Broomrape Control in Sunflower with Glyphosate

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ABSTRACT

Sunflower (*Helinathus annuus*) is a susceptible host to the holoparasite hemp broomrape (*Orobanche ramosa*) in central parts of Iran, causing yield loss due to severe infestations. A field study was conducted in 2006 to evaluate the efficacy of glyphosate for controlling the parasitic weed hemp broomrape in sunflower. Glyphosate was applied once or twice at five rates ranging from 0.075 to 0.450 kg ae ha^{-1}. Most efficient control was obtained from once or twice application of gyphosae at 0.225 and 0.350 kg ae ha^{-1} at both application times. There were a significant reduction in hemp broomrape dry weight at 0.225 and 0.350 kg ae ha^{-1} (75 and 87.5 %), respectively compared to control. Glyphosate at 0.075 kg ae ha^{-1} was not sufficient enough to provide acceptable control, but duplicating the application of this rate provided good control of weed. Nearly no hemp broomrape shoot and dry weight were measured when glyphosate was applied twice at 0.450 kg ae ha^{-1}. However, sunflower grain yield loss (63%) resulting from glyphosate toxicity at 0.450 kg ae ha^{-1} was observed when applied twice, compared to its application at 0.225 kg ae ha^{-}

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Results showed that hemp broomrape was unable to survive after the twice application of glyphosate at 0.225 or 0.350 kg ae ha^{-1}.

Key words: herbicide, parasitic plants, host.

چکیده

گل آفتابگردان میزبان حساسی برای علف هرز انگلی گل جالیز در ایران می‌باشد که خسارت معنی‌داری به این گیاه به دلیل آلودگی بالا ایجاد می‌کند. بر همین اساس آزمایشی مزرعه ای برای ارزیابی تاثیر علف کش گلیفوسیت در کنترل علف هرز انگلی گل جالیز در مزارع آفتابگردان قزوین در سال ۱۳۸۵ انجام گرفت. در این تحقیق علف‌کش گلیفوسیت مقادیر در ۰/۰۷۵، ۰/۱۵۰، ۰/۲۲۵، ۰/۳۵۰ و ۰/۴۵۰ کیلوگرم معادل اسید در هکتار) و دو زمان مختلف بکار برده شد. نتایج نشان داد که مطلوب-ترین میزان کنترل گل جالیز در غلظت‌های ۰/۲۲۵ و ۰/۳۵۰ کیلوگرم در هکتار گلیفوسیت و در هر دو زمان مصرف بدست آمد. مقدار ماده خشک اندام‌های هوایی گل جالیز دو مقدار مصرف یاد شده در مقایسه با شاهد بطور معنی‌داری و به ترتیب ۷۵ و ۸۷/۵ درصد کاهش یافت. گلیفوسیت به مقدار ۰/۰۷۵ کیلوگرم در هکتار بعد از یک مرحله کاربرد، قادر به کنترل مطلوب گل جالیز نبود، اگر چه نتیجه کنترل بعد از دو مرحله کاربرد در این مقدار، مطلوب ارزیابی گردید. تقریبا هیچ اندام هوایی از گل جالیز در مقدار ۰/۴۵۰ کیلوگرم ماده موثر در هکتار بعد از دو مرحله کاربرد مشاهده نگردید، اگر چه در این غلظت بدلیل تنش، عملکرد دانه آفتابگردان نسبت به تیمار ۰/۲۲۵ کیلوگرم در هکتار ۶۳ درصد کاهش یافت. پس از دو مرحله کاربرد گلیفوسیت در همه غلظت‌های مورد آزمایش گل جالیز رشد مجدد نکرد.

واژه های کلیدی: علف کش، گیاهان انگلی، میزبان .

INTRODUCTION

In Iran, broomrape (*Orobanche ramosa* L. and/or *O. aegyptiaca* Pers.) is a parasite for several crops (Schmitt *et al*., 1979; Parker, 1986; Minbashi, and Mazaheri, 2002). The main host crop for this parasitic weed species are sunflower (*Helinathus annuus* L.) cabbage (*Brassica oleracea* L.), celery (*Apium graveolens* L.), tomato (*Lycopersicon* *esculentum* Mill.), eggplant (*Solanum melongena* L.), melon (*Cucumis melo* L.), and watermelon (*Citrullus lanatus* Thunb.),

Broomrape is an achlorophyllous, phanerogamic holoparasite that attacks roots of many dicotyledonous crops. It obtains carbon, nutrients, and water through haustoria which connect the parasite to the host vascular system. Broomrape infestations cause extensive reduction in crop yield, adversely affect crop quality, and result in loss of cropping alternatives in infested fields (Al-Menoufi, 1994; Gressel, 1992; Gressel *et al*., 1996).

