The use of imidazolinone resistant *Brassica napus* L. followed by rotations of strip-tillage glyphosate resistant *Gossypium hirsutum* L. or *Zea mays* L.

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Abstract

Imidazolinone resistant (IR) *Brassica napus* (canola) has potential in the southeastern United States (US) as an alternative oilseed sense it can be incorporated into *Gossypium hirsutum* and tropical *Zea mays* rotations. IR canola is a viable option for rotations with these crops due to its resistance to acetolactate synthase herbicides (ALS). These herbicides are commonly postemergence applied in *Gossypium hirsutum* and *Arachis hypogaea* to control many broadleaf weeds. However, these herbicides often have residual carryover issues that restrict non-IR canola production. IR canola could reduce the potential for crop injury or failure from herbicides applied to previous crops. Imazamox is a postemergence herbicide labeled for IR canola and other crops. Imazamox provides good to excellent control of many troublesome weed species in these crops. Herbicide carryover is influenced by herbicide persistence and sensitivity to rotational crops. Crops differ in their response to herbicides, with some being injured at a given concentration while others are not affected. Current label restrictions for imazamox applied in canola indicate that *Gossypium hirsutum* and *Zea mays* cannot be planted for 9 months after application. Factors that influence carryover include soil type, moisture, and herbicide chemistry. Strip-tillage *Gossypium hirsutum* currently comprises approximately 35% of Georgia production. This continues to increase as farmers seek new ways to decrease fuel and other high cost inputs while implementing soil conservation. Research indicated that imazamox applied at 1, 2, or 4 times the normal use rate at 1, 2, or 3 months after *Brassica naupus* was planted did not reduce its yield. Research indicated that rotation to tropical *Zea mays* did not affect its stand establishment and early season growth when planted after IR canola. Glyphosate resistant *Gossypium hirsutum* exhibited significant stand reduction and reduced early season growth when planted after IR *Brassica nupus*.

Key words: canola, *Brassica napus*, *Zea mays*, *Gossypium hirsutum*, imazamox, herbicide, carryover

Introduction

Imidazolinone resistant (IR) *Brassica napus* (canola), also known as *Clearfield canola,* has potential in the southeastern US as an alternative oilseed since it can be incorporated into *Gossypium hirsutum* and tropical *Zea mays* rotations (Buntin et al., 2002). IR canola is a viable option for rotations with these crops due to its resistance to certain acetolactate synthase (ALS) herbicides. These herbicides are commonly postemergence applied in *G. hirsutum* and *Arachis hypogaea* to control many broadleaf weeds. However, these herbicides often have residual carryover issues that restrict non-IR canola production. IR canola could reduce the potential for crop injury or failure from herbicides applied to previous crops. Imazamox is a postemergence herbicide labeled for IR canola and other crops. Imazamox provides good to excellent control of many troublesome weed species in these crops (Grey et al., 2006).

Herbicide carryover is influenced by herbicide persistence and sensitivity to rotational crops. Crops differ in their response to herbicide carryover, with some being injured at a given concentration while others are not affected. Current label restrictions for imazamox applied in canola indicate that *G. hirsutum* and *Z. mays* cannot be planted for nine months after application (WSSA, 2002). Factors that influence carryover include soil type, moisture, and herbicide chemistry. Strip-tillage *G. hirsutum* currently comprises approximately 35% of Georgia *G. hirsutum* (NASS, 2006). This continues to increase as farmers seek new ways to decrease fuel and other high cost inputs while implementing soil conservation.

One reason for the imazamox nine month rotational restriction for *G. hirsutum* and *Z. mays* is the activity this class of herbicides has with respect to carryover potential. Other imidazolinone herbicides include imazapic and imazethapyr and both have eighteen month rotational *G. hirsutum* and *Z. mays* restrictions (WSSA, 2002). However, they have half-lives of 120 and 90 days, respectively. Both are applied at rates of 0.070 kg ai/ha. Imazamox is applied at 0.035 kg ai/ha in IR canola with a half-life of 20 to 30 days. Imazamox is applied at rates that are 50% of imazapic and imazethapyr while having one-third of the half-life would indicate that the rotational restriction for *G. hirsutum* after imazamox maybe to restrictive in the southeastern U.S. In addition, Georgia has moderate winter temperatures coupled with October to May rainfall amounts averaging 66 cm. These combined factors should be conducive to imazamox degradation and minimize persistence.

