HERBICIDE SELECTIVITY IN RELATION TO THE DIFFERENT APPLICATION TIMES IN SUNFLOWER PRE-EMERGENCE

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Abstract
The results regard a three year trial carried out in Western Sicily aimed at evaluating any alterations in selectivity of five of the most widely used herbicides in pre-emergence weed control of the sunflower. The herbicides were applied in three different times between sowing and cotyledon withdrawal from soil.
The results obtained revealed traces of visible phytotoxicity and a reduction in sunflower development, which could be attributed to the use of all the herbicides tested when applied on hypocotyl appearance (E3).
In any case, over the three years seed production was not significantly affected by the various treatments compared (data not reported).

Introduction

Standard sunflower cultivation technique foresees weed control with herbicidal application at pre-emergence. Treatment is normally carried out at sowing or immediately after, over a limited period.
Due to unfavourable climatic conditions (abundant rainfall), or reasons linked to organizational difficulties, timely intervention is not always possible and hence weed control is carried out at seed germination or when plantlet emergence is near. Hence knowledge of herbicide selectivity may be inadequate with regard to late application.
Recently research has been carried out (Rapparini, 1990; Covarelli et al., 1991; Saleri, 1992), to evaluate any reduction in selectivity of some of the most common chemical formulations adopted in pre-emergence weed control of the sunflower, when applied between sowing and complete cotyledon emergence.
This paper reports the results of a three year trial carried out in Western Sicily in the "Sunflower" subproject of the "Oil Crops" Project set up by the Ministry of Forestry and Agriculture.

Materials and Method

The three year trial was carried out by the Istituto di Agronomia Generale e Coltivazioni Erbacee in Palermo in two locations in Western Sicily between 1987/89.
The herbicides adopted and application times are reported in tables 1 and 2.
The main information regarding cultivation and experiment techniques, and the physical and chemical characteristics of the soil, are reported in tab.3.
Herbicidal treatment was carried out with an F320-type portable pump which distributed 400 l/ha of solution when at least 50% of

observed seeds had reached the phenological stage desired.
To improve the evaluation of the trial the plots were periodically weeded manually.
In order to obtain the predetermined plant density, thinning out was made about 20 days after emergence.
Herbicidal selectivity on the crop was evaluated through 3 separate visual inspections 20, 40 and 60 days after emergence, adopting the standard EWRS method; moreover, various biometric and weight measurements were carried out both at thinning out and at harvesting. The data obtained was submitted to variance analysis and differences between the significant means were calculated by Duncan's test.
The thermopluviometric trend over the three years is reported in figs. 1-3.

Results
Selectivity of the herbicides on the crop was evaluated according to the number, average height and dry weight of seedlings uprooted at thinning out. This was carried out at the same time as the first of the three inspections regarding visible phytotoxicity in the crop, measured by the EWRS method. Successively, plant height at harvesting, dry matter production in the aerial part of the plant, and achene production were also measured.
The results obtained in this three year trial demonstrated, a variability in selectivity of all five herbicides tested according to the application time. In particular the active ingredients caused an increase in phytotoxicity when applied after seed germination, with quite marked symptoms resulting from the third application period.
With regard to visible crop phytotoxicity 20 days after emergence (tab.4), all the herbicides gave rise to more or less marked symptoms of toxicity in relation to the application time. These symptoms were however temporary, progressively diminishing till they completely disappeared; 60 days after emergence for pendimethalin and prometrine and for all application times; for linuron for the first and second time; and for metobromuron only in the first time. For all other treatments traces of phytotoxicity were still present at the final inspection.
From observations made at thinning out (tab.5), a progressive reduction in selectivity was observed with delayed herbicides application. Indeed, the number, height and dry weight of the uprooted seedlings constantly decreased from the first application time through to the third. The differences were statistically significant.
Of the herbicides linuron was the least selective, determining statistically the lowest values in all the observations carried out at thinning out.
Plant height at harvesting and dry matter production of the aerial part of the plant also demonstrated a reduction in selectivity between the first and third application times of herbicides.
For the herbicides statistically signicant differences were only noted in 1987. These regarded plant height at harvest, and dry matter production of the aerial part in the first two years. In

