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Chemical Control of Downy Brome, Littleseed Canarygrass and Green Foxtail in Rapeseed in Southern Iran

Niusha Valaie[1] Seyed Abdolreza Kazemeini[1*] and Habiballah Hamzehzarghani[2]
[1] Department of Crop Production and Plant Breeding, College of Agriculture, Shiraz University, IRAN
[2] Department of Plant Protection, College of Agriculture, Shiraz University, Shiraz, IRAN

ABSTRACT

In order to investigate the effect of herbicide and choice of adjuvant on three grass weed species; downy brome (*Bromus tectorum*), littleseed canarygrass (*Phalaris minor*) and green foxtail (*Setaria viridis)*; a greenhouse study was conducted in a factorial experiment laid out in randomized complete block design. Treatments included herbicide at five levels (propaquizafop, fluazifop-p-butyl, cycloxydim, sethoxydim and quizalofop-p-ethyl) each applied at two concentrations and either with/without adjuvant (volck or citoweet). The performance of herbicides and adjuvants was evaluated by rating the effect of treatment on an ordinal scale in each experimental unit at 10 and 20 days after planting (DAP). The results showed that herbicide efficiency rating distributions were significantly different between two times (10 and 20 DPA). Application of quizalofop-p-ethyl and propaquizafop were recorded as the best herbicide treatments in controlling the weeds used in this study 10DAP, however the difference between herbicides faded at 20 DAP. Also, no significant effect was found for concentration of herbicides and type of adjuvant. In addition, 30 days after herbicide application, maximum dry weight and leaf area of canola was recorded for cycloxydim, propaquizafop and quizalofop-p-ethyl, respectively whereas minimum dry weight and leaf area of canola was observed in pots sprayed with sethoxydim and fluazifop-p-butyl respectively.

Key Words: Adjuvant, herbicide, canola, downy brome, littleseed canarygrass, green foxtail.

INTRODUCTION

Rapeseed also called canola (*Brassica napus* L.) is an economically important member of the mustard family. It forms a thick rosette of leaves close to the ground before beginning to develop a flowering stalk (Brown et al. 1996). Flowering is delayed until spring in winter types of canola. Canola seeds are a rich source of oil and an important supply of vitamin E. Global production of rapeseed rose to 46.4 million metric tons in 2005 (FAO 2005). High protein content and market demand and advantages like purchase guaranteed scheme by government has made canola a crop of choice for growers in Iran (Ghadiri and Naderikharaji 2008; Miri and Rahimi 2009). Despite high competitive ability of winter canola with weeds, weed control strategies should be devised to target reducing weed competition during seedling emergence using mechanical or chemical means. Weed infestation by species of the Brassicaceae and Poaceae is one of the important challenges of canola growers in Iran as a result of the lack of efficient selective herbicides (Bagherani and Shimi, 2001). Herbicides such as Propaquizafop and fluazifop-p-butyl, (Aryloxyphenoxypropionate group), sethoxydim, cycloxydim (cyclohexanedione group) and quizalofop-p-ethyl (oryloxy phenoxy propionate) are postemergence graminicides that has been used to control annual and perennial grass weeds such as littleseed canarygrass (*Phalaris minor* Retz.), downy brome (*Bromus tectorum* L.) and green foxtail (*Setaria viridis* L. Beauv.) (Baghestani *et al.* 2008; Rashed Mohassel *et al.,* 2010). These herbicides act by inhibiting acetyl coenzyme A carboxylase and disrupting fatty acid biosynthesis. In order to reduce the risk of side effects and costs of chemicals, dose optimization and choice of suitable adjuvant for these herbicides is necessary. An adjuvant is defined by Weed Science Society of America (1994) as *"Any substance in a herbicide formulation or added to the spray tank to modify herbicidal activity or application characteristics"*. Adjuvants also modify many other characteristics of the herbicide such as reducing surface tension (Kudsk 2008), solubilization of leaf cuticle, delaying drying time of spray solution especially in dry weather, micelle formation by serving as emulsifier and increasing spray retention on plant foliage (Penner, 2000). Two well known adjuvants, volck and citoweet are petroleum oils and utilized for improving herbicide efficiency. Regardless of the benefits of application of adjuvants, some reports indicate that certain adjuvants may decrease foliar activity of some herbicides (Devendra *et al.,* 2004) but, Kudsk and Mathiassen (2007), have shown that any kind of adjuvant is able to increase the absorption rate of all kinds of herbicides. The objective of the present study was to investigate the effect of five different herbicides (each at two concentrations chosen based on label information) on three grass weeds namely downy brome, littleseed canarygrass and green foxtail, and the influence of two adjuvants on the efficacy of herbicides.