Management of broomrapes is often difficult because of the high amount of seed production, viability of seeds in the soil over years (Cubero and Moreno, 1979; Puzzilli, 1983; Linke and Saxena, 1991), lack of seed germination in the absence of a chemical trigger from a suitable host, vigorous growth habit after emergence, and close association with the host crop. Despite many management strategies applied against broomrape, few methods have been reliable and economical, especially for use in high-value crops (Foy *et al*. 1989; Parker and Riches, 1993; Jain and Foy, 1997).

Glyphosate [N-(phosphonomethyl) glycine] as a systemic, nonselective, and foliar applied herbicide, is readily translocated to underground parts, immature leaves, and meristems of the treated plants. It has been reported to be very stable in plants (Gottrup *et al*., 1976; Coupland, 1984; Devine and Bandeen, 1983). The site of action of glyphosate is inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase that leads to the production of the aromatic amino acids, phenylalanine, tyrosine, and tryptophan. Since the discovery of its herbicidal properties in 1971 and commercial introduction in 1974, glyphosate has been used extensively in both cultivated and non-crop lands (Baird *et al*., 1971). Despite its non-selectivity, degrees of selectivity in some certain crops which are broomrape hosts, has been reported (Foy *et al*., 1989; Parker and Riches, 1993). Many studies have shown that herbicides are effective for the control of *Orbanche spp*. (Colquhoum *et al*., 2006). They found that imazamox effectively controls small broomrape (*Orobanche minor* Sm.) when applied post to red clover (*Trifolium pretense*). A single application of 200 g/ha glyphosate gave complete control of *Orobanche* with no crop damage in medic (Matthews, 2002).

The objective of this research was to determine the use of glyphosate for controlling hemp broomrape and its selectivity on sunflower plants at low rates of application in field condition.

MATERIALS AND METHODS

In 2006, a field experiment was carried out in a suburb of Khozmin in Ghazvin Province, Iran. A clay loam soil type containing 3.6 to 5.8% organic matter with a pH of 6.9 and was naturally infested with broomrape. The plot size was 15 m^2 consisting of five rows of 0.75 m apart and 4 m long. According to the local fertilizer recommendations, diammonium phosphate (18% N, 20% P) at 80 kg ha^{-1} and urea (46% N) at 60 kg ha^{-1} were applied at planting stage and when the sunflower plants were 40 cm high. The experiment was designed as a randomized complete block design with 4 replications.

Treatments consisted of single and twice applications of glyphosate at 0, 0.075, 0.150, 0.225, 0.350 or 0.450 kg ae $ha^{-1.}$ The single application of the herbicide was carried out 5 weeks after planting of sunflower seeds on June 22, 2006. The second use of the herbicide for the twice application treatment, was sprayed on July 15, 2006 at the mentioned rates in appropriates plots. The herbicide for all treatments was applied using a 15-L knapsack sprayer equipped with a flat fan nozzle.

Sunflower plants were dug up periodically to check the parasitic attachment of broomrape. Sunflower shoot and root dry weight, broomrape dry weight, and number of live attachments were determined two weeks after the first and the second applications of glyphosate. The crop was harvested from three central rows of each plots and grain yield determined.

Data were subjected to analysis of variance followed by separation of means by least significant differences (LSD) tests, at the p=0.05 level, using SAS statistical software (SAS 1989).

RESULTS AND DISCUSSION

Initial attachments of hemp broomrape on the host roots were found 25 days after planting. Selective control of broomrape by glyphosate in some host crops is due to rapid translocation of herbicide away from the crop foliage to the parasitic attachments on the host roots (Foy *et al*., 1989). Any herbicide that can translocate, without being metabolized, through a host plant into broomrape attached to the host roots may have the potential to control broomrape. This aspect was first demonstrated by Saghir *et al*., (1973), Mesa-Garcia *et al*., (1984), Jacobsohn and Levy (1986) and Jain (1987) when glyphosate was applied to the host plant; it was accumulated in broomrape several times more than the crop.

