Available online at www.sciencedirect.com
ScienceDirect
Crop Protection 26 (2007) 1150–1157
Crop Protection
www.elsevier.com/locate/cropro

Use of herbicide mixtures for pre and post-emergence weed control in sunflower (*Helianthus annuus*)

E. Pannacci*, F. Graziani, G. Covarelli

Department of Agricultural and Environmental Sciences, University of Perugia, Borgo XX Giugno, 74–06121 Perugia, Italy

Received 18 October 2006; accepted 18 October 2006

Abstract

Three field experiments were carried out on sunflower (*Helianthus annuus* L.) from 2002 to 2004 in central Italy, to assess weed control efficacy and selectivity to the crop for some herbicides. These were used in pre or post-emergence applications at different doses and in different mixtures. All herbicides showed a good selectivity to the crop; however, oxyfluorfen in pre-emergence and aclonifen in post-emergence showed some transitory phytotoxicity effects, with no damage to crop yield. Considering pre-emergence applications, mixtures with *s*-metolachlor gave best control of grasses, followed by mixtures with flufenacet. All herbicides gave a very good efficacy against broadleaves, except linuron in the case of *Polygonum lapathifolium* L. In presence of mixed infestations (grasses + broadleaves), *s*-metolachlor + aclonifen and *s*-metolachlor + oxyfluorfen seemed to be the best options for pre-emergence weed control. Considering post-emergence applications, aclonifen showed a satisfactory efficacy against broadleaves and its weed control spectrum could be completed by mixtures with quizalofop-ethyl. However, this option seemed to be advisable only with high grasses infestation levels. Differences in crop yield were on average small with yield levels of pre-emergence treatments higher than those of post-emergence treatments. Otherwise, high infestation levels during the early crop stages caused severe damage to crop yield, in the cases of insufficient weed control.

Keywords: Aclonifen; Flufenacet; Oxyfluorfen; Linuron; *s*-metolachlor; Tank-mixing

1. Introduction

Sunflower is one of the most important crops in central Italy and is mainly grown following winter wheat in non-irrigated cropping systems (Monotti, 2004). With respect to weed control, due to its sowing period (mid-March to mid-April), this crop is very often characterised by a complex plurispecific weed flora, composed of grass and broad-leaved weeds (Fried et al., 2006). This weed flora has been traditionally controlled with pre-emergence herbicide applications, due to a scarce availability of post-emergence herbicides (Rapparini, 1996). However, short rotation cycles and repeated applications of the same pre-emergence herbicides have determined a strong increase in the frequency of several 'difficult to control' weed species (Covarelli, 2002), forcing farmers to adopt less simplified weed control strategies.

In particular, in order to optimise weed control efficacy and minimise the application costs, the use of complex combinations of pre and post-emergence herbicides, as well as herbicide mixtures, has become the rule rather than the exception in many countries (Kudsk, 2002). This strategy also represents an important tool to avoid problems related to herbicide resistance (Friesen et al., 2000; Sattin et al., 2000; Lucchin et al., 2001), but it requires some preliminary information to assist farmers with the process of herbicide and dose selection, depending on the floristic situation (Matthews, 2006).

The objective of this research was to investigate weed control efficacy and phytotoxicity to the crop of some herbicides applied in sunflower at different doses, in different mixtures and with different application timings.

*Corresponding author. Tel.: +39 075 5856342; fax: +39 075 5856344.
E-mail address: pannacci@unipg.it (E. Pannacci).

