Evaluation of reduced dosages of Rimsulfuron compared to standard dosages with nonionic surfactant on field bind weed (Convolvulus arvensis L.) in potato (Solanum tuberosum L.) field

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Abstract
In order to evaluate reduced dosages of Rimsulfuron (Titus 25% DF) efficacy with nonionic surfactant in comparison to standard dosages on field bind weed (Convolvulus arvensis L.) biomass, field experiment was carried out at the Sheikh Kalkhoran of Ardabil during 2015. For this purpose, a factorial experiment was performed in the base of Randomized Complete Block Design, in three replications on Agria cultivar. Experiment included standard dosages of Rimsulfuron (0, 10, 20, 30, 40, 50, 60 g a.i/ha), reduced dosages (0, 5, 10, 15, 20, 25, 30 g a.i/ha) which were used at one stage (potato emergence), two stages (potato emergence + stoloning) and three stages (potato emergence + stolonning + tuber bulking), with and without nonionic surfactant (0.2 L/ha). Fitting standard dosages without nonionic surfactant data by the sigmoidal or logistical three parameters equations showed, application of 18.70, 11.44, 7.18 g a.i/ha Rimsulfuron in one stage, two stages, three stages reduced 50% field bind weed biomass. ED50 of standard dosages and with nonionic surfactant were from 17.60, 7.52, 8.59 g a.i/ha Rimsulfuron in one stage, two stages, three stages, respectively. Fitting reduced dosages of Rimsulfuron without nonionic surfactant data by the sigmoidal or logistical three parameters equations showed ED50 dosages were 18.11, 12.06, 7.81 g a.i/ha in one stage, two stages, three stages, respectively. Also, reduced dosages of Rimsulfuron ED50 with nonionic surfactant were 15.64, 10.55 and 7.45 g a.i/ha in one stage, two stages, three stages, respectively.

Keywords: Dose-response, chemical weed control, Adjuvant, weed biomass

Introduction
In the world, potato (Solanum tuberosum L.) is forth important crop after rice, wheat and corn (Haas et al., 2008; Camir et al. 2009; Van der Linden et al 2011). The most important of potato weeds in Iran were Amaranth spp., common lamsquarters (Chenopodium album L.), common purslane (Portulaca oleracea L.), polygonum spp., setaria spp., common barnyardgrass (Echinochloa crus gali), mouse barley (Hordeum leporinum), Lolium spp. (Plant Protection Organization of Iran 2016).

Herbicides are very important chemical agents for controlling weeds in agriculture. The aim of using herbicides in agriculture is to increase crop returns. However, excessive and continuous use of agrochemicals has negatively affected environment and agricultural sustainability thus reduced crop returns (Pimentel et al 1992). For this reason, it is very important to keep the weed population at an acceptable level, not to eradicate all weeds, to
achieve environmental and agricultural sustainability. Registered doses of herbicides are set to ensure adequate weed control over a wide spectrum of weed species, weed densities, growth stages and environmental conditions (Zhang et al. 2000). From this point of view, reducing the label rates of herbicides is becoming an important tool. This reveals that herbicide rates can vary and be reduced according to weed spectrum, density, growth stages and environmental conditions.

Currently Paraquat and Metribuzin are herbicides registered for use in potato production in Iran and metribuzin commonly used both preemergence (PRE) and postemergence (POST) (Alerahim et al. 2012). Rimsulfuron (Titus 25% DF) belongs sulphonylurea herbicides and applied pre and post emergence (Hutchinson 2004). Alerahim et al., (2012) reported application of Rimsulfuron PRE and POST at the highest dose of 12.5 g/ha provided 100% control of redroot pigweed (Amaranthus retroflexus) and 95-98% control of common lambsquarter (Chenopodium album) (95%). Alerahim et al. (2012) reported application of 7.5, 10 and 12.5 g ai/ha Rimsulfuron at PRE and POST reduced common lambsquater and redroot pigweed more than 82 percent. Also, POST Rimsulfuron application compare to PRE reduced weed biomass more.

Several studies have demonstrated good weed control with reduced herbicide dosages (Brain et al. 1999; Bostrom and Fogelfors 2002; Hamill et al. 2004). For example, Belles et al. (2000) reported that a 50% dose of tralkoxydim consistently gave >85% wild oat (Avena fatua L.) control in barley (Hordeum vulgare L.). O’Donovan et al. (2001) similarly documented that tralkoxydim at belowlable doses often gave good control of wild oat. An Australian study found that clodinafop and tralkoxydim efficacy on wild oat (Avena ludoviciana Durieu) and paradoxa grass (Phalaris paradoxa L.) remained high at 50–75% of the recommended doses (Walker et al. 2002). Wallac and Bellinder (1990) reported application of 2/3 labeled dose of Metribuzin provided 43% redroot pigweed control and increased total tuber yield 48.78 percent.

