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ADOPTION OF PRE-EMERGENCE WEED CONTROL TECHNOLOGY IN SUNFLOWERS IN MEXICO

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Abstract: In Mexico, there are no specific commercial herbicide recommendations for controlling broadleaf and narrowleaf weeds in sunflower crops. Therefore, sunflower growers use a combination of mechanical and manual control methods, which are carried out in the first 20 and 35 days after sowing, respectively, after sowing, which represents a high investment cost in labor. The new technology consists of applying the herbicide trifluralin, in its new formula called Premerlin 600 CE, which is insensitive to solar photodegradation, applying the commercial dose of 2.0 L ha^{-1}in pre-emergence, diluted in 200 L of water, and then applying irrigation at emergence. under seasonal conditions, apply the herbicide in the first 5 days after sowing and before the crop emerges, provided that the soil has good moisture. For the adoption of the technology, the recommendation was applied to three plots in the municipalities of Comonfort, Salvatierra, and Irapuato in the state of Guanajuato, Mexico. The average weed control results for the locations were 91% for broadleaf weeds and 92% for narrowleaf weeds. This is more economical for sunflower producers in the state of Guanajuato than combined mechanical and manual control.

Keywords: *Helianthus annuus*, chemical control, profitability, labor savings.

INTRODUCTION

Globally, the main countries that stand out for their sunflower planting and harvesting areas are: Russia with 29%, Ukraine 29%, Argentina 9%, Romania 9%, and China 8% (Bye *et al.*, 2009). Mexico is part of the center of origin of the sunflower (*Helianthus annuus*) (Lentz *et al.*, 2001). It is believed that the sunflower was brought from America to Europe (Heiser, 1998) by Spanish, English, and French colonizers. All subspecies are native to the Americas (Harter, 2004), but little or no importance has been given to their cultivation in Mexico (Rieseberg and Seiler, 1990). In Mexico, the area planted in 2020 was 2,779 ha, with a production of 4,950 t of grain and an average yield of 1.79 t ha^{-1}. The oil industry demands the production of oilseed, as Mexico is not self-sufficient in this area. Sunflower cultivation has not been promoted, so oilseed is imported from the US and Argentina, as there is no breeding program in Mexico (Márquez, 1988).

The National System of Plant Genetic Resources of Mexico considers that only 25% of the genetic diversity of wild sunflowers has been collected in the country (Lentz *et al.*, 2008). The main producing states are: Guanajuato 30%, Zacatecas 22%, Sonora 20%, Jalisco 18%, and Tamaulipas 10%.

Since 2013, sunflower planting has been promoted in the state of Guanajuato through the Secretariat of Agrifood and Rural Development (SDAyR, 2020), and since 2015, contract farming (CF) has been offered for the planting of high-oleic sunflowers. The companies offering CA are: Aceites Especiales Tron Hermanos de Morelia, AK de Jalisco, PepsiCo, and Aceites el Mayo. In 2018-19, 1,300 hectares of high oleic sunflowers were planted and harvested under CA in Guanajuato (INEGI, 2022).

Ninety percent of oilseeds in Mexico are imported due to the lack of promotion of these crops in the country (CONASIPRO, 2014). Currently, sunflower cultivation is a low-season alternative that improves the income of agricultural producers

who are interested in growing sunflowers (Bukasov, 1981), because it minimizes losses due to drought and is more tolerant to frost than corn and beans. Sunflowers are therefore considered a strategic crop in the face of scenarios caused by climate change (Rincón and Hernández, 2000).

The Secretariat of Agricultural and Rural Development (SDAyR) of the state of Guanajuato (2019-20) recorded a sunflower planting area of 1,230 hectares under irrigation (25%) and under rainfed conditions (75%), benefiting 310 families in the state of Guanajuato. However, there are currently no specific herbicides on the market for the control of broadleaf and narrowleaf weeds for this crop, so the producer carries out a combined mechanical and manual weeding control 20 and 35 days after sowing, which costs 15 days' wages ($250/day), one or two weedings ($700/weeding), for a total cost of $5,150.00/hectare.

This represents a high but essential cost for the producer, since if the weeds are not controlled, grain yield decreases sharply by up to 80%, or 2,400 kg ha^{-1} under irrigation conditions, from an expected average yield of 3,000 kg ha^{-1} and under rainfed conditions, it decreases by 1,600 kg ha^{-1} from an expected total of 2,000 kg ha^{-1}. This makes sunflower cultivation unprofitable (Hernández, 2011).

To solve the problem of broadleaf and narrowleaf weeds, 14 formulations and/or products for weed control were tested at the Bajío Experimental Field, and it was found that the product called Premerling 600 CE (Trifluralin), which is insensitive to photodegradation, applied pre-emergence before irrigation, controls about 90% of weeds and that under seasonal conditions, it can be applied in the first 5 to 6 days before the crop emerges, controlling broadleaf and narrow-leaf weeds. The objective was to transfer the adoption of weed management through chemical control with Premerling 600 CE in sunflower cultivation, applying the recommended commercial dose.

