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CONVENTIONAL AND INNOVATIVE APPROACHES FOR THE MANAGEMENT OF GENUS *Euphorbia* WEEDS: AN INSIGHT

Asif Tanveer[1]***,** Abdul Khaliq and Ahsan Aziz[2]

ABSTRACT

Euphorbia esula L. (leafy spurge), E. geniculata Forssk. (painted spurge), E. heliescopia L. (sunspurge), E. hirta L. (pill bearing spurge), E. heterophylla L. (wild poinsettia) and E. microphylla B. Heyne ex Roth (Box-leaved Barberry) are the most damaging Euphorbia weed species found in pastures, rangelands, grasslands and field crops in Pakistan. Herbicides like picloram, dicamba, 2, 4-D, glyphosate, quinclorac, sulfometuron, clopyralid, diflufenzopyr are effective in controlling Euphorbia species in pastures, grasslands and rangelands. Oxadiazon, chlorimuron, pendimethalin, 2, 4-D, sulfosulfuron, metribuzin, metsulfuron-methyl, fluroxypyr, fluchloralin, trifluralin, bispyribac-sodium, penoxsulam, glyphosate, chloransulam-methyl, chlorimuron-ethyl, imazethapyr, fomesafen, lactofen, flumiclorac-pentyl, bentazone, carfentrazone-ethyl, imazipic, amicarbazone, sulfentrazone, mesotrione, ametryn, atrazine, diuron, trifloxysulfuron-sodium, oxyflurofen and prometryn gave an efficient control of Euphorbia species in soybean (Glycine max (L.) Metrill, Chilli (Capsicum annum L.), wheat (Triticum aestivum L.), mustard (Brassica juncea L.), citrus, rice (Oryza sativa L.), sugarcane (Saccharum officinarum L.) and cotton (Gossypium hirsutum L.). Addition of N and adjuvant to herbicides has potential for improved control of Euphorbia species. Innovative herbicide application methods like roller applicator, nontrope pipewick applicator, ropewick applicator and microfoil nozzle boom could reduce herbicide input by 50% without compromising level of control. Antennaria microphylla has been reported to be allelopathic to Euphorbia spp. Grass competition (crested wheatgrass, pubescent wheatgrass, reliant intermediate wheatgrass, Russian wild rye and rebound smooth brome) have been recognized as an effective way to control Euphorbia spp.

Key words: Euphorbia species, herbicides, cultural and biological control, field crops, innovative herbicide application methods.

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[1]Dept. of Agronomy, University of Agriculture, Faisalabad, Pakistan
[2]University College of Agriculture, University of Sargodha, Pakistan
*Corresponding Author: drasiftanveeruaf@hotmail.com

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INTRODUCTION

Mechanical, cultural, biological and chemical weed control methods are commonly employed to combat weed menace, nevertheless, any single method at a time seldom provides adequate weed control under field conditions. Herbicides are the most widely used tool to control weeds. This paper provides information about management of various *Euphorbia* species in pastures, rangelands and field crops through the chemical and biological means.

Leafy spurge (*Euphorbia esula*) is a most widely studied pernicious perennial *Euphorbia* weed that is competitive in croplands, pastures, rangelands, woodlands, roadsides, farmsteads and house lots (Messersmith, 1983; Messersmith and Lym, 1983). It spreads rapidly by seeds and rhizomes. Chemical control of leafy spurge with herbicides, refinements in herbicides application techniques (Rees *et al.,* 1986); biological control with insects (Harris *et al.,* 1985; Rees *et al*., 1986); fungi (Bruckart and Dowler, 1986; Harris *et al*., 1985); sheep (Landgraf *et al.,* 1984); allelopathic plants (Manners and Galitz, 1985) and cultural practices (Derscheid *et al.,* 1986) has been reported. Several herbicides have been reported to control leafy spurge (Table-1). *Euphorbia geniculata* (painted spurge) is an important weed of soybean crop (Jain and Tiwari, 1993) and is effectively controlled by pre-emergence application of herbicides listed in Table-2. *Euphorbia hirta* (pill bearing spurge) is an important weed of soybean (Tiwari *et al.,* 1988), Chilli and *Brassica juncea* L. It has been reported to be effectively controlled with herbicides mention in Table-2.

