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Sensitivity of sunflower cultivar PR63E82 to tribenuron and propaquizafop in different weather conditions

Lukáš TICHÝ[1,*], Miroslav JURSÍK[2], Michaela KOLÁŘOVÁ[2], Václav HEJNÁK[1], Jiří ANDR[2], Jaroslava MARTINKOVÁ[1]

[1]*Department of Botany and Plant Physiology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic*
[2]*Department of Agroecology and Biometeorology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic*
**Corresponding author: tichylukas@af.czu.cz*

ABSTRACT

Tichý L., Jursík M., Kolářová M., Hejnák V., Andr J., Martinková J. (2018): Sensitivity of sunflower cultivar PR63E82 to tribenuron and propaquizafop in different weather conditions. Plant Soil Environ., 64: 479–483.

The aim of this work was to verify and assess the tolerance of the PR63E82 (ExpressSun) sunflower cultivar to tribenuron, propaquizafop and their tank-mix combination in two rates under various weather conditions. Three small-plot field trials were carried out on sunflower in Prague, Czech Republic, from 2015 to 2017. High phytotoxicity (25–56%) of tribenuron (TBM) + non-ionic surfactant was observed in 2015 and 2016 when the sunflower was sown in mid-April. In 2017, phytotoxicity was significantly lower (4–6%), probably due to a later sowing of sunflower (May), and hence higher temperatures. The main symptoms of TBM phytotoxicity were leaf chlorosis, necrosis and growth retardation. Propaquizafop (PQF) injury was minimal in 2015 and 2017. A higher phytotoxicity (10–13%) was recorded in 2016, probably due to a hail which occurred 2 days after T2 (second application term (sunflower BBCH 14)) application. Plant injury had puckered leaves and also made more side branches. TBM + PQF damaged sunflower plants most of the tested herbicide treatments (phytotoxicity 3–62%). High phytotoxicity caused stem branching, increased number of sunflower heads and decreased yield.

Keywords: *Helianthus annuus* L.; oilseed crop; weed control; pesticide; application date; herbicide tolerant crop

Sunflower is an important oilseed crop of the world. It is valued especially for quality oil (De la Vega and Hall 2002, Mangin et al. 2017). Sunflower is a wide-row crop with low competitive ability. Therefore, up to three weeks of development, it is extremely sensitive to weeds (Elezovic et al. 2012). In this period, weeds can compete very strongly and significantly reduce yield by up to 80% (Daugovish et al. 2003, Simic et al. 2011). For this reason, weed control in the sunflower is a primary prerequisite for the successful growing of this crop.

Areas of sunflower conventional cultivars have been decreasing year after year, mainly due to a low efficacy of pre-emergent herbicides in dry condition (Jursík et al. 2015) and a risk of commonly used post-emergent herbicides damaging sunflower. Sunflower cultivars tolerant to acetolactate synthase (ALS) inhibitors have been bred since 1996 (Tan et al. 2005). The best known and most widely used cultivars are naturally tolerant to imidazolinone herbicides – Clearfield technology (Al-Khatib and Miller 2000), but there are also cultivars with natural tolerance to other ALS inhibitors, especially to sulfonylureas – ExpressSun technology (Miller and Al-Khatib 2004).

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ExpressSun technology uses the tolerance of cultivars to tribenuron (trade name Express 50 SX). This herbicide is used post-emergently and control only dicotyledonous weeds (Zollinger 2004). Some pre-emergent herbicide can be used for control of grass weeds, but their efficacy is affected by soil moisture and can fail in dry conditions. Second option of grass weed control is an application of leaf graminicides (acetyl-CoA carboxylase inhibitors). The tank-mix (TM) combination of sulfonylurea and leaf graminicide, however, presents certain risks. First, it may reduce the efficacy on grass weeds (Jursík et al. 2017) and second, in particular, it can cause sunflower injury (Kammler et al. 2010). Especially cultivars whose tolerance to tribenuron is heterozygous can be strongly damaged (Kolkman et al. 2004). Herbicide-stressed plants usually grow slowly. Their leaves are yellow, stems are branching and flower heads are malformed. As a final result, their yield is also negatively affected. A higher injury occurs when some environmental stress factors join the herbicide stress. In nature, however, the effects of one stress factor occur very rarely, so plants are normally exposed to the joint action of several stress factors (Mittler 2006).

