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SELECTIVE CHEMICAL WEED CONTROL IN SUNFLOWER CROP. RESULTS OF A THREE–YEAR EXPERIMENTAL PERIOD

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SUMMARY

Trials were conducted in the three–year period 1987–89 at the Experiment Centre of the Department of Agronomy and Agro–Ecosystem Managment, Pisa University, situated at Torretta, San Piero a Grado (PI).

In an experimental randomized block design with 5 replications, 15 treatments of chemical weedkilling,made up of active compunds singly or in mixtures, intended for distribution at crop pre–emergence, with the exception of Imazametabenz applied at post–emergence, were compared each year with the control.

At the site on which the experiments took place, the tested pre–emergence compounds showed in general a good herbicide efficacy; Fluorchloridone, the mixure Oxyfluorfen + Alachlor, which appeared however slightly phytotoxic, and those obtained by adding Methabenzthiazuron or Metobromuron or Linuron to Pendimethalin, were seen to be particualrly active.

Concerning the achene yield, in the first two experiment years the treatments which gave the best results were Fluorchloridone and Methabenzthiazuron + Pendimethalin. Whereas in 1989 the best results were given by the mixtures Alachlor + Linuron, Oxadiazon + Metolachlor and Pendimethalin + Linuron.

Key words: Sunflower, weed control, herbicide efficacy

INTRODUCTION

A fundamental principle concerning the competition between cultivated plants and weeds, is that the plants which first occupy the ground tend to exclude the others (Crafts and Robbins, 1962). The sunflower crop is damaged but rarely completely overwhelmed by weeds. The extent of such damage depends on the adventitious species present, on their impact and on their period of emergence with respect to the crop (Robinson, 1978).

It has been shown experimentally that the sunflower is negatively influenced in particular by weeds that appear in the first weeks of its biological cycle, when the latter is characterized by a slow rate of development (Johnson, 1971; Nalewaja et al., 1972; Covarelli and Tei, 1983). Timely weed control in the first twenty days after emergence enables the depressive effect on the crop to be curbed. The lack of control of the adventitious plants in the first 20–30 days of the vegetative cycle can give rise to falls in the production of as much as 25% (Nalewaja et al., 1972; Covarelli et al., 1983). This is also linked to the fact that the sunflower is most suitable in Italy in environments without irrigation, where weed elimination is essential for guaranteeing the plant maximum exploitation of the limited water resources (Salera and Baldini, 1988). On the other hand, when the crop is well established, any adventitious flora that may emerge displays in such a situation a nagligible competitiveness.

The sowing date also takes on a decisive role since it has an effect, not only on the rapidity of emergence and growth of the sunflower, but also on the type of weed present. In the crops sown in central Italy at the end of winter–beginning of spring, the adventitious species mainly present belong to the orders *Centauretalia cyani* and *Chenopodietalia albi*, while with later sowing the latter order assumes a greater importance, as the species of the former floristic association are almost completely dead in May–June (Covarelli, 1986; Vannozzi et al., 1990). However, when the sunflower is sown late or for second harvest, the weed species present are similar to those encountered in maize crops and these belong to the association *Panico–Setarion* (Covarelli, 1981; Tei, 1986).

The use of chemical herbicides in sunflower cultivation has today become indispensable. The elimination of such intervention on soil previously treated for weeds can cause yield losses due to weed action even greater than 50% (Chubb, 1975; Covarelli and Tei, 1985); moreover, in various experiments conducted in different Italian environments (Covarelli and Tei, 1984; Laureti, 1985; Salera, 1986) hoeing and/or earthing up have been shown to be unnecessary when they are carried out in addition to pre–emergence chemical weed control.

Therefore the research of active compounds showing a wide spectrum of action for moderate doses, in whatever environment, appears of prime importance also for the sunflower crop. For this purpose, specific research has been carried out also in Italy in the last few years (Laureti, 1986; Vannozzi and Salera, 1986; Tei, 1986; Covarelli, 1988; Salera and Baldini, 1988; Pirani, 1989; Tei et al., 1991) with the aim of identifying new formulations for this crop to be used in pre– and post–emergence chemical weed control.

The availability of new active compounds and the new formulations of those already known, have prompted us to carry out the experiment to which this paper refers, so as to effect an evaluation of them directed at determining their efficacy as a herbicide and their selectivity with regard to the sunflower.

Table 1. Physical–chemical characteristics of the trial soils

Characteristic	Value		
	1987	1988	1989
Sand (%)	29	28	27
Silt (%)	28	30	29
Clay (%)	43	42	44
pH (in water)	7.59	7.65	7.64
Total lime (%)	12.30	12.10	12.50
Total nitrogen (%.)	1.64	1.71	1.69
Assimilable phsphorus (ppm) (Olsen method)	7.63	7.45	7.56
Exchangeable potassium (ppm) (international method)	278.20	267.50	284.50
Organic matter (%) (Lotti method)	1.78	1.74	1.85

MATERIALS AND METHODS

The trials were conducted in the three–year period 1987–89 at the Experiment Centre of the Department of Agronomy and Agro–Ecosystem Managment, Pisa University, situated at Torretta, San Piero a Grado (PI).

