A Novel Technology in Chemical Weed Management Systems: Seed Oils plus Herbicide Application

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ABSTRACT
The present study was designed to determine the effect of Nicosulfuron along with seed oils as surfactant on weeds control in popcorn. Before stem elongation in spring the plots were differently foliar sprayed by 750 g and 1500 g ai ha\(^{-1}\) as 50% and full recommended doses of Nicosulfuron respectively along with sitogate and two seed oil based adjuvants. To formulate the relationship among independent growth variables for corn crop with a dependent variable, multiple regression analysis was carried out. When crop plants were sprayed with 750 g ai ha\(^{-1}\), ear developed on the height of 55 cm, but only at 43 cm in full-dose application; that may cause difficulty in mechanical harvesting. Seed number per ear was a dose dependent trait in corn, and good responded to herbicide application. Weeds biomass in plots sprayed with herbicide in absent of surfactant was 14 g m\(^{-2}\) higher than other treatments. The highest seed yield (625 g m\(^{-2}\)) obtained from 750 g ai ha\(^{-1}\) herbicide sprayed plants along with sunflower oil. The ear development height, seed number per ear and 300 seed weight had a marked increasing effect on yield of corn. It may be necessary for popcorn farmers to minimize herbicide application to sub-optimum rate by proper surfactant usage.

INTRODUCTION

Adjuvants and surfactants are spray solution additives, and are considered to be any product added to a pesticide solution to improve the performance of the spray mixture. Seed oils are a type of adjuvant designed to enhance the absorbing, emulsifying, dispersing, spreading, sticking, wetting, or penetrating properties of pesticides. Surfactants are most often used with herbicides to help a pesticide spread over a leaf surface and penetrate the waxy cuticle of a leaf or to penetrate through the small hairs present on a leaf surface. Surfactants are compounds that lower the surface tension (or interfacial tension) between two liquids or between a liquid and a solid. Surfactants may act as detergents, wetting agents, emulsifiers, foaming agents, and dispersants [1]. Providing a weed-free environment from the time of planting to canopy closing is important for strengthening the native ground cover’s competitive ability against weed invasions. Selective and dual purpose herbicides kill specific targets while leaving the desired crop relatively unharmed [6].

Chemical weed control seems indispensable and has proved efficient in controlling weed [5]. In Iran, herbicide usage accounts for 41% of the total pesticide consumption. Out of total imports of herbicides into the country 50% were used in wheat and corn fields. There are normally many groups of damaging weeds in corn fields. Success of a herbicide application is dependent upon weed species, the timeliness and thoroughness of application, conditions at the time of application, herbicide rate, adjuvants application and crop management after the application [1].

The effects of surfactants on the foliar uptake of herbicides are complex and only partially understood. In an experiment, when a suitable surfactant was used, herbicide uptake into both bean and wheat foliage increased steadily with increasing surfactant concentration and reached a maximum at 0.5%. In the presence of a constant surfactant, higher percentage uptake of herbicide was obtained with higher concentrations for glyphosate, but with lower concentrations in the case of 2,4-D. In the presence of an organosilicone surfactant, the stomatal uptake of glyphosate varied with both surfactant concentration and plant species. The effect of non-silicone surfactants on the cuticular uptake of glyphosate also varied with plant species [12].
The efficacy of any herbicide depends predominantly on the dose used [10] and in many instances the same is also decisive for its selectivity. Registered herbicide doses are set to achieve upper limits of weed control under varying compositions, densities, weed growth stages and environmental conditions, and there may be an overestimation of the dose required to get adequate control [14]. However, it is not always necessarily to apply full herbicide dose [11] and there can flexibility regarding herbicide rates depending on the weed spectrum, densities, their growth stage and environmental conditions [2]. Dose-response and surfactant application studies are an important tool in weed science. The use of such studies has become especially prevalent following the widespread development of herbicide resistant weeds [9]. The present study was designed to determine the effect of Nicosulfuron along with seed oils as surfactant on weeds control in popcorn.

**MATERIAL AND METHODS**

This experiment was conducted in Tabriz, Iran, in a sandy loam soil with pH of 7.9 and organic matter of 0.9%. The climate of research site is semi-arid and cold with an average annual precipitation of 270-mm.

