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Chemical Control of volunteer Licorice (*Glycyrrhiza glabra* L.) in rainfed wheat in Iran

Mozhgan Veisi
Assistant Professor, Plant Protection Research Department,
Kermanshah Agricultural and Natural Resources Research and Education Center, AREEO, Kermanshah, IRAN

(Corresponding author: Mozhgan Veisi)
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ABSTRACT: Licorice (*Glycyrrhiza glabra* L.) is a nuisance perennial weed in different crops especially rainfed wheat fields of Iran. Field experiments were conducted in Mahidasht and Sararood Agricultural Research Stations of Kermanshah province during 2007-2009 to study effect of post emergence applications of 2,4-D plus MCPA, Picloram, 2,4-D plus MCPA plus picloram and untreated control at three growth stages of *G. glabra* L.. Results indicated that 2,4-D plus MCPA at podding stage provided the best control of *G. glabra* L. density compared with other treatments in fallow rotation. In order to evaluate the herbicides effectiveness on *G. glabra* L. control in next rotation, wheat was planted over the sprayed plots. *G. glabra* L. dry weight had the lowest rate at blooming stage in the wheat. The application of 2,4-D plus MCPA caused the most reduction in G. glabra L. density and dry weight as well as the highest wheat yield in all treatments.

Key words: *Glycyrrhiza glabra* L.; Chemical control; Application timing

INTRODUCTION

Licorice (*Glycyrrhiza glabra* L.) is a nuisance weed in rainfed and irrigated wheat and chickpea fields in western Iran. G. glabra L. frequency and mean density per meter square are 46.48 and 5.82 respectively in wheat fields of Kermanshah province (Veisi and Minbashi, 2005). Its rooting system consists of a tap-root and stolons which are underground organs of different histological nature, characterized by the presence of a pith cells containing storage substances, mostly starch and calcium oxalate crystals (Marzi *et al.,* 1993a). More than a dozen *Glycyrrhiza* species are spread throughout Asia and the most commonly grown species is *G. glabra* L. (Gladyshev, 1991). It is a deep-rooted perennial weed that evacuates soil moisture. *G. glabra* L. consumes 20000 m3.ha-1 of water annually (Khaidarov, 1977). *G. glabra* L. not only competes with wheat and decreases its yield but also makes difficulties at harvest stage (Montazeri, 1985). *G. glabra* L. root can last, up to 15 years (Gladyshev, 1991). Some plants have been found with a root collar of 12 cm in diameter and a life span of 20-25 years. In 1966 a *G. glabra* L. with a root collar of 32 cm in diameter was also found in flood plain of Amudarya (Gladyshev, 1991). *G. glabra* L. tolerates long lasting water stress through its extensive vertical and horizontal root system. The optimal temperature for its rooting is around 15°C and optimal cutting size for *G. glabra* L. establishment is about 15-20 cm in length and 1.5-2 cm in diameter (Marzi *et al.,* 1993b). It's roots dip in the soil between 2 to 6 meters and tillage operations can not effectively control it (Ozer *et al.,* 1977). Since *G. glabra* L emergence in wheat fields often occurs after usual recommended herbicide application in wheat fields, it can rapidly spreads over the field (Veisi *et al.,* 1999). There is no selective herbicide to control *G. glabra* L. in agricultural crops (Robson *et al.,* 1975). Therefore finding an appropriate herbicide to control this weed is important. Another experiment in Wyoming, showed picloram at pod and bloom stages during fallow rotation controlled *G. glabra* L. 65% and 45% respectively (Whitson and Tatman, 1992) and dicamba and 2,4-D ester amin applied at flowering stage weakened rhizome sprouting in Turkey (Ozer *et al.,* 1977). Application of 2,4-D plus MCPA at the lowest rate increased and at the highest rate decreased the root protein contents of *G. glabra* L. and root solvable sugar was decreased by 2,4-D plus MCPA compared with control (Veisi *et al.,* 1999). Veisi and Rahimian, (2006) reported satisfactory control *G. glabra* L dry weight with soil incorporated eradican and trifloralin (94.5% and 83.7% respectively). Sabeti et al. (2006) stated that tillage decreased *G. glabra* L population and height but herbicide treatments were more effective when *G. glabra* L. plants were previously plowed and sprayed. Spring sweep plough in farm lands increases perennial weeds density, because sweep breaks apical dominance of the youngest and most active growing bud (Robertson *et al.,* 1989). When the apical buds are disrupted by mowing or plowing, this process stimulates growth of dormant buds. Which buds produce shoots and increases the rate of above and below ground biomass (Shieh *et al.,* 1993). Long term *G. glabra* L cultivation reduced soil volumetric weight, porosity and water permeability (Nigmatov and Zhuravleva, 1977).

