# The Effect of Adjuvants on the Effectiveness of Some ACCase and ALS Inhibitors in Controlling Winter Wild Oat (Avena ludoviciana)

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# Abstract

The current study was conducted in 2020 to evaluate the effect of five adjuvants on increasing the efficiency of doses of various common herbicides in a wheat field in Iran to control wild oats. mesosulfuron + iodosulfuron. The experiment was carried out at the research greenhouses of the weed research department of the Iranian Plant Protection Research Institute. The experimental factors were included: 1) herbicide treatment at five levels (various doses of herbicides including Clodinafop-Propargyl (TopiK EC 8% and EC 24%), mesosulfuron + iodosulfuron (Atlantis OD 1.2% and WG 3.6%) and Pinoxaden (Axial EC 5%), 2) various adjuvants at five levels including Ino Alg NPK (containing 20% seaweed extract at a rate of four liters per hectare), Ino Alg NPK (NG) fertilizer containing 20% seaweed extract and 10% free amino acids with 2 liters per hectare, Torpedo II adjuvant with a dose of 0.1 liters per hectare, Doctil adjuvant with a dose of 0.04 liters per hectare, and the amino acid leucine (3% production produced by Sigma Aldrich, USA) and 3) winter wild oat populations (susceptible and resistant). In this study, the effect of the above adjuvants on increasing the effectiveness of the above herbicides was repeated to control winter wild oats (Avena sterilis subsp. ludoviciana (Durieu) Gillet & Magne). The study was done by a randomized design with a factorial experiment and four replications. Treatments were performed in 3-4 leaf stage of winter wild oats. The Fresh weight, dry weight, and survival percentage of the populations was measured twenty-eight days after application of the treatmentsfresh. The results of the experiment showed that the use among all herbicides, the recommended doses of herbicides along with Ino Alg NPK (NG) adjuvant showed the most significant effect in reducing the dry weight of wild oats.


# 1 Introduction

Wheat (*Triticum aestivum* L.) from the Poaceae family is one of the most important cereals worldwide and Iran (Montazeri et al., 2005), and the self-sufficiency of this product in Iran has always been considered by agricultural policymakers. Weeds have been one of the most important limiting factors in wheat production as they can cause damage and reduce its yield (Olesen et al., 2004). Wild oats are one of the most important weeds in irrigated and rainfed cereals, including wheat, which is a predominant weed in the fields, especially in autumn crops (Medd, 1996). Among weed management strategies, using herbicides in wheat fields is the most common way to control weeds (Chhokar et al., 2006). So far, 25 herbicides have been registered in Iran to control weeds in wheat fields, including 9 graminicides, 10 broadleafcides, and 6 dual-purpose herbicides (Zand et al., 2020). The f Acetyl-CoA carboxylase (ACCase) Inhibitors, including clodinafop-propargyl and pinoxaden, and enzyme acetolactate synthase (ALS) inhibitors, including mesosulfuron + iodosulfuron is one of the most important herbicides used in the control of narrow-leaved weeds in Iranian wheat fields (Zand et al., 2020).

On the other hand, increasing the efficiency of these herbicides in controlling wheat weeds, especially narrow-leavedweeds, has always been the focus of researchers and those in charge of wheat production. One of the strategies emphasized in the chemical control of weeds and increasing the efficiency of herbicides is the use of adjuvants (Barrosa et al., 2007). These substances are commonly used with post-emergence herbicides to increase herbicide efficacy and help increase herbicide effectiveness, especially in adverse conditions (Hassan et al., 2005). Adjuvants usually do not have a herbal or toxic effect, but combining with herbicides, they increase the efficacy (Jeffrey et al., 2004). A group of adjuvants increases the delivery of herbicides to the target site without harming the main plant (Travlos, 2012). Some adjuvants such as fertilizers (Ino Alg NPK and Ino Alg NPK (NG)) due to the reduction of antifouling effect through the presence of some salts and ions in the spray water (water quality) with herbicides and also more absorption of herbicides by the target plant increases herbicide efficiency and ultimately reduces their dose to control weeds (Robert et al., 2008). Torpedo II adjuvant is also a unique adjuvant to use with herbicides, the formulation of which is an emulsion (Abbaspoor, 2006).

According to the study by Naghshbandi et al (2008), the use of some vegetable oils or non-ionic surfactants added to the herbicide foramsulfuron resulted in a 20% increase in fox tail grass (*Alopecurus myosuroides* Huds.) control. In a similar study, the use of the adjuvant led to a 25% reduction in the recommended dose of the tribenuron-methyl herbicide in spring grain weed control (Domaradzki & Kieloch., 2009). According to Stevan et al. (Stevan et al., 2010), the dose of the active ingredient ofSaflufenacilherbicide in combination with adjuvants was reduced from 303 g.a.i.$h^{-1}$ of active ingredient to 201 g of the substance. In another study, it was reported that there was no significant difference in terms of wheat grain yield and control percentage of wild oats in the recommended dose and reduced dose (33% reduction) of the herbicide clodinafop-propargyl. This result suggests that it is possible to reduce the dose of clodinafop-propargyl without reducing grain yield (Armin et al., 2006).

Therefore, considering the importance of using herbicides in weed management despite many environmental problems, including the resistance of weeds to these chemicals, this study aims to investigate the ability of five adjuvants used in this experiments to increase the effectiveness of herbicides for controlling narrow-leaved weeds, including winter wild oats.

# 2 Materials And Methods

In order to evaluate the effect of adjuvant type on the efficacy of different doses of clodinafop-propargyl with two formulations (EC 8% and EC 24%), mesosulfuron + iodosulfuron (WG 3.6% and OD 1.2%) and Pinoxaden (EC 5%) herbicides in controlling resistant and susceptible biotypes of winter wild oat (*Avena sterilis* subsp. *Ludoviciana* (Durieu) Gillet & Magne), a factorial experiment was conducted with a completely randomized design in the greenhouse of the Iranian Research Institute of Plant Protection from 2020 to 2022. The first factor tested was the different doses of clodinafop-propargyl herbicides (0.51 (40.8 g.ai.$ha^{-1}$), 0.64 (51.2 g.ai.$ha^{-1}$), 0.8 (64 g.ai.$ha^{-1}$) and one L/h (80 g.ai.$ha^{-1}$), clodinafop-propargyl herbicides (0.154 (4 g.ai.$ha^{-1}$), 0.192 (5 g.ai.$ha^{-1}$), 0.24 (6 g.ai.$ha^{-1}$) and 0.3 L/h (7 g.ai.$ha^{-1}$), mesosulfuron + iodosulfuron(OD 1.2%) 1.05 (12.6 g.ai.$ha^{-1}$), 1.2 (14.4 g.ai.$ha^{-1}$), 1.35 (16.2 g.ai.$ha^{-1}$) and 1.5 (18 g.ai.$ha^{-1}$), mesosulfuron + iodosulfuron (WG 3.6%) 0.154 (6 g.ai.$ha^{-1}$), 0.192 (7 g.ai.$ha^{-1}$), 0.240 (9 g.ai.$ha^{-1}$), 0.3 (11 g.ai.$ha^{-1}$), as well as Pinoxaden herbicide including doses of 0.62 (31 g.ai.$ha^{-1}$), 0.77 (38.5 g.ai.$ha^{-1}$), 0.96 (48 g.ai.$ha^{-1}$) and ((60) 1.2). The second factor included various adjuvants: Ino Alg NPK (containing 20% seaweed extract at a rate of four liters per hectare), Ino Alg NPK (NG) fertilizer (containing 20% seaweed extract and 10 % free amino acids at a dose of 2 liters per hectare), Torpedo II adjuvant (at a dose of 0.1 liters per hectare), Doctil adjuvant (at a dose of 0.04 liters per hectare) and the amino acid leucine (at a dose of 3% produced by the company Sigma Aldrich, USA). The third factor was winter wild oat populations (susceptible and resistant) (Table 1 and 2).