Sunflower plant has been found to be tolerant to low rates of glyphosate. Application of this herbicide at 0.225, 0.350 or 0.450 kg ae ha^{-1}, significantly reduced the growth of hemp broomrape compared to the controls (Table 1). In this experiment, glyphosate at 0.225, 0.350 and 0.450 kg ae ha^{-1} caused a significant increase in sunflower grain yield, compared to control, after single and twice applications. The average sunflower grain yield ranged from 1656 to 1730 kg ha^{-1} for single application of 0.350 and 0.450 kg ae ha^{-1} of glyphosate, respectively, and 605 kg ha^{-1} for the control (Table 1).

Furthermore, the results indicated a no significant effect of glyphosate on shoot and root growth of sunflower plants. Comparison of means of individual treatment revealed that glyphosate reduced hemp broomrape dry weight and live attachments in all applications (Table 1).

Glyphosate effectively controls hemp broomrapes at a single and twice application of 0.350 and 0.450 kg ae ha^{-1}. However, despite this reduction in the hemp broomrape infection, sunflower yield did no increase significantly by twice application of 0.150 and 0.225 kg ae ha^{-1} to 0.350 and 0.450 ae ha^{-1}. Twice application of glyphosate at 0.350 or 0.450 kg ae ha^{-1}, was also highly effective against hemp broomrape, but reduced yield of sunflower. This could be explained by an early damage to sunflower seedlings. Glyphosate had no effect on hemp broomrape at 0.075 kg ae ha^{-1}, whereas at the 0.450 ae kg ha^{-1}, sunflower plants were highly suppressed after twice application. The number of live attachments of hemp broomrape was greatly reduced with glyphosate at 0.360 and 0.450 kg ae ha^{-1} (Table 1). Twice application of glyphosate at 0.150 and 0.225 kg ae ha^{-1} showed more reliable control of hemp broomrape than single application of 0.350 and 0.450 kg ae ha^{-1}, However, further research is required to find the optimum rate.

Glyphosate has been applied for selective control of *Orobanche* in several crops. As early as 1973, selective control of *O. crenata* in broad bean was obtained with glyphosate at 0.2 to 0.3 kg ae ha^{-1} applied 6 weeks after sowing (Kasasian, 1973). The results have not been very encouraging in pea (*Pisum sativum* L.) (Jacobsohn and Kelman, 1980), lentil (*Lens culinaris* Medic.) (Kelili *et al*., 1983; Arjona-Berral *et al*., 1988, 1990) and broad bean (*Vicia faba* L.) (Sauerborn *et al*., 1989; Kharrat and Halila, 1996). However, results from some studies (Amsellem *et al*., (1994) and Perez-De-Luque *et al*., 2005) indicate that glyphosate is the best translocated herbicide for broomrape control in many susceptible hosts at the tubercle and bud stage of the parasite.

For estimating the efficacy of glyphosate or other herbicides in controlling broomrape, determination of the number of live plant parasite may be a better measure than their fresh weight. Similar relationships have been reported for oilseed rape (Nandula *et al*., 1999).

Zemrag (1994) and Zermane *et al*., (2001) reported complete prevention of broomrape in different variety of oilseed rape after application of glyphosate at 0.720 kg ae ha^{-1}. They separately reported that number of live broomrape was significantly reduced at increased rates of glyphosate with no broomrape surviving at 0.750 kg ae ha^{-1}.

Finally, glyphosate has provided good control of hemp broomrape in sunflower field in central parts of Iran. Results from this study indicate that tolerance to glyphosate in sunflower is contributed, at least in part, by metabolism of the herbicide more than the hemp broomrape.

Table 1. Sunflower and *O. ramosa* response to post emergence applications of glyphosate under field conditions in Ghazvin Province, Iran, 2006.

Glyphosate (kg ae ha^{-1})	Sunflower root dry weight (g)		Sunflower shoot dry weight (g)		Live broomrape per plant		Broomrape dry weight (g/plant)		Sunflower grain yield (kg/ha)	
	1st application	2nd application	1st application	2nd application	1st application	2nd application	1st application	2nd application	1st application	2nd application
Control (0)	46a*	46a	90a	90a	5a	5a	6a	6a	450a	450a
0.075	31b	27b	84ab	77b	4.75a	3.25b	4.25b	3.5b	615a	750b
0.150	30b	23b	77b	70b	3.5b	2.5c	3.50b	2.75b	900b	1683d
0.225	29b	20bc	65c	55c	2c	1d	2c	1.5c	1100b	1755d
0.350	28b	14d	59cd	46cd	1d	0.5de	1.25dc	0.75dc	1656c	1200c
0.450	27b	9d	47d	33e	0.5d	0e	0.5d	0e	1730c	650b

*In each column, means followed by the same letter are not significantly different at 0.01

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REFERENCES

Al-Menoufi, O. A. 1994. The Orobanche problem and management in Egypt. In: Pieterse,

A.H., et al. (Ed.), Biology and Management of Orobanche. Royal Tropical Institute, Amsterdam, pp. 663–671.