The physical–chemical characteristics of the soils on which the research was carried out, are shown in Table 1.

In an experimental randomized block design with 5 replications and on plots of 25 m^2, 15 treatments of chemical weed control, made up of active compunds singly or in mixtures, intended for distribution at crop pre–emergence, with the exception of Imazametabenz applied at post–emergence, were compared each year with the control. The products tested during the three–year period, as well as their commercial names, the period of use and the relative doses, are reported in Table 2.

Table 2. Active compounds compared during the three–year experimental period

Active compounds and their percentage in commercial formulations	Commercial formulations	Period of use	Dose of c.f. (1/ha or kg/ha)
Alachlor 35% + Linuron 10%	Lasso + Linuron	Pre–emergence	5.0
Ethofumesate 71,1% + Linuron 50%	Tramat + Linuron	"	5.0 + 1.0
Ethofumesate 71,1% + Metobromuron 50%	Tramat + Patoran	"	5.0 + 1.5
Fluorchloridone 25%	Racer	"	2.5
Imazametabenz 10% + Pendimethalin 25%	Assert + Stomp	"	4.0
Linuron 23,7% + Monolinuron 23,7%	Aresin S	"	2.0
Methabenzthiazuron 70%+ Pendimethalin 31,7%	Tribunil + Stomp	"	2.7 + 2.0
Metobromuron 50% + Metazachlor 50%	Patoran + Butisan S	"	1.5 + 1.5
Metobromuron 50% + Metazachlor 68,5%	Patoran + Dual S	"	1.5 + 1.5
Metobromuron 50% + pendimethalin 31,7%	Patoran + Stomp	"	1.3 + 3.5
Metobromuron 50% + Prometrine 50%	Patoran + Gesagard	"	1.0 + 2.0
Oxadiazon 25% + Metolachlor 86,5%	Ronstar + Erbifos	"	2.0 + 1.5
Oxyfluorfen 23,6% + Alachlor 43,2%	Goal + Lasso	"	1.0 + 4.0
Pendimethalin 16% + Linuron 50%	Panter, Inex	"	6.0
Imazametabenz 20%	Assert	Post–emergence	2.0

For the crop, which followed durum wheat in all cases, were always adopted the hybrid Gloriasol and a density of 4,5 plants per m2 (65cm x 34cm). The sunflower was always sown with an excess of seed with respect to the density desired, so as to have available at the moment of thinning (20–30 days after emergence) a sufficient number of plants per plot on which to evaluate, by the determination of the plant's mean dry weight, the selectivity of the active compunds towards the sunflower.

Fertilization consisted of 150 kg/ha of nitrogen, applied at the moment of sowing, and of 100 kg/ha of phosphoric anhydride at ploughing.

Sowing of the sunflower took place on the 29th April 1987, the 18th April 1988 and the 26th April 1989, while the herbicide treatments took place: at pre–emergence on 30/4/1987, 19/4/1988, and 27/4/1989; at post–emergence on 2/5/1987, 20/5/1988 and 29/5/1989 in correspondence with the sunflower's four true leaf stage.

The application of chemicals for weed control, diluted in a ratio of 600 litres of water per hectare, was always carried out by means of a special pump for plot treatment.

For every trial the following observations were carried out:

a) on the crop:

— periodic visual observations to evaluate possible phytotoxic phenomena due to the herbicides: the conventional E.W.R.S. scale was used (European Weed Research Society), (Vercesi, 1983; Ferrari et al., 1987), which allows for values from 1 to 9 (1 = absence of phytotoxicity, 9 = death of all plants);

— mean dry weight of the plants collected at thinning (20–30 days after emergence), again with the aim of evaluating the selectivity of the active compunds toward the sunflower;

— plant height and head diameter at physiological maturity;

— achene yield, expressed in t/ha at 0% humidity;

— dry weight of 1000 achenes;

— percentage content of oil (% on dry matter of the seed);

b) on the weeds:

— parcel floristic survey by visual estimation according to the phyto–sociological abundance–predominance method of Braun–Banquet (Braun–Blanquet, 1964; Ferrari et al., 1987), when herbicide action was clearly displayed and the competitive effect of weeds towards the crop was considered at its maximum (Tei et al., 1991).

All the values recorded, including the percentage ones suitably transformed, underwent variance analysis according to a factorial (AxB) pattern in which the years of execution of the trial represented the principal treatment (A) and the theses in comparison the secondary one (B). This was made possible since homogeneous and exactly comparable areas of the same plot of land were used in the research.

Climatic trends

Figures 1, 2 and 3 show the values of the mean temperatures over ten days and of the rainfall recorded on the site of the experiment, during the experimental three–year period and from March to September of the years 1967 to 1986.

