FIELD PERFORMANCE OF A TRANSGENIC FLAX LINE RESISTANT TO SULFONYLUREA HERBICIDES

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Background:

The introduction and use of soil residual sulfonylurea herbicides has provided farmers with an additional option for the control of hard to kill and late germinating broadleaved weeds. However, their benefits in terms of weed control are negated, to some extent, because their use limits the choice of rotational crops. The two major products in question are metsulfuron methyl (Ally, DuPont) and triasulfuron (Amber, Ciba Geigy). Currently, the safe rotation interval for flax on Ally treated fields ranges from 10 to 34 months depending on soil zone and pH. For Amber treated fields, the safe interval ranges from 22 months in fields with a soil pH of 7.5 and for an indefinite period that must be determined by conducting a field bioassay in fields with a pH .7.5. Thus the use of these soil residual products can limit rotational crop choices to cereals in most areas of the province for extended periods of time. The availability of dicot crops capable of growing in sulfonylurea treated soils would allow these farmers a greater variety of rotational crops and thus contribute to the effort to diversify crop production in the province.

At the Crop Development Centre, Dr. A. McHughen and co-workers have developed Agrobacterium-based gene transfer techniques for flax (McHughen *et al.,* 1986; Jordan and McHughen, 1988). This technology has been used to transfer a gene for resistance to sulfonylurea herbicides to several flax lines (McHughen, 1989). This paper outlines the results of field tests conducted on the most promising line which has been recommended for registration in Canada. The proposed name for this line, which was tested as numbers 12115 and FP 967, is CDC Triffid.

Methods

Small plot (2 x 4 m), four replicate field trials were conducted to assess the resistance of the transgenic line to soil residues of various sulfonylurea herbicides. Trials in 1991-1993 were conducted at the Kemen Crop Research Farm on Sutherland heavy clay soil (12% sand, 28% silt, 60% clay) with 4.5% organic matter and a pH of 7.2. In 1994, the trial was conducted at the Goodale Research Farm on a Bradwell fine sandy loam soil (5 1% sand, 29% silt, 20% clay) with 3.1%. organic matter and a pH of 5.6. From 1992-94, the herbicides were applied in the fall previous to planting the crop. In 1991, the herbicides were applied in the spring, and incorporated with shallow cultivation shortly before seeding the crop. Thus, in effect, the flax crop was exposed to higher levels of soil residue than would normally be the case if a cereal crop was grown prior to rotating to flax. In the case of Ally, the label rate and 2X the label rate (4.5 and 9.0 g ai/ha) were applied. Glean was applied at the low and high label rates (11.3 and 22.5 g ai/ha). Amber was applied at the highest rate registered for fall use (25 g ai/ha) and at 8 g ai/ha which is the rate being evaluated for post-emergent applications. Each plot consisted of seven flax rows spaced 15 cm apart. Plots were straight combined with a HEGE small-plot combine. All experiments included the standard cultivar, Norlin, which is the mother line of CDC Triffid.

Results

Treatments were evaluated for gram yield, %damage, days to flowering and plant height. Per cent damage was assessed visually using the Expert Committee on Weeds (Western Canada Section)

assessment system in which 10% is considered the maximum acceptable level of crop injury. In this system, an initial crop injury rating of 10% or less will usually be outgrown and will not result in yield losses.

(a) Flax Seed Yield:

The effect of SU herbicide residues on the yield of Norlin flax and on the genetically transformed resistant line is shown in Table 1. Low rates of Ally and Amber did not reduce the final yield of either variety although Norlin exhibited significant injury symptoms (reduced plant stand, delayed maturity, reduced crop height). That the severe initial injury noted for the low rates of Ally and Amber did not result in reduced seed yield is likely due to surviving plants compensating for the reduction in stand. Norlin was severely injured the high rates of Ally and Amber and by both rates of Glean which was included in the test for only the first two years. In contrast, seed yield of the genetically transformed line, CDC Triffid, was not affected by the herbicide residues. In untreated soil, CDC Triffrd yield averaged 108% of the yield of Norlin. Additional information on the agronomic performance of the two cultivars in the absence of herbicide residue is presented in Table 6.

(b) Resistance to SU Herbicide Residues:

Visual crop injury ratings are summarized in Table 2. All herbicide treatments resulted in severe damage to Norlin. Very minor injury was noted in some of the CDC Triffid plots but this had no effect on any agronomic character except crop height. CDC Triffrd planted in soil that had received the recommended rate of Ally the previous fall showed no sign of herbicide injury.

Table 1. Effect of SU Herbicide Residue on Yield (g/m^{-2})of Norlin and CDC Triffid Flax at Saskatoon, SK (1991–1994).