Amsellem, Z., Barghouthi, S., Cohen, B., Goldwasser, Y., Gressel, J., Hornok, L., Kerenyi, Z., Kleifeld, Y., Klein, O., Kroschel, J., Sauerborn, J., Muller-Stover, D., Garcia-Torres, L., Lopez-Grandados, F. and Castejon-Munoz, M. 1994. Pre-emergence herbicides for the control of broomrape (Orobanche cernua Loefl.) in sunflower (Helianthus annuus L.). *Weed Research* **34**: 395–402.

Arjona-Berral, A., Mesa-García, J. and García-Torres L. 1988. Herbicide control of broomrapes in peas and lentils. FAO Plant Prot. Bull **36:**175-78.

Arjona-Berral, A., Mesa-García, J. and García-Torres L. 1990. Distribution of 14C-glyphosate in legumes parasitised by Orobanche crenata. *Weed Research* 30: 53-59.

Baird, D. D., Upchurch, W. B., Homesley, W. B. and Franz, J. E. 1971. Introduction of a new broad spectrum postemergence herbicide class with utility for herbaceous perennial weed control. Proc. North Cent. *Weed Control Conf*. **26**:64-68.

Cubero, J. I., and Moreno, M. T. 1979. Agronomic control and sources of resistance in Vicia faba and Orobanche sp. In D. A. Bond, G. T. Scarascia-Mugnozza, and M. H. Poulsen, eds. Some current research on Vicia faba in Western Europe. Commission of the European Communities, pp. 41-80.

Coupland, D. 1984. The effect of temperature on activity and metabolism of glyphosate applied to rhizome fragments of Elymus repens (= Agropyron repens). *Pesticide Science* **15**: 226-34.

Colquhoum, J. B., Eizenberg, H. and Mallory, C. A. 2006. Herbicide placement site affects small broomrape (Orbanche minor) control in red clover (Trifolium pretense). *Weed Science* **20**: 356-360.

Devine, M. D. and Bandeen, J. D. 1983. Fate of glyphosate in Agropyron repens (L.) Beauv. growing under low temperature conditions. *Weed Research* **23**: 69-75.

Foy, C. L., Jain, R. and Jacobsohn, R. 1989. Recent approaches for chemical control of broomrape (Orobanche spp.). Rev. *Weed Science* **4**:123-52.

Gottrup, O., O'Sullivan, P. A., Schraa, R. J. and Vanden Born, W. H. 1976. Uptake, translocation, metabolism and selectivity of glyphosate in Canada thistle and leafy spurge. *Weed Research* **16**:197-201.

Gressel, J. 1992. The needs for new herbicide-resistant crops. In: Denholm, I., et al. (Ed.), Achievements and Developments in Combating Pesticide Resistance. Elsevier, London, pp. 283–294.

Gressel, J., Segel, L. E. and Ransom, J. K. 1996. Managing the delay of evolution of herbicide resistance in parasitic weeds. Int. J. Pest Manage. **42**: 113–129.

Jacobsohn, R., and Kelman, Y. 1980. Effectiveness of glyphosate in broomrape (Orobanche spp.) control in four crops. *Weed Science* **28**: 692–699.

Jacobsohn, R., and Levy, D. 1986. Glyphosate for Orobanche control in various crops: problems and promises. In: ter Borg, S.J. (Ed.), Proceedings of the Workshop on Biology and Control of Orobanche. Wageningen, The Netherlands, pp. 172–175.

Jain, R. 1987. Physiological aspects of broomrape (Orobanche spp.) parasitism, host specificity, and selective control by glyphosate. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, USA. 131 p.

Jain, R. and Foy. C. L. 1997. Translocation and metabolism of glyphosate in Egyptian broomrape (Orobanche aegyptiaca) infested sunflower (Lycopersicon esculentum) plants. PGRSA Quart 25: 1-7.

