herbicide treatments in the control of Fallaris and had no negative effect on wheat. Also, fenoxaprop and clodinafop treatments controlled 87 and 86 percent of wild oat. [7].

In Shahzad and colleagues field experiment, they examined the effectiveness of eight herbicides against the main weeds of wheat (P.minor, A.fatua and Emex spinosa) [7]. The results of their experiments showed that all herbicides significantly reduced the dry weight of weeds, and the highest reduction was related to clodinafop propargil (topic 15 wp) with 87-89% [8]. In another experiment, weed control of iodosulfuron + mesosulfuron (Atlantis 3.6WG) with different doses (100, 75, 50 and 25% recommended) was investigated in control of wheat weeds. Maximum dry matter reduction of weeds (99%) was observed at the recommended dose (100%). Reduced doses had a significant decrease in weed density (72-95%) and dry matter (83.94%) of wheat [9]. Many studies have been conducted on the effects of drought on wheat, but there is insufficient information on the interference of wheat and wild oats. Akey and

Morrison, by arranging a simple experiment, examined the growth of wild oat at different levels of moisture [10]. In this study, the effects of water on oat growth (such as leaf area, dry weight, and tiller number) in both farm and greenhouse conditions were investigated. In both greenhouse and field conditions, they concluded that growth in low moisture conditions was lower than high humidity (10% and 20% moisture content). Also, if the wild oat is at a pre-4-leaf stage, when moisture is reduced from 20% to 10%, the biomass loss rate is much higher. In this experiment, although the soil conditions, light, temperature, and thermal regimes were different, the experimental results were consistent with each other [10]. Another experiment examined the carbon allocation in wild oat and reproduction of wild oats at different levels of soil moisture without competition with wheat. The results of physiological studies in this experiment showed that in conditions of water stress, wild oat allocates 10% more carbon to roots than shoots [11].

The presence of Iran in a dry area would always cause drought stress in wheat. Chemical management of weeds under drought stress is one of the challenges of farm management. Therefore, the goal of this research is to investigate the effects of drought stress on herbicide efficacy.

2. MATERIALS AND METHODS

In order to investigate the effects of drought stress on the effect of herbicides of Clodinafop-Propargyl (Topic) and Mesosulfuron-methyl (Chevalier) in greenhouse conditions, a split factorial experiment was conducted in 4 replications in a completely randomized design. The main plot consisted of three levels of irrigation (no stress, moderate stress and severe stress) and subplots in a factorial arrangement including 6 doses (0, 25%, 50%, 75%, 100% and 125% of the recommended dose) herbicides Clodinafop-Propargyl (Topic) and Mesosulfuron-methyl (chevalier) in 20 × 20 × 25 pots (with 15 plants of wild oat per pot). The soil used was a combination of clay, sand and cow manure at a ratio of 2: 3: 2. Before the experiment, soil fertility was measured and the pots were irrigated twice a week. Drought treatments were used to weigh the pots which had the same weight at the beginning of the experiment. At each irrigation time, depending on the type of stress treatment, the required water content (100%, 75% and 50% of the field capacity, respectively) Calculated and given to each pot. In fact, pots that irrigated 100% of their field capacity were as without drought stress treatment and 75% and 50% of the field capacity, respectively, as moderate and severe drought stress treatments, respectively. There were 36 pots in each replicate. In the greenhouse, the temperature was controlled with a range of 24 ± 3, 15± 3°C day and night. The amount of light in the greenhouse was in accordance with normal conditions and was not used in artificial light. The length of the day and night was 11.5 and 12.5 hours, respectively. Spraying both herbicides separately and in the 2-3 leafy stage of wild oat. Two weeks after spraying, all plant samples were harvested from the soil surface and placed in an electric oven for 72 hours at a temperature of 75°C and their dry weight was measured. All statistical calculations were performed using SAS statistical software and Excel and Word software were used to draw charts and tables. For fitting the equations, Sigma plot software was used.