Although the sunflower is a thermophilic crop, it exhibits some tolerance to low temperatures which are the highest at the beginning of a growing season and gradually decreasing, which can cause damage to plants in case of occurrence of late spring frosts (Kováčik 1997). The aim of this work was to verify and assess the tolerance of heterozygous ExpressSun cultivar PR63E82 to tribenuron, propaquizafop and their tank-mix combination in basic and double rates under various weather conditions.

MATERIAL AND METHODS

Three small-plot field experiments were carried out in sunflower (ExpressSun cultivar PR63E82) in Prague, Czech Republic, Central Europe (286 m a.s.l., 50°7'N, 14°22'E) from 2015 to 2017. The study region is characterised by temperate climate (mean annual air temperature around 9°C, mean annual precipitation nearly 500 mm). The soil of the experimental field was classified as a Haplic Chernozem and with clay content of 19%, sand content of 25% and silt content of 56% (silt loam soil). Soil pH_{KCl} was 7.2 and sorption capacity 212 $mmol_+$/kg. Heterozygous ExpressSun cv. PR63E82 was used in all experimental years. This cultivar was chosen for its low level of tolerance to tribenuron, which was useful for determination of the effect of weather conditions and growth stage on sunflower phytotoxicity.

Experimental design. Pre-crop had been the winter wheat in all experimental years. Sunflower was sown on 15th, 13th of April and 11th of May (in 2015, 2016 and 2017, respectively). Plots were established as randomised blocks with three replications. The area of plots was 21 m^2 (3 × 7 m). For drilling, a precise small-plot sowing machine was used. The row spacing was 0.75 m, and the in-row plant spacing was 0.18 m.

The tribenuron (TBM) was tested at application rate of 22.5 g/ha + 0.1% of non-ionic surfactant (NIS) – 1N and at application rate 45 g/ha (+ 0.1% of NIS) – 2N. The propaquizafop (PQF) was used at the rate 100 g/ha (1N) and 200 g/ha (2N). The TM combination of both herbicides was used in the same application rates. Used herbicides are described in Table 1. Herbicides were applied by a small-plot sprayer with Lurmark 015F110 nozzles at a spray volume of 250 L/ha (water) and a pressure of 0.25 MPa and they were applied in two terms – T1, T2. The first application term was always performed on a day with low minimal temperatures or higher precipitation before application, and the second application term was performed on a day with optimal temperatures for sunflower growth. Weather conditions (5 days before and after herbicide applications) are described in Table 2.

Table 1. Description of used herbicides and adjuvants

Herbicide/adjuvant (active ingredient)	Trade name	Formulation	Content of g/kg (L) a.i.	Supplier
Tribenuron	Express 50 SX	SG	500	DuPont
Isodecyl alcohol ethoxylate	Trend 90	EC	900	DuPont
Propaquizafop	Garland Forte	EC	100	Dow AgroSciences

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Table 2. Weather conditions five days before and five days after the application of herbicides

Application term			Average of mean day temperatures (°C)	Average of ground minimum temperatures (°C)	Total precipitation (mm)
2015	T1	BT	14.3	2.6	1.6
		AT	13.5	4.9	9.2
	T2	BT	12.6	4.7	9.3
		AT	13.3	6.3	0.5
2016	T1	BT	13.1	5.7	2.5
		AT	14.2	4.4	0.5
	T2	BT	10.6	4.1	0.5
		AT	17.0	7.3	29.2
2017	T1	BT	20.3	8.8	6.8
		AT	17.0	7.5	12.1
	T2	BT	17.0	7.6	12.1
		AT	19.8	7.9	1.8

T1 – first application term (15.5.2015, 16.5.2016, 2.6.2017); T2 – second application term (22.5.2015, 20.5.2016, 8.6.2017); BT – before treatment; AT – after treatment

The sunflower phytotoxicity was assessed 3 weeks after the herbicide application. For the evaluation of visual phytotoxicity a percent scale of 0% to 100% was used. Flower heads were harvested after ripening of achenes from two middle rows. Achene yields were adjusted to 8% moisture content. Numbers of flower heads were counted during the harvest from two middle rows.