Surfactants are important components of most pesticidal formulations since they may function as spreaders, stickers, antifoamers, compatibility agents or activators. Surfactants play an important role in formulating herbicides, as emulsifiers for emulsifiable concentrates and microemulsions or as wetting and dispersing agents for wettable powders, water dispersible granules and suspension concentrates. They can also be used as spraysk tank additives to enhance adhesion and wetting of foliage and uptake into the plant (Kirkwood, 1993).

Four classes of surfactant have been defined (anionic, cationic, nonionic and amphoteric) according to their molecular and lipophilic groups; compounds of low Hydrophilic-Lipophilic Balance (HLB) are relatively lipophilic while those of high HLB are relatively watersoluble. It is therefore possible to select a surfactant for a specific situation or purpose on the basis of its HLB value (Foy et al. 1991).

Nevertheless, the labels of many postemergence sulfonylurea herbicides only specify the use of certain types of adjuvants or combinations of adjuvants (Hazen 2000; Tu and Randall 2003). Considering the wide-spread use of tribenuronmethyl, the identification of the most appropriateadjuvant for tribenuron-methyl in contrasting rainfallconditions and/or against different weed species was found to be necessary. The effects of certain types of non-ionic surfactants on the performance and rainfastness of tribenuron-methyl were studied previously by Kudsk and Mathiassen (1993).
Therefore, the objective of this study was to compare reduced and standard dosages of Rimsulfuron with non-ionic surfactants.

Materials & Methods

Trials were conducted in personal farm of Kalkhoran Sheikh of Ardabil in 2013. The experiment performed as does-response based on factorial experiment of Randomized Complete Block Design with three replications and potato’s cultivar was Agria (common cultivar in Ardabil). There are three factors in this experiment. Experiments include standard dosages of Rimsulfuron (0, 10, 20, 30, 40, 50, 60 g a.i/ha) and reduced dosages (0, 5, 10, 15, 20, 25, 30 g a.i/ha) which dosages were used at one stage (potato emergence), two stages (potato emergence + stoloning) and three stages (potato emergence + stoloning + tuber bulking) and with and without nonionic surfactant (0.2 L/ha). Tubers were hand sown on 22th Avril in rows 75 cm apart and 20 cm on the rows at 10 cm depth. Herbicide was applied by backpack sprayer fitted with 8001 flat fan nozzles and 2-2.5 bar pressure. Three weeks after treatment, weed sampling was carried out by units of the sample (fix plot 0.75× 0.50 m²). Three weeks after treatment harvested weed and dry weight were recorded.

Two three parameter model were fitted to the data to compare doses including:

1. Three parameter logistic function
   \[ y = \frac{a}{1+e^{-(x-x_0)/b}} \]
2. Three parameter sigmoid function
   \[ y = \frac{a}{1+e^{-(x-x_0)/b}} \]
   a: maximum weed biomass b: The slope and x₀ (ED₅₀): the dose causing 50% reduction weed biomass.

Data were statistically analyzed using the SAS 9.1. In addition to creat the graph and calculate the regression equations were used EXCEL 2013 and Sigmaplot 11 softwares, respectively. Analysis of variance was used to test the significance of variance sources, while LSD test (P = 0.05) was used to compare the differences among treatment means.

Results and Discussion

Results showed interaction of different dosages * stages * nonionic surfactant had significant effect 1% on field bind weed biomass. Application 60, 50, 40 g a.i/ha, two and three stages, with and without surfacatan provided effective control of field bind (100 %). The maximum reduction percentage of reduced dosages at 30 g a.i/ha, two and three stages, with and without surfactant was 100% that had not significant difference 25 g a.i/ha, three stages, with and without surfactant.

Fitting standard dosages and without nonionic surfactant data by the sigmoidal or logistical three parameters equations showed, application of 18.70, 11.44, 7.18 g a.i/ha Rimsulfuron in one stage, two stages, three stages and without surfactant provided effective control of field bind weed biomass, respectively (Figure 1, Table 1). ED₅₀ dosages of standard dosages and with surfactant data were from 17.60 to 7.52 g a.i/ha Rimsulfuron in one stage, two stages, three stages, respectively (Figure 2, Table 2). Fitting reduced dosages of Rimsulfuron without nonionic surfactant data by the sigmoidal or logistical three parameters equations showed ED₅₀ dosages ranged 18.11, 12.06,
7.81 g a.i/ha in one stage, two stages, three stages, respectively (Figure 3, Table 3). Also, application of 15.64, 10.55 and 7.45 g a.i/ha Rimsulfuron in one stage, two stages, three stages and with nonionic surfactant reduced 50% field bind weed biomass, respectively (Figure 4, Table 4). So, reduced dosages of Rimsulfuron provided effective control of field bind weed.