[*] Corresponding author: kazemeini22@gmail.com

MATERIALS AND METHODS

Plant materials

Downy brome and green foxtail seeds collected from college of Agriculture, Badjgah fields, Shiraz University and littleseed canarygrass seeds were obtained from the Plant Protection Research Institute in Tehran, Iran. One gram seeds of each weed species was mixed and the seed mixture was sown with 10 canola seeds (cv. Talaye) 2 cm deep in 30-cm diameter pots filled with a mixture of silty loam soil texture (sand=15.5%, silt= 57.7%, clay= 26.8%), pH=7.65 and 0.76% organic carbon. The pots were irrigated every four days until chemical spray. The experimental design was a factorial laid out in randomized complete block design with 20 treatments in four replications. Each replication was consisted of 20 pots and each pot was separately and randomly assigned with a treatment which was a combination of the choice of herbicide (at five levels), herbicide concentration, and adjuvant (each at two levels). The pots were kept in greenhouse at 25/16°C (±0.5°C) day/night temperatures and 60% (±5%) relative humidity.

Herbicide application

Propaquizafop (Agil 10% EC, 100 g ai/L propaquizafop; Viale citta d'Europa, agrimix s.r.l), cycloxydim (Focus 10% EC, 100 g ai/L cycloxydim; BASF, Limburgerhof, Germany), quizalofop-p-ethyl (Targa super 5% EC, 50 g ai/L quizalofop-p-ethyl; Nisan chemical, Japan), fluazifop-p-butyl (Fusilade super 12.5% EC, 125 g ai/L fluazifop-p-butyl; Singenta, Bazel, Switzerland) and sethoxydim (Nabus 12.5% OEC, 125 g ai/L sethoxydim; Nipon sodan, Japan) were purchased from the local market and used separately against the even mixture of downy brome, green foxtail and littleseed canarygrass. These herbicides were applied at two concentrations with either citoweet (petroleum oil) at 2/1000 (v/v)or with volck (petroleum oil) at 2/1000 (v/v) as adjuvant (Table 1).

Table 1. Herbicide treatments, rates and adjuvants types used to control three grass weed species in canola in greenhouse experiment.

Treatment	Application rates
Check	-
A(P)[1] + Volck	1 lit ai/ha + 2/1000 v/v
A(P)[1] + Volck	1.5 lit ai/ha + 2/1000 v/v
A(P)[1] + citoweet	1 lit ai/ha + 2/1000 v/v
A(P)[1] + citoweet	1.5 lit ai/ha + 2/1000 v/v
F(C)[2] + Volck	1.5 lit ai/ha + 2/1000 v/v
F(C)[2] + Volck	2 lit ai/ha + 2/1000 v/v
F(C)[2] + citoweet	1.5 lit ai/ha + 2/1000 v/v
F(C)[2] + citoweet	2 lit ai/ha + 2/1000 v/v
T(Q)[3] + Volck	1.5 lit ai/ha + 2/1000 v/v
T(Q)[3] + Volck	2 lit ai/ha + 2/1000 v/v
T(Q)[3] + citoweet	1.5 lit ai/ha + 2/1000 v/v
T(Q)[3] + citoweet	2 lit ai/ha + 2/1000 v/v
FS(F)[4] + Volck	2 lit ai/ha + 2/1000 v/v
FS(F)[4] + Volck	3 lit ai/ha + 2/1000 v/v
FS(F)[4] + citoweet	2 lit ai/ha + 2/1000 v/v
FS(F)[4] + citoweet	3 lit ai/ha + 2/1000 v/v
N(S)[5] + Volck	2 lit ai/ha + 2/1000 v/v
N(S)[5] + Volck	3 lit ai/ha + 2/1000 v/v
N(S)[5] + citoweet	2 lit ai/ha + 2/1000 v/v
N(S)[5] + citoweet	3 lit ai/ha + 2/1000 v/v