In order to break the dormancy of winter wild oat seeds, the seed was separated by hand, and Lemma and Palea were peeled (Beckie et al., 2000). Then, the seeds were placed on two water-saturated filter paper in 9 cm glass Petris and cooled at 4 °C for a week to break the dormancy. After that, 10 seeds were planted in half-liter pots (9 cm in diameter and 12 cm high). The pots placed in a greenhouse at 16/8 hours day/night photoperiod under

25/15 °C temperature. After the emergence of seedlings (root length of 3 mm) and before spraying herbicides to prevent intra-species competition, the number of plants in the pot was reduced to 7. In 3 to 4 leaf stage, 28 days after planting, wild oat seedlings were exposed to different doses of herbicides with the five adjuvants listed above (Table 1) in the greenhouse of the Iranian Research Institute of Plant Protection. Spraying the seedlings was performed by an electric back sprayer equipped with a blowing nozzle and a volume of the solution of 200 liters per hectare at a pressure of 2 times. The evaluation was done according to the EWRC index, 14 and 28 days after spraying. Twenty-eight days after spraying, the aerial parts of live plants were cut from the soil surface, and their fresh weight was measured by a susceptible scale with an accuracy of 0.01. Dry weight (after being placed in the oven for 48 hours at 72 °C) was weighted up to 0.01 g of precision.

After data collection, all statistical analyses were performed using SAS statistical software (SAS Institute, USA). Before performing the analysis of variance, we made sure that the distribution of the residues was normal using the procedure (Univariate) and that the variances were homogeneous. Analysis of variance of experimental data was performed using the procedure of GLM. The comparison of the mean of the main effects of the experimental treatments and if the interactions were significant was made based on the physical cutting method and Duncan's method.

**Table 1. Specifications of adjuvants used in the experiment**

| Adjuvants(trade names) | Ingredients | **Manufacturing company** | (dosage (L / h) |
|---|---|---|---|
| **Ino Alg NPK** | Phosphorus 7%, Potassium 4%, Seaweed extract 20% (Ascophyllom Nodusum) | de sangosse France | 4 |
| **Ino Alg NPK (NG)** | Nitrogen 9%, Phosphorus 7%,4%, Seaweed extract 20% (Ascophyllom Nodusum) | de sangosse France | 2 |
| **Torpedo II** | Alkvaksalat amino Tau, Ethoxylate alcohol, Natural fatty acids, and Polyalkolin glycol | Agrydin France | 0.1 |
| **Doctil** | - | AMC Spain | 0.04 |
| **Lusin acid-amine** | - | Merck Germany | 0.03 |

**Table 2. Specifications of herbicides and adjuvants used in the experiment**

| Specifications of herbicides | | | | | | |
|---|---|---|---|---|---|---|
| **Common Name** | Trade name | Formulation | Recommended amount (L/ha) | Chemical family | Consumption time | dose (L/ha) |
| **Clodinafop-propargyl** | Topik | EC 8% | 1 | Fops | Early to late wheat tillering | 0.51<br>0.64<br>0.8<br>1 |
| **Clodinafop-propargyl** | Topik | EC 24% | 0.3 | Fops | Early to late wheat tillering | 0.154<br>0.192<br>0.24<br>0.3 |
| **Mesosulfuron- + iodosulfuron** | Atlantis | OD 1.2% | 1.5 | Sulfonyl ureas | 2-3 leaf stage weed | 1.05<br>1.2<br>1.35<br>1.5 |
| **Mesosulfuron- + iodosulfuron** | Tifis | WG 3.6% | 0.3 | Sulfonyl ureas | 2-3 leaf stage weed | 0.1540.1920.24<br>0.3 |
| **Pinoxaden** | Axail | EC 5% | 1.2 | Fops | Early to late wheat tillering | 0.62<br>0.77<br>0.96<br>1.2 |
| | | | | | | |

# 3 Results And Discussion

3-1- The effect of different doses of herbicides with adjuvants on fresh and dry weight loss of winter wild oats

3-1-1- Clodinafop-Propargyl Herbicide (EC 8%)

Comparing the mean between different doses of Clodinafop-Propargyl herbicide on susceptible and resistant accessions of wild oat showed that with increasing herbicide dose, the fresh weight of susceptible and resistant accessions of winter wild oat decreased. The highest and lowest fresh weight loss in both susceptible and resistant accessions were related to doses of 80 g.ai.ha$^{-1}$ and 40.8 g.ai.ha$^{-1}$, respectively. The fresh weight of susceptible susceptibleand resistant accessionin the dose of 80 g.ai.ha$^{-1}$ has decreased three times compared to 40.8 g.ai.ha$^{-1}$. Also, comparing the average interaction of adjuvant * population on fresh weight loss showed that Ino Alg NPK adjuvant in both susceptible and resistant accessions had the highest efficacy on Clodinafop-Propargyl herbicide and caused more herbicide effect in fresh weight loss of susceptible accession (percentage of mean fresh weight loss compared to control 84.12%) and resistant accession (percentage of average weight loss of fresh weight compared to control 33.53%) is winter wild oats. Among the adjuvants used, the least effective was related to the amino acid leucine adjuvant, so the average percentage of fresh weight loss was observed in 75.29% of susceptible accessions and 22.35% in resistant accessions (Table 3).

In general, while applying all adjuvants and the doses used in the herbicide clodinafop-propargyl, the average weight loss percentage, compared with control, decreased more regarding the susceptible accession of winter wild oats in comparison with the resistant accession of this weed (Table 3). The addition of ammonium sulfate to the herbicide solution of bentazone has been reported to increase the control of cow dung (Frisoy & Martin, 1985).