Planting forage crops (annual and perennial alfalfa) as a competitive plant may gradually decreases *G. glabra* L. population (Ozer *et al.*, 1977). Mastro *et al.* (1993) Stated that wheat competes with *G. glabra* L. because their intercropping reduced *G. glabra* L. root yield, plant height and branch number more than barley, wax barley, grain barley and control (pure *G. glabra* L.). The main objectives of this study were to investigate herbicides efficacy and application timing (*G. glabra* L. growth stages) for a long period of controlling.

MATERIAL AND METHODS

A. Herbicides treatments and application timings

Experiments were conducted in a uniform *G. glabra* L. naturally infested field at Sararood Rainfed Research Station (SRRS) and Mahidasht Research Station (MRS) located in Kermanshah province, western Iran during 2007-2009. Herbicides were applied in fallow rotation on May 15 (6 leaf), June 10 (blooming) and July 1 (podding) in 2002 during fallow year at SRRS and May 16 (6 leaf), June 12 (blooming), July 3 (podding) in 2003 at MRS second field. Herbicides were applied with hand held boom sprayer equipped with flooding nozzle and calibrated to deliver 300 L/ha of spray solution at pressure of 2.5 bar.

In the following November, wheat (Alborz cross cultivar) was planted over the sprayed plots on 16 Nov 2003 in SRRS and on 14 Nov 2004 at MRS. Wheat density was 300 plants per m2. Each Plot consisted of 17 rows, 6 m in length with 0.25 m row spacing. Broadleaf weeds were effectively controlled by tribenuron - methyl (0.15 g a.i./ha) at wheat tillering stage. The plots were subsequently evaluated for *G. glabra* L. regrowth in the wheat field which had been planted after fallow.

B. Experimental measurements and statistical analysis

The experimental design was a factorial complete block design with four replications. The first factor levels included application of 2,4-D plus MCPA at 1.32 + 2.68 kg a.i./ha, picloram at 0.28 kg a.i./ha and combination of 2,4-D plus MCPA plus picloram at 0.99 + 2 + 0.14 kg a.i./ha and nontreated control. The second factor was application timing (based on *G. glabra* L. phenological stages) including 6 leaf (20-25cm height), blooming and podding stages. Density and dry weight of *G. glabra* L. were measured separately 30 days after treatment using 1 m2 quadrates in each plot. *G. glabra* L. was cut at the ground level and oven dried at 75?c for 48 h. The reduction was calculated by dividing *G. glabra* L. density / dry weight in the treated plot by *G. glabra* L. density / dry weight in the untreated plot and multiplying by 100. Through sampling the middle section of each plot (9.6m2), wheat grain yield was measured too. All data were subjected to analysis of variance using SPSS statistical software and means were separated using Duncan, s Multiple Range test (DMRT) set as 0.05. Data at each location were analyzed separately with combined analysis of data was performed in fallow rotation for 2002 and 2003 data, and wheat rotation for 2008 and 2004 data at SRRS and MRS sites respectively.