Nicosulfuron as a post-emergence herbicide was used to control corn weeds. This herbicide has been previously tested safe on well-established corn plants. Seeds of corn (*Zea mays* var. popcorn) used for this study were obtained from Seed and Plant Improvement Institute of Karaj, Iran. The cultivar under study was a late-repining variety with growth period of 120-125 days. The experimental field had been in a wheat-sunflower rotation cycle for the last two years. The experiment was laid out factorially in a randomized complete block design in field condition with three replicates.

In all the plots two cultivations with a tractor-drawn cultivator along with manuring 12 t ha$^{-1}$ followed by planking were given to achieve desirable soil structure. Then fields were furrowed and plotted in the early spring before sowing. Seeds were hand sown on 8th May in rows 75 cm apart and 20 cm on the rows at 5-6-cm depth. Based on soil analysis fertilizers P and K were applied basally at the rate of 120 and 40 kg ha$^{-1}$ respectively. Nitrogen was applied at the rate of 140 kg ha$^{-1}$, of which 50% was applied basally and the rest prior to tasseling. Eight irrigations were given to all treatments until 30 days prior to harvesting. No herbicide before sowing was used to control weeds. Before stem elongation in spring the plots were differently foliar sprayed by 750 g and 1500 g ai ha$^{-1}$ as 50% and full recommended doses of Nicosulfuron respectively along with sitogate and two seed oil based adjuvants of sunflower oil and corn oil. Plots receiving no herbicide treatment served as control.

At harvesting stage, the middle four corn rows of each plot were hand harvested. Any pesticide used to control insects. The yield harvested separately for each plot between 26-30 September when the seeds were fully ripened. Agronomic traits and yield components was examined by standard procedures.

Data were statistically analyzed using the software MSTAT-C. Analysis of variance was used to test the significance of variance sources, while Duncan’s Multiple range test (P=0.05) was used to compare the differences among treatment means. In statistics, stepwise regression includes regression models in which the choice of predictive variables is carried out by an automatic procedure. In this study, to formulate the relationship among six independent growth variables measured in our experiment for corn crop with a dependent variable, multiple regression analysis was carried out for the stem height ($X_1$), ear development height ($X_2$), ear length ($X_3$), seed row number per ear ($X_4$), seed number per ear ($X_5$), 300 seed weight ($X_6$) and seed yield (SY) as a dependent variable. Furthermore, the stepwise regression analysis was also carried out for the data obtained to test the significance of the independent variables affecting the seed yield.

**RESULTS AND DISCUSSION**

Surfactants are almost always present in herbicide solutions with the aim to improve spray droplet retention on and penetration of active ingredients into plant foliage. When the herbicide foliar sprayed with 750 g ai ha$^{-1}$, stem height of crop plants at ripening stage improved 17 cm, compared to full-dose application. Similarly, when crop plants was sprayed with 750 g ai ha$^{-1}$, first ear developed on the height of 55 cm on stem, but only at 43 cm in full-dose application (Table 1), that may cause difficulty in mechanical harvesting.

Ear length in those plants sprayed with herbicide at 750 g g ai ha$^{-1}$, was longer than 1500 g ai ha$^{-1}$ (Table 1). Seed oil concentrates are composed of paraffin based petroleum oil and surfactants. Seed oil concentrates reduce surface tension and improve herbicide uptake and leaf surface spreading. Among surfactant materials, higher ear length was obtained from sitogate and sunflower oil, and the lower from corn oil and control (Table 2).

Seed row number per ear in 750 g ai ha$^{-1}$ was greater than 1500 g ai ha$^{-1}$ (Table 1). Study effects of surfactans on seed row number per ear revealed that there is a positive response to sitogate and sunflower oil in corn plants. Whereas, when plants treated with corn oil or in control, seed row number per ear reduced from 20 rows up to 14.5 rows (Table 2). Seed number per ear was a dose dependent trait in corn, and good responded to herbicide application. Number of seeds per ear was greater in limited dose of herbicide (Table 1). Seed number per ear ranged from 666 seeds in sunflower oil to 540 seeds in control plots (Table 2).
Table 1: Mean comparisons of some of studied traits in popcorn affected by herbicide dose.

<table>
<thead>
<tr>
<th>Herbicide dose (g ai ha⁻¹)</th>
<th>Stem height (cm)</th>
<th>Ear development height (cm)</th>
<th>Seed row number per ear</th>
<th>Seed number per ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>180.4</td>
<td>55</td>
<td>17.3</td>
<td>650</td>
</tr>
<tr>
<td>1500</td>
<td>163.5</td>
<td>43</td>
<td>14.7</td>
<td>549</td>
</tr>
</tbody>
</table>

ai; means active ingredient.