MATERIALS AND METHODS

At the INIFAP Bajío Experimental Field, based in Celaya, Guanajuato, Mexico, different herbicides and combinations or mixtures of herbicides (14 formulations and/or products) were evaluated in pre-emergence for the control of broadleaf and narrow-leaf weeds in sunflower crops.

The best result of the field evaluation was the pre-emergence application of trifluralin in its new Premerling 600 EC formulation, at the commercially recommended dose of 2.0 L ha^{-1} diluted in 200 L of water.

The recommendation generated by INIFAP for producers is that, once the sunflowers have been sown (with furrows 76 or 80 cm apart and 4 or 5 seeds per linear meter), the pre-emergence herbicide Premerling should be applied and then irrigation should be applied so that the chemical control can take effect.

In the case of planting under seasonal conditions, there must be moisture at least 10 cm deep at the bottom of the furrow in order to apply the herbicide to the moist soil, with a window of opportunity of 5 days before the seedling emerges, which represents an efficient and profitable technology for sunflower producers.

To promote and transfer the technology among sunflower producers, transfer plots were set up for adoption, with the cooperation of producers and the advice

of technicians from the Guanajuato State Secretariat of Agricultural and Rural Development (SDAyR) in coordination with INIFAP.

Locations. Three transfer plots were established, one with producer Luciano Espinoza Razo in the town of Neutla in the municipality of Comonfort; another in the Los García ejido in Urireo in the municipality of Salvatierra, with producer Francisco Rodríguez Pérez; and the third in the municipality of Irapuato, on the premises of Irrigation District No. 11 "Alto Lerma." The sunflower hybrid planted was Syngenta 3950, on an area of 1.0 ha in each location, under irrigation conditions, with agronomic management of fertilization at planting, formula 80-40-00 (N-P-K), applying the herbicide in pre-emergence once planted, followed by emergence irrigation and three additional irrigation cycles scheduled for 35, 70, and 110 days after planting.

Variables recorded. At each location, these were: 1) Frequency of each weed species present in the control furrows in each module, for which four furrows were left without herbicide application as a reference for weed presence, counting the species and their frequency 20 days after planting in four replicates along the furrows; 2) Frequency of weeds present in each module 20 days after chemical control was applied; this was expressed as a percentage and analyzed after transforming the data to arcsine; 3) Grain yield at 12% moisture content, in tons per hectare in the plot without control and with chemical control, taking four samples 10 m long (furrow width 0.80 m). The Student's t-test was performed for comparisons of the control without chemical application vs. with chemical application.

Training events. The training events for producers focused on the calibration of sprinkler equipment, counting and frequency of each species and type of weed, and were held in three locations: with producer Luciano Espinoza Razo in the town of Neutla in the municipality of Comonfort, another in the Los García ejido in Urireo de Salvatierra, Guanajuato, with producer Mr. Francisco Rodríguez Pérez, and the third at the facilities of Irrigation District No. 11 "Alto Lerma" in Irapuato, Guanajuato.

RESULTS AND DISCUSSION

The plots were established in the second half of June in the municipalities of Comonfort, Salvatierra, and Irapuato, covering an area of 1.0 hectare. The herbicide Premerlin 600 CE was applied at a dose of 2.0 $L\ ha^{-1}$ diluted in 200 liters of water, and four furrows were not treated with herbicide to represent the untreated control. Immediately afterwards, the seedlings were watered. After 20 days, chemical control was evaluated by counting the weeds controlled in comparison to the weeds present in the furrows without chemical control. This was done in each location using a 25 x 25 cm quadrant for sampling in eight replicates.

Location of Neutla, municipality of Comonfort, Guanajuato. Table 1 shows the frequency of each weed species that appeared in the sampling, which in general was 8 in the control without application, compared to the sampling where chemical control was applied with Premerlin 600 CE at the recommended dose, as well as the average percentage of chemical control for each weed species. The results of the comparisons made using the 5% Student's t-test are also shown, comparing the differences

between counts in the untreated control and the chemical control treatment.

Location of Acámbaro, Guanajuato. Table 2 shows the frequency of each weed species that appeared in the sampling, which in general was 9 in the control without application, compared to the sampling where chemical control was applied with Premerlin 600 CE at the commercially recommended dose of 2.0 L/ha diluted in 200 L of water, as well as the average percentage of chemical control for each weed species. The results of the comparisons made using the 5% Student's t-test are also shown, comparing the differences between counts in the untreated control and the chemical control treatment.