Topic, An emulsifiable concentrate formulation containing 240 g/l clodinafop-propargyl (and 60 g/l cloquintocet-mexyl as a safener), for the control of wild oats. Rates of Use in Topik at 0.25 litres per hectare. This herbicide is ACCase inhibitor [12]. Chevalier (Mesosulfuron, Iodosulfuron) is a sulfonyl urea herbicide, which are ALS inhibitors and have fully systemic activity on the target weeds – via both foliage & soil. Rates of Use this herbicide was 400 gr per hectare [13].

3. RESULTS AND DISCUSSION

The results of analysis of variance showed that the type of herbicide had no significant difference in the amount of wild oat dry matter and in fact both herbicides had the same effect. However, drought stress had a significant effect on dry weight of wild oat (P = .05). In fact, the biomass of dry matter of wild oat has a different response between herbicide treatments under stress conditions. Herbicide dosage also had a significant effect (P = .01) on dry weight of wild oat. The interaction between herbicides and doses was not significant. In fact, the doses were independent of the type of herbicide use. The interaction between drought stress and herbicide doses was also significant (P = .01). In fact, herbicide doses have a different effect on different levels of stress (Table 1).

Table 1. Analysis of variance of wild oat dry matter under the influence of drought stress and herbicide and herbicide doses

Source of variation	df	Mean of square	F	Pr>F
Herbicide	1	0.005	0.88	0.351
Replication	3	0.008	1.40	0.247
Herbicide× replication	3	0.014	0.24	0.865
Drought stress	2	0.019	3.33	0.039
Herbicide× Drought stress	2	0.004	0.72	0.49
Herbicide dose	5	3.51	589.08	0.001
Herbicide × dose	5	0.010	1.80	0.119
Drought stress × dose	10	0.133	22.44	0.001
Herbicide× Drought stress × dose	10	0.002	0.35	0.965
Error	102	0.0059	-	-
Total	143	-	-	-

The comparison of the mean dry weight of wild oat in different levels of stress is presented in Fig. 1. The mean dry matter of wild oat in treatments without stress, moderate stress and severe stress was 0.50±0.06, 0.46±0.04 and 0.41±0.03 g/plant, respectively. There was no significant difference between treatments without stress and moderate stress. There was also no significant difference between severe stress and moderate stress. However, two severe stress and without stress treatments showed a significant difference (Fig. 1).

The average dry weights of wild oat in different herbicide doses were also significantly different. The highest amount of wild oat dry weight was related to control without herbicide treatment or zero dose with mean dry weight of 0.96±0.051 g/plant, and the lowest was 125% with 0.07±0.006 gr/plant. All different levels of herbicide doses were placed in separate groups (Fig. 2). Doses of 25, 50, 75 and 100 respectively with dry matter of 0.88±0.04, 0.46±0.03, 0.23±0.01 and 0.14±0.01 g/plant, were arranged after zero dose.

The interaction effects of drought stress and herbicide doses on wild oat dry matter was also significant (Table 1). Drought stress reduces the effectiveness of herbicides in wild oat control, and its dry matter varies in different levels at each stress level. Only in dose of 125%, there was no significant difference between the three levels of stress. As the dose of herbicide decreases, the difference between the three levels of stress also increases. Because stress even without presence of herbicide, reduces the amount of dry matter of wild oats. Therefore, in two doses of 0 and 25%, we can see the reduction in the mean of dry mater after applying the stress, while in the doses of 50%, this trend is reversed and the stress increases the dry matter Because the effectiveness of herbicide has decreased in stress and in better conditions, irrigation has been better for herbicide (Table 2).

The response curve for herbicide doses in three levels of drought stress was fitted to data from two herbicides. The results of the coefficients are presented in Table 3. The numerical value of the Max and Min coefficients decreased from non-stressed to moderate stress and severe stress. As it is seen, mortality of 50% of oat plants occurred in non-stress, moderate stress and severe stress in doses, 42.63%, 48.85% and 24.25% of the recommended amount. In fact, drought has reduced the mortality of wild oats in herbicide doses, and two moderate and severe stress treatments require higher doses of herbicide to eliminate the same amount in non-stress conditions.