Examining Figure 1, it can be seen how in 1987, in correspondence with the sunflower's emergence–two true leaf period, a total precipitation of 47.6 mm is recorded, thanks to which more suitable conditions were made available for a valid verification of the herbicide efficacy and of the selectivity of the various pre–emergence active compunds compared one with another. Even in the days immediately following the application of the post–emergence products a certain amount of rain (25mm) occurred. In general we can say that in the span of its complete biological cycle, the sunflower benefited from favourable conditions of humidity, thanks to the rain spread almost uniformly from sowing to maturity, and of temperature.

The following year (Figure 2) the climatic trend for the experimental period, displayed a total precipitation (347.9mm) higher than the mean for the last twenty years (300.4mm). The mean temperatures were also seen to be generally higher than those recorded over a period of several years. This special seasonal trend, even though it allowed the sunflower an optimum vegetative growth, also encouraged the emergence and the growth of weeds, which in this particular experimental year showed the greatest covering percentage.

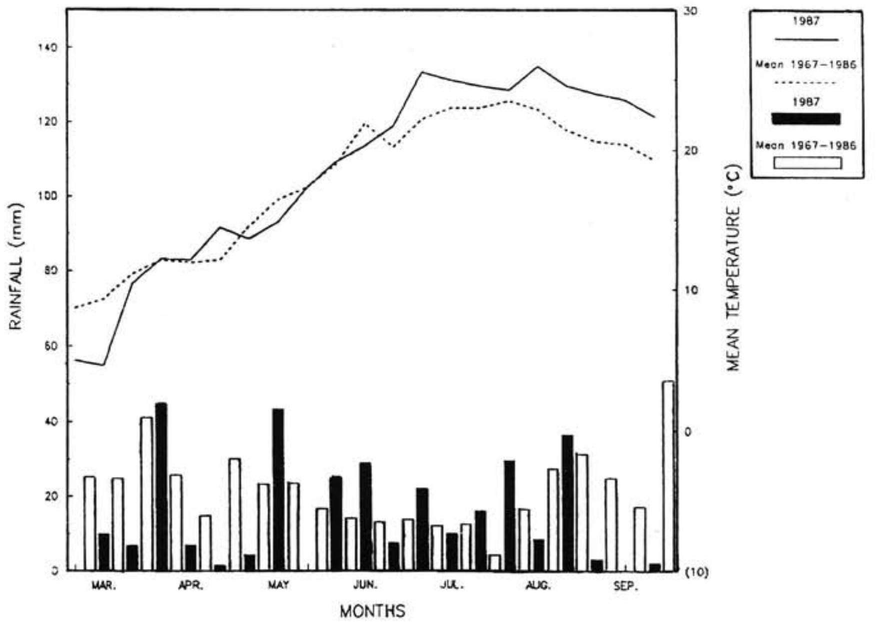

Fig. 1 – Temperature and rainfall during the experimental period (March – September 1987).

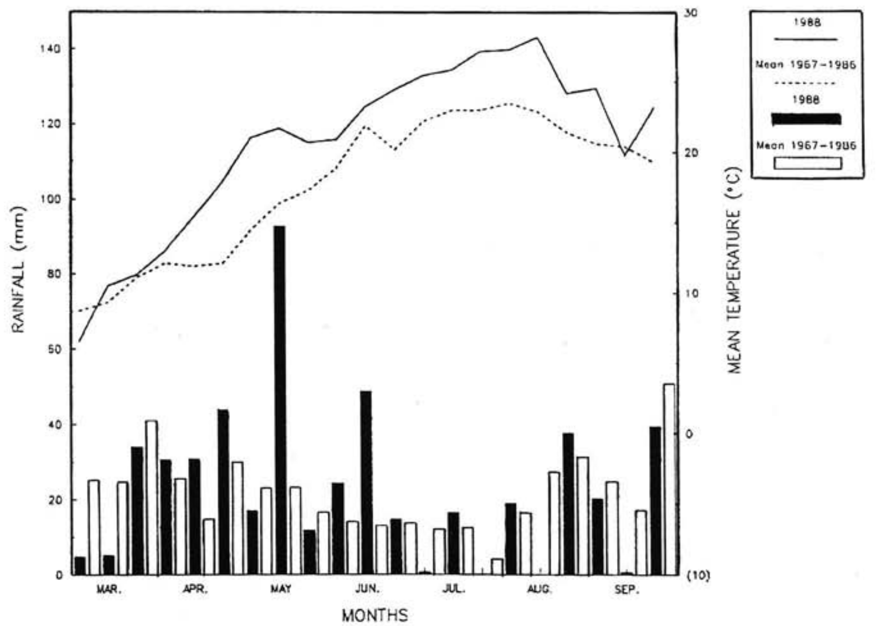

Fig. 2 – Temperature and rainfall during the experimental period (March – September 1988).