**Table 3. Comparing the mean of interactions (dose*population) and (adjuvant*population) on fresh weight loss of susceptible and resistant winter wild oats population.**

| | | Population | Fresh weight (g.plant$^{-1}$) | Fresh weight loss compared to control (%) |
|---|---|---|---|---|
| **Dose (g.ai.h$^{-1}$)** | 40.8 | S[1] | 0.40$^{b}$ | 76.47$^{a}$ |
| | | R[2] | 1.49$^{a}$ | 12.35$^{b}$ |
| | 51.2 | S | 0.36$^{b}$ | 78.82$^{a}$ |
| | | R | 1.33$^{a}$ | 21.76$^{b}$ |
| | 64 | S | 0.33$^{b}$ | 80.59$^{a}$ |
| | | R | 1.25$^{a}$ | 26.47$^{b}$ |
| | 80 | S | 0.12$^{b}$ | 92.94$^{a}$ |
| | | R | 1.17$^{a}$ | 31.18$^{b}$ |
| **Adjuant** | 0 | S | 0.45$^{b}$ | 73.53$^{a}$ |
| | | R | 1.47$^{a}$ | 13.53$^{b}$ |
| | Ino Alg NPK | S | 0.29$^{b}$ | 82.94$^{a}$ |
| | | R | 1.19$^{a}$ | 30.00$^{b}$ |
| | Ino Alg NPK (NG) | S | 0.27$^{b}$ | 84.12$^{a}$ |
| | | R | 1.13$^{a}$ | 33.53$^{b}$ |
| | Torpedo II | S | 0.31$^{b}$ | 81.76$^{a}$ |
| | | R | 1.44$^{a}$ | 15.29$^{b}$ |
| | Doctil | S | 0.35$^{b}$ | 79.41$^{a}$ |
| | | R | 1.26$^{a}$ | 25.88$^{b}$ |
| | Lusin acid-amine | S | 0.42$^{b}$ | 75.29$^{a}$ |
| | | R | 1.32$^{a}$ | 22.35$^{b}$ |
| **Untreated control** | | | 1.70 | |
| **Numbers followed by the same letter are not significantly different (P<0.05)** | | | | |

Also, the use of different adjuvants on susceptible and resistant stands of wild oats showed a decrease in dry weight in both populations compared to the lack of adjuvants, so the greatest dry weight loss in both susceptible and resistant populations was related to Ino Alg NPK adjuvant (NG) and the dose of 80 g of active substance per hectare (average dry weight loss 65.71% compared to the control) (Table 4).

**Table 4. The comparison of mean dose dose*adjvuant on dry weight loss of susceptible and resistant populations**

| Dose ($g.ai.h^{-1}$) | Adjuant | Dry weight ($g.plant^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|
| **40.8** | 0 | $0.22^{a}$ | $37.14^{ab}$ |
| | Ino Alg NPK | $0.21^{a}$ | $40.00^{a}$ |
| | Ino Alg NPK (NG) | $0.18^{ab}$ | $48.57^{a}$ |
| | Torpedo II | $0.19^{a}$ | $45.71^{a}$ |
| | Doctil | $0.19^{a}$ | $45.71^{a}$ |
| | Lusin acid-amine | $0.21^{a}$ | $40.00^{a}$ |
| **51.2** | 0 | $0.17^{a}$ | $51.43^{a}$ |
| | Ino Alg NPK | $0.16^{ab}$ | $54.29^{a}$ |
| | Ino Alg NPK (NG) | $0.14^{b}$ | $60.00^{a}$ |
| | Torpedo II | $0.20^{a}$ | $42.86^{ab}$ |
| | Doctil | $0.20^{a}$ | $42.86^{ab}$ |
| | Lusin acid-amine | $0.19^{a}$ | $45.71^{ab}$ |
| **64** | 0 | $0.16^{ab}$ | $51.43^{ab}$ |
| | Ino Alg NPK | $0.17^{a}$ | $51.43^{ab}$ |
| | Ino Alg NPK (NG) | $0.13^{b}$ | $62.86^{a}$ |
| | Torpedo II | $0.19^{a}$ | 45.71 |
| | Doctil | $0.16^{ab}$ | $51.43^{ab}$ |
| | Lusin acid-amine | $0.16^{ab}$ | $51.43^{ab}$ |
| **80** | 0 | $0.17^{a}$ | $51.43^{a}$ |
| | Ino Alg NPK | $0.14^{a}$ | 60.00 |
| | Ino Alg NPK (NG) | $0.12^{b}$ | 65.71 |
| | Torpedo II | $0.15^{a}$ | 57.14 |
| | Doctil | $0.16^{a}$ | 54.29 |
| | Lusin acid-amine | $0.15^{a}$ | 57.14 |
| **Untreated control** | | 0.35 | |

Furthermore, using different adjuvants on susceptible and resistant stands of wild oats showed a decrease in dry weight in both populations compared to the lack of adjuvants so the greatest dry weight loss in both susceptible and resistant populations (the average dry weight loss in susceptible and resistant accessions was 63% and 54%, respectively, compared to the control) is related to Ino Alg NPK (NG) adjuvant (Table 5).

**Table 5. The comparison of mean dose adjuvant*population on dry weight loss of susceptible and resistant populations.**

| Adjuvant | Population | Dry weight (g.plant $^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|
| **0** | S | 0.17$^{b}$ | 51$^{a}$ |
| | R | 0.22$^{a}$ | 1$^{b}$ |
| **Ino Alg NPK** | S | 0.15b$^{a}$ | 58$^{a}$ |
| | R | 0.19$^{a}$ | 46$^{b}$ |
| **Ino Alg NPK (NG)** | S | 0.13$^{b}$ | 63$^{a}$ |
| | R | 0.16$^{a}$ | 54$^{b}$ |
| **Torpedo II** | S | 0.16$^{b}$ | 54$^{a}$ |
| | R | 0.19$^{a}$ | 46$^{b}$ |
| **Doctil** | S | 0.16$^{b}$ | 54$^{a}$ |
| | R | 0.19$^{a}$ | 46$^{b}$ |
| **Lusin acid-amine** | S | 0.15$^{b}$ | 57$^{a}$ |
| | R | 0.20$^{a}$ | 42$^{b}$ |
| **Untreated control** | | 0.35 | |

3-2-1-2- Clodinafop-Propargyl Herbicide (EC 24%)

The results of comparing the mean effect of the triple dose of dose* adjuvant * population on the fresh weight loss of winter wild oats showed that increasing the dose of clodinafop-propargyl herbicide (EC 24%)of the fresh weight of wild oats was affected and decreased. The lowest and highest fresh weight in doses of 4 g.ai.ha$^{-1}$ (susceptible and resistant accession with fresh weight loss of 82.22 and 21.48, respectively) and 7 g.ai.ha$^{-1}$ (susceptible and resistant accession with fresh weight loss of 91.11 and 43.70, respectively) of active substance was observed. However, in general, the effect of this herbicide on the susceptible accession was better than on the resistant accession. In both susceptible and resistant accessions, the highest fresh weight loss was observed due to the accessionof a dose of 7 g.ai.ha$^{-1}$ of active substance per hectare (Table 6). The effect of using adjuvant along with doses used also affected the fresh weight of susceptible and resistant accessions. In all doses used, the highest fresh weight loss was related to Ino Alg NPK (NG) adjuvant (Table 6).