1.P= Propaquizafop, 2.C= Cycloxydim, 3.Q= quizalofop-p-ethyl, 4.F= fluazifop-p-butyl, 5.S= sethoxydim.

The plants were sprayed at the two- to three-leaf stage of canola after 5 weeks by using an overhead trolley sprayer. The efficacy of herbicides (in combination with adjuvants) was rated visually based on an ordinal scale at fives levels of poor, fair, good and excellent approximately 10 and 20 days after spraying. At the end of the experiments (30 days after spraying), dry weight, height and leaf area (LA) of canola in each pot were recorded.

Statistical analysis

Statistical analysis was performed by applying generalized linear model techniques and a proportional odds model was fitted to the data containing herbicide, type of adjuvant and concentration as main effects and their interaction using the proc genmod of the statistical software SAS 9.1 (SAS Institute, 2000). The genmod procedure with a cumulative logit link function and multinomial distribution was used. To test whether main and interaction effects are significant, type 3 option was added to proc genmod statement to invoke "*LR Statistics For Type 3 Analysis*". To determine the multinomial ordinal rating distributions for the marginal herbicide, adjuvant and concentration effects, the marginal treatment means were constructed with estimate statements and eventually the marginal distributions were compared with estimate statement (Schabenberger and Pierce, 2002). Ordinal data analysis was performed by running Proc Genmod of SAS and selecting link= cumlogit dist= multinomial.

RESULTS AND DISCUSSION

The results showed that the main effect of herbicide at 10 days post application was significant ($P<0.0001$), however adjuvant and concentration did not have any significant effect ($P=0.4095$ and $P=0.1580$) on the efficiency of weed control by herbicides. Also herbicide efficiency rating (poor: Score < 3, fair to good labeled from now on as good: Score =3 and excellent: Score >3) distributions were significantly different between two times (10 and 20 days post application). The performance of cycloxydim, fluazifop-p-butyl, sethoxydim and quizalofop-p-ethyl was significantly better at 20 DAP (with LR Statistics for type 3 analysis of $P=0$, $P<0.0001$, $P<0.0003$, $P<0.0006$, $P<0.0001$ respectively), however the best herbicide in the group (i.e. propaquizafop) performed equally well at both 10 and 20 DAP with an LR statistics of $P=0.2334$,(Fig 2, a-e). While at 10 DAP the overall distribution of score < 3 and ≥ 3 were 50 and 50 percent respectively, it changed to 10 and 90 percent 20 DAP. There was also no significant interaction between type of herbicides and adjuvant at 10 days post application ($P=0.8975$).

Herbicides created very similar probability distributions 20 days after spraying the even mixture of three grass weeds and consequently there was no discernible significant difference in herbicide efficiency for the herbicides used in this study 20 DPA ($P=0.1412$). No significant effect was found for concentration of herbicides ($P=0.9465$), type of adjuvant ($P=0.7089$) and interaction between herbicide and adjuvant 20 days post application ($P=0.4846$).

Application of propaquizafop and quizalofop-p-ethyl caused maximum suppression of the three grass weeds with 40 to 60^+ percent score≥3 while the ratio of score<3 increased significantly to 80^- to 90^+ in sethoxydim, cycloxydim, and fluazifop-p-butyl (Fig.2 lower panel). Also, application of quizalofop-p-ethyl 20 DPA maximized suppression of the three grass weeds with 98^+ percent score≥3 as compared to the other herbicides.

Pots of canola sprayed with cycloxydim, propaquizafop and quizalofop-p-ethyl recorded significantly higher canola dry matter and leaf area than those sprayed with other herbicides at 30 days post herbicide application and irrespective of the concentration of herbicide and choice of adjuvant (Fig. 3).