As seen in Fig. 3, in a non-stressed treatment, at a dose of about 42, there is a very high loss in wild oat dry matter and in two levels of drought stress (severe and moderate), the slope of dry matter loss is much lower and the loss dry matter also occurred a later, and with increasing stress level, the slope has become more less (Fig. 3). In this regard, Parker et al. stated that the effectiveness of many herbicides varies under drought conditions [14]. Absorption and especially the transfer of herbicides depend on the vegetative growth status of the plant, thus having a direct effect on the transfer and arrival of the herbicide to the target.

In conditions of lack of moisture, increasing transpiration of the plant prevents the increasing of leaf area. Therefore, it is clear that the higher amount of dry matter to the leaf area has the benefits of growth, but it also results in more water loss from the leaves [4]. Soil dryness limits plant growth. Ahmad et al. reported that drought stress reduces dry matter content [15]. Boutraa and Sanders also suggested that the average drought stress caused a 25% reduction in the relative growth rate of the plant [16].

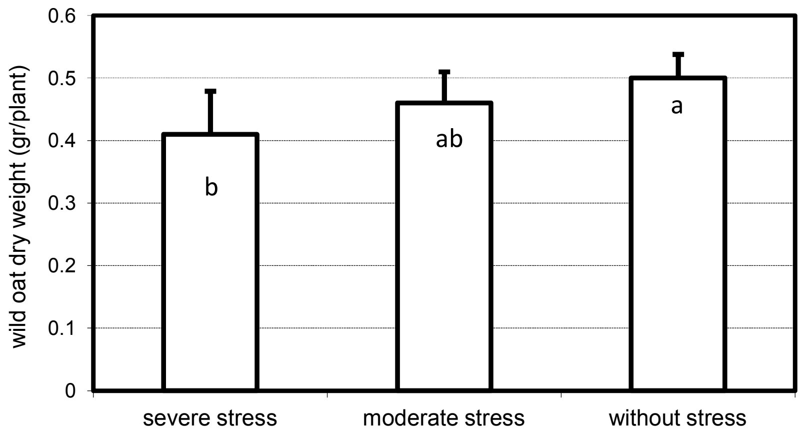

Fig. 1. Effect of drought stress on mean dry weight of wild oat in different herbicide doses (The similarities and non-similarities of the words indicate a significant and non-significant difference between the two groups). n=48

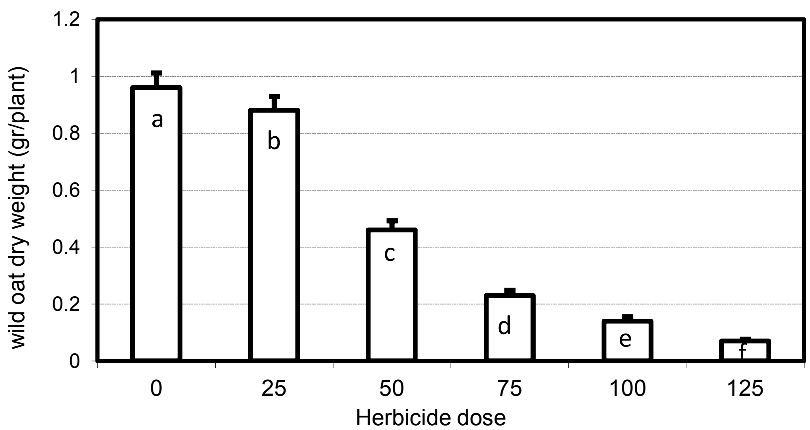

Fig. 2. Effect of herbicide dose on mean dry weight of wild oat in different drought stress (The similarities and non-similarities of the words indicate a significant and non-significant difference between the two groups). n=18

