Tribenuron-methyl resistance in accessions of annual wild sunflower species from the Novi Sad germplasm collection

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ABSTRACT

The trial was performed to check whether the tribenuron-methyl (Express) resistance is a novel trait or that it was already present in the wild sunflower. The majority of tested accessions were collected in the USA between 1980 and 1991 and some accessions were obtained through exchange from Argentina. Two treatments with tribenuron-methyl at a 1X rate (17.3 g/ha) were applied one week apart. Moderately resistant plants with slight chlorosis or leaf damage were found in 12 of the total 73 tested accessions. Resistant plants with no visible herbicide damage symptoms were found in three accessions of *H. argophyllus* and one accession of *H. annuus*. At least one plant in 63 of 73 tested accessions continued to grow by branching after the vegetation cone was destroyed. The obtained results suggest that resistance was present in wild sunflower before tribenuron-methyl application started.

Key words: acetolactate synthase – herbicide resistance – wild sunflower.

INTRODUCTION

The genus *Helianthus* is native to North America and rich in genetic diversity with annual and perennial species of sunflower (Schiling and Heiser, 1981). The common sunflower (*Helianthus annuus*) can frequently be found along crop fields and roads. It is a major weed in corn (*Zea mays*), soybean (*Glycine max* (L.) Merr.), wheat (*Triticum aestivum* L.) and sugar beet (*Beta vulgaris* L.).

The use of herbicides for the control of common sunflower has been encouraged because it reduces the cost of labor-intensive manual control. Herbicide families like sulfonylureas, imidazolinones, triazolopyrimidines and pyrimidinyl thiobenzoates inhibit activity of acetolactate synthase (ALS, also known as acetohydroxyacid synthase AHAS). ALS inhibitors proved to be successful in control of common sunflower and were therefore used extensively. Such use resulted in the first occurrence of imazethapyr resistant plants of common sunflower in a soybean field in northeast Kansas where imazethapyr had been applied continuously for the previous seven years (Al-Khatib et al., 1998).

Sulfonylurea herbicides were used for broad-leaf weed control in Canada for cereal crops since 1982 (PMRA EDDENet, Product Information). Tribenuron-methyl resistance has been reported for native *Helianthus annuus* L. populations found mostly in or close to crop fields in Canada (1994) and USA (2002) with 52% and 57% of the total tested respectively (Miller and Seiler, 2005; Olson et al., 2004).

The objective of this study was to determine whether resistance to tribenuron-methyl (Express) is a novel trait or that it was already present in the wild sunflower species.

MATERIALS AND METHODS

After reviewing the seed reserve status for all the accessions of wild annual species in the sunflower collection at Novi Sad, it was found that 73 of them were available for the trial (Table 1.).

The seeds were collected during six collecting trips in the USA from 1980 to 1991. After that period, seven populations of *H. annuus* were collected in 2001, five in the USA and two in Mexico, and three populations of *H. petiolaris* were obtained through exchange from Argentina in 2005 and labeled as GRR accessions. Seven annual species were represented in this trial with 1 to 30 accessions per species.

Table 1. Accessions of wild *Helianthus* species used in the trial.