Data evaluation. The experimental data were evaluated using the Statistica 13 for MS Windows software (Tulsa, USA). One-way and multifactorial ANOVA were used. The contrasts between treatments were verified by the *LSD* (least significant difference) test (α = 0.05). Bartlett's test was used to determine whether data do not violate the assumption of homogeneity of variance. If necessary, arcsine square root percent transformations or log transformation of X + 1 were made for some data columns. In such case, the multiple comparisons tests were applied to the transformed data.

RESULTS AND DISCUSSION

Sunflower plants treated with TBM (+ NIS) showed initially a slight yellowing of the leaves between the veins, especially in plots where a double rate was used. These symptoms of phytotoxicity disappeared quickly within 3 weeks. Other symptoms of phytotoxicity were slow growth, leaf deformation, stem branching and generally smaller leaf area that occurred for the whole growing season, especially in 2015 and 2016 when the herbicide application was performed earlier (mid-May) (Table 3). Damages of sunflowers were significantly influenced by weather conditions before and after the application of herbicides. Especially precipitations before the second application term in 2015 caused significantly ($LSD_{0.05}$) higher phytotoxicity (33% and 38%) compared to the first application term (8% and 25%). The sunflower was damaged by a strong storm with hail in 2016. Matzenbacher et al. (2014) reported that precipitation before the application of the herbicide increases efficiency but also may reduce selectivity. Despite this fact, high precipitations did not cause high phytotoxicity before the herbicide application in 2017. Phytotoxicity was the lowest (4–6%) in this year, probably due to later sowing of sunflower (mid-May), and higher temperatures at the time of both applications (Table 2). Higher temperatures can increase tolerance of crops to herbicides. This is due to the faster metabolism of the herbicide in the plant tissues (McCullough and Hart 2006, Vidal et al. 2017). In homozygous ExpressSun cv. P63LE10 symptoms of phytotoxicity after TBM (+ NIS) application were not observed (Jursík et al. 2017) at the same location in 2011–2015.

Stems were branched and some branches made sunflower heads due to the phytotoxic effect of herbicides on sunflower plants. After the 2N application rate, the number of sunflower heads increased by 68% (T2) and 96% (T1), respectively, compared to untreated check in 2015 (Table 3). A minimal increase of sunflower heads number (3.3%) was recorded in 2017. Damages of sunflower affected negatively the yield of achenes. On plots treated at T2 application term (both tested application rates), sunflower yield was significantly ($LSD_{0.05}$) lower (by 3.4 t/ha and 1.9 t/ha respectively) compared to the untreated check in 2015 (Table 3). A significant ($LSD_{0.05}$) decrease of yield was also recorded in 2016, when a lower yield was recorded at the untreated check after the T2 application at 2N rate. Yields ranged from 6.7 to 7.9 t/ha, without significant ($LSD_{0.05}$) differences among treatments in 2017.

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Table 3. Sunflower visible phytotoxicity three weeks after the herbicide application in experimental years