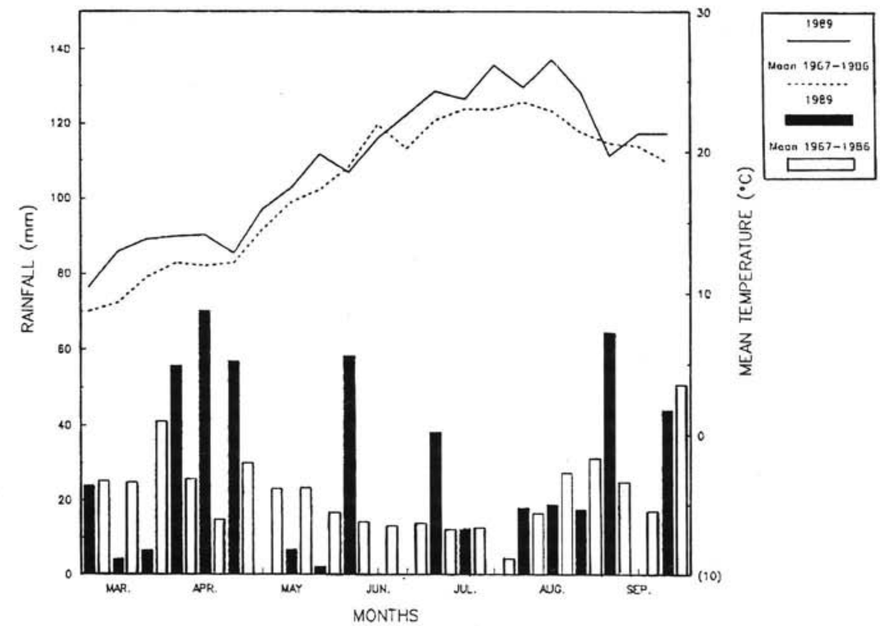

Fig. 3 – Temeprature and rainfall during the experimental period (March – September 1989).

In 1989 (Fig. 3) after sowing of the sunflower, an almost total absence of rain (5.9mm) occurred for about a month. However during the first ten days of June and July, a certain quantity of rain was recorded (in both cases greater than 30mm) which favoured the development of the sunflower. Finally the rainfall which occurred in the month of September (108.2mm) during the filling and ripening of achenes, enabled good yields to be achieved. Regarding the mean temperatures: their trend during the trial was greater than that of the mean taken over several years.

RESULTS AND DISCUSSION

Weed species

In the three–year experimental period 15 weed species were recorded altogether, mainly very competitive subthermophile or thermophile species, belonging to 9 botanical families (Tab. 3). Generally in every trial was found a predominance of broad–leaved adventitious plants, while among the grasses *Echinochloa crus–galli*, present in all three years, and *Lolium multiflorum*, present in two trials, resulted to be the the most representative monocotyledons, with a mean covering of 13% for the former and of 11% for the latter. Dicotyledon infestation was shown to be mainly made up of: *Amaranthus retroflexus, Chenopodium album* and *Polygonum avicueare*, for which in the control were recorded three–yearly mean values of the covering percentage coefficient of 20, 17 and 16%, respectively. In two trials a significant quntity of *Polygonum persicaria* (16% mean covering), *Solanum nigrum* (10%) and *Sinapis arvensis* (9%) was also recorded. Other weed species (Tab. 3), whose presence was sporadic and of modest proportions, were taken into consideration as a whole for statistical processing.

Table 3. Biological form, preferential period of emergence, frequency and mean percentage of covering of the weed species detected in the three–year experimental period

Weed species	Botanical family	Biological form (*)	Preferred period of emergence (**)	Absolute frequency in 3 trials	Mean covering (%)
Monocotyledons					
Alopecurus myosuroides	*Gramina*	A	A–W	1	2
Avena fatua	*Gramina*	A	A–W	1	3
Echinochloa crus–galli	*Gramina*	A	Sum.	3	13
Lolium multiflorum	*Gramina*	A	Ind.	2	11
Dicotyledons					
Amaranthus retroflexus	*Amaranthaceae*	A	Sum.	3	20
Anagallis arvensis	Primulaceae	A	Spr.	1	2
Chenopodium album	Chenopodiaceae	A	Spr.	3	17
Fumaria officianalis	Papaveraceae	A	Ind.	1	3
Matricaria chamomilla	Compositae	A	Ind.	1	2
Polygonum aviculare	Polygonaceae	A	Spr.	3	16
Polygonum persicaria	Polygonaceae	A	Spr.	2	16
Raphanus raphanistrum	Cruciferae	A e B	Ind.	1	3
Sinapis arvensis	Cruciferae	A e B	Ind.	2	9
Solanum nigrum	Solanaceae	A	Sum.	2	10
Sonchus arvensis	Compositae	A e B	Ind. 1	3	

(*) A = annual; B = biennial. (**) A–W = autumn–winter; Sum. = summer; Spr. = spring; Ind. = indifferent