RESULTS AND DISCUSSION

A. Effects of treatments G. glabra L. control in fallow rotation in Sararood (site1) and Mahidasht (site2) .

At Sararood (site 1) 2,4-D plus MCPA controlled *G. glabra* L. population at least 97.5% at podding stage (Table 1), while the highest weed survival occurred where picloram was applied at 6 leaf stage (32.4%). The application of 2,4-D plus MCPA plus picloram reduced *G. glabra* L. density by 73.1%. *G. glabra* L. density reduction at podding stage was highest and ranged from 47.8% to 97.5% (Table 1), while blooming and 6 leaf treatments resulted in less reductions than podding stage. Generally, 2,4-D plus MCPA at all growth stages provided the highest *G. glabra* L. control (>86%), and the least control was observed in picloram application (<48%) (Table 1).This results are consistent with finding of Ozer *et al.* (1977) who reported that 2,4-D ester had an adequate control of *G. glabra* L. population and Menalled (2006) who found, that fall application of 2,4-D ester provided a good control of perennial Sonchus arvensis L. (Sowthistle), when applied at the rosette or bud stage.

Table 1: Effects of herbicide treatments at different phenological stages on percent *G. glabra* L. reduction during fallow at Sararood (2007) and Mahidasht (2008).

Herbicide Treatment	Rate (kg a.i./ha)	*G. glabra* L. density reduction(%)		
		6 leaf	Blooming	Podding
Sararood (2007)				
2.4-D+ MCPA	1.32+2.68	86.4b*	94.8a	97.5a
2.4-D+ MCPA+picloram	0.99+2+0.14	32.4g	50.96e	73.1c
Picloram	0.28	32.4g	40.3f	47.8d
Untreated control	--	--	--	--
Mahidasht (2008)				
2.4-D+ MCPA	1.32+2.68	95.5a	98.4a	98.3a
2.4-D+MCPA+picloram	0.99+2+0.14	29.5e	49.9d	80.2b
Picloram	0.28	29.5e	56.2c	55.5c
Untreated control	--	--	--	--

*Means within each column followed by the same letter , are not significantly different at 0.05 probability level according to DMRT test.

At Mahidasht (site 2), while 2,4-D plus MCPA plus picloram and picloram alone resulted in density reductions by 81% and 57% respectively, 2,4-D plus MCPA provided the highest reduction in *G. glabra* L. density (>95%) (Table 1). No significant differences existed among three growth stages with application of 2,4-D plus MCPA (Table 1).

Generally, higher control of *G. glabra* L. was obtained by herbicide application at podding stage compared to 6 leaf stage (Table 1).*G. glabra* L. control was higher at blooming compared to other application timing in picloram treatment (56.2%) (Table 1). However application of 2,4-D plus MCPA plus picloram caused significant difference among three application timing (Table 1). This result approves observations of Smith et al. (1973) and Lauifenberg et al. (2005), who found that herbicide efficiency in controlling perennial weeds differ according to their growth stages. 2,4-D plus MCPA applied at podding stage, provided better control of *G. glabra* L. (98.3%) compared to picloram application at the same stage (55.5%) (Table 1).

Results of experiments at two sites (Sararood and Mahidasht) and their combined analysis showed that all treatments significantly reduced *G. glabra* L. density compared to untreated control (Table 2). Mean camparison with Duncans multiple range test (0.05) showed significant differences among application timings. Highest *G. glabra* L. control was obtained, when it was treated at podding stage (74.81%). Herbicide effects indicated that 2,4-D plus MCPA resulted in the lowest *G. glabra* L. population compared with other treatments, While the poorest control was achieved where *G. glabra* L. was treated by picloram (43.9%). How ever Ahari mostafavi *et al.* (2002) found that the best application timing of 2,4-D for being translocated to the root system of the plant is at 6 leaf stage treated *G. glabra* L. by labeled herbicides 14C through the adaxial. Also other experiments suggest that clopyralid plus 2,4-D is most effective for controlling *Acroptilon repens* (L.) DC. (Russian knapweed) when applied after full bloom until the first killing frost (Bussan and Dyer, 1999). Herbicides applied at bloom stage were less effective (65.5%) than podding stage (74.8%). These results are consistent with findings of Whitson and Tatman, (1990) who reported that all herbicide treatments such as 2,4-D, picloram and clopyralid provided better control of *G. glabra* L at podding (August) comparing to bloom stage (July).