Location in Irrigation District No. 11 in Irapuato, Guanajuato. Table 3 shows the frequency of each weed species found in the sampling, which in general were practically the same species in the three locations, in the untreated control, compared to the sampling where chemical control was applied with Premerlin 600 CE at the commercially recommended dose of 2.0 L ha^{-1} diluted in 200 L of water, as well as the average percentage of chemical control for each weed species. The results of the comparisons made using the Student's t-test at 5% are also shown, comparing the differences between counts in the untreated control and the chemical control treatment.

When analyzing the three tables, it can be seen that the town of Comonfort had the highest amount of weeds, followed by the town of Irapuato and finally the town of Acámbaro.

When analyzing the overall control percentages for the three locations, it was found that the overall control percentage for broadleaf weeds was 92% and for narrowleaf weeds was above 91%, with a lower cost to the producer, who generally harvests the crop 20 days after planting and weeds manually at 35 days.

Effect of not controlling weeds. Table 4 shows the sunflower grain yield per hectare in the different irrigated locations where the herbicide Premerlin was applied, as well as the sampled yield of the four rows that represented the control without chemical control and the percentage decrease in yield, which averaged between 79% and 84% across the three locations. This reflects the importance of weed control management in the crop, benefiting the producer.

Attendance at training-demonstration event. Training-demonstration events were generally held in localities or modules 50 to 60 days after planting, close to the flower bud initiation stage, inviting producers interested in sunflower cultivation, with an attendance of 26 to 36 interested producers per locality.

Cost of the technology. The new recommended technology, which focuses on weed control in sunflower cultivation, costs $2,350.00, and the producer's cost is between $4,450.00 and $5,150.00. This benefits the producer, as this technology allows sunflower producers to save between 47% and 54%.

CONCLUSIONS

The application of Premerling 600 CE 2.0 L ha^{-1} in pre-emergence allowed for 91% control of narrow-leaf weeds and 92% control of broad-leaf weeds.

Chemical control of narrow-leaved and broad-leaved weeds with Premerling in

Weed species	Frequency Control without control	Frequency with chemical control	% weed control
Purslane *Portulaca oleracea*	21	0	10
Mallow *Malva parviflora*	15	1	93
Amaranth *Amaranthus* sp.	26	2	92
Johnson grass *Sorghum halepense*	35	5	86
Blue grass *Poa annua*	8	0	100
Pinto grass *Echlinochloa colona*	24	2	92
Bermuda grass *Cynodon dactylon*	26	2	92
Water grass *Ixophorus unisetus*	15	1	93
Mexican feather grass *Eragrostis mexicana*	8	1	87
Student's *t-test* 5%	b	a	

Table 1. Neutla locality in the municipality of Comonfort, Guanajuato, average frequency of weed species sampled without chemical control and with chemical control, and the average percentage of control for each species.

Weed species	Frequency Control without application	Frequency with chemical control	% weed control
Purslane *Portulaca oleracea*	15	0	100
Mallow *Malva parviflora*	21	2	90
Amaranth *Amaranthus* sp.	14	1	93
Johnson grass *Sorghum halepense*	21	2	90
Blue grass *Poa annua*	5	0	100
Pinto grass *Echlinochloa colona*	18	1	94
Bermuda grass *Cynodon dactylon*	14	1	93
Water grass *Ixophorus unisetus*	12	2	83
Mexican feather grass *Eragrostis mexicana*	14	1	93
Student's *t-test* 5%	b	a	

Table 2. Urireo locality in the municipality of Acámbaro, Guanajuato, frequency of weed species sampled without chemical control and with chemical control, and average percentage of control for each species.

Weed species	Frequency Control without application	Frequency with chemical control	% weed control
Purslane *Portulaca oleracea*	24	2	92
Mallow *Malva parviflora*	23	3	87
Amaranth *Amaranthus* sp.	22	2	91

Johnson grass *Sorghum halepense*	20	3	85
Blue grass *Poa annua*	2	0	100
Pinto grass *Echlinochloa colona*	20	2	90
Bermuda grass *Cynodon dactylon*	28	3	89
Water grass *Ixophorus unisetus*	8	0	100
Mexican feather grass *Eragrostis mexicana*	4	0	100
Student's *t-test* 5%	b	a	

Table 3. Location: Irrigation District No. 11 "Alto Lerma" in the municipality of Irapuato, Guanajuato, frequency of weed species sampled without chemical control and with chemical control, and average percentage of control for each species.

Module / Yield	Chemical control	Without chemical control	% decrease in yield
	Kg ha^{-1}	Kg ha^{-1}	
Loc. Comonfort	3,120	485	-84.4
Loc. Salvatierra	3,280	681	-79.2
Irapuato	2,970	542	-80.0

Table 4. Sunflower grain yield by location, with chemical control and without chemical control, and percentage decrease in yield if no control had been applied.

sunflower cultivation improved crop profitability, saving the producer just over 47% of the total investment in weed control through mechanical and manual weeding.

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