Herbicide efficacy and selectivity of the active compunds

With regard to herbicide efficacy (Tab. 4), the various tested products, with the exception of Ethofumesate mixed with Linuron or with Metobromuron and Imazametabenz applied at post–emergence, displayed for this character mean values all statistically similar during the three–year period. Among these, Fluorchloridone with 87% and the mixtures Methabenzthiazuron + Pendimethalin, Oxyfluorfen + Alachlor and Pendimethalin + Linuron, all with 85%, were the active compunds that showed the highest numerical values of the weed percentage control. Moving on to examine the mean herbicide efficacy, expressed by the various pre–emergence treatments towards the individual weeds, it is noted in Table 4 how *Amaranthus retroflexus* was only partially controlled (75%) by the mixture Imazametabenz + Pendimethalin, which showed limitations also towards *Lolium multiflorum* (72%) and *Solanum nigrum* (76%). *Chenopodium album* on the other hand partly escaped the herbicide action of the mixture Methabenzthiazuron + Pendimethalin (83%) and that produced by Ethofumesate + Metobromuron (83%) or plus Linuron (78%). These last two mixtures, as it has already been said, provided in general the significantly smallest herbicide efficacy. Regarding the grasses present, the two treatments mentioned above and those made up of Linuron + Monolinuron and Metobromuron + Prometrine, were the ones that showed the smallest phytocide activity.

Table 4. Weed percentage control, mean values over the three–year experimental period

Active compounds and their mixtures Weed species	*Amaranthus retroflexus*	*Chenopodium album*	*Echinochloa crus-galli*	*Lolium muliflorum* (*)	*Polygonum aviculare*	*Polygonum persicaria* (*)	*Sinapis arvensis* (*)	*Solanum nigrum* (*)	Others (*)	Total herbicide efficacy
Alachlor + Linuron	93 a	86 ac	83 ab	86ab	65 c	72 bc	81 ab	84 ac	77 ac	82 ab
Ethofumesate + Linuron	86 ab	78 c	75 bc	76 bc	65 c	71 c	70 bc	74 ce	78 ac	75 b
Ethofumesate + Metobromuron	89 ab	83 bc	75 bc	72 c	65 c	75 ac	75 ac	62 de	66 cd	76 b
Fluorchloridone	95 a	96 a	65 c	94a	83 a	78 ac	88 a	94 a	88 ab	87 a
Imazametabenz + Pendimethalin	75 b	87 ac	92 ab	72 c	76 ab	81 ac	88 ac	76 bd	95 a	82 ab
Linuron + Monolinuron	86 ab	89 ac	75 bc	77 bc	65 c	72 bc	88 a	94 a	87 ab	81 ab
Methabenzthiazuron + Pendimethalin	88 ab	83 bc	88 ab	86 ab	82 a	86 a	75 ac	90 ab	84 ac	85 ab
Metobromuron + Metazachlor	95 a	90 ac	75 bc	82 ac	71 ab	75 ac	81 ab	65 de	79 ac	80 ab
Metobromuron + Metolachlor	86 ab	88 ac	87 ab	82 ac	65 c	83 ab	75 ac	72 ce	67 bd	79 ab
Metobromuron + Pendimethalin	89 ab	94 ab	97 a	86 ab	77 ac	83 ab	80 ab	70 ce	88 ab	85 ab
Metobromuron + Prometrina	94 a	88 ac	64 c	80 bc	69 b	75 ac	86 a	74 c	67 bd	79 ab
Oxadiazon + Metolachlor	91 ab	84 ac	95 a	82 ac	65 c	75 ac	81 ab	90 ab	84 ac	83 ab
Oxyfluorfen + Alachlor	93 a	86 ac	85 ab	82 ac	79 ab	84 a	81 ab	95 a	71 bd	85 ab
Pendimethalin + Linuron	92 a	88 ac	80 ac	82 ac	76 ab	85 a	81 ab	82 ac	84 ac	85 ab
Imazametabenz	54 c	40 d	34 d	46 d	23 d	37 d	65 c	60 e	55 d	43 c

(*) = Mean herbicide efficacy over a two–year period.

Values that have no common letter among those indicated at their side, including the intermediate ones not quoted, are significantly different for P<0,05.

Of all the weeds present *Polygonum aviculare* is the one that proved to be the most difficult to control. In fact half the pre–emergence products were not seen to display a herbicide efficacy greater than 65%. The best results were shown instead by Fluorchloridone (83%) and Methabenzthiazuron + Pendimethalin (82%). *Polygonum persicaria* was generally fairly well controlled, the only exceptions being the mixtures obtained by adding Alachlor or monolinuron or Ethofumesate to Linuron. The latter mixture was moreover the one which showed the significantly lowest values of herbicide efficacy (70%) with respect to *Sinapis arvensis*. To conclude: for *Solanum nigrum*, over and above the treatments whose efficacy towards this weed has already been mentioned, all those obtained with Metobromuron showed very little activity. On the other hand excellent results were provided by Oxyfluorfen + Alachlor (control equal to 95%), by Linuron + Monolinuron (94%) and by Fluorchloridone (94%).