Fresh weight loss when applying adjuvant was also more effective in susceptible accessions than in resistant accessions. So that when the dose of 40.8 $g.ai.ha^{-1}$ of active ingredient per hectare is applied along with the application of Ino Alg NPK (NG), the fresh weight of susceptible and resistant accessions has been reduced 1.45 and 1.3 times, respectively, compared to the non-application of adjuvant. It can also be inferred that increasing the dose of clodinafop-propargyl herbicide has led to dry weight loss (Table 6). Investigating the effect of Adigor, Citogate, Volk, and Citohefadjuvants on the efficacy of Pinoxaden in controlling *Phalaris minor* Retz, wild oats, and *Lolium temulentum* L. Mousavinik et al. (2009) reported Volk oil to have the greatest effect on increasing the effectiveness of Pinoxaden herbicide in controlling ryegrass, canary grass, and wild oats. The researchers concluded that the proper use of adjuvants could reduce the use of herbicides without compromising their effectiveness, which is economically and environmentally important.

**Table 6. The comparison of mean dose*population*adjuvant interactions on fresh weight and dry weight loss of the *Avena ludoviciana***

| Dose (g.ai.h$^{-1}$) | reaction | Adjuvant | Fresh weight (g.plant$^{-1}$) | Fresh weight loss compared to control (%) | Dry weight (g.plant$^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|---|---|---|
| 4 | S | 0 | 0.40 $^{d}$ | 70.37b | 0.15 $^{c}$ | 62.50b |
| | | Ino Alg NPK | 0.39 $^{d}$ | 71.11b | 0.11 $^{dc}$ | 72.50ab |
| | | Ino Alg NPK (NG) | 0.24 $^{e}$ | 82.22a | 0.10 $^{d}$ | 75.00a |
| | | Torpedo II | 0.36 $^{de}$ | 73.33ab | 0.12 $^{dc}$ | 70.00ab |
| | | Doctil | 0.29 $^{de}$ | 78.52ab | 0.12 $^{dc}$ | 70.00ab |
| | | Lusin acid-amine | 0.28 $^{de}$ | 79.26ab | 0.12 $^{dc}$ | 70.00ab |
| | R | 0 | 1.55 $^{a}$ | 0e | 0.39 $^{a}$ | 2.50d |
| | | Ino Alg NPK | 1.11 $^{bc}$ | 17.78cd | 0.35 $^{a}$ | 12.50d |
| | | Ino Alg NPK (NG) | 1.06 $^{c}$ | 21.48c | 0.20 $^{b}$ | 50.00c |
| | | Torpedo II | 1.22 $^{ab}$ | 9.63d | 0.35 $^{a}$ | 12.50d |
| | | Doctil | 1.08 $^{c}$ | 20.00c | 0.35 $^{a}$ | 12.50d |
| | | Lusin acid-amine | 1.13 $^{bc}$ | 16.30 | 0.36 $^{a}$ | 10.00d |
| 5 | S | 0 | 0.32 $^{b}$ | 76.30 | 0.13 $^{dc}$ | 67.50ab |
| | | Ino Alg NPK | 0.25 $^{b}$ | 81.48b | 0.11 $^{dc}$ | 72.50ab |
| | | Ino Alg NPK (NG) | 0.23 $^{c}$ | 82.96a | 0.08 $^{d}$ | 80.00a |
| | | Torpedo II | 0.31 $^{b}$ | 77.04b | 0.11 $^{dc}$ | 72.50ab |
| | | Doctil | 0.27 $^{b}$ | 80.00b | 0.12 $^{c}$ | 70.00b |
| | | Lusin acid-amine | 0.26 $^{b}$ | 80.74b | 0.11 $^{dc}$ | 72.50ab |
| | R | 0 | 1.23 $^{a}$ | 8.89c | 0.20 $^{a}$ | 50.00d |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Ino Alg NPK | 0.95 a | 29.63c | 0.21 a | 47.50d |
| | | Ino Alg NPK (NG) | 0.92 a | 31.85c | 0.16 b | 60.00c |
| | | Torpedo II | 1 a | 25.93c | 0.19 ab | 52.50cd |
| | | Doctil | 1.16 a | 14.07c | 0.19 ab | 52.50cd |
| | | Lusin acid-amine | 1.09 a | 19.26c | 0.17 b | 57.50 |
| **6** | S | 0 | 0.31 d | 77.04b | 0.12 dc | 70.00 |
| | | Ino Alg NPK | 0.29 d | 78.52b | 0.10 d | 75.00b |
| | | Ino Alg NPK (NG) | 0.24 e | 82.22a | 0.07 e | 82.50a |
| | | Torpedo II | 0.28 d | 79.26b | 0.11 dc | 72.50bc |
| | | Doctil | 0.29 d | 78.52b | 0.10 d | 75.00b |
| | | Lusin acid-amine | 0.29 d | 78.52b | 0.10 d | 75.00b |
| | R | 0 | 1.11 a | 17.78e | 0.19 a | 52.50e |
| | | Ino Alg NPK | 0.96 bc | 28.89bcd | 0.15 b | 62.50d |
| | | Ino Alg NPK (NG) | 0.86 c | 36.30c | 0.13 c | 67.50c |
| | | Torpedo II | 1.02 ab | 24.44d | 0.14 b | 65.00d |
| | | Doctil | 0.91 bc | 32.59cd | 0.18 a | 55.00e |
| | | Lusin acid-amine | 1.10 a | 18.52e | 0.16 b | 60.00d |
| **7** | S | 0 | 0.32 d | 76.30b | 0.11 c | 72.50c |
| | | Ino Alg NPK | 0.13 e | 90.37a | 0.10 c | 75.00c |
| | | Ino Alg NPK (NG) | 0.12 e | 91.11a | 0.05 d | 87.50a |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Torpedo II | 0.15 e | 88.89a | 0.10 c | 75.00c |
| | | Doctil | 0.30 d | 77.78b | 0.09 c | 77.50b |
| | | Lusin acid-amine | 0.22 ed | 83.70ab | 0.10 c | 75.00c |
| | R | 0 | 1.09 a | 19.26d | 0.15 a | 62.50e |
| | | Ino Alg NPK | 0.86 bc | 36.30cd | 0.14 a | 65.00e |
| | | Ino Alg NPK (NG) | 0.76 c | 43.70c | 0.11 ab | 72.50d |
| | | Torpedo II | 1.07 a | 20.74d | 0.13 a | 67.50e |
| | | Doctil | 1.06 a | 21.48d | 0.12 ab | 70.00de |
| | | Lusin acid-amine | 0.98 b | 27.41 | 0.13 a | 67.50e |
| **Untreated control** | | | 1.35 | | 0.40 | |