Table 1 - Herbicides and rate of application

Active ingredients e % nel f.c.	Rate of c.f. l or kg/ha	Codes
Linuron 50%	1,5	T1
Metobromuron 50%	2,5	T2
Alachlor 43,2%	5,0	T3
Pendimethalin 31,7%	5,0	T4
Prometrine 50%	2,0	T5

Tab. 2 - Treatment times

Phenological stage	Cod. stage
Ungerminated seed	E1
Seed with radicle and hypocotyl 3-4 cm	E2
Appearance of hypocotyl "elbow"	E3

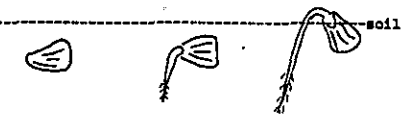


Table 3 - Agronomic and experimental trial information

Year	1987	1988	1989
Location	Orleans	Sparacia	Sparacia
Previous crop	tomato	durum wheat	clover
Experimental design	split-plot with 4 replications		
Plots area	20 m²	20 m²	20 m²
Seed quantity	4 time as big as 4 plants/m²		
Sowing date	8 May	6 May	11 May
Seed depth	5 cm	5 cm	5 cm
Variety adopted	Gloriasol	Gloriasol	Gloriasol
Phosphatic fertilization (P_2O_5)	100 kg/ha	180 kg/ha	180 kg/ha
Nitric fertilization (N)	100 kg/ha	100 kg/ha	100 kg/ha
Potassic fertilization (K_2O)	100 kg/ha	75 kg/ha	75 kg/ha
Thinning out	24 June	13 June	22 June
Irrigation	4 interventions		
Watering quantity	380 m³/ha	485 m³/ha	460 m³/ha
Harvesting	18 Sept.	19 Sept.	8 Sept.
Soil characteristics			
Texture	A/S	A	A
Organic matter %	1,9	1,5	1,1
pH (in H_2O)	7,9	8,4	8,7
Total nitrogen % (Kjeldahl)	1,6	1,2	1,0
P_2O_5 absor. ppm	211,0 (Ferrari)	16,1. (Olsen)	19,4 (Olsen)
K_2O trans.	1,8 mg/100g (Dirks-Shef.)	381,2 ppm (M.Int.)	363,6 ppm (M.Int.)
Total $CaCO_3$ % (De Astis)	---	7,1	6,0
Active $CaCO_3$ % (Droineau)	---	4,6	4,0

