NEW WEED CONTROL OPTIONS FOR SWEET CORN

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Callisto (mesotrione) and Impact (topramezone) are the two HPPD-inhibiting herbicides that are currently labeled for postemergence use on sweet corn. Laudis (tembotrione) is another HPPD-inhibiting herbicide that is currently under development by Bayer CropScience for postemergence use on sweet corn. Laudis may be available as soon as 2008 for commercial use. While Callisto is primarily for broadleaf weed control, Impact and Laudis are active on both broadleaf and grass weeds. Impact and Laudis would be the only other options for postemergence grass control other than Accent (nicosulfuron) and Poast (sethoxydim) on sethoxydim-resistant (SR) sweet corn hybrids. Accent has a risk of injuring sensitive fresh market and processing hybrids and only a limited number of SR sweet corn varieties are currently available. Previous research has shown hybrids can have differential tolerance to Callisto, however, little information has been provided about potential injury risks with Impact or Laudis.

Callisto is labeled at 3 oz/a for postemergence applications in sweet corn. Several practices to prevent or minimize sweet corn injury from Callisto are: 1) do not use the adjuvants urea ammonium nitrate (UAN) or ammonium sulfate (AMS); 2) do not apply Callisto postemergence to sweet corn that has been treated with Counter or Lorsban.; 3) do not tank mix Callisto with organophosphate or carbamate insecticides; and 4) do not apply foliar postemergence applications of organophosphate or carbamate insecticides 7 days prior to or 7 days after Callisto applications. Weeds controlled by Callisto are listed in Table 1. Rotational restrictions are listed in Table 2.

Table 1. Weed control ratings of selected postemergence sweet corn herbicides. †

		Callisto	Impact	Accent	Poast
Grass	Barnyardgrass	P	F/G	**G/E**	**E**
	Crabgrass	F/G	F/G	P	**E**
	Fall Panicum	P	F	**G**	**E**
	Foxtails	P	F/G	**G/E**	**E**
	Field sandbur	P	–	**G**	**E**
	Wild proso millet	P	F	**G/E**	**E**
	Woolly cupgrass	P	F	**G/E**	**G**
Broadleaf	Cocklebur	**G**	**G**	P	N
	Common ragweed	F/G	**G**	P	N
	Giant ragweed	**G**	**G**	P	N
	Eastern black nightshade	**E**	**G/E**	P	N
	Common lambsquarters	**E**	**E**	P	N
	Pigweeds	**E**	**E**	**G**	N
	Smartweeds	**E**	**G**	**G**	N
	Velvetleaf	**G/E**	**G/E**	F	N
Perennial	Canada thistle	P/F	F	P	N
	Hemp dogbane	P	–	P/F	N
	Nutsedge	F	–	P	N
	Quackgrass	P	–	**G/E**	F/G

† Control ratings: E=excellent; G=good; F=fair; P=poor; N=none; – = insufficient information

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Table 2. Planting intervals for selected rotational crops after applications of Callisto, Impact, Accent, or Poast.

Herbicide	Alfalfa	Barley	Snap beans	Oats	Peas	Potato	Soybean	Wheat
Callisto	10M	120D	18M	120D	18M	10M	10M	120D
Impact	9M	3M	18M	3M	9M	9M	9-18M†	3M
Accent	10M	8M	10M	8M	10M	10-18M‡	15D	4-8M§
Poast	0	0	0	0	0	0	0	0

† Wait 9M if using 0.5 oz/a rate.
‡ If the soil pH is 6.5 or greater do not plant for 18M.
§ 4M for spring wheat and 8M for winter wheat.

Impact is labeled at 0.75 oz/a unless rotating to soybean. Use 0.5 oz/a if rotating to soybean the following season. The use of methylated seed oil (MSO) and crop oil concentrate (COC) are both labeled adjuvants, but MSO is recommended if possible. A nitrogen fertilizer adjuvant is also recommended. Impact works synergistically with atrazine, so tank mixtures with 0.25 to 1.0 lb ai/a atrazine are recommended. Weeds controlled by Impact are listed in Table 1. Rotational restrictions are listed in Table 2.

Laudis is a new HPPD herbicide that is planned to be registered in 2008. Laudis is currently under development at a use rate of 3.0 oz/a. Final adjuvant requirements and rotational restrictions have not been released at this time.

Efficacy of HPPD-Inhibiting Herbicides in Sweet Corn

Field experiments were conducted at Arlington, WI and Waseca, MN in 2006 to compare herbicide efficacy of Callisto, Impact, and Laudis to several other postemergence programs for broadleaf control. The sweet corn hybrid Legacy was used at both locations. Table 3 lists the treatments used in the experiments.

Table 3. HPPD-inhibiting herbicides and selected broadleaf herbicide treatments evaluated for efficacy in sweet corn.