No.	Accession	Plant Introd. No.	Collect. date	Country	State/province	Habitat/Locality
1	ANN-1	-	2001	USA	Texas	Roadside ditch
2	ANN-10	-	2001	USA	Ohio-Idaho border	Highway No. 20, near cultivated field
3	ANN-13	-	2001	Mexico		Palmitos
4	ANN-14	-	2001	Mexico		Torreon
5	ANN-2	-	2001	USA	Texas	Seymour, highway 114
6	ANN-3	-	2001	USA	Texas	Roadside ditch
7	ANN-9	-	2001	USA	Wyoming	Riverton
8	ANN 1965	PI 531011	1987	USA	Idaho	Roadside ditch, near lava beds
9	ANN 1977	PI 531017	1987	USA	Washington	Disturbed moist roadside ditch
10	ANN 1983	PI 531022	1987	USA	Montana	Roadside ditch near sagebrush rangeland
11	ANN 1992	PI 531027	1987	USA	Idaho	Roadside ditch near sagebrush rangeland
12	ANN 2034	PI 547165	1989	USA	Illinois	Waste area, roadside ditch
13	ANN 2101	PI 586807	1991	USA	North Dakota	Roadside ditch by James River
14	ANN 2104	PI 586809	1991	USA	North Dakota	Poor sandy loam soil in roadside ditch
15	ANN 2114	PI 586815	1991	USA	North Dakota	Disturbed area of roadside ditch
16	ANN 2125	PI 586820	1991	USA	Montana	Disturbed soil in roadside ditch
17	ANN 2134	PI 586827	1991	USA	Wyoming	Disturbed area in roadside ditch
18	ANN 2138	PI 586830	1991	USA	Wyoming	Disturbed roadside ditch
19	ANN 2141	PI 586833	1991	USA	South Dakota	Disturbed backslope of roadside ditch
20	ANN 2144	PI 586835	1991	USA	South Dakota	Roadside ditch, along guard rail
21	ANN 2150	PI 586839	1991	USA	Wyoming	Roadside ditch
22	ANN 2165	PI 586845	1991	USA	Colorado	Disturbed roadside ditch
23	ANN 2168	PI 586846	1991	USA	Colorado	Disturbed roadside ditch
24	ANN 2169	PI 586847	1991	USA	Colorado	Disturbed roadside ditch
25	ANN 2170	PI 586848	1991	USA	Colorado	Disturbed area along roadside ditch
26	ANN 2183	PI 586860	1991	USA	Kansas	Roadside ditch
27	ANN 2187	PI 586864	1991	USA	Kansas	Roadside ditch, along corn field
28	ANN 2191	PI 586866	1991	USA	Nebraska	Along railroad track
29	ANN 2206	PI 586877	1991	USA	Nebraska	Roadside ditch
30	ANN 2223	PI 586884	1991	USA	South Dakota	Along edge of cultivated sunflower
31	ARG 1317	PI 468649	1980	USA	Texas	Sandy roadside area
32	ARG 1575	PI 468651	1980	USA	Florida	Two sandy, empty lots and yard
33	ARG 1677	-	-	-	-	-
34	ARG 1805	PI 494571	1984	USA	Texas	4.8 km south of Rodfield Road
35	ARG 1807	PI 494573	1984	USA	Texas	Along Highway P53
36	ARG 1812	PI 494576	1984	USA	Texas	Along Highway 181
37	DEB 1134	PI 468678	1979	USA	Texas	Along Highway 43
38	DEB 1810	PI 494583	1984	USA	Texas	Along Highway 59
39	DEB 1565	PI 468690	1980	USA	Florida	Beach, east edge of Carrabelle
40	GRR 269	-	2004	Argentina	San Luis	Highway 7, near Villa Mercedes
41	GRR 276	-	2004	Argentina	Buenos Aires	Quenuma
42	GRR 283	-	2004	Argentina	La Pampa	Highway 5, Anguil
43	NEG 1181	PI 468765	1979	USA	Texas	Along Highway 18
44	NEG 1183	PI 468865	1979	USA	New Mexico	Along Highway 18
45	NEG 457	PI 435761	1976	USA	Texas	Along Highway 18
46	NIV 1452	PI 468788	1980	USA	California	Along Highway 99
47	PET 2004	PI 531056	1987	USA	Montana	Ditch by the road,
48	PET 2009	PI 531057	1987	USA	Montana	Ditch by the road, on sandy soil,
49	PET 2011	PI 531058	1987	USA	North Dakota	Sandy soil, by the road
50	PET 2119	PI 586912	1991	USA	Montana	Roadside ditch close to small grain field
51	PET 2126	PI 586916	1991	USA	Montana	Roadside ditch, extending to rangeland
52	PET 2158	PI 586922	1991	USA	Colorado	Sandy roadside ditch
53	PET 2163	PI 586924	1991	USA	Colorado	Sandy roadside ditch
54	PET 2164	PI 586925	1991	USA	Colorado	Sandy roadside ditch
55	PET 2167	PI 586927	1991	USA	Colorado	Sandy soil in disturbed roadside ditch
56	PET 2178	PI 586928	1991	USA	Kansas	Sandy roadside ditch
57	PET 2208	PI 586931	1991	USA	Nebraska	Sandy roadside ditch
58	PET 71	-	1984	USA	North Dakota	S. W. Kindred
59	PET 722	PI 435831	1977	USA	Kansas	Junction of Highways 83 and 50
60	PET 74	-	1984	USA	North Dakota	Northwood
61	PET 1383	PI 468811	1980	USA	New Mexico	Along Highway 18
62	PET 1910	PI 503232	1985	USA	New Jersey	sandy waste area
63	PRA 1142	PI 468851	1979	USA	Texas	Along Highway 146
64	PRA 1145	PI 468852	1979	USA	Texas	Along Alternate 90
65	PRA 1168	PI 468847	1979	USA	Texas	Along Highway 44
66	PRA 1819	PI 494609	1984	USA	Texas	Along Highway 281
67	PRA 1821	PI 494610	1984	USA	Texas	Along Highway 281
68	PRA 1824	PI 494601	1984	USA	Texas	Along Highway 3005
69	PRA 1826	PI 494603	1984	USA	Texas	Along Highway 87
70	PRA 1340	PI 468848	1980	USA	Texas	Along Highway 83
71	PRA 1341	PI 468849	1980	USA	Texas	Along Highway 2644
72	PRA 1342	PI 468850	1980	USA	Texas	Along Highway 2644
73	PRA 1333	PI 468865	1980	USA	Texas	Along Highway 285