Table 4 - Crop observations

Active ingredients	Treatment time	At thinning out: Plants (n/m²) 1987	1988	1989	Plant height (cm) 1987	1988	1989	Plant dry weight (t/ha) 1987	1988	1989	At harvesting: Plant height (cm) 1987	1988	1989	Dry weight production of the aerial part (t/ha) 1987	1988	1989
Linuron	E1	6,5 bc	7,5 d	7,2 cd	20,3 de	19,5 d	21,5 bc	2,8 c	2,8 ac	2,8 ac	144,5 df	147,7 bd	126,7 ab	7,04 a	6,49 bc	5,40 a
	E2	5,3 cd	7,1 d	5,9 e	20,2 de	20,2 bd	18,6 e	2,6 cd	2,3 de	2,3 ef	157,1 a	149,6 b	123,1 ad	6,40 bc	6,68 ab	4,77 cd
	E3	0,2 e	1,9 h	4,9 f	15,5 h	16,0 f	14,0 h	1,9 g	1,9 f	2,0 g	137,0 g	135,3 h	120,1 ce	6,79 ab	5,92 d	4,77 cd
Metobromuron	E1	8,5 a	10,1 b	7,8 bd	21,3 bc	21,0 ab	20,4 cd	3,2 ab	2,9 a	2,7 cd	140,8 fg	150,4 b	127,3 a	6,10 cd	6,04 cd	5,33 a
	E2	5,5 cd	6,9 de	7,0 d	20,4 de	20,0 cd	20,0 d	2,8 cd	2,8 ab	2,6 ce	142,4 f	142,5 ef	121,2 be	6,89 a	6,22 cd	4,72 cd
	E3	4,5 d	5,8 f	5,4 ef	18,7 g	19,6 d	15,3 g	2,4 de	2,5 bd	2,0 g	152,8 ac	148,9 bc	118,0 df	6,34 bc	6,19 cd	4,48 d
Alachlor	E1	4,8 d	7,2 d	8,8 a	20,4 ce	20,5 bc	21,9 ab	2,9 bc	2,4 ce	3,0 ab	153,4 ab	154,6 a	128,8 a	6,94 a	7,05 a	5,38 a
	E2	5,1 d	6,3 ef	8,0 ad	20,0 ef	19,5 d	19,7 d	2,7 cd	2,7 ac	2,5 de	150,1 bc	146,7 be	120,8 ce	7,05 a	6,13 cd	5,24 ab
	E3	4,4 d	6,1 f	5,5 ef	18,8 g	18,2 e	17,2 f	2,3 ef	2,1 ef	2,2 fg	141,4 fg	137,2 gh	116,4 eg	6,65 ab	5,76 d	4,80 cd
Pendimethalin	E1	8,1 a	10,9 a	8,5 ab	22,6 a	21,7 a	22,8 a	3,2 ab	3,1 a	3,0 a	149,5 bd	148,0 bc	123,8 ac	6,09 cd	6,83 ab	5,25 ab
	E2	7,5 ab	10,1 b	8,1 ac	21,7 b	20,8 bc	19,9 d	3,3 a	2,9 a	2,4 df	142,9 ef	143,5 df	126,6 ab	5,68 d	6,41 bc	5,13 ac
	E3	4,8 d	4,4 g	3,9 g	15,6 h	15,0 g	18,4 e	1,9 g	1,7 f	2,3 ef	148,0 ce	137,2 gh	112,4 g	5,73 d	5,79 d	4,05 e
Prometrine	E1	7,2 ab	8,8 c	7,8 bd	21,4 b	20,6 bc	20,5 cd	2,9 bc	2,7 ac	2,7 bd	140,3 fg	142,9 ef	124,9 ac	5,91 cd	5,91 d	5,00 ac
	E2	7,2 ab	7,4 d	7,5 bd	20,9 bd	20,0 cd	19,9 d	2,7 cd	2,5 bd	2,5 de	149,5 bd	144,6 cf	120,3 ce	5,99 cd	5,75 d	4,89 bd
	E3	7,1 ab	7,0 de	7,0 d	19,2 fg	18,5 e	20,2 d	2,0 fg	2,0 f	2,5 de	144,5 df	141,0 fg	114,5 fg	6,00 cd	5,78 d	4,73 cd
Mean treatment times																
	E1	7,0 a	8,9 a	8,0 a	21,2 a	20,7 a	21,4 a	3,0 a	2,8 a	2,9 a	145,7 b	148,7 a	126,3 a	6,42	6,46 a	5,27 a
	E2	6,1 b	7,6 b	7,3 b	20,6 b	20,1 b	19,6 b	2,8 b	2,7 a	2,5 b	148,4 a	145,4 b	122,4 b	6,40	6,24 b	4,95 b
	E3	4,2 c	5,0 c	5,3 c	17,6 c	17,5 c	17,0 c	2,1 c	2,0 b	2,2 c	144,7 b	140,1 c	116,3 c	6,30	5,89 c	4,56 c
Mean treatments																
Linuron		4,0 d	5,5 d	6,0 c	18,7 c	18,6 c	18,0 b	2,4 c	2,3 b	2,4	146,2	144,5 bc	123,3	6,75 a	6,36 a	4,98
Metobromuron		6,2 b	7,6 b	6,7 b	20,1 ab	20,2 a	18,6 b	2,8 a	2,8 a	2,4	145,3	147,3 a	122,2	6,44 b	6,15 b	4,84
Alachlor		4,8 c	6,5 c	7,4 a	19,7 b	19,4 b	19,6 a	2,6 b	2,4 b	2,6	148,3	146,2 ab	122,0	6,88 a	6,32 a	5,14
Pendimethalin		6,8 a	8,5 a	6,8 b	20,0 b	19,2 bc	20,3 a	2,8 a	2,6 ab	2,6	146,8	142,9 c	121,0	5,83 c	6,34 a	4,81
Prometrine		7,2 a	7,8 b	7,5 a	20,5 a	19,7 ab	20,2 a	2,5 bc	2,4 b	2,6	144,7	142,8 c	119,9	5,97 c	5,82 c	4,88

Means within the same column not having in common one letter or one of the letter between the exstremes of the pair are significantly different for P=0,05.

