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Evaluation the Effect of Cationic and Nonionic Surfactants on ALS-inhibitor Herbicides Efficacy on wild oat (*Avena ludoviciana*) Control

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Introduction: The genus of oat contains several species often infesting both wheat and barley fields all over the world. They compete tightly with these crops for space, water, nutrients, and light. Due to a continuous high selection pressure, herbicide resistance to ACCase inhibitors developed in wild oat populations. Accordingly, these observations approved the necessity of replacement of ACCase-inhibiting herbicides with other herbicide modes of action. The sulfonylurea herbicides were assessed as good alternatives for this purpose. Due to sulfonylurea herbicides ability to control a broad spectrum of grass and broad-leaved weeds, combined with their low application rate and low mammalian toxicity. The efficacy of herbicides can be enhanced using surfactants (1 and 18).

Materials and Methods: This pot experiment was repeated twice during 2013 at Ferdowsi University of Mashhad, Iran; once in greenhouse conditions and once in outdoor conditions.

An experiment was separately conducted with each herbicide which repeated one in glasshouse and one outdoor. The treatments were include: sulfosulfuron at 0, 2.5, 5, 10, 15, and 20 g a.i. ha^{-1} (Apyrous® WG, 75% sulfosulfuron); and metsulfuron-methyl + sulfosulfuron at 0, 5.625 (0.351+5.273), 11.25 (0.703+10.546), 22.5 (1.406+21.094), 33.75 (2.109+31.641), and 45 (2.813+42.187) g a.i. ha^{-1} (Total® WG,5% metsulfuron-methyl + 75% sulfosulfuron). Each of these doses was applied alone or with the surfactants of nonionic and cationic surfactants at two concentrations of 0.1% and 0.2% (v/v). The spray treatments were applied at the four-leaf stage using a calibrated moving boom sprayer (Matabi 121030 Super Agro 20 L sprayer; Agratech Services-Crop Spraying Equipment, Rossendale, UK), equipped with an 8002 flat fan nozzle tip delivering 200 L ha^{-1} at a pressure of 200 kPa. A capillary rise technique was used to measure the static surface tension of aqueous solutions.

Results and Discussion: The tap water surface tension was recorded 68.61 mN m^{-1}. The data from this study showed that both surfactants were effective at lowering the surface tension of all spray solutions; however, nonionic surfactant was more effective than cationic surfactant.Difference among the surface tension of herbicides may be related to the difference in their formulations. Aliverdi et al. (2009) observed that clodinafop-propargyl (emulsifiable concentration (EC) formulation) reduced the surface tension of distilled water more than tribenuron-methyl (dry flowable (DF) formulation). The performance difference in lowering static surface tension by those two surfactants can be ascribed to their physicochemical properties. The tested nonionic surfactant contains low ethylene oxide [$C_8H_{16}C_6H_4(C_2H_4O)_{10}H$], while the tested cationic surfactant contains high ethylene oxide [$R\text{-}N(C_2H_4O)_7H(C_2H_4O)_8H$] in its chemical structure. It is well established by experimental evidence that surfactants with low ethylene oxide content were more effective than surfactants with high ethylene oxide content in decreasing the static surface tension of spray solutions. Sulfosulfuron and metsulfuron-methyl + sulfosulfuron dose responses in greenhouse experiments indicated an $ED_{50}$of 8.94 and 13.13 g a.i. ha^{-1} for wild oat, respectively. In outdoor experiments, ED_{50}parameter valueswere 13.11 and 27.86 g a.i. ha^{-1}, respectively. These findings suggest two points; firstly, in equivalent doses metsulfuron-methyl + sulfosulfuron was lower effect than the sulfosulfuron. Secondly, the herbicide efficacy on wild oat was higher in greenhouse experiments than outdoor experiments. This finding can be related to the difference in traits of plants grown in two different environments, which influences leaf micro-morphology and cuticle thickness. Compared with nonionic surfactant, cationic surfactant had a greater ability to enhance the activity of herbicides tested both in greenhouse and in outdoor experiments. Surfactants ethylene oxide content has an important role in herbicide efficacy. Previous research showed that high ethylene oxide content surfactants often work best with herbicides with high water solubility (log Kow< 1) and low ethylene oxide content surfactants often work best with

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herbicides with low water solubility (log Kow> 1) (1, 12, 20).

Conclusion: The results confirm the idea that the HLB value can help to select the type of surfactant that is appropriate for a given herbicide. Thus, high-HLB surfactant will be more suitable for water-soluble herbicides than low-HLB surfactant; and vice versa. As judged by data obtained, the tested cationic surfactant with a high-HLB value was more effective to enhance the activity of four herbicides tested with a log Kow< 1, although the tested nonionic surfactant with a low-HLB value was more effective at lowering the surface tension of all spray solutions. Therefore, a recommendation for choosing the best surfactant for a given application is the use of the HLB system.

Keywords: Citogate, Dose-response, Frigate, Metsulfuron-methyl + Sulfosulfuron, Sulfosulfuron

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