One hundred seeds of each accession were used for the study. The seeds were placed in petri dishes with filter paper saturated with distilled water for 24h at +25˚C in the dark. The seed coat was then removed and the seeds were placed on a new filter paper in the same manner. The dishes were

checked daily for germination and formation of the roots. Germinating seedlings were each planted into separate jiffy 7 pots expanded from compressed peat moss disks and placed in the greenhouse with 16/8-h day/night periods. At the two- to three-leaf stage the plants were transferred to the field.

When plants reached the six- to eight-leaf stage they were treated with tribenuron-methyl (Express) at 1x rate (17.3 g ai/ha). Susceptible and total plants were counted one week later and the surviving plants were again treated with the same dosage of tribenuron. After another week, plants with slight chlorosis or leaf damage were noted as moderately resistant and plants with no herbicide damage symptoms were noted as resistant, as described by Miller and Seiler (2005). Plants that continued growing through branches even though their vegetation cone was destroyed were also noted.

RESULTS AND DISCUSSION

Plants in the majority of tested accessions were susceptible, showing symptoms of herbicide damage like chlorosis, growth slowdown and necrosis of young leaves. Moderately resistant plants were found in accessions of three wild species *Helianthus annuus*, *H. argophyllus* and *H. petiolaris*. After the second treatment the number of accessions with healthy plants was reduced to three in *H. argophyllus* and one in *H. annuus* (Table 2.).

Table 2. Number of accessions per wild *Helianthus* species that were susceptible (SUS), moderately resistant (MR), or resistant (R) to tribenuron (Express) herbicide and which survived both treatments

Wild species	Total No. of accessions	No. SUS	No. MR	No. R	No. of survived accessions
Helianthus annuus	30	24	6	1	28
Helianthus petiolaris	19	18	1		14
Helianthus praecox	11	11			8
Helianthus argophyllus	6	1	5	3	6
Helianthus debilis	3	3			3
Helianthus neglectus	3	3			2
Helianthus niveus	1	1			1

Plants that were scored as resistant had no visible herbicide damage and continued to develop as if there was no herbicide treatment. The resistance that was recorded in *H. argophyllus* accessions may have been influenced and increased by the leaf hairiness as well.

If the survival of a plant is considered as resistance and plant death as susceptibility, then the number of resistant plants in this trial was much higher. At least one plant in 63 out of 73 tested accessions continued to grow by branching after the vegetation cone was destroyed and all tested species had at least one accession with plants that survived the full treatment (Table 3.). This is due to the fact that the majority of plants that showed symptoms of herbicide damage started to regenerate and formed lateral branches after the treatment. The decrease in sensitivity of ALS to herbicide active ingredient has been found to contribute to whole-plant resistance more than the differences in absorption, translocation and metabolism (Al-Khatib et al., 1998). The resulting whole-plant resistance may be of interest from the aspect of weed control in wild sunflower-infested crop fields.

This research confirmed that tribenuron-methyl resistance was present in the wild annual species of sunflower before the release of Express-tolerant cultivated sunflower. It occurred in low frequencies which will now probably increase because of the expected use of Express herbicide and applied selection pressure.