Results of rating herbicide efficiency (Fig. 1 & 2) and canola performance (Fig. 3) suggest that although both propaquizafop and quizalofop-p-ethyl guarantee good control of the notorious weeds with no adverse effect on canola yield; propaquizafop is preferred to quizalofop-p-ethyl as it does not cause any reduction in canola leaf area.

As no significant difference found between two concentrations of herbicides used in this study we conclude that propaquizafop and quizalofop-p-ethyl can be considered as candidate herbicides for controlling downy brome, littleseed canarygrass and green foxtail in rapeseed at a reduced rate with minimum unfavorable environmental impacts. Further field validation of these findings is required for field application of the herbicides in canola fields.

Bijanzadeh, Ghadiri and Behpouri (2010) showed that maximum reduction in wild mustard biomass (82%) could be achieved with trifluralin plus propaquizafop plus isoxaben in canola fields. Moreover, the crop oil concentrate adjuvants used with sethoxydim did affect the level of sethoxydim activity on wild oats and increasing the volume of adjuvant tended to increase sethoxydim activity (McMullan and Chow, 1993). In another experiment, application of sethoxydim plus Frigate and citogate adjuvants, wild oat control was significantly increased and was more than when it was used alone (Rashed Mohassel and et al. (2011). In this study no significant difference was observed between application of sethoxydim and fluazifop-p-butyl herbicides on leaf area in canola.