Table 5 - Visible fitotoxicity on the crop (EWRS)

Active ingredients	Treatment periods	I inspection (20 gg after emergence)			II inspection (40 gg after emergence)			III inspection (60 gg after emergence)		
		1987	1988	1989	1987	1988	1989	1987	1988	1989
Linuron	E1	3	2	1	2	2	1	1	1	1
	E2	2	2	2	2	1	1	1	1	1
	E3	4	3	2	4	3	2	2	2	1
Metobromuron	E1	3	3	1	2	2	1	1	1	1
	E2	3	3	2	3	3	2	2	2	1
	E3	4	4	2	3	4	2	2	2	2
Alachlor	E1	3	2	1	2	1	1	1	1	1
	E2	2	3	2	2	2	1	1	1	1
	E3	4	4	2	3	3	2	2	2	1
Pendimethalin	E1	2	2	2	1	1	2	1	1	1
	E2	2	2	2	1	1	1	1	1	1
	E3	3	4	2	2	3	2	1	1	1
Prometrine	E1	2	2	1	1	1	1	1	1	1
	E2	2	2	1	1	1	1	1	1	1
	E3	3	3	2	2	2	2	1	1	1

Fig.1 - Temperatures and rainfall distribution at Palermo

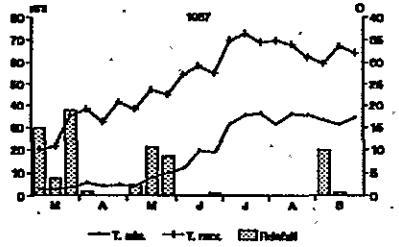


Fig.2 - Temperatures and rainfall distribution at Sparacia

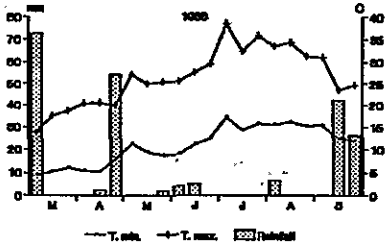
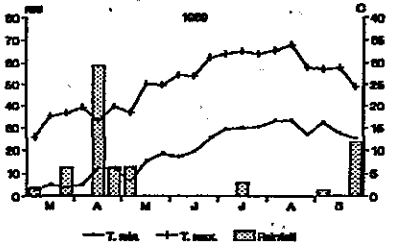


Fig.3 - Temperatures and rainfall distribution at Sparacia



particular the most developed plants were obtained from metobromuron and from alachlor, whereas pendimethalin and prometrine provided the lowest values; the highest biomass production was obtained with linuron and with alachlor, the lowest with prometrine. The action of pendimethalin was anomalous as it provided the lowest production of aerial dry matter in 1987 and the highest in 1988.
As concerns achene production at 10% humidity (not reported), statistically significant differences did not emerge either between the herbicidal products or application periods. On average yields resulted about 2.52 t/ha; 2.79 t/ha and 2.26 t/ha respectively for the first, second and third year of the trial.

Conclusions
The herbicides tested in this three year trial were shown to be highly selective when utilized immediately after sowing (E1), and adequately selective when adopted at the stage in which the radicle and hypocotyl emerge from the seed (E2); nonetheless, the same products employed at an advanced stage when the hypocotyl "elbows" out of the soil (E3), caused manifest phytotoxic effects which however did seem to be temporary. Of the herbicides linuron caused the most significant reduction in sunflower development. Seed production in all three years did not show statistically significant differences that could be attributed to the use of the products or the different application times.

References
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