3-3-1-2- Pinoxaden Herbicide (EC 5%)

The results of comparing the mean of the three effects of dose* adjuvant* population on the fresh weight loss of wild oats showed that with increasing the dose of Pinoxaden herbicide, fresh weight decreased in susceptible accessions (Table 7). Considering the average fresh weight loss between doses of Pinoxaden herbicide, it can be said that the reduced doses of this herbicide along with adjuvants can be used to control wild oats to prevent the occurrence of some problems such as the emergence of resistance. Also, the highest fresh weight loss in both susceptible and resistant accessions is related to the Ino Alg NPK (NG) adjuvant and different doses of Pinoxaden herbicide (Table 7).

When applying doses of 37.2, 46.2, 57.6, and 72 g.ai.ha$^{-1}$ with Ino Alg NPK (NG) adjuvant, the percentage of fresh weight loss of susceptible wild oat accession, compared to the control, decreased 80.30, 84.91, 86.75 and 93.69%, respectively. In addition, by applying doses of 37.2, 46.2, 57.6, and 72 g.ai.ha$^{-1}$ with Ino Alg NPK (NG) adjuvant, the percentage of fresh weight loss of wild oat resistant accession compared to the control decreased by 76.35, 81.30, 82.65, and 87.39%, respectively. Comparing the mean of the triple effects of dose*population*adjuvant on the EWRC index also showed that in all doses of Pinoxaden herbicide, the percentage of winter wild oat control was the same and equal to 100%. None of the doses used with different adjuvants were different in any of the susceptible and resistant accessionof winter wild oats and did not differ significantly (Table 7). Therefore, according to the tested results, reducing doses of Pinoxaden herbicide with adjuvants can be used to control susceptible and resistant accessions of winter wild oats. However, it should be noted that reducing doses of herbicides over time may cause resistance of winter wild oat weeds to the herbicide Pinoxaden, and even increasing doses of this herbicide cannot be effective in controlling this herb. In an experiment to evaluate the effect of nitrogen fertilizer application on glyphosate herbicide efficacy in controlling *Abutilon theophrasi*, it was found that the effective dose of glyphosate was to reduce 50% of cowpea biomass ($ED_{50}$) at low soil nitrogen level (0.7 mM) was 431 g of commercial glyphosate per hectare. However, at high levels of soil nitrogen (7.7 mM), the dose was reduced to 241 g of commercial glyphosate per hectare (Cathcart et al., 2004).

**Table 7. The comparison of mean dose*population*adjuvant interactions on fresh weight loss of the *Avena ludoviciana***

| Dose (g.ai.h$^{-1}$) | | Adjuvant | Fresh weight (g.plant$^{-1}$) | Fresh weight loss compared to control (%) |
|---|---|---|---|---|
| **31** | S | 0 | 0.30 $^{c}$ | 74.33 $^{b}$ |
| | | Ino Alg NPK | 0.25 $^{c}$ | 77.25 $^{b}$ |
| | | Ino Alg NPK (NG) | 0.20 $^{d}$ | 81.30 $^{a}$ |
| | | Torpedo II | 0.23 $^{c}$ | 78.83 $^{b}$ |
| | | Doctil | 0.22 $^{c}$ | 79.95 $^{b}$ |
| | | Lusin acid-amine | 0.24 $^{c}$ | 78.60 $^{b}$ |
| | R | 0 | 0.53 $^{a}$ | 52.02 $^{d}$ |
| | | Ino Alg NPK | 0.47 $^{a}$ | 57.43 $^{d}$ |
| | | Ino Alg NPK (NG) | 0.26 $^{c}$ | 76.35 $^{b}$ |
| | | Torpedo II | 0.38 $^{b}$ | 65.76 $^{c}$ |
| | | Doctil | 0.51 $^{a}$ | 53.43 $^{d}$ |
| | | Lusin acid-amine | 0.49 $^{a}$ | 55.40 $^{d}$ |
| **38.5** | S | 0 | 0.25 $^{bc}$ | 76.92 $^{b}$ |
| | | Ino Alg NPK | 0.17 $^{d}$ | 84.91 $^{b}$ |
| | | Ino Alg NPK (NG) | 0.16 $^{e}$ | 85.36 $^{a}$ |
| | | Torpedo II | 0.17 $^{d}$ | 84.91 $^{b}$ |
| | | Doctil | 0.21 $^{cd}$ | 81.98 $^{ab}$ |
| | | Lusin acid-amine | 0.17 $^{d}$ | 84.68 $^{b}$ |
| | R | 0 | 0.42 $^{a}$ | 68.47 $^{d}$ |
| | | Ino Alg NPK | 0.27 $^{bc}$ | 75.45 $^{bcd}$ |
| | | Ino Alg NPK (NG) | 0.20 $^{d}$ | 81.30 $^{ab}$ |
| | | Torpedo II | 0.27 $^{bc}$ | 75.45 $^{bcd}$ |
| | | Doctil | 0.24 $^{cd}$ | 77.62 $^{b}$ |

| | | | | |
|---|---|---|---|---|
| | | Lusin acid-amine | 0.32 b | 70.72 dc |
| **48** | S | 0 | 0.20 bc | 79.58 bc |
| | | Ino Alg NPK | 0.17 c | 83.7 b |
| | | Ino Alg NPK (NG) | 0.15 d | 86.75 a |
| | | Torpedo II | 0.16 cd | 84.26 ab |
| | | Doctil | 0.17 c | 83.78 b |
| | | Lusin acid-amine | 0.16 cd | 84.46 ab |
| | R | 0 | 0.31 a | 71.61 d |
| | | Ino Alg NPK | 0.24 b | 76.93 c |
| | | Ino Alg NPK (NG) | 0.18 c | 82.65 b |
| | | Torpedo II | 0.19 bc | 82.43 bc |
| | | Doctil | 0.20 bc | 81.98 bc |
| | | Lusin acid-amine | 0.23 b | 77.15 c |
| **60** | S | 0 | 0.15 bc | 86.48 b |
| | | Ino Alg NPK | 0.09 d | 91.89 a |
| | | Ino Alg NPK (NG) | 0.07 d | 93.69 a |
| | | Torpedo II | 0.08 d | 92.97 a |
| | | Doctil | 0.09 d | 91.89 a |
| | | Lusin acid-amine | 0.11 cd | 90.09 ab |
| | R | 0 | 0.23 a | 79.28 c |
| | | Ino Alg NPK | 0.20 ab | 81.98 cb |
| | | Ino Alg NPK (NG) | 0.14 c | 87.39 b |
| | | Torpedo II | 0.15 bc | 86.48 b |
| | | Doctil | 0.19 ab | 82.88 cb |
| | | Lusin acid-amine | 0.20 ab | 81.98 cb |