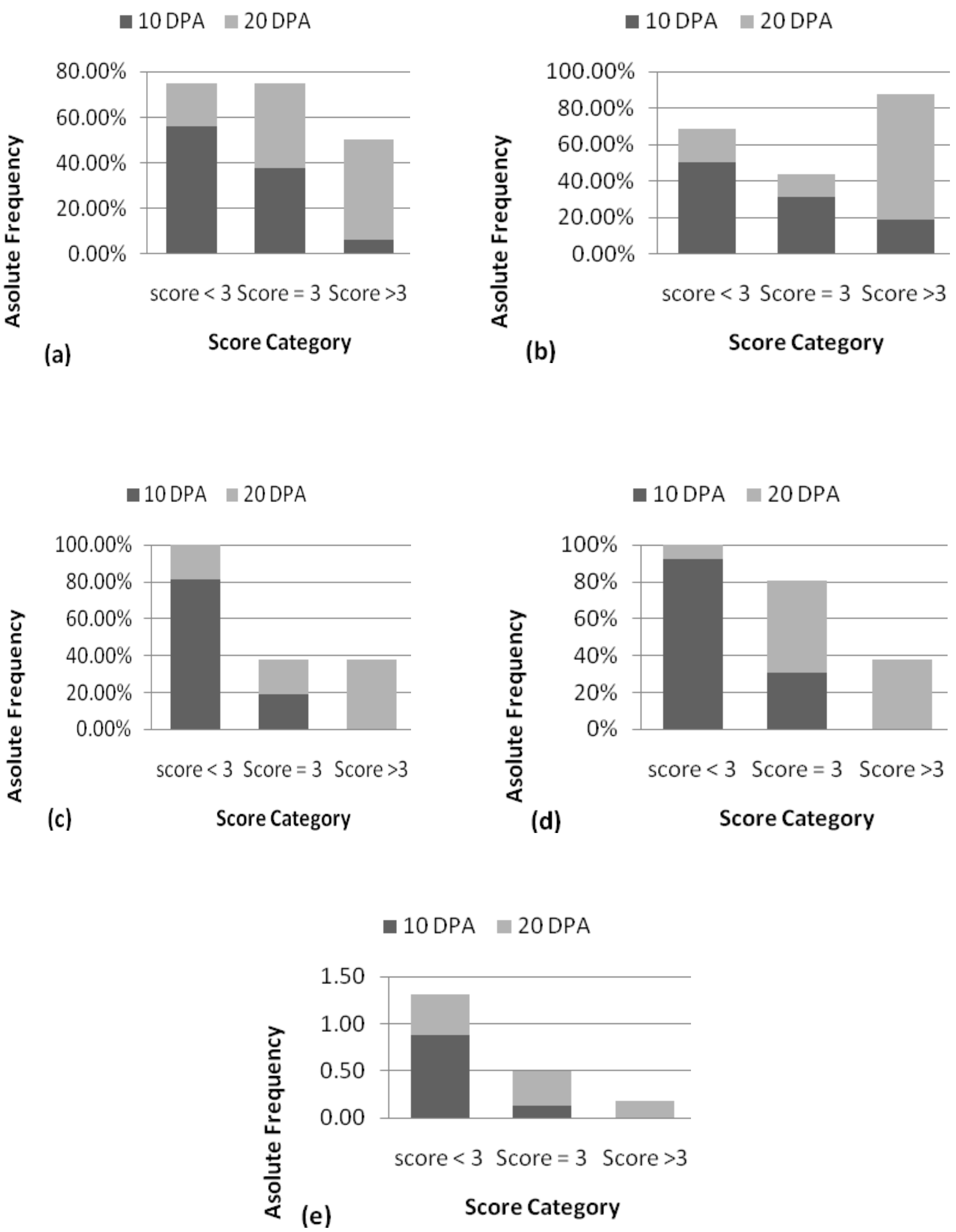
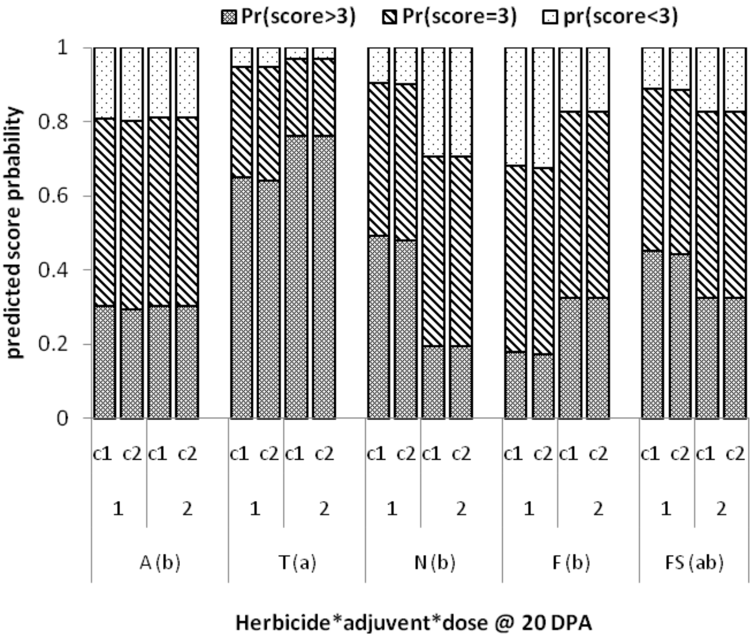


Figure 1. Frequency distributions of three score categories (poor, good and excellent) of control efficiency of five different herbicide 10 and 20 days POST application respectively:
(a) propaquizafop, **(b)** cycloxydim **(c)** fluazifop-p-butyl **(d)** sethoxydim, , **(e)** quizalofop-p-ethyl.