Rotational scenarios for IR canola using imazamox herbicide followed by *G. hirsutum* and *Z. mays* have not been evaluated. Thus, research was conducted to establish if imazamox carryover would have an effect on *G. hirsutum* and *Z. mays* when planted in rotation with IR canola. Using a double-crop systems approach, the effect of imazamox carryover from IR

canola to strip-tillage *G. hirsutum* and *Z. mays* rotations was evaluated in field experiments.

Materials and Methods

Field studies were established at two locations: Plains and Tifton, Georgia US. Soils at Plains and Tifton were a Faceville sandy clay loam and Tifton loamy sand, respectively. Plots were conventionally prepared using a moldboard plow, then disk harrowed, and rotary tilled to form a bed 1.82 m wide. Plots at Plains were 9.14 m long and at Tifton 7.62 m long. The IR canola cultivar 'Clearfield Nexera US040503' supplied by Dow AgroSciences was planted 11 November, 2005 at both locations. Treatments were arranged as a factorial for three different application timings (2 leaf, 4 leaf, and >8 leaf canola) with three different imazamox rates (0.035, 0.070, and 0.14 kg ai/ha). Studies included a nontreated IR canola control and the conventional canola cultivar 'Flint' for a total of 11 treatments. Treatments were applied 1 December 2005, 4 January 2006, and 10 February 2006 at both locations. Stand counts and injury ratings were taken after each treatment. Canola was harvested in May 2006 at both locations using a small plot combine when standing canola was naturally desiccated. For each location, each test was replicated twice so that two different rotational crops could be planted in 2006.

At each location after the canola harvest, a strip-tillage rig with a 30 cm long shank in tandem with 25 cm wide fluted coulters along with rolling sweeps were used to prepare 2 rows in each plot. In one study, the *G. hirsutum* cultivar DP 445 BG/RR was planted and in the other *Z. mays* was planted, i.e. in different areas of the same field. Tests were maintained weed free by utilizing appropriate herbicides required for weed control for that respective crop along with appropriate pesticides for other pest control.

After *G. hirsutum* and *Z. mays* emergence, stand counts and height measures were taken weekly for the first month after planting. *G. hirsutum* was defoliated when sufficient bolls were open and final seed cotton yield determined by mechanically harvesting the entire plot. At physiological maturity, *Z. mays* silage yield was taken from 2 m of row by hand harvesting the entire stalk by clipping at the base of each plant. *Z. mays* grain yield was determined by hand harvesting 2 m of row.

Results

Canola stand establishment was not affected by herbicide treatment for any location (Tables 1 and 2). There was variability for the Plains (Table 1) planting, but there was no trend for imazamox rate or time of application response. IR canola yields were similar for each treatment by location. Clearfield Nexra may not be fully adapted to this region so actual yield (1130 to 1900 kg/ha) was not representative of potential production for this region. Flint canola, developed by University of Georgia scientist, yielded the highest across the studies (1770 to 2200 kg/ha).

G. hirsutum at Tifton and Plains was not affected by any carryover imazamox treatment (Table 1). These data would indicate that imazamox dissipation was sufficient during the course of the canola growing period (November to May) and that it did not negatively affect cotton growth. There was no significant difference for any factor for *G. hirsutum* with respect to the nontreated check for IR or Flint canola for stand, height, or yield for Tifton or Plains in 2006.

Table 1. Imidazolinone resistant and Flint canola stand and yield evaluating imazamox herbicide at Tifton and Plains Georgia, USA. *Gossypium hirsutum* stand, height and yield when strip-till planted after canola harvest: Values in a single column followed by the same letter are not significantly different at the 5% probability level.