Tank-mixing can minimize cost of application and make best use of suitable spray weather provide synergism, enhance the performance of herbicides, providing better weed control than when herbicide is used alone, or when used in separate applications. Increase in leafy spurge control was reported by tank mixed application of 2, 4-D with picloram, dicamba, sulfometuron, glyphosate and clopyralid (Alley *et al.,* 1983; Gylling and Arnold, 1985; Lym and Messersmith, 1985 a&b, 1987, 1988, 1990, 1994; Steven and Arnold, 1985; Rodney *et al.,* 1987; Lym *et al.,* 1991; Lym and Whitson, 1991; Beck *et al.,* 1993; Lym, 2000; Markle and Lym, 2001; Lym and Deibect, 2005). Similarly, leafy spurge injury was increased when diflufenzopyr was applied in mixture with dicamba (Lym and Christianson, 1998); quinclorac (Lym and Deibect, 2005); picloram (Lym and deibect, 2005); clopyralid (Lym and deibect, 2005) or quinclorac in combination with Scoil (Kuehl and Lym, 1997). According to Bharat and Karchoo (2007 and 2010) tank mix application of sulfosulfuron and 2, 4-D (25 + 500 g ha^{-1}), fenoxaprop + metribuzin (120 + 100 g ha^{-1}), clodinafop + metsulfuron methyl (60 + 2 g ha^{-1}) significantly reduced the population of *Euphorbia helioscopia* in wheat. Tank mix application of glyphosate with chloransulam-methyl (30.24 g ha^{-1}), chlorimuron-ethyl (12.5 g ha^{-1}), imazethapyr (80 g ha^{-1}), fomesafen (62.5 g ha^{-1}) lactofen (72.0 g ha^{-1}), flumiclorac-pentyl (30.0 g ha^{-1}) and bentazone (480 g ha^{-1}) was effective for *E. heterophylla* control at 4-6 leaf stage.

Herbicide efficacy is affected by environmental factors like soil moisture. The application of imazapic (0.147 kg ha^{-1}) during dry season was efficient for *E. heterophylla* control (Correia and Kronka, 2010). However, the amicarbazone (1.4 kg ha^{-1}) and sulfentrazone (0.9 kg ha^{-1}) required mesotrione (0.192 kg ha^{-1}) application, alone or mixed with ametryn (1.5 kg ha^{-1}) atrazine (1.5 kg ha^{-1}) or diuron (0.702 kg ha^{-1}) plus hexazone to control *E. heterophylla* during wet season (105-230 days after application during the dry season) in Sao Paulo, Brazil (Correia and Kronka, 2010).

Use of surfactants/modifications in herbicide usage

Leafy spurge is very difficult to control, largely due to its deep and extensive root system (Coupland *et al.,* 1955) and, on the other hand, it may be advantageous to increase herbicide movement to the root system for control of leafy spurge. The addition of N has been shown to stimulate growth of dormant buds thereby creating metabolic sinks and resulting in increased herbicide translocation in leafy spurge with potential for improved control (Melntyre, 1972; Hunter and Melntyre, 1974). Application of 84 kg ha^{-1} N in fall prior to a spring treatment of 0.3 a.i kg ha^{-1} picloram decreased the original stand (75%) compared to no N (18%) (Regimbal and Martin,1985). Imazapic at 140 g ha^{-1} applied with adjuvant or with 28% N plus adjuvant gave 72% leafy spurge control at 12 months after treatment compared to 33% control by imazapic alone and 40% by picloram plus 2, 4-D (Markle and Lym, 2001). Chlorflurenol at 0.6 kg a.i ha^{-1} or mefluidide at 0.3 kg a.i ha^{-1} has been shown to increase leafy spurge control when added to picloram (0.3 kg a.i. ha^{-1}) by stimulating root and shoot growth and increased absorption (Messersmith and Lym, 1980; Gregg *et al.,* 1985). Lym (2000) reported increase in leafy spurge control with glyphosate plus 2, 4-D due to removal of root dormancy with glyphosate which subsequently increased the amount of 2, 4-D in the root.

Modification in application methods

The risk of ground water contamination and high cost of herbicide application on pasture land often makes the treatments impractical where large areas are involved. Therefore, leafy spurge control with lower rates of herbicide would be desirable. The cost of weed control in pasture and rangeland could be reduced by limiting herbicide application to target weed species with innovative methods from 1981 like roller applicator that avoids herbicide drift and reduces the amount of herbicide per hectare (Messersmith and Lym, 1981). Messersmith and Lym (1985) found that picloram at concentrations of 30 to 60 g L^{-1} dispensed with a roller applicator controlled leafy spurge similar to picloram broadcast at 1.1 to 2.2 kg ha^{-1}. The roller application method reduced dosage of picloram by 60% as compared to broadcast treatments. According to Alley and Messersmith (1985) a nontrope pipewick applicator dispersed 17-25% as much picloram as a broadcast application of 2.2 kg ha^{-1}. Moomaw and Martin (1990) stated that picloram at 80 g a.i L^{-1} solution through ropewick applicator controlled leafy spurge equal to broadcast picloram at 1.1 kg ha^{-1} while using 36% as much picloram. Similar results were reported by Regimbal *et al.* (1983). Roller-applied picloram at 30 to 60 g a.e. ha^{-1} gave similar control to leafy spurge as spray-applied picloram at 1.1 to 2.2 kg a.e. ha^{-1}. When used on dense leafy spurge stands the roller applicator applied only 40% as much as picloram spray treatment of 2.2 kg ha^{-1} (Calvin *et al.,* 1985). Lym (1989) noted 50% reduction in dose of picloram and various 2, 4-D formulations when applied with microfoil nozzle boom.