Table 2: Some of studied traits as affected by surfactant use.

<table>
<thead>
<tr>
<th>Surfactants</th>
<th>Sitogate</th>
<th>Sunflower oil</th>
<th>Corn oil</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear length (cm)</td>
<td>23 a</td>
<td>22 a</td>
<td>15 b</td>
<td>18 b</td>
</tr>
<tr>
<td>Seed row number per ear</td>
<td>19.5 a</td>
<td>20 a</td>
<td>560 b</td>
<td>540 b</td>
</tr>
<tr>
<td>Seed number per ear</td>
<td>650 a</td>
<td>666 a</td>
<td>37 b</td>
<td>36 b</td>
</tr>
<tr>
<td>300 seed weight (g)</td>
<td>42 a</td>
<td>43 a</td>
<td>13 b</td>
<td>26.7 b</td>
</tr>
</tbody>
</table>

Means with different letters have significant difference at 5% probability level.

Table 3: Standard regression coefficients, T values and probability levels of model of seed yield in corn.

<table>
<thead>
<tr>
<th>Standard regression coefficients (β)</th>
<th>Ear development height</th>
<th>Seed number per ear</th>
<th>300 seed weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>T values</td>
<td>+2.100</td>
<td>+1.000</td>
<td>+1.520</td>
</tr>
<tr>
<td>prob.</td>
<td>0.04</td>
<td>0.05</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Seeds produced in those plants treated with Nicosulfuron at 50% of recommended dose was heavier than full-dose treatment. Similarly, crop plants Nicosulfuron sprayed along with sitogate and sunflower oil produced larger seeds with 300 seed weight of 42.5 g, but only 36.5 g from control and corn oil (Table 2). Seed oils are produced by reacting fatty acids from seed oils with an alcohol to form esters. The methyl or ethyl esters produced by this reaction are combined with surfactants/emulsifiers to form an esterified seed oil. These surfactants reduce surface tension and improve herbicide uptake by improving herbicide distribution on the leaf surface, which is lead to improvement of crop yield and its components [4].

Above ground biomass of weeds in those plots sprayed with herbicide in absent of surfactant was 14 g m⁻² higher than average of herbicide application along with all kind of surfactants (Table 2). On the other hand, weeds under foliar application of Nicosulfuron along with surfactant materials used better controlled than other treatments studied. Adjuvants enhance the efficacy of post-emergence herbicides [3, 8, 12, 13]. Application of herbicides in limited dose along with suitable surfactants would reduce off-target movement of herbicide, and maximize weed control efficiency [1]. In an experiment imazethapyr controlled Kochia (Kochia scoparia) and green foxtail (Setaria viridis) better when applied with various petroleum oil adjuvants [7]. Also, Imazethapyr controlled yellow nutsedge more effectively when applied with Plex, Silkin, Agri-Dex, Kinetic, Chaser, or Sun-It as surfactants [4]. The highest seed yield (625 g m⁻²) obtained from 750 g ai ha⁻¹ herbicide sprayed plants along with sunflower oil (Figure 1).

Fig. 1: Seed yield of corn as affected by herbicide dose and surfactant ai; means active ingredient.

Stepwise regression analysis:

Standard regression coefficients, T values and probability levels of model of seed yield in corn are indicated in Table 3.

The multiple regression equation is shown as follows:

\[ \text{Seed yield (g m}^{-2} \text{)} = 0.943 + 1.080 (X_1) + 0.888 (X_2) + 1.525 (X_3) + 1.299 (X_4) + 0.100 (X_5) + 0.462 (X_6); \]
The resulted stepwise regression equation for corn is shown as follows:

$$\text{Seed yield} = 4.56 + 2.410 (X_2) + 2.001 (X_5) + 2.761 (X_6); R^2 = 80$$

The stepwise regression analysis verified that the ear development height, seed number per ear and 300 seed weight had a marked increasing effect on seed yield of corn. Therefore, it was concluded that these traits are as major attributes of corn yield offer the best guide for selection by plant breeders at interference with troublesome weeds.

Conclusion:

It may be necessary for popcorn farmers to minimize herbicide application to sub-optimum rate by proper surfactant usage.

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REFERENCES