Imazamox	Timing	Canola stand		Canola yield		*G. hirsutum* stand		*G. hirsutum* height		*G. hirsutum* yield	
kg/ha		Tifton	Plains	Tifton	Plains	Tifton	Plains	Tifton	Plains	Tifton	Plains
		#/m row		kg/ha		#/m row		cm/plant		kg/ha	
0.035	2 leaf	43 a	31 ab	1480 b	1680 a	9.1 a	3.4 a	23.9 a	15.3 a	2830 a	3090 a
	4 leaf	42 a	24 b	1340 b	1840 a	11.6 a	4.8 a	22.3 a	18.8 a	2780 a	3260 a
	>8 leaf	53 a	38 a	1490 b	1760 a	9.5 a	6.3 a	23.9 a	16.5 a	2940 a	3310 a
0.070	2 leaf	21 a	41 a	1130 b	1840 a	11.9 a	4.6 a	22.4 a	17.2 a	2920 a	3300 a
	4 leaf	49 a	30 ab	1250 b	1770 a	11.8 a	7.3 a	24.4 a	16.4 a	2880 a	3220 a
	>8 leaf	21 a	32 ab	1230 b	1840 a	11.4 a	6.6 a	22.6 a	15.7 a	2930 a	3670 a
0.14	2 leaf	26 a	34 ab	1350 b	1810 a	13.0 a	6.1 a	24.1 a	15.8 a	2760 a	3320 a
	4 leaf	41 a	35 ab	1360 b	1850 a	11.2 a	6.4 a	24.6 a	15.7 a	2960 a	3060 a
	>8 leaf	36 a	37 b	1610 a	1830 a	11.3 a	4.8 a	19.2 a	15.3 a	2700 a	2820 a
Nontreated	IR canola	38 a	35 ab	1410 b	1760 a	11.6 a	6.4 a	21.9 a	14.9 a	2880 a	3130 a
	Flint	31 a	40 a	1790 a	1810 a	12.8 a	4.6 a	24.1 a	17.5 a	2920 a	3470 a

For *Z. mays*, stand counts and silage production, data were not significantly different between the nontreated and imazamox treatments (Table 2). However, there was *Z. mays* grain yield variability which led to the concern that imazamox carryover could potentially be negatively affecting this crop as it developed over time. But trends in yield reduction were not evident with respect to imazamox rate and timing of application.

Discussion

Imazamox carryover did not affect *G. hirsutum* when it was planted within 3 months of application to >8 leaf IR canola. Time of application for the 2 and 4 leaf treatments until *G. hirsutum* planting was 5 and 4 months, respectively. When in rotation with IR canola using imazamox, *Z. mays* stand establishment and early season growth was not negatively affected but variability in yield was a concern.

Table 2. Imidazolinone resistant (IR) and Flint canola stand and yield evaluating imazamox herbicide at Tifton and Plains Georgia, USA. *Zea mays* stand, silage, and grain yield when strip-till planted after canola harvest: Values in a single column followed by the same letter are not significantly different at the 5% probability level.

Imazamox	Timing	Canola stand		Canola yield		*Z. mays* stand		*Z. mays* silage		*Z. mays* grain yield	
kg/ha		Tifton	Plains	Tifton	Plains	Tifton	Plains	Tifton	Plains	Tifton	Plains
		#/m row		kg/ha		#/m row		T/ha		kg/ha	
0.035	2 leaf	32 a	31 a	1510 b	1660 a	9.9 a	8.1 a	39 a	47 a	7660 a	6790 b
	4 leaf	34 a	22 a	1360 b	1800 a	10.6 a	8.6 a	40 a	52 a	7190 ab	6900 b
	>8 leaf	36 a	30 a	1370 b	1760 a	10.4 a	8.8 a	45 a	55 a	6920 abc	6700 b
0.070	2 leaf	30 a	28 a	1430 b	1820 a	10.2 a	8.7 a	42 a	49 a	6340 bc	7240 b
	4 leaf	38 a	31 a	1610 b	1730 a	9.9 a	9.2 a	42 a	52 a	7010 abc	5990 c
	>8 leaf	38 a	31 a	1610 b	1850 a	10.6 a	8.9 a	43 a	45 a	6770 abc	6770 b
0.14	2 leaf	39 a	46 a	1510 b	1900 a	10.0 a	9.1 a	39 a	48 a	5930 c	8790 a
	4 leaf	28 a	33 a	1580 b	1790 a	10.4 a	8.3 a	40 a	51 a	7220 ab	6100 c
	>8 leaf	27 a	24 a	1450 b	1790 a	10.5 a	8.1 a	43 a	52 a	6740 abc	7190 b
Nontreated	IR canola	38 a	26 a	1550 b	1780 a	9.9 a	7.9 a	45 a	51 a	7360 ab	6970 b
	Flint	33 a	31 a	2200 a	1770 a	10.1 a	8.2 a	40 a	52 a	6430 bc	8460 a

Conclusions

IR (Clearfield) and Flint canola were successfully established as a winter crop in Georgia November 2005. Imazamox herbicide was applied at 0.035, 0.070, and 0.14 kg/ha at 2, 4 and >8 leaf timing applications with no adverse affect on canola and the higher rates and delayed timings did not influence yield. Furthermore, *G. hirsutum* and *Z. mays* were grown in rotation after canola. This allowed for the production of two crops in a 12 month period. Future research will include repeating these studies.

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