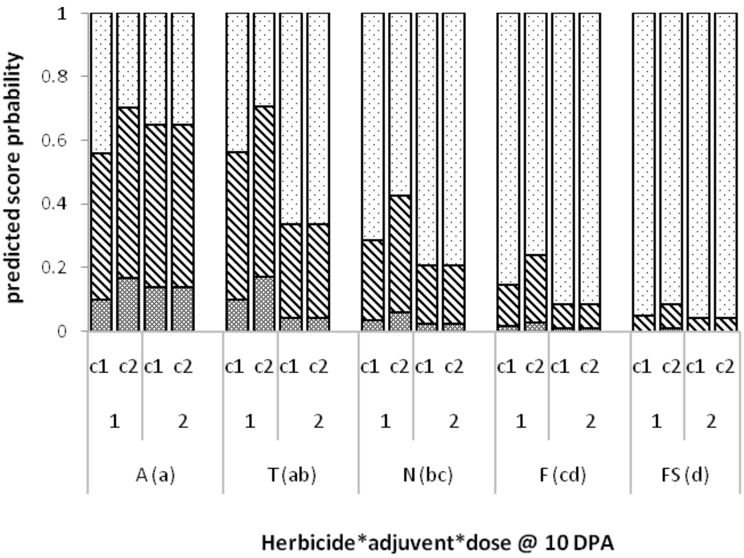


Figure 2 (a & b). Shift in score distributions of five different herbicides (A= propaquizafop, T= quizalofop-p-ethyl, N= sethoxydim, F= cycloxydim, FS= fluazifop-p-butyl), at two concentrations (1=1.5 and 2=2 liter/ha) and with two adjuvants at the rate of 2/1000 (v/v) (1=citoweet, 2=volk). Herbicides with the same letter do not differ significantly at alpha<0.05.

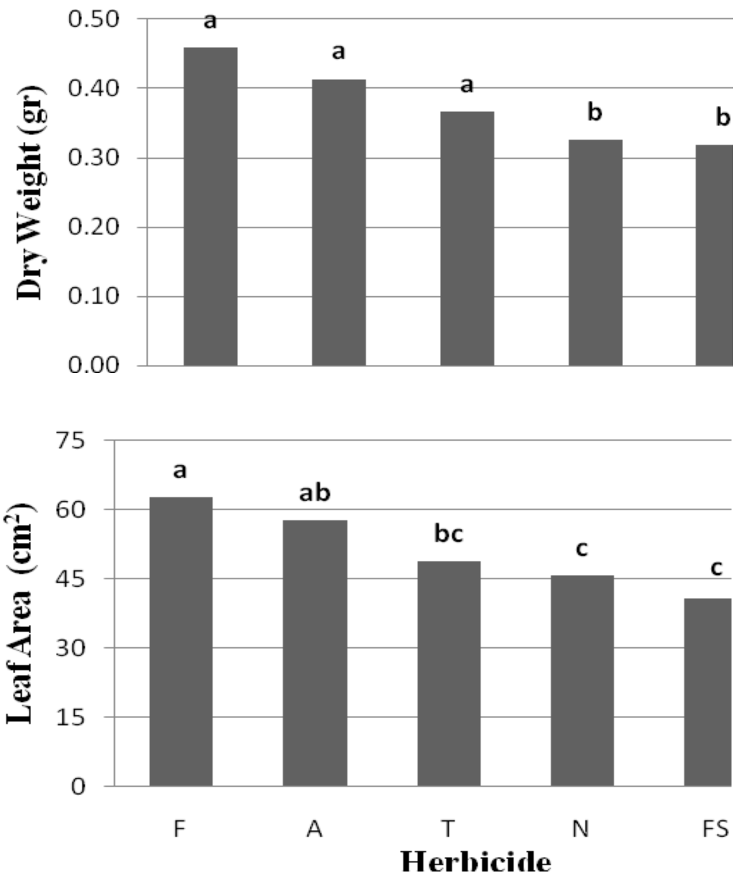


Figure 3. Dry weight and leaf area of canola 30 after application of five different herbicides (A= propaquizafop, T= quizalofop-p-ethyl, N= sethoxydim, F= cycloxydim, FS= fluazifop-p-butyl), each used at the rate of 2/1000 (v/v) with two adjuvant (1=citovit, 2=volk) and at two concentrations (1=1.5 and 2=2 liter/ha). Herbicides with the same letter do not differ significantly at alpha <0.05.

CONCLUSIONS

The results of this study showed that the highest weed control efficacy can be achieved by application of propaquizafop at either of the two concentrations and two types of adjuvants. No significant difference was found in the global efficacy of weed control between two concentrations of the applied herbicides and the type of adjuvants. Minimum concentration of propaquizafop plus either adjuvants is recommended for maximum suppression of noxious weeds and to guarantee minimum risk of side effects.

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