B. Effects of treatments on G. glabra L. control in wheat, one year after treatment in Sararood (site1) and Mahidasht (site2)

Results of experiments at Sararood and Mahidasht showed that all treatments significantly reduced *G. glabra* L. density compared to untreated control in subsequent wheat crop (one year after treatments) (Table 2).

At Sararood 2,4-D plus MCPA provided the highest density control ranged from 67.8% to 71.2% (Table 2). No significant differences was observed in *G. glabra* L. stand reduction among treatments at three growth stages (Table 2). However, there was a tendency for an increase in weed density at 6 leaf and blooming stages compared to podding (Table 2). However, considering *G. glabra* L. dry weight, better control was achieved at blooming stage in all herbicide treatments, while podding and 6 leaf stage were not significantly different (except for picloram) (Table 2). Lauifenberg et al. (2003) and Whitson *et al*. (1991) in similar researches, found that applying clopyralid plus 2,4-D to Acroptilon repens (L) DC. control at bud-bloom in May provided the lowest biomass and density , one year after treatment. The overall results indicate that 2,4-D plus MCPA provided effective control of *G. glabra* L. . Carpenter et al. (2005) reported that timing of application to the late bud is critical with most herbicides to achieve good control of *A. repens* (L.) DC.

Table 2: Effects of treatments on percent *G. glabra* L. density and dry weight one year after applications in wheat rotation at Sararood (2008) and Mahidasht (2009).

Herbicide Treatment	Rate (kg a.i./ha)	*G. glabra* L. Density reduction(%)			*G. glabra* L. Dry Weight reduction(%)		
		6 leaf	Blooming	Podding	6 leaf	Blooming	Podding
Sararood (2008)							
2.4-D+ MCPA	1.32+2.68	70.7a	67.8a	71.2a	60b	70.9a	61.7b
2.4-D+ MCPA+picloram	0.99+2+0.14	38b	42.8b	40.5b	49.4f	70.5a	49.33dc
Picloram	0.28	23c	27.6c	22.5c	31.3e	46.4d	38.8e
Control (untreated)	--	--	--	--	--	--	--
Mahidasht (2009)							
2.4-D+ MCPA	1.32+2.68	86a	79.3a	84.4a	76.96b	90.9a	76.1f
2.4-D+MCPA+picloram	0.99+2+0.14	52.7b	45.6b	47.7b	63.96c	64.53a	65dc
Picloram	0.28	25.8c	27.2c	23.3c	39.7f	60.8d	51.3e
Control (untreated)	--	--	--	--	--	--	--

*Means within each column followed by the same letter , are not significantly different at 0.05 probability level according to DMRT test.

At Mahidasht better control of G .glabra L. density was provided by 2,4-D plus MCPA and ranged from 84% to 86% at three growth stages (Table 2). *G. glabra* L. dry weight was reduced between 76% to 91%, when sprayed by 2,4-D plus MCPA (Table 4). Herbicides application at blooming stage decreased dry weight of this weed between 61% and 91%, while other application timings controls were less effective (Table 2). No significant differences were observed among three growth stages in *G. glabra* L. density reduction (Table 2). Combined analysis of two experiments at two sites showed that all treatments significantly reduced *G. glabra* L. density and dry weight (Table 3).

Table 3: Effects of treatments on percent *G. glabra* L. density and dry weight one year after applications in wheat rotation averaged over two sites during 2008-2009.

Herbicide Treatment	Rate (kg a.i./ha)	*G. glabra* L. Density reduction(%)			*G. glabra* L. Dry weight reduction(%)		
		6 leaf	Blooming	Podding	6 leaf	Blooming	Podding
2.4-D+ MCPA	1.32+2.68	77.6a*	73.5a	77a	67.3c	79.7a	67.8c
2.4-D+ MCPA+picloram	0.99+2+0.14	44.6b	44.1b	43.8b	55.4e	75.2b	55.4e
Picloram	0.28	24.2c	27.4c	22.9c	59.9d	53.2f	44.17g
Control (untreated)	--	--	--	--	--	--	--

*Means within each column followed by the same letter , are not significantly different at 0.05 probability level according to DMRT test.