Imazametabenz, applied post–emergence at the four true leaf stage of the sunflower, had a limited range of action and an incomplete herbicide efficacy, not comparable on average with the pre–emergence products. This active compound however, showed a certain phytocide activity with regard to the *Cruciferae (Sinapis arvensis* and *Raphanus raphanistrum*) and *Papaveraceae* present.

Visual evaluation of the phytotoxicity produced in the crop by the various herbicide treatments (E.W.R.S.), at 20 and at 40 days after their application, pointed out slight chlorosis and slowing down of the sunflower's vegetative development, values of 2 and 3 on the E.W.R.S. scale (phytotoxicity, respectively, in traces and very low), particularly on the plots treated at pre–emergence with Oxyfluorfen + Alachlor, Linuron + Monolinuron and Oxadiazon + Metolachlor. In every case these symptomatologies had already lessened or disappeared at 40 days from the application of the products. These evaluations were confirmed by the plants' dry weight determination at thinning (Table 5). Interaction between the treatments in fact showed that in the different trial years the above–mentioned mixtures caused a significative reduction in the development of the sunflwer in the first phases of its vegetative development. Similar depressive action also resulted, although on a smaller scale and mainly in the 1988 trial, from the products made up of Alachlor + Linuron, Metobromuron + Metolachlor and Metobromuron + Prometrine. In the treatments showing the significantly lowest values, the development percentage reduction with respect to the control or to the apparently less phytotoxic treatment (Imazametabenz + Pendimethalin), resulted on average between a maximum of 15% (Oxyfluorfen + Alachlor) and a minimum of 4% (Ethofumerate + Metobromuron).

Yield and biometric characters

Regarding the sunflower's height (Table 5), the statistical analysis did not show any interaction between the treatments. The means of the three–year period showed on the contrary the statistically smallest values in the control and where Imazametabenz was to be used at postemergence. Also the various seasonal trends which occurred during the experimental period influenced significant the plants' development. In general also the head diameter (Table 5) was little influenced by the various herbicide compounds. In fact interaction (A x B) generally displayed significant differences only in relation to the control and to the post–emergence herbicide which always showed the statistically lowest

Table 5. Selectivity of the active compounds and crop biometric characters

Active compounds and their mixtures / Characters	Dry weight of 100 thinned plants (g)				Plant height (cm)				Head diameter (mm)		
	1987	1988	1989	Mean	1987	1988	1989	Mean	1987	1988	1989
Alachlor + Linuron	164 gi	108 km	266 cd	179 e	163	184	145	164 a	160 lm	202 ab	188 cf
Ethofumesate + Linuron	161 gi	117 jl	284 ab	187 ad	164	183	145	164 a	180 di	203 ab	182 dh
Ethofumesate + Metobromuron	162 gi	112 jm	281 ac	185 bc	163	182	144	163 a	169 hl	203 ab	180 di
Fluorchloridone	167 g	123 jk	274 bd	188 ab	165	183	145	164 a	186 dg	204 a	186 dg
Imazametabenz + Pendimethalin	163 gi	122 jk	290 a	192 a	166	182	146	165 a	168 im	202 ab	190 b
Linuron + Monolinuron	150 i	92 o	249 ef	164 fg	166	184	145	165 a	178 ej	203 ab	180 di
Methabenzthiazuron + Pendimethalin	162 gi	123 jk	283 ab	189 ac	163	182	144	163 a	179 di	203 ab	184 dg
Metobromuron + Metazachlor	162 gi	115 jl	280 ac	186 ae	163	183	146	164 a	165 jm	203 ab	184 dg
Metobromuron + Metolachlor	162 di	109 kn	273 bd	181 de	162	182	144	162 a	170 hl	203 ab	184 dg
Metobromuron + Pendimethalin	163 gi	115 jl	281 ac	186 ad	165	182	145	164 a	164 km	202 ab	186 dg
Metobromuron + Prometrina	162 gi	105 lo	284 ab	183 ce	164	182	145	164 a	173 gl	202 ab	186 dg
Oxadiazon + Metolachlor	153 gi	98 mo	260 de	170 f	165	183	146	165 a	175 fk	202 ab	192 ad
Oxyfluorfen + Alachlor	151 hi	95 no	244 f	163 g	166	183	143	164 a	184 dg	201 ac	182 dh
Pendimethalin + Linuron	166 gh	116 jl	288 ab	190 ac	165	184	146	165 a	174 gk	202 ab	188 cf
Imazametabenz	166 gh	123 jk	278 ac	189 ac	160	167	141	156 b	155 mn	184 dg	174 gk
Control	165 gi	125 j	283 ab	191 ab	153	167	138	152 b	145 n	188 df	176 fk
Year mean	165 b	112 c	275 a		163 b	181 a	144 c		170 c	200 a	184 b

Values that have no common letter among those indicated at their side, including the intermediate ones not quoted, are significantly different fo P<0,05.

values. On the other hand the greatest head sizes were given in the first two trial years by the treatment providing for the use of Fluorchloridone and in 1989 by the mixture Oxadiazon + Metolachlor. It should moreover be noted that in the case of Imazametabenz + Pendimethalin, Oxadiazon + Metolachlor and Imazametabenz, the values shown by each of these products in 1988 and 1989, did not differ significantly one with another, notwithstanding that in these two years the mean head dimensions were found to be significantly different.