Biological control of Euphorbia

Traditionally, herbicides have been used to control leafy spurge and have been relatively successful when a long term program is followed (Lorenz and Lym, 1993). However, herbicides are not always acceptable due to their cost, potential for groundwater contamination and prohibition in environmentally sensitive areas. Consequently nonchemical methods for leafy spurge control must be established.

Biological control utilizing insects and pathogens has been successful in controlling leafy spurge infestations in Europe (Schroeder, 1980). *Alternaria* sp. is considered to be a potential bio-control agent for leafy spurge (Krupinsky and Lorenz, 1983). Small everlasting plant (*Antennaria microphylla*) has been reported to be allelopathic to leafy spurge (Rice, 1984) by producing hydroquinone, arbutin and caffeic acid that inhibit leafy spurge seed germination and seedling growth (Selleck, 1972; Manners and Galitz, 1985).

Enhancing the competition to control Euphorbia weeds

Grass competition has been recognized as an effective way to control leafy spurge (Lym, 1994). Crested wheatgrass can suppress leafy spurge because it emerges early and competes for early soil moisture (Selleck, 1959; Morrow, 1979). Competition from crested wheatgrass along with 2, 4-D applied twice per year resulted in leafy spurge root eradication after 3 years (Selleck *et al.,* 1962). 'Luna' pubescent wheatgrass and 'Bozoisky' Russian wildrye reduced leafy spurge by over 90% for at least 3 years (Ferrell *et al.,* 1993). The other competing grasses against leafy spurge are little bluestem, crested wheatgrass and intermediate wheatgrass (Biesboer *et al.,* 1993; Wallander and Olson, 1995). Potential of grasses to compete with leafy spurge depends on tillage and soil type as well. According to Ferrell *et al*. (1998) pubescent wheatgrass limited percent canopy cover of leafy spurge to 10 and 15% or less in tilled and no-till plots, respectively, 7 and 10 year after seeding. Russian wild rye limited percent canopy cover of leafy spurge to 21% or less in tilled and 7 and 27% in the no-till plots, respectively, 7 or 10 year after seeding. 'Rebound' smooth brome, 'Rodan' western wheatgrass, 'Bozoisky' Russian wild rye, and 'Arthur' Dahurian wild rye reduced leafy spurge stem density by 63% after 3 year in a silt clay soil. 'Reliant' intermediate wheatgrass reduced leafy spurge stem density every year for 3 years, including a 85% reduction during the second year after planting. Rebound smooth brome and Reliant intermediate wheatgrass caused 72% leafy spurge reduction 3 year after seeding in a loamy soil (Lymand Tober, 1997). Combination of *Aphthona* spp. (flea beetles) and herbicides (picloram and 2, 4-D) can increase leafy spurge control when compared with either method used (Lym and Nelson, 2000; Nelson and Lym, 2003). Similarly Lym *et al*. (1997) reported that grazing by goat combined with picloram plus 2, 4-D reduced the leafy spurge density rapidly and maintained longer control than either method used alone.

Allelopathic, cultural and integrated control

By using integrated approach to control weeds one can reduce the chance that weed species will adapt to the control techniques, which is likely if only one technique is used. Pre-emergence application of penaxalin at 1.0 L ha^{-1} followed by hard hoeing at 25 days after sowing gave 62% control of *Euphorbia* spp. in soybean (Tiwari *et al.,* 1988). Sorghum residues at 28.6tha^{-1} decreased 50% emergence of *E. heterophylla* (Trezzi *et al.,* 2006). Sugarcane straw at 15 and 20tha^{-1} significantly reduced the population of *E. heterophylla* in sugarcane (Monquero *et al.,* 2007). Integrated application of diuron + hexazinone (1330 + 160 g a.e ha^{-1}) and trifloxysulfuron-sodium + ametryn (1463 + 37 g a.i ha^{-1}) as pre-emergence with 15 t ha^{-1} sugarcane straw gave 90% control of *E. heterophylla.* Kumar *et al*. (2009) reported significant reduction in *E. hirta* population and growth with 20 chilli varieties.