While picloram application resulted in the least reduction in *G .glabra* L. dry weight, 2,4-D plus MCPA provided the highest reduction in *G. glabra* L. dry weight (71.68%). However Sabeti *et al.* (2006) found that triclopyr controlled *G. glabra* L. (85%) in comparison with 2,4-D plus MCPA (67%) and combination of 2,4-D plus MCPA plus triclopyr (65%). *G. glabra* L. density was reduced 76.12%, 44.2% and 26.3% when sprayed by 2,4-D plus MCPA, 2,4-D plus MCPA plus picloram and picloram alone, respectively. Although picloram reduced *G. glabra* L. dry weight at 6leaf stage (59.9%) better than other application timings, 2,4-D plus MCPA , 2,4-D plus MCPA plus picloram at blooming stage controlled *G. glabra* L. by 79.7% and 75.2%, respectively (Table 3). All of these herbicide treatments reduced *G. glabra* L. dry weight at blooming 69.3%, while treating at podding and 6 leaf stage resulted in reductions 55.7% and 60.8% respectively, compared with untreated control. No significant differences existed among application timings of herbicides on *G. glabra* L. density, While the lower *G. glabra* L. dry weight achieved significantly at blooming. The higher reduction in *G. glabra* L. dry weight at blooming stage compared with other application timings indicates that all treatments had caused negative impact on *G. glabra* L. growth and as a result dry weight production, although they were less effective in terms of weed density. Results showed that 6 leaf and podding stages of herbicides applications appear to provide effective short - term *G. glabra* L. suppression.

Our results confirm Anderson et al. (1998) reports on *Lolium* spp. (Sod) control that herbicides if applied at early vegetative growth, when roots are supplying carbohydrates to leaves , the shoots will die, but root buds dormancy will subsequently break and establish new plants. Results show that 2,4-D plus MCPA when applied at blooming stage, provided better control of *G. glabra* L. comparing to other treatments.

C. Effects of herbicide treatments on grain yield of subsequent wheat crop at site1 (Sararood) and site2 (Mahidasht) (One year after treatment).

Significant differences existed among herbicide treatments at two sites, However no major differences existed among three application timings (Table 4).

Table 4: Percent wheat grain yield increase obtained under different treatments in subsequent wheat crop at Sararood (2008) and Mahidasht (2009).

Herbicide Treatment	Rate (kg a.i./ha)	wheat Grain yield increase(%)		
		6 leaf	Blooming	Podding
Sararood (2008)				
2.4-D+ MCPA	1.32+2.68	17.6a*	21a	21.4a
2.4-D+ MCPA+picloram	0.99+2+0.14	10.53b	10.6b	10.97b
Picloram	0.28	11.37b	10.5b	11.1b
Control (untreated)	--	--	--	--
Mahidasht (2009)				
2.4-D+ MCPA	1.32+2.68	23.2a	27.03a	76.5a
2.4-D+MCPA+picloram	0.99+2+0.14	11.3b	13.2b	13.13b
Picloram	0.28	10.9b	12.9b	13.3b
Control (untreated)	--	--	--	--

*Means within each column followed by the same letter , are not significantly different at 0.05 probability level according to DMRT test.

In the herbicide treatments at Sararood, yield was highest, when 2,4-D plus MCPA was applied (ranged from 1451 to 1461 kg/ha), while the lowest yield was achieved when *G. glabra* L. treated by picloram (ranged from 1330 to 1337 kg/ha) (Table 4). These results indicate that 2,4-D plus MCPA brought about satisfactory season long control of *G. glabra* L. compared to other treatments. Similarly at Mahidasht, 2,4-D plus MCPA resulted in greater wheat yield than other treatments (ranged from 1256 to 1277 kg/ha) (Table 4). Dadri and Mani (2005) stated that the general positive effects of herbicides in suppressing weeds might be responsible for the promotion of crop growth grain yield of wheat.

Altogether results from these experiments reveals that herbicides especially 2,4-D plus MCPA obtained satisfactory long term control of *G. glabra* L..

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