With regard to yield characters (Table 6), the weight of achenes and the percentage of oil present in them, were seen to be significantly influenced only by the different seasonal trends experienced during the trial. Both the characters in 1989 showed the statistically greatest values.

Concerning the yield, expressed in t/ha at 0% humidity, the interaction between the treatments showed how the significantly greatest values were obtained in 1989 with Alachlor + Linuron (3.12 t/ha) and Oxadiazon + Metolachlor (3.11 t/ha), while the lowest were provided in 1987 by the control and the treatment at post–emergence with Imazametabenz (respectively 2.09 and 2.23 t/ha). In the first experimental year the products providing the best achene yield were seen to be: Fluorchloridone (2.75 t/ha with an increase in the yield with respect to the control of 0.66 t/ha equal to 31.6%), Oxyfluorfen + Alachlor (2.74 t/ha) and Methabenzthiazuron + Pendimethalin (2.72 t/ha). In 1988 due to the fact that the infestation was particularly great that year, Fluorchloridone enabled, with 2.96 t/ha, a yield increase of as much as 0.92 t/ha (+45.1%). Statistically similar results were also displayed by te mixtures Imazametabenz + Pendimethalin, Methabenzthiazuron + Pendimethalin and Metobromuron + Pendimethalin (all with 2.95 t/ha). In 1989 the covering percentage given by the adventitious flora was lower. In this case the mixture that displayed the best phytocide action (Alachlor + Linuron 3.12 t/ha), provided a yield increase of 0.59 t/ha (+23.3%). Good returns were also given by the mixtures Oxadiazon + Metolachlor (3.11 t/ha) and Pendimethalin + Linuron (3.09 t/ha).

Although the average field yield resulted to be significantly different in the different years of the trial, in the case of the mixtures Ethofumesate + Linuron, Ethofumesate + Metobromuron, Linuron + Monolinuron and Oxyfluorfen + Alachlor, the returns provided in the various years by each of them were not statistically very different one from another.

CONCLUSIONS

At the site of the experiments, the weed flora was mainly composed of dicotyledons. Under these particular conditions the tested pre–emergence compounds showed in general a good herbicide efficacy; Fluorchloridone, the mixture Oxyfluorfen + Alachlor, which appeared however slightly phytotoxic, and those obtained adding Methabenzthiazuron or Metobromuron or Linuron to Pendimethalin, were seen to be particularly active. Imazametabenz, applied at post–emergence, was never able to adequately control the weeds present; however its selectivity towards the sunflower was seen to be good.

Concerning the achene yield, in the first two experimental years the treatments which gave the best results were Fluorchloridone and Methabenzthiazuron + Pen-

Table 6. Crop yield characters

Active compounds and their mixtures / Characters	Dry weight of 1000 achenes (g)				Achene yield (t/ha 0% humidity)				Oil in the achenes (% on the d.m.)		
	1987	1988	1989	Mean	1987	1988	1989	Mean	1987	1988	1989
Alachlor + Linuron	45.8	50.8	54.6	50.4	2.53 no	2.84 cn	3.12 a	2.83 ac	51.7	49.6	53.2
Ethofumesate + Linuron	46.3	51.4	52.6	50.1	2.69 io	2.85 bl	2.75 go	2.76 bc	52.6	49.6	51.8
Ethofumesate + Metobromuron	46.0	51.6	52.8	50.1	2.58 mo	2.83 dm	2.77 fn	2.73 c	52.1	49.3	51.6
Fluorchloridone	47.1	52.4	53.6	51.0	2.75 go	2.96 ah	3.02 af	2.91 a	52.9	50.4	52.8
Imazametabenz + Pendimethalin	45.9	52.4	54.3	50.8	2.59 mo	2.95 ah	3.07 ad	2.87 ab	51.7	50.3	53.2
Linuron + Monolinuron	46.7	52.3	52.8	50.6	2.67 jo	2.90 aj	2.79 en	2.79 bc	52.6	50.4	52.4
Methabenzthiazuron + Pendimethalin	47.4	52.4	52.8	50.9	2.72 ho	2.95 ai	2.86 al	2.84 ac	52.7	50.3	52.0
Metobromuron + Metazachlor	45.7	52.4	54.0	50.7	2.54 no	2.89 aj	3.04 ae	2.82 ac	51.8	50.4	52.8
Metobromuron + Metolachlor	46.0	51.1	54.2	50.4	2.56 no	2.83 cm	2.98 ag	2.79 bc	51.9	49.3	52.0
Metobromuron + Pendimethalin	45.3	52.3	53.8	50.5	2.50 op	2.95 ah	3.06 ad	2.84 ac	51.9	50.3	53.0
Metobromuron + Prometrina	46.3	52.3	54.0	50.9	2.60 lo	2.88 ak	3.02 af	2.83 ac	52.6	50.4	52.6
Oxadiazon + Metolachlor	46.5	52.3	54.5	51.1	2.59 mo	2.89 aj	3.11 ab	2.86 ab	52.0	50.4	53.0
Oxyfluorfen + Alachlor	46.9	52.5	52.7	50.7	2.74 go	2.91 aj	2.84 cm	2.83 ac	52.7	50.3	51.6
Pendimethalin + Linuron	46.3	52.3	53.6	50.7	2.63 ko	2.90 aj	3.09 ac	2.87 ab	52.5	50.4	53.2
Imazametabenz	45.6	51.3	52.3	49.7	2.23 q	2.26 pq	2.60 lo	2.36 d	50.8	48.7	51.0
Control	44.4	51.7	51.7	49.3	2.09 q	2.04 q	2.53 no	2.22 e	51.0	49.1	50.8
Year mean	46.1 c	52.0 b	53.4 a		2.56 c	2.80 b	2.92 a		52.1 a	50.0 b	52.3 a