Table 2. Interaction between different doses of herbicide and drought stress on dry weight of wild oat (The similarities and non-similarities of the words indicate a significant and non-significant difference between the two groups). n=6

Percent of recommended dose of herbicides	Severe stress	Moderate stress	Without stress
0	0.76±0.01 de	0.96±0.01 c	1.15±0.03 a
25	0.74±0.02 e	0.83±0.03 d	1.06±0.04 b
50	0.47±0.04 g	0.53±0.03 f	0.38±0.05 h
75	0.33±0.01 i	0.24±0.01 j	0.14±0.01 k
100	0.21±0.02 j	0.15±0.00 k	0.05±0.00 i
125	0.09±0.00 i	0.07±0.00 i	0.04±0.00 i

Table 3. The coefficients obtained from fit equation * dose response curve in three levels of drought stress

Treatment	Parameter*	Value	Standard error (±)	R2
Stress (0%)	Min	0.0724	0.0213	
	Max	1.1730	0.0386	0.96
	Log Ec50	42.630	0.6940	
	b	-0.052	0.0082	
Stress (75%)	Min	0.0863	0.0230	
	Max	1.0155	0.0298	0.96
	Log Ec50	48.85	0.2766	
	b	-0.0524	0.0033	
Stress (50%)	Min	0.0613	0.0537	
	Max	0.8652	0.0681	0.93
	Log Ec50	57.240	0.8394	
	b	-0.0174	0.0042	

*y=min + (max-min)/(1+10^((logEC50-x)×b)) **

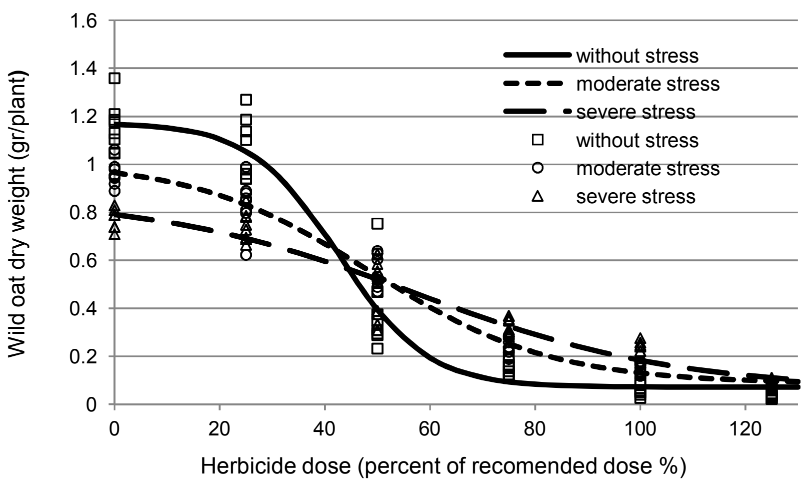

Fig. 3. The response curve of wild oat herbicide in three levels of moisture stress

4. CONCLUSION

Drought stress reduces the efficiency of herbicides and, by increasing the dose of herbicide from the recommended dose, this defect can be eliminated. In this experiment, with a 25% increase in dosage of herbicides, their efficacy was similar to that in the recommended dosage in non-stress conditions.

In order to investigate more precisely, it is recommended that experiments be carried out in the presence of drought stress treatments and, in field conditions, also be repeated to provide better results to farmers.

Physiological examination was not possible in this study, but the reduction of herbicide efficacy could be considered as two causes. A reduction in the herbicide uptake of herbicide may be one of these reasons. Some literature have reported that by increasing drought stress, the plant increases its cuticle thickness. The second reason can be related to metabolic processes. The results of some studies have shown that under drought conditions, severe activity of antioxidant enzymes reduces the level of peroxidation of fats and increases drought stress tolerance [3]. Therefore, radioactive isotopes (carbon-14) can be used to better understand the cause of reducing herbicide efficacy under drought conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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