| | |
|---|---|
| **Untreated control** | 1.11 |

The results of comparing the mean effect of adjuvants and the interaction of dose * population on dry weight loss of winter wild oats showed that increasing the dose of Pinoxaden herbicide in both susceptible and resistant accessions led to fresh weight loss. The highest and lowest dry weight loss was related to the application of doses of 72 g.ai.ha$^{-1}$ (80.15% dry weight loss compared to control) and 37.2 g.ai.ha$^{-1}$ (74.41% dry weight loss compared to control) (Table 8). However, dry weight loss in both susceptible and resistant accessions was negligible with increasing herbicide doses. The use of adjuvants used in this experiment also showed that Ino Alg NPK (NG), Ino Alg NPK, and Torpedo II adjuvants showed the same dry weight loss compared to no adjuvant. Also, the use of the amino acid adjuvants leucine and Doctil showed the least dry weight loss compared to the non-use of adjuvants (Table 8). The results of Mahoney et al (2001) showed that the application of glyphosate reduced the dry matter of cow dung by 77% and ammonium sulfate by 93%.

**Table 8. The comparison of mean dose*population* interactions effect and adjuvant effect on dry weight loss of the *Avena ludoviciana***

| | | | Dry weight (g/plant$^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|---|
| **Dose (g.ai.h$^{-1}$)** | 31 | S | 0.11$^{b}$ | 82.88 a |
| | | R | 0.16$^{a}$ | 74.41 b |
| | 38.5 | S | 0.09$^{b}$ | 84.34 a |
| | | R | 0.12$^{a}$ | 75 b |
| | 48 | S | 0.08$^{b}$ | 87.89 a |
| | | R | 0.09$^{a}$ | 85.22 b |
| | 60 | S | 0.07$^{a}$ | 88.80 a |
| | | R | 0.07$^{a}$ | 80.15 a |
| **Adjuant** | 0 | S | 0.14a | 78b |
| | Ino Alg NPK | S | 0.10ab | 84a |
| | Ino Alg NPK (NG) | S | 0.10ab | 84a |
| | Torpedo II | S | 0.10ab | 84a |
| | Doctil | S | 0.11b | 82ab |
| | Lusin acid-amine | S | 0.11b | 82ab |
| **Untreated control** | | | 0.64 | |
| **Numbers followed by the same letter are not significantly different (P<0.05)** | | | | |

3-4-1-2- Mesosulfuron + Iodosulfuron (WG 3.6%) Herbicide

The results showed that increasing the dose of mesosulfuron + iodosulfuron herbicide had a significant effect on the fresh weight loss of wild oats, so that the lowest and highest average weight loss in both susceptible and resistant populations were 6 g.ai.ha$^{-1}$ and 11 g.ai.ha$^{-1}$ 3, respectively (Table 3). At a dose of 6 g.ai.ha$^{-1}$, the average fresh weight in susceptible and resistant accessions was 0.55 and 0.59 g/plant, respectively (64.40 and 61.40% weight loss compared to the control without Treatment). Also, the average fresh weight per dose of 11g.ai.ha$^{-1}$liters per hectare in susceptible and resistant accessions was 0.37 and 0.33 g/plant, respectively (76.13 and 78.71% fresh weight loss compared to the untreated control).

Therefore, it can be stated that the average fresh weight loss in susceptible and resistant accessions of winter wild oats decreased by 1.47 times and 1.79 times, respectively, by increasing the dose from 6g.ai.ha$^{-1}$to 11g.ai.ha$^{-1}$, respectively. The adjuvants used in combination with different doses showed fresh weight loss in susceptible and resistant populations of wild oats compared to the non-use of these adjuvants (Table 9). Among the populations, in general, the resistant accessionshowed more fresh weight loss compared to the susceptible accessionwith increasing doses of herbicide mesosulfuron + iodosulfuron; with increasing the consumption dose from 1.05 to 1.5, it decreased by 1.47 times and 1.79 times. Among the adjuvants used in all doses of 6, 7, 9, and 11 g.ai.ha$^{-1}$, the Ino Alg NPK (NG) adjuvant, more fresh weight loss was observed in both susceptible and resistant accessions compared to other adjuvants (Table 9).

Application of Ino Alg NPK (NG) also showed that the susceptible accessionof wild oats showed more fresh weight loss than the non-resistant accessionin all doses used (Table 9). Therefore, according to the inferred results, the best and most effective adjuvant used and the doses used herbicide mesosulfuron + iodosulfuron, Ino Alg NPK (NG) adjuvant has the highest efficiency or the freshest weight loss in winter wild oats. Therefore, the application of this adjuvant with this herbicide can be effective in winter wild oat weed management. Rashed Mohassel et al. (2011) showed that adjuvants in combination with the herbicide sethoxydim increased the effectiveness of this herbicide in controlling wild oats.

**Table 9. The comparison of mean dose*population*adjuvant interactions on fresh weight loss and EWRC of the *Avena ludoviciana***

| Dose (g.ai.h-1) | | Adjuvant | Fresh weight (g/plant-1) | Fresh weight loss compared to control (%) |
|---|---|---|---|---|
| 6 | S | 0 | 0.79 a | 49.03e |
| | | Ino Alg NPK | 0.58 b | 56.12ef |
| | | Ino Alg NPK (NG) | 0.39 d | 74.84a |
| | | Torpedo II | 0.45 c | 70.96a |
| | | Doctil | 0.5 b | 67.74b |
| | | Lusin acid-amine | 0.5 b | 67.74b |
| | R | 0 | 0.72 a | 53.55e |
| | | Ino Alg NPK | 0.53 cde | 65.81bcd |
| | | Ino Alg NPK (NG) | 0.52 cde | 66.45bc |
| | | Torpedo II | 0.62 bcd | 60.00cde |
| | | Doctil | 0.53 cde | 65.81bcd |
| | | Lusin acid-amine | 0.67 abc | 56.77def |
| 7 | S | 0 | 0.52 a | 66.33d |
| | | Ino Alg NPK | 0.51 ab | 67.75c |
| | | Ino Alg NPK (NG) | 0.38 d | 78.01a |
| | | Torpedo II | 0.40 cd | 74.20b |
| | | Doctil | 0.44 bc | 71.61 abcd |
| | | Lusin acid-amine | 0.48 ab | 69.03bcd |
| | R | 0 | 0.5 a | 67.09cd |
| | | Ino Alg NPK | 0.42 bc | 72.9 abcd |
| | | Ino Alg NPK (NG) | 0.38 d | 75.48ab |
| | | Torpedo II | 0.40 c | 74.20b |
| | | Doctil | 0.44 b | 71.61abcd |