Table 3. Number and percentage of plants from wild *Helianthus* species which were susceptible (SUS), moderately resistant (MR), or resistant (R) to tribenuron (Express) herbicide and the number of plants that survived both treatments

No.	Accession population	Total No. of plants	No. SUS	No. MR	% MR	No. R	% R	No. of survived plants
1	A-1	22	22		0.0%		0.0%	17
2	A-10	15	15		0.0%		0.0%	1
3	A-13	17	17		0.0%		0.0%	11
4	A-14	11	11		0.0%		0.0%	5
5	A-2	17	14	3	17.6%		0.0%	11
6	A-3	11	11		0.0%		0.0%	8
7	A-9	9	9		0.0%		0.0%	3
8	ANN 1965	16	16		0.0%		0.0%	0
9	ANN 1977	9	9		0.0%		0.0%	3
10	ANN 1983	12	12		0.0%		0.0%	6
11	ANN 1992	8	7	1	12.5%		0.0%	7
12	ANN 2034	29	28	1	3.4%		0.0%	13
13	ANN 2101	21	21		0.0%		0.0%	5
14	ANN 2104	28	28		0.0%		0.0%	8
15	ANN 2114	10	10		0.0%		0.0%	4
16	ANN 2125	14	14		0.0%		0.0%	0
17	ANN 2134	11	8	3	27.3%		0.0%	8
18	ANN 2138	15	15		0.0%		0.0%	9
19	ANN 2141	22	22		0.0%		0.0%	9
20	ANN 2144	17	17		0.0%		0.0%	1
21	ANN 2150	20	20		0.0%		0.0%	14
22	ANN 2165	21	19	2	9.5%		0.0%	12
23	ANN 2168	24	24		0.0%		0.0%	17
24	ANN 2169	10	9	1	10.0%	1	10.0%	3
25	ANN 2170	24	24		0.0%		0.0%	14
26	ANN 2183	11	11		0.0%		0.0%	4
27	ANN 2187	12	12		0.0%		0.0%	11
28	ANN 2191	9	9		0.0%		0.0%	4
29	ANN 2206	11	11		0.0%		0.0%	7
30	ANN 2223	24	24		0.0%		0.0%	10
31	ARG 1317	17	0	17	100.0%		0.0%	17
32	ARG 1575	15	2	13	86.7%		0.0%	12
33	ARG 1677	35	0	35	100.0%	35	100.0%	35
34	ARG 1805	31	7	24	77.4%	7	22.6%	31
35	ARG 1807	27	9	18	66.7%	9	33.3%	22
36	ARG 1812	27	27		0.0%		0.0%	27
37	DEB 1134	20	20		0.0%		0.0%	1
38	DEB 1810	13	13		0.0%		0.0%	6
39	DEB 1565	23	23		0.0%		0.0%	1
40	GRR 269	17	17		0.0%		0.0%	0
41	GRR 276	9	9		0.0%		0.0%	3
42	GRR 283	24	24		0.0%		0.0%	4
43	NEG 1181	20	20		0.0%		0.0%	4
44	NEG 1183	11	11		0.0%		0.0%	2
45	NEG 457	9	9		0.0%		0.0%	0
46	NIV 1452	16	16		0.0%		0.0%	6
47	PET 2004	25	25		0.0%		0.0%	6
48	PET 2009	14	14		0.0%		0.0%	0
49	PET 2011	17	17		0.0%		0.0%	1
50	PET 2119	14	14		0.0%		0.0%	3
51	PET 2126	17	17		0.0%		0.0%	0
52	PET 2158	11	11		0.0%		0.0%	4
53	PET 2163	17	17		0.0%		0.0%	1
54	PET 2164	16	16		0.0%		0.0%	0
55	PET 2167	15	15		0.0%		0.0%	1
56	PET 2178	23	23		0.0%		0.0%	3
57	PET 2208	21	21		0.0%		0.0%	7
58	PET 71	13	13		0.0%		0.0%	1
59	PET 722	16	16		0.0%		0.0%	1
60	PET 74	25	24	1	4.0%		0.0%	7
61	PET 1383	21	21		0.0%		0.0%	2
62	PET 1910	23	23		0.0%		0.0%	0
63	PRA 1142	13	13		0.0%		0.0%	2
64	PRA 1145	9	9		0.0%		0.0%	1
65	PRA 1168	12	12		0.0%		0.0%	0
66	PRA 1819	21	21		0.0%		0.0%	12
67	PRA 1821	17	17		0.0%		0.0%	5
68	PRA 1824	10	10		0.0%		0.0%	0
69	PRA 1826	21	21		0.0%		0.0%	4
70	PRA 1340	11	11		0.0%		0.0%	3
71	PRA 1341	10	10		0.0%		0.0%	0
72	PRA 1342	10	10		0.0%		0.0%	1
73	PRA 1333	11	11		0.0%		0.0%	3

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