CONCLUSION

This review suggests that there are lots of possibilities of efficient *Euphorbia* management in cropped and non-cropped systems. It is therefore recommended that whenever there is a need to control *Euphorbia* weed species one should adopt situation dependent option.

Table-1. Post-emergence herbicides for control of *E.esula*

Herbicides	Dose a.i. kg ha^{-1}	Level of suppression %	Reference
Picloram	0.6-2.2	80-90	Leavitt, 1976; Messersmith and Lym, 1980; Vore and Alley, 1980; Alley *et al.,* 1983; Gylling and Arnold, 1985; Lym and Messersmith, 1985, a& b; Lym ad Messersmth, 1994
Picloram	0.28 (4 treatments) 0.42 (4 treatments) 0.56 (4 treatments)	48 75 90	Rodney *et al.*, 1987
Dicamba	2.0	80-85	Lym and Messersmith, 1994
2,4-D	1.7	80-95	Selleck, 1959; Gylling and Arnold 1985; Lym and Messersmith, 1990
Glyphosate	0.8	80-90	Lym and Messersmith, 1985; Steven and Arnold, 1985,
Quinclorac	1.1-1.7	80-95	Ferrel, 1993; Lym, 1992; Kuehl and Lym, 1997

Table-2. Herbicides and cultural practices for control of *Euphorbia* species

Crop	Weed species	Herbicides/ cultural practices	Dose ha^{-1}	Time of application	Level of suppre-ssion %	Reference
Mustard	*Euphorbia hirta*	Trifluralin	1.0 kg	Pre- plant incorporate	70	Singh and Agarwal, 2004
Chilli	*E. hirta*	Fluchloralin+ Hand weeding	2.0 kg+one	Post- em.	78	Rajput *et al*., 2013
;Citrus	*E. microphylla*	Atrazine Diuron Glyphosate	2.0 kg 2.5 kg 2.5 L	Pre-em. Pre-em. Post-em.	18-61 18-61 73	Josan *et al*., 2013

Cotton	*E. heterophylla*	Diuron Oxyflourfen Prometryn	2.0 kg	Pre-em. Pre-em. Pre-em.	75 75 75	Oliveira *et al*., 2011
Soybean	*E. geniculata*	Oxadiazon Pendimethalin Chlorimuron Penaxalin + Hand weeding	6,9,12 g 1.0 kg 6,9,20 g 1 litre + once	Pre-em. Pre-em. Pre-em. Pre-.em.	75 75 75 62	Jain and Tiwari, 1995; Sharma and Raghuwanshi, 1999 Tiwari *et al*., 1988
Sugarcane	*E. heterophylla*	Sulfentrazone Sulfentrazone+Amicarbazone Diuron+ Hexazione Trifloxy sulfuron-sodium+ Ametryn+ Sugarcane straw	600 g 500 g+700g 1330g+160 g 1464 g+ 37 g+15 t	Pre-em. Pre-em. Pre-em. Pre-em.	85 85 90 90	Azania *et al*., 2009; Morquero *et al*., 2007
Wheat	*E. helioscopia*	Sulfosulfuron+2,4-D Feoxaprop+ Metribuzin Clodinafop+Metsulfuron-methyl Sulfosulfuron Metribuzine Fluroxypyr	25 g+500 g 120 g + 100g 60 g + 2g 25 g 175, 200 g 2 g	Post- em. Post- em. Post- em. Post- em. Post- em. Post- em.	73 75 74 71 70 60	Bharat and Karchoo, 2007, 2010
Rice	*E.geniculata*	Bispyribac-sodium Penoxsulam	25 g 25 g 20-22.5	Post-em. Pre-em. Post-em.	73	Yadav *et al*., 2008, 2009

Table-3. Herbicides recommended for control of *E. heterophylla* in non-cropped area

Herbicide	Dose a.e.gha^{-1}	Time of application	Level of Suppression %	Reference
Glyphosate	360, 720,100 960	Post-em. Post-em.	78 78	Zanatta *et al.,* 2007 Ramires *et al*., 2010
Glyphosate+ chloransulam-methyl	960 +30.24			
Glyphosate+chlorimuron-methyl	960 + 125			
Glyphosate+ imazethapyr	960 +80			
Glyphosate+fomesafen	960 + 62.50			
Glyphosate+lactofen	960 +72.50			
Glyphosate+flumicloraapentyl	960 +30.0			
Glyphosate+bentazone	960 +480			
Carfentrazone- ethyl	30.0	Post-em.	72	Carvalho *et al*., 2001
Fomesafen	60,120,18,240	Post-em.	50	Raus *et el*., 2005

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