![Graph showing response of reduction percentage of field bind weed biomass at standard dosages of Rimsulfuron without surfactant](image)

**Figure 1** - The response of reduction percentage of field bind weed biomass at standard dosages of Rimsulfuron without surfactant.

**Table 1** - Estimated sigmoidal and logistic parameters for Rimsulfuron on field bind biomass

<table>
<thead>
<tr>
<th>Variable</th>
<th>a (SE)</th>
<th>b (SE)</th>
<th>ED$_{50}$ (SE)</th>
<th>R$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>One stage (Sigmoid)</td>
<td>89.92 (4.31)</td>
<td>3.02 (1.56)</td>
<td>18.70 (1.25)</td>
<td>0.97</td>
</tr>
<tr>
<td>Two stages (Logistic)</td>
<td>102.37 (1.81)</td>
<td>-2.85 (0.31)</td>
<td>11.44 (0.38)</td>
<td>0.99</td>
</tr>
<tr>
<td>Three stages (Logistic)</td>
<td>100.43 (0.29)</td>
<td>-3.10 (0.20)</td>
<td>7.18 (0.15)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

ED$_{50}$ index is the herbicide dose that reduced field bind biomass 50%. The values in parentheses are standard errors.
Figure 2 - The response of reduction percentage of field bind weed biomass at standard dosages of Rimsulfuron with surfactant.

Table 2 - Estimated sigmoidal and logistic parameters for Rimsulfuron on field bind weed biomass

<table>
<thead>
<tr>
<th>Variable</th>
<th>a</th>
<th>b</th>
<th>ED₅₀</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>One stage (Logistic)</td>
<td>98.82 (2.87)</td>
<td>-3.21 (0.40)</td>
<td>17.60 (0.76)</td>
<td>0.99</td>
</tr>
<tr>
<td>Two stages (Sigmoid)</td>
<td>95.66 (3.01)</td>
<td>1.19 (5.41)</td>
<td>7.52 (1.18)</td>
<td>0.97</td>
</tr>
<tr>
<td>Three stages (Logistic)</td>
<td>100.00 (0.002)</td>
<td>-7.22 (0.03)</td>
<td>8.59 (0.006)</td>
<td>1</td>
</tr>
</tbody>
</table>

ED₅₀ index is the herbicide dose that reduced field bind biomass 50%. The values in parentheses are standard errors.

Figure 3 - The response of reduction percentage of field bind weed biomass at reduced dosages of Rimsulfuron without surfactant.
Table 3- Estimated sigmoidal and logistic parameters for Rimsulfuron on field bind weed biomass

<table>
<thead>
<tr>
<th>Variable</th>
<th>a</th>
<th>b</th>
<th>ED50</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>One stage (Logistic)</td>
<td>79.05 (4.57)</td>
<td>-5.40 (0.80)</td>
<td>18.11 (0.63)</td>
<td>0.99</td>
</tr>
<tr>
<td>Two stages (Sigmoid)</td>
<td>94.92 (5.63)</td>
<td>3.30 (0.81)</td>
<td>12.06 (0.97)</td>
<td>0.97</td>
</tr>
<tr>
<td>Three stages (Logistic)</td>
<td>100.61 (0.93)</td>
<td>-3.37 (0.14)</td>
<td>7.81 (0.12)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

ED50 index is the herbicide dose that reduced field bind biomass 50%. The values in parentheses are standard errors.

Figure 4- The response of reduction percentage of field bind weed biomass at reduced dosages of Rimsulfuron with surfactant

Table 4- Estimated sigmoidal and logistic parameters for Rimsulfuron on field bind weed biomass

<table>
<thead>
<tr>
<th>Variable</th>
<th>a</th>
<th>b</th>
<th>ED50</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>One stage (Logistic)</td>
<td>79.74 (5.53)</td>
<td>-4.41 (0.85)</td>
<td>15.64 (0.82)</td>
<td>0.99</td>
</tr>
<tr>
<td>Two stages (Sigmoid)</td>
<td>93.03 (6.58)</td>
<td>3.00 (1.01)</td>
<td>10.55 (1.17)</td>
<td>0.96</td>
</tr>
<tr>
<td>Three stages (Sigmoid)</td>
<td>98.19 (1.80)</td>
<td>2.48 (0.26)</td>
<td>7.45 (0.31)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

ED50 index is the herbicide dose that reduced field bind biomass 50%. The values in parentheses are standard errors.

Conclusions

This study confirmed that the application of 60 g a.i/ha Rimsulfuron three stages and with nonionic surfactant create maximum reduction percentage of field bind weed that had not significant difference 30 and 25 g a.i/ha, three stages, with and without surfactant. So, use of reduced dosages of Rimsulfuron with nonionic surfactant increase Rimsulfuron efficacy. However, suggested to carry out the experiment over several years, to evaluate potato tolerance of varieties to Rimsulfuron and the effectiveness of other herbicides mixing with Rimsulfuron for future researches.
References