| | | | | |
|---|---|---|---|---|
| | | Lusin acid-amine | 0.41 bc | 73.55ab |
| **9** | S | 0 | 0.47 a | 69.68e |
| | | Ino Alg NPK | 0.43 b | 72.25cde |
| | | Ino Alg NPK (NG) | 0.25 e | 83.87a |
| | | Torpedo II | 0.33 cd | 78.71b |
| | | Doctil | 0.46 ab | 70.32de |
| | | Lusin acid-amine | 0.36 c | |
| | R | 0 | 0.48 a | 69.03e |
| | | Ino Alg NPK | 0.46 ab | 70.32de |
| | | Ino Alg NPK (NG) | 0.35 cde | 77.41bc |
| | | Torpedo II | 0.43 abc | 72.25cde |
| | | Doctil | 0.37 cd | 76.12bcd |
| | | Lusin acid-amine | 0.37 cd | 76.12bcd |
| **11** | S | 0 | 0.48 a | 69.03e |
| | | Ino Alg NPK | 0.45 ab | 72.90d |
| | | Ino Alg NPK (NG) | 0.22 e | 85.80a |
| | | Torpedo II | 0.29 d | 81.29b |
| | | Doctil | 0.42 b | 72.90d |
| | | Lusin acid-amine | 0.37 bc | 76.13cd |
| | R | 0 | 0.41 a | 70.97de |
| | | Ino Alg NPK | 0.30 b | 80.64b |
| | | Ino Alg NPK (NG) | 0.28 b | 81.93b |
| | | Torpedo II | 0.36 ab | 76.77cd |
| | | Doctil | 0.30 b | 80.64b |
| | | Lusin acid-amine | 0.32 b | 79.35bc |

| | |
|---|---|
| **Untreated control** | 1.55 |

Effect of dose interaction * population and the main effect of adjuvant on dry weight loss of winter wild oats showed that by increasing the dose from the lowest dose used 6 g.ai.ha$^{-1}$ to the highest dose (11 g.ai.ha$^{-1}$) The dry weight of wild oats has decreased in both susceptible and resistant populations (Table 5), so that the dry weight loss in the susceptible and resistant accession of winter wild oats has decreased 1.55 and 1.42 times, respectively. This indicates that dry weight loss was greater in the susceptible population compared to the resistant population. Also, among the adjuvants used in this study, compared to the non-use of adjuvants, there was not much effect in reducing the dry weight of the accessions, but the lowest (0.11 g / plant or 86.993%) and the highest (0.15 g / plant or 84.44). The observed dry weight was the population treated with Ino Alg NPK (NG) and no adjuvant (Table 10), respectively. In a greenhouse study, the combination of non-ionic surfactant adjuvants with the dose of bentazone herbicide reduced dry weed weight by 50% (Bellinder et al., 2003). Panachi et al. (2010) also stated that the effective herbicide Benuron Methyl (Granstar) in controlling broadleaf weeds when mixed with adjuvants including ionic surfactants and Non-ion increases.

**Table 10. The comparison of mean dose*population* interactions effect and adjuvant effect on dry weight loss of the *Avena ludoviciana***

| | | | Dry weight ($g.plant^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|---|
| **Dose ($g.ai.h^{-1}$)** | 12.60 | S | 0.14 $^{b}$ | 80.29$^{b}$ |
| | | R | 0.17 $^{a}$ | 84.42$^{a}$ |
| | 14.4 | S | 0.12 $^{b}$ | 84.32$^{b}$ |
| | | R | 0.14 $^{a}$ | 86$^{a}$ |
| | 16.2 | S | 0.10 $^{b}$ | 87$^{a}$ |
| | | R | 0.11 $^{a}$ | 87.70$^{a}$ |
| | 18 | S | 0.09 $^{b}$ | 86.5$^{a}$ |
| | | R | 0.1 $^{a}$ | 89.77$^{a}$ |
| **Adjuant** | 0 | S | 0.15 $^{a}$ | 84.44$^{c}$ |
| | Ino Alg NPK | S | 0.14 $^{a}$ | 85.43$^{cb}$ |
| | Ino Alg NPK (NG) | S | 0.11 $^{b}$ | 86.93$^{a}$ |
| | Torpedo II | S | 0.12 $^{bc}$ | 85.75$^{b}$ |
| | Doctil | S | 0.13 $^{b}$ | 85.75$^{b}$ |
| | Lusin acid-amine | S | 0.12 $^{b}$ | 85.75$^{b}$ |
| **Untreated control** | | | 0.88 | |
| **Numbers followed by the same letter are not significantly different ($P<0.05$)** | | | | |

3-5-1-2- Mesosulfuron + Idosulfuron (OD 1.2%) Herbicide

According to the results obtained by comparing the mean effect of the trinary dose of * adjuvant * population on the dry weight loss of wild oats, it can be stated that with increasing doses of herbicide mesosulfuron + iodosulfuron reduced the dry weight of susceptible and resistant wild oat accessions (Table ?). Of course, this fresh weight loss is more noticeable in the resistant accession of this weed. Due to the control of this weed with decreasing doses, in the susceptible accession, the dry weight of this weed did not show a significant decrease with increasing the dose. The mentioned adjuvants along with the herbicide doses of mesosulfuron + iodosulfuron showed a different effect of these adjuvants in reducing the fresh weight of wild oats. In all four doses used and in both susceptible and resistant wild oats populations, the highest and lowest fresh weight loss were related to the use of leucine amino acid adjuvant and no adjuvant, respectively (Table 11).

Comparing the mean effect of the trinary dose of * adjuvant * population on the dry weight loss of wild oats, it can be stated that increasing doses of herbicide mesosulfuron + iodosulfuron results in the dry weight reduction of the susceptible and resistant wild oats accessions (Table 11). However, the decrease in dry weight in winter wild oat accessions, especially the susceptible accession of this weed, is not so noticeable; and increasing the dose has not shown much effect on dry weight loss. Consumed adjuvants along with applied doses of this herbicide did not have much effect on reducing the dry weight of wild oats, and in most doses, the dry weight was the same when using and not using adjuvants.