0261-2194/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cropro.2006.10.008

2. Materials and methods

From 2002 to 2004, three field experiments on sunflower (*Helianthus annuus* L.) were carried out in central Italy (Experimental Station of Papiano, 42°57′N, 12°22′E, 165 m a.s.l.) on a clay-loam soil (25% sand, 30% clay and 45% silt, pH 8.2, 0.9% organic matter). The main agronomic practices are shown in Table 1. The trials were carried out in accordance with good ordinary practices, as concerns soil tillage and seedbed preparation (Bonciarelli and Bonciarelli, 2001). Experimental design was always a randomised block with three replicates and plot size of 17.5 m^2 (2.5 m width). In each trial, some herbicides were used in pre or post-emergence applications at different doses and in different mixtures in order to assess weed control ability and selectivity to the crop. The experimental layout was slightly adjusted during time, to include a few treatments according to the results obtained in previous years. Herbicides under investigation (Table 2) were: *s*-metolachlor (Dual Gold, 960 g a.i. L^{-1}, Syngenta Crop Protection), oxyfluorfen (Goal 2XL, 240 g a.i. L^{-1}, Dow AgroSciences Italia), linuron (Afalon DS, 450 g a.i. L^{-1}, Makhteshim-Agan Italia), aclonifen (Challenge, 600 g a.i. L^{-1}, Bayer CropScience), pendimethalin (Stomp 330E, 307 g a.i. L^{-1}, Basf Italia—Divisione Agro), imazametabenz-methyl (Assert, 200 g a.i. L^{-1}, Basf Italia—Divisione Agro), flufenacet (Cadou WP, 600 g a.i. L^{-1}, Bayer CropScience) and quizalofop-ethyl (Targa Gold, 600 g a.i. L^{-1}, Bayer CropScience) were applied with a backpack plot sprayer fitted with four flat fan nozzles (Albuz APG 110—Yellow) and calibrated to deliver 300 L ha^{-1} aqueous solution at 200 kPa. Untreated plots were always added as checks.

Post-emergence treatments were always performed with the crop at the 2–4 leaves stage, broadleaved weeds at the 2–4 true leaves stage and grasses at the 3–5 leaves stage.

In each trial, herbicide phytotoxicity was rated visually 25 and 45 days after emergence (DAE) on a 0–10 scale

Table 1
Agronomic practices in the field experiments

Year	2002	2003	2004
Preceding crop	Wheat	Wheat	Wheat
Sowing date	15/4	15/4	5/4
Sunflower cultivar	Sanbro	Sanbro	Sanbro
Density (plants m^{-2})	5	5	5
Spacing between rows (m)	0.5	0.5	0.5
Fertilisation (kg ha^{-1})	100 N; 80 P_2O_5	100 N; 80 P_2O_5	100 N; 80 P_2O_5
Emergence date	26/4	27/4	13/4
Pre-emergence treatments date	17/4	18/4	8/4
Post-emergence treatments date	13/5	8/5	10/5
Harvest	13/9	20/8	30/8

Table 2
Herbicide treatments on sunflower in 2002, 2003 and 2004

Code	Treatment	Dose (g a.i. ha^{-1})	Application time	Year		
				2002	2003	2004
A	*s*-metolachlor + oxyfluorfen	720 + 168	Pre-em.	x	x	x
B	*s*-metolachlor + oxyfluorfen	960 + 144	Pre-em.	x	x	x
C	*s*-metolachlor + linuron	960 + 315	Pre-em.	x	x	x
D	*s*-metolachlor + linuron	960 + 540	Pre-em.	x	x	x
E	*s*-metolachlor + aclonifen	960 + 720	Pre-em.	—	x	x
F	*s*-metolachlor + aclonifen	960 + 900	Pre-em.	x	x	x
G	Pendimethalin	921	Pre-em.	—	x	x
H	Pendimethalin + linuron	921 + 540	Pre-em.	x	x	x
I	Pendimethalin + aclonifen	921 + 900	Pre-em.	x	x	x
L	Pendimethalin + imazametabenz	768 + 400	Pre-em.	—	x	x
M	Flufenacet + linuron	360 + 540	Pre-em.	x	x	x
N	Flufenacet + aclonifen	360 + 900	Pre-em.	x	x	x
O	Oxyfluorfen	240	Pre-em.	—	—	x
P	Aclonifen	900	Post-em.	x	x	x
Q	Aclonifen + quizalofop-ethyl	900 + 60	Post-em.	x	x	x
R	Quizalofop-ethyl	60	Post-em.	x	x	x
S	Untreated check	—	—	x	x	x