Herbicide (+ adjuvant)	Application term	Rate	Phytotoxicity (%)			Number sunflower heads (%)			Yield of achenes (t/ha)		
			2015	2016	2017	2015	2016	2017	2015	2016	2017
Untreated check									5.2^{de}	4.9^{de}	6.7^{a}
TBM (+ NIS)	T1	1N	8.3^{de}	37.3^{d}	4.6^{c}	1.2^{cd}	14^{bcd}	3.3^{a}	3.9^{bcd}	3.5^{abcd}	7.3^{a}
		2N	25^{c}	56.3^{ab}	5.9^{bc}	95.8^{ab}	56.7^{ab}	0^{a}	4.1^{bcd}	1.9^{a}	7.9^{a}
PQF	T1	1N	0^{f}	11.3^{e}	0.1^{d}	0^{d}	4.5^{cd}	0^{a}	5.6^{e}	4.6^{de}	6.7^{a}
		2N	0.3^{f}	12^{e}	0^{d}	0^{d}	1.1^{d}	6.7^{a}	5.1^{de}	4.4^{de}	6.4^{a}
TBM + PQF	T1	1N	14^{d}	38^{d}	9^{b}	1.2^{cd}	50.1^{abc}	0^{a}	3.6^{abc}	3.6^{bcd}	7.2^{a}
		2N	31^{bc}	53^{bc}	14.3^{a}	153.8^{a}	72^{a}	6.7^{a}	4.2^{cde}	2.2^{ab}	6.2^{a}
TBM (+ NIS)	T2	1N	32.7^{b}	35^{d}	4^{c}	12.6^{bc}	9.3^{bcd}	3.3^{a}	2.8^{ab}	4.2^{de}	7.3^{a}
		2N	37.7^{b}	49.3^{bc}	4.7^{c}	67.6^{ab}	23.2^{abcd}	3.3^{a}	3.3^{abc}	2.5^{abc}	7.0^{a}
PQF	T2	1N	0^{f}	10^{e}	0^{d}	0^{d}	10^{bcd}	0^{a}	5.2^{de}	5.3^{e}	6.9^{a}
		2N	1.7^{ef}	12.7^{e}	0^{d}	1.2^{cd}	4.5^{cd}	0^{a}	5.1^{de}	4.5^{de}	6.7^{a}
TBM + PQF	T2	1N	37.3^{b}	48^{c}	3.3^{c}	119.1^{a}	19.3^{abcd}	0^{a}	3.1^{abc}	3.9^{cde}	6.9^{a}
		2N	50^{a}	62^{a}	5.3^{bc}	111.5^{a}	46.6^{abc}	0^{a}	2.4^{a}	1.9^{a}	6.6^{a}
***P*-value**											
Herbicide			< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.7443	< 0.0001	< 0.0001	0.1272
Dose			< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0041	0.3747	0.9883	0.0006	0.2634
Herbicide × dose			< 0.0001	< 0.0001	0.0002	< 0.0001	0.0955	0.5487	0.0730	0.0627	0.3516
Application term			0.0188	0.8154	0.0412	0.6005	0.0788	0.3481	0.0295	0.3958	0.8013
Year				< 0.0001			< 0.0001			< 0.0001	
Data transformation			–	–	AT	LT	AT	–			

TBM – tribenuron methyl; PQF – propaquizafop; NIS – non-ionic surfactant (isodecyl alcohol ethoxylate); T1 – first application term (sunflower BBCH 14); T2 – second application term (sunflower BBCH 14); 1N – registered dose; 2N – double dose; AT – arcsine square root % transformation; values within a column with the same letter are not significantly different ($LSD_{0.05}$); LT – log transformation of X + 1

Sunflower injury caused by PQF was minimal in 2015 and 2017, when phytotoxicity was observed only on plants treated with 2N rate. Small necrosis was observed on the youngest leaves (growing point) (Table 3). A minimal injury of sunflower, soybean and potato by leaf graminicides were also recorded by Bedmar (1997). A higher phytotoxicity (10–13%) was found in our study in 2016, which was probably due to a hail which occurred two days after T2 application. Injured plants had puckered leaves and also made more side branches, which led to the creation of adventive flowerheads (increase by 1% to 10%). This sunflower injury, however, did not affect the sunflower yield (Table 3). Sunflower was most damaged by TM combination of TBM + PQF (Table 3). The highest phytotoxicity (31–62%) was recorded in 2015 and 2016. On the contrary, phytotoxicity did not exceed 14% in 2017. Sunflower injury caused by TM combination was similar to solo TBM (+ NIS). TM combination of sulfonylurea and leaf graminicide may reduce the effectiveness of graminicide (Jursík et al. 2017). Isaacs et al. (2003), Kammler et al. (2010), Matzenbacher et al. (2015) also found out a decreasing selectivity of these TM combinations.

Weather conditions shortly before and after the application significantly affect the efficacy and selectivity of herbicides (Stewart et al. 2010). Low herbicide selectivity was recorded in our experiments especially in 2015 and 2016 when sunflower plants

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were stressed by unsuitable weather conditions (low temperatures before and after the application and intense precipitation before application). The lowest phytotoxicity was recorded in 2017 when the herbicide application was performed at the beginning of June. Higher temperatures during this period (10–25°C) probably eliminated the negative effect of rainfall before application of herbicides.

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