Values that have no common letter among those indicated at their side, including the intermediate ones not quoted, are significantly different fo P<0,05.

dimethalin, which allowed an increase in the achene yield, with respect to the control, from about 30% the first year to 45% the second year. Whereas in 1989 the best results were given by the mixtures Alachlor + Linuron, Oxadiazon + Metolachlor and Pendimethalin + Linuron, which showed with respect to the control a yield increase of more than 20%.

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CONTROL QUIMICO SELECTIVO DE MALAS HIERBAS EN GIRASOL. RESULTADOS DE UN PERIODO EXPERIMENTAL DE TRES AÑOS

RESUMEN

Los ensayos fueron conducidos en un periodo de tres años 1987–89 en el Centro Experimental del Departamento de Agronomia y Manejo de Agrosistemas, Universidad de Pisa situado en Torretta, San Piero a Grado (PI).

Con un diseño experimental de bloques al azar con 5 repeticiones, 15 tratamientos de harbicidas, formados de compuestos simples y en mezcla, y diseñados para distribución como herbicidas de preemergencia con la excepción de Imazametabenz aplicado en post–emergencia, fueron comparados cada año con el control.

En el lugar en el cual tuvieron lugar los experimentos, los compuestos de preemergencia testados mostraron en general, una buena eficacia. Fluorchloridone, la mezcla Oxyfluorfen + Alachlor, los cuales aparecieron ligéramente fitotóxicos, sin embargo, a los obtenidos añadiendo a Pendimethalin Methabenzthiazuron o Metobromuron o Linuron, se observaron particularmente activos.

Con respecto al rendimiento de aquenios, en los primeros años de experimentos los tratamientos que dieron los mejores resultados fueron Fluorchloridone y Methabenzthiazuron + Pendimethalin. Mientras en 1989 los mejores resultados fueron dados por las mezclas Alachlor + Linuron, Oxadiazon + Metolachlor y Pendimethalin + Linuron.

CONTRÔLE CHIMIQUE SÉLECTIF DES ADVENTICES DANS LES CULTURES DE TOURNESOL. RÉSULTATS PORTANT SUR TROIS ANNÉES D'EXPÉRIMENTATION.

RÉSUMÉ:

Les essais ont été menés sur une période de trois ans (1987-1989) au Centre Expérimental du Département d'Agronomie et d'Exploitation des Agro-écosystémes, Université de Pise, situé à Torretta, San Piero a Grado (PI).

Dans un plan expérimental (blocs aléatoires, 5 répétitions), 15 traitements de désherbants chimiques comportant des matières actives seules ou en association et pulvérisés en prè-émergeance (exeption faite pour l'Imazametabenz appliqué en post-émergeance) ont été comparés chaque année au contrôle.

Sur les sites choisis pour l'expérimentation, les composés pulvérisés en prè-émergeance ont montré une bonne efficacité herbicide; Fluorcloridone, l'association Oxyfluorfen + Alachlor - qui sont apparus être légérement phytotoxique - et les associations obtenues par adjonction de Pendimethalin Methalbenzthiazuron ou Methobromuron ou Linuron, se sont révélés particulièrement actifs.

En ce qui concerne le rendement en grains, au cours de la première des deux années d'expérimentation les traitements à base de Fluorchloridone et Meythalbenzthiazuron + Pendimethalin ont donné les meilleurs résultats. Cependant en 1989, les meilleurs résultats ont été obtenus avec les associations Alachlor + linuron, Oxadiazon + Metolachlor et Pendimethalin + Linuron.