Kasasian, L. 1973. Control of Orobanche. PANS 19: 368-71.

Kelili, D., Zemgarh, M. and Marliere, A. M. 1983. Broomrape control in Morocco: assessment and future prospects (in French). Compte Rendu de la 12e Conference de COLUMA 195-202.

Kharrat, M. and Halila, M. H. 1996. Control of Orobanche foetida on Vicia faba: comparison between different control measures. In: Moreno, M.T., et al. (Ed.), Advances in Parasitic Plant Research. Junta de Andalucia, Cordoba, Spain, pp. 734–738.

Linke, K. H. and Saxena, M. C. 1991. Study on viability and longevity of Orobanche seed under laboratory conditions. In K. Wegmann and L. J. Musselman, eds. Proc. International Workshop in Orobanche Research. Tübingen, Germany: Eberhard-Karls-Universität, pp. 110-114.

Matthews, J. M. 2002. Herbicide and cropping trials relevant to the eradication of branched broomrape (Orobanche ramosa) in South Australia. Proc. 13th Australian Weeds Conference Perth. 274-275.

Minbashi Moeini, M. and Mazaheri, A. 2002. Investigation on Integrated control (Mechanical and Biological) of broomrape (Orbanche aegyptiaca) in tomato fields.

15th Iranian Plant Protection Congress, September, Razi University of Kermanshah, p. 127.

Mesa-García, J., Haro, A. and García-Torres, L. 1984. Phytotoxicity and yield response of broadbean (Vicia faba L.) to glyphosate. *Weed Science* **32**: 445-50.

Nandula, V. K., Foy, C. L. and Orcutt, D. M. 1999. Glyphosate for Orobanche aegyptiaca control in Vicia sativa and Brassica napus. *Weed Science* **47**: 486-491.

Parker, C. and Riches, C. R. 1993. Parasitic Weeds of the World: Biology and Control. Wallingford, UK:CAB International. 332 p.

Parker, C., 1986. Scope of the problems caused by Orobanche species. In: Ter Borg, S.J. (Ed.), Biology and control of Orobanche. LH/VPO, Wageningen, pp. 11–17.

Press, M. C. and Graves, J. D. 1995. In: Parasitic Plants. Chapman & Hall, London, pp. 1–292.

Perez-DE-Luque, A. D., Rubiales, D., Cubero, J., Press, M., Scholes, J., Youneyama, K., Takeuchi, Y., Plakhine, D. and Joel, D. 2005. Interaction between Orobanche crenata and its Host Legumes: Unsuccessful Haustorial Penetration and Necrosis of the Developing Parasite. Annals of Botany **95**(6): 935-942.

Puzzilli, M. 1983. Tobacco broomrapes and their control and some useful references to other parasite and host species. Rev. Agric. Sub-tropical Tropicale **78**: 209-248.

[SAS] Statistical Analysis Systems. 1989. The SAS System for Windows. Version 6.12. Cary, NC: Statistical Analysis Systems Institute.

Saghir, A. R., Foy, C. L., Hameed, K. M., Drake, C. R. and Tolin, S. A. 1973. Studies on the biology and control of Orobanche ramosa L. Proc. Eur. Weed Res. Counc. Symp. Parasitic Weeds. Malta, pp. 106-116.

Sauerborn, J. 1991. Parasitic Flowering Plants: Ecology and Management. Weikersheim, Germany: Verlag Josef Margraf. 129 p.

Schmitt, U., Schluter, K. and Boorsma, P. A. 1979. Chemical control of Orobanche crenata in broadbean. FAO Plant Prot. Bull 27:89-91.

Sauerborn, J., Saxena, M. C. and Meyer, A. 1989. Broomrape control in faba bean (Vicia faba L.) with glyphosate and imazaquin. *Weed Research* **29**: 97–102.

Zemrag, A. 1994. Orobanche problem and management in Morocco. In: Pieterse, A.H., et al. (Ed.), Biology and Management of Orobanche. Royal Tropical Inst, Amsterdam, pp. 635–638.

Zermane, N., Kroschel, J., Souissi, T. and Kharra, M. 2001. Investigations on the Orobanche problem in Tunisia. In: Fer, A., et al. (Ed.), Proceedings of the Seventh International Parasitic Weed Symposium. Nantes, France, pp. 46.