**Table 11. The comparison of mean dose*population*adjuvant interactions on fresh weight, dry weight loss and EWRC[3] of the *Avena ludoviciana***

| Dose (g.ai.h$^{-1}$) | | Adjuvant | Fresh weight (g.plant$^{-1}$) | Fresh weight loss compared to control (%) | Dry weight (g.plant$^{-1}$) | Dry weight loss compared to control (%) |
|---|---|---|---|---|---|---|
| **12.60** | S | 0 | 0.22 $^{c}$ | 85.99b | 0.13 $^{ab}$ | 41ab |
| | | Ino Alg NPK | 0.19 $^{c}$ | 87.90b | 0.12 $^{ab}$ | 45ab |
| | | Ino Alg NPK (NG) | 0.15 $^{c}$ | 91.08b | 0.10 $^{b}$ | 54a |
| | | Torpedo II | 0.14 $^{c}$ | 90.45b | 0.10 $^{b}$ | 54a |
| | | Doctil | 0.19 $^{c}$ | 87.90b | 0.10 $^{b}$ | 54a |
| | | Lusin acid-amine | 0.13 $^{d}$ | 91.72a | 0.10 $^{b}$ | 54a |
| | R | 0 | 1.55 $^{a}$ | 1.27e | 0.17 $^{a}$ | 23b |
| | | Ino Alg NPK | 1.49 $^{a}$ | 5.10d | 0.15 $^{ab}$ | 32ab |
| | | Ino Alg NPK (NG) | 1.30 $^{ab}$ | 17.20cd | 0.16 $^{a}$ | 27b |
| | | Torpedo II | 1.35 $^{ab}$ | 14.01cd | 0.16 $^{a}$ | 27b |
| | | Doctil | 1.25 $^{ab}$ | 20.38cd | 0.16 $^{a}$ | 27b |
| | | Lusin acid-amine | 1.12 $^{b}$ | 28.66c | 0.16 $^{a}$ | 27b |
| **14.4** | S | 0 | 0.16 $^{c}$ | 89.81a | 0.11 c | 50 |
| | | Ino Alg NPK | 0.12 $^{c}$ | 92.36a | 0.10 c | 54 |
| | | Ino Alg NPK (NG) | 0.12 $^{c}$ | 92.36a | 0.09 $^{cd}$ | 59 |
| | | Torpedo II | 0.12 $^{c}$ | 92.36a | 0.08 $^{d}$ | 63 |
| | | Doctil | 0.13 $^{c}$ | 91.72a | 0.10 $^{c}$ | 54 |
| | | Lusin acid-amine | 0.11 $^{c}$ | 92.99a | 0.05 $^{d}$ | 77 |
| | R | 0 | 1.41 $^{a}$ | 10.19c | 0.15 $^{a}$ | 32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Ino Alg NPK | 1.28 ab | 18.47bc | 0.15 a | 32 |
| | | Ino Alg NPK (NG) | 1.22 ab | 22.29bc | 0.15 a | 32 |
| | | Torpedo II | 1.23 ab | 21.66bc | 0.15 a | 32 |
| | | Doctil | 1.18 b | 24.84b | 0.14 ab | 41 |
| | | Lusin acid-amine | 1.06 b | 32.48b | 0.13 b | 36 |
| **16.2** | S | 0 | 0.14 d | 91.08a | 0.10 bc | 54 |
| | | Ino Alg NPK | 0.11 d | 92.99a | 0.10 bc | 54 |
| | | Ino Alg NPK (NG) | 0.11 d | 92.99a | 0.09 c | 59 |
| | | Torpedo II | 0.13 d | 91.72a | 0.08 cd | 63 |
| | | Doctil | 0.11 d | 92.99a | 0.10 bc | 54 |
| | | Lusin acid-amine | 0.10 d | 93.63a | 0.05 d | 77 |
| | R | 0 | 1.38 a | 12.10e | 0.13 a | 41 |
| | | Ino Alg NPK | 1.05 bc | 33.12cd | 0.13 a | 41 |
| | | Ino Alg NPK (NG) | 1.18 ab | 24.84d | 0.12 ab | 45 |
| | | Torpedo II | 1 c | 36.31c | 0.12 ab | 45 |
| | | Doctil | 1.25 ab | 20.38d | 0.12 ab | 45 |
| | | Lusin acid-amine | 0.41 cd | 73.89b | 0.11 b | 50 |
| **18** | S | 0 | 0.13 d | 91.72a | 0.07 d | 68 |
| | | Ino Alg NPK | 0.11 d | 92.99a | 0.05 e | 77 |
| | | Ino Alg NPK (NG) | 0.11 d | 92.99a | 0.05 e | 77 |

| | | | | | |
|---|---|---|---|---|---|
| | Torpedo II | 0.10 d | 93.63a | 0.06 de | 73 |
| | Doctil | 0.10 d | 93.63a | 0.06 de | 73 |
| | Lusin acid-amine | 0.09 d | 94.27a | 0.05 e | 77 |
| R | 0 | 1.19 a | 24.20d | 0.13 a | 41 |
| | Ino Alg NPK | 1.06 ab | 32.48cd | 0.11 b | 50 |
| | Ino Alg NPK (NG) | 0.81 b | 48.41c | 0.13 a | 41 |
| | Torpedo II | 0.76 b | 51.59c | 0.11 b | 50 |
| | Doctil | 0.77 b | 50.96c | 0.12 ab | 45 |
| | Lusin acid-amine | 0.37 c | 76.43b | 0.11 b | 50 |
| **Untreated control** | | 1.57 | | 0.22 | |

[1] Susceptible
[2] Resistant
[3] European Weed Research Committee

# 4 Conclusion

The results of the second-year experiments also showed that, in general, increasing the doses of clodinafop-propargyl herbicides with two forms (EC 8% and EC 24%) and mesosulfuron + iodosulfuron with two forms (OD 1.2% and WG 1.2%) lead to better control of winter wild oat weed. However, reduced doses of the herbicide Pinoxaden had the same recommended dose of this herbicide in reducing dry fresh weight and controlling this weed. The addition of used adjuvants to different doses of herbicides used in the experiment also showed that among the used adjuvants, adding Ino Alg NPK (NG) adjuvants to doses of clodinafop-propargyl herbicides (EC 8%) And EC 24%), mesosulfuron + iodosulfuron (OD 1.2% and WG 1.2%) and pinoxaden have been most effective in fresh and dry weight loss and EWRC index or control of winter wild oats. However, Ino Alg NPK adjuvant application and different doses of clodinafop-propargyl herbicide (EC 8%) was most effective in fresh weight loss and control percentage of winter wild oats.

# Declarations

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## Conflict of Interest

Alireza Ghafouri, Leila Alimoradi, MohammadAli Baghestani, Eskandar Zand, Mohamad Hassan Rashed Mohase declare that they have no competing interests.

## Consent for publication

All authors consent to the publication of this article.

## Availability of data and materials

'Not applicable'

## Competing interests

'Not applicable'

## Authors' contributions

All authors participated in the project

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