Herbicide *	g ai/ha	Seed Yield (g/m^{-2})		CDC Triffid as % of Norlin
		Norlin	CDC Triffid	
Ally (4)	4.5	194	187	96
	9.0	80	198	248
Amber (4)	8.0	146	188	128
	25.0	56	177	316
Glean (2)	11.3	59	110	186
	22.5	30	119	397
Untreated (2)	0.0	99	114	115
Untreated (4)	0.0	157	166	108

* (Number of years in test)

Table 2. SU Herbicide Residue Injury to Norlin and CDC Triffid Flax at Saskatoon, SK (1991–1994).			
Herbicide *	g ai/ha	Injury (%)	
		Norlin	CDC Triffid
Ally (4)	4.5	49	0
	9.0	68	3
Amber (4)	8.0	37	5
	25.0	73	4
Glean (2)	11.3	58	0
	22.5	86	3
Untreated (4)	0.0	0	0

* (Number of years in test)

(c) Days to Flower:
The number of days to flower (Table 3) was recorded in 1993 and 1994 to determine the effect of herbicide residue on the early development of the plants. In untreated soil, CDC Triffrd reached the flowering stage an average of one day later than Norlin. The time to flowering of Norlin was increased by one to four days in the presence of SU residues whereas CDC Triffid was unaffected. See Table 6 for further information on the time to maturity of the two cultivars in the absence of herbicide residues.

(d) Plant Height and Lodging Resistance:
The effect of herbicide residue on plant height was recorded in 1991 only and the data are shown in Table 4. The height of the two cultivars was similar in untreated soil. The presence of SU residues in the soil reduced the height of both cultivars but CDC Triffid appeared to be slightly less affected. See Table 6 for additional information from tests conducted in the absence of herbicide residues. CDC Triffid has lodging resistance similar to that of Norlin which is rated good.

(e) Tolerance to Recommended Herbicides:
A test was conducted in 1994 to compare the tolerance of Norlin and CDC Triffrd to recommended rates of registered herbicides that are commonly used for weed control in flax. The results are shown in Table 5. There was no difference between the cultivars in terms of their tolerance to the herbicides tested. Seed yield was similar to the untreated check in all cases except for the Poast + Buctril M treatment which resulted in a yield increase due to the control of both broadleaved and grassy weeds.

(f) Quality:
Table 6 presents data which show that CDC Triffid and Norlin are very similar with respect to seed size, oil content and iodine number. The varieties are also very similar in terms of meal protein content. In 18 tests, Norlin averaged 32.3 % and CDC Triffid 32.2 %.

(g) Disease Reaction:
Like Norlin, CDC Triffid is immune to Rust race 371 and is moderately resistant to Fusarium wilt (data not shown).

Table 3. Effect of SU Herbicide Residue on Days to Flower in Norlin and CDC Triffid Flax at Saskatoon, SK (1993-1994).

Herbicide *	g ai/ha	Days to Flower	
		Norlin	CDC Triffid
Ally (2)	4.5	55	55
	9	57	55
Amber (2)	8	56	54
	25	59	55
Untreated (2)	0	54	55

* (Number of years in test)

Table 4. SU Herbicide Residue Effect on Height of Norlin and CDC Triffid Flax at Saskatoon, SK (1991).

Herbicide	g ai/ha	Height (cm)	
		Norlin	CDC Triffid
Ally	4.5	53	55
	9.0	**53**	**53**
Amber	**8.0**	**52**	**55**
	25.0	**52**	**54**
Glean	11.3	52	59
	22.5	49	56
Untreated	0.0	60	60

Table 5. Tolerance of Norlin and CDC Triffid flax to recommended herbicides, 1994.

Herbicide	Rateg ai/ha	% Injury		Yield (g/m^{-2})	
		Norlin	Triffid	Norlin	Triffid
Untreated	0	0	0	159	169
MCPA A	420	6	8	163	168
Buctril M	560	8	3	172	166
Poast	202	6	0	208	195
Poast + Buctril M	202 + 560	4	7	220	217

Table 6. Agronomic and quality characteristics of Norlin and CDC Triffid Flax in Western Canada Co-op Tests, 19921993.

Character (no. of tests)	Norlin	CDC Triffid	CDC Triffid as % of Norlin
Yield-kg/ha (29)	2050	2000	98
Maturity-day (19)	116	114	98
Height-cm (32)	64	63	98
Seed Wt-mg (23)	5.9	5.9	100
Oil-% (32)	44.5	44.3	100
Iodine No. (32)	192	191	100

Summary:

The genetically transformed cultivar, CDC Triffid, has a high level of resistance to soil residues of the sulfonylurea herbicides, Ally and Amber and thus will provide farmers with a new crop rotation option where these herbicides are used. In the absence of SU herbicide residues, the cultivar is very similar to Norlin in agronomic and quality characteristics.

CDC Triffid was recommended for registration in Canada in February of 1994. As of February 1995, final registration has not been granted by Agriculture and Agri-Food Canada and so the cultivar has not yet been released for general distribution. It was grown by Select Seed Growers in 1994, making it the worlds first commercial transgenic seed crop.

References:

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