Herbicide	Timing	Rate	Atrazine	NIS	COC	28% UAN
Lumax	Pre	3 qt/a				
Dual II Magnum	Pre	1.66 pt/a				
fb† Laudis	Post	3 fl oz/a			1%	3 pt/a
fb Laudis	Post	3 fl oz/a	3 pt/a		1%	3 pt/a
fb Callisto	Post	3 fl oz/a		0.25%		
fb Callisto	Post	3 fl oz/a	3 pt/a	0.25%		
fb Impact	Post	0.5 fl oz/a			1%	3 pt/a
fb Impact	Post	0.5 fl oz/a	3 pt/a		1%	3 pt/a
fb Permit	Post	0.67 oz/a	3 pt/a	0.25%		
fb Aim	Post	0.5 oz/a	3 pt/a	0.25%		
fb Laddok	Post	2.33 pt/a				

† fb = followed by.

Postemergence treatments were applied when weeds reached 2 to 4 inches. Weed control ratings were evaluated at 14 and 35 days after treatment. Trials were harvested mechanically and fresh ear weights were recorded.

Efficacy Results

Impact and Laudis, with or without atrazine, provided better giant foxtail control than Callisto when applied after Dual II Magnum at both locations (Table 4). Common lambsquarters control was greater than 90% for all treatments at both locations. Atrazine synergized Impact at the Wisconsin site increasing common lambsquarters control from 91 to 100%. All treatments at Wisconsin controlled velvetleaf at 96% or greater. No statistical differences in velvetleaf control at Minnesota were observed even though the Permit + atrazine treatment only controlled 89% of the velvetleaf. Common ragweed control at Wisconsin was at least 95% for all treatments. Atrazine synergized Callisto at Minnesota increasing common ragweed control from 87 to 100%. Sweet corn yields did not differ among the herbicide treatments.

Table 4. Weed control and yield following postemergence applications of HPPD-inhibiting and other broadleaf herbicides. †

	GIFT		COLQ		VELE		CORW		Yield	
Treatment	WI	MN	WI	MN	WI	MN	WI	MN	WI	MN
	control (%)								tons/a	
Lumax pre	84	99	100	100	100	100	100	100	6.3	7.5
Dual II Magnum pre										
fb ‡ Laudis	89	96	98	100	96	100	98	97	6.0	7.3
fb Laudis + atrazine	97	99	100	100	100	100	100	100	6.1	7.1
fb Impact	98	97	91	98	98	96	95	97	6.6	6.5
fb Impact + atrazine	98	99	100	100	100	100	100	99	6.8	7.1
fb Callisto	82	87	100	100	100	100	96	87	6.4	7.1
fb Callisto + atrazine	82	89	100	100	100	100	100	100	6.7	6.6
fb Permit + atrazine	73	91	99	100	100	89	99	85	5.9	7.3
fb Aim + atrazine	81	81	100	100	100	100	100	87	7.0	6.9
fb Laddok S-12	81	94	99	100	100	100	100	99	7.1	6.6
Nontreated	-	-	-	-	-	-	-	-	3.0	1.9
LSD p=0.05	6	7	8	3	4	18	7	6	1.3	1.2

† GIFT = giant foxtail, COLQ = common lambsquarters, VELE = velvetleaf, CORW = common ragweed

‡ fb = followed by.

Sweet Corn Tolerance to HPPD-Inhibiting Herbicides

Field experiments were conducted at Arlington, WI and Waseca, MN in 2006 to test postemergence applications of Callisto, Impact, and Laudis on six sweet corn hybrids that have suspected low, medium, and high sensitivity based on previous experience with Callisto. The six hybrids tested were Cahill, Dynamo, GH 2042, GH 2547, GH 9597, and Merit. Three herbicide treatments were applied at labeled (1x) and twice labeled (2x) rates. The labeled rates for each herbicide are listed below:

1. Laudis at 3 fl oz/a + 1 pt/a atrazine + 1% COC + 1.5 qt/a 28% UAN
2. Callisto at 3 oz/a + 1 pt/a atrazine + 1% COC
3. Impact at 0.75 fl oz/a + 1 pt/a atrazine + 1% COC + 1.5 qt/a 28% UAN

A preemergence treatment was applied to the entire trial to prevent early season weed competition. The postemergence treatments were applied at the V3-V4 growth stage on June 29 at Arlington and June 26 at Waseca, MN. Crop stunting and chlorosis were evaluated at 7, 14, and 35 days after treatment (DAT). The experiments were harvested for green husk yields. The yields of the nontreated controls are not reported for Waseca because of partial competition from broadleaf weeds.

Tolerance Results

Stunting and chlorosis were greater at the 2x rates of these herbicide treatments. However, the results presented below are the average of the 1x and 2x rates. The hybrid Merit had more stunting and chlorosis than the other five hybrids in the HPPD- inhibiting herbicide tolerance trial (Table 5). This was expected because Merit is homozygous sensitive for the *nsf*1 gene, which encodes a P_{450} enzyme that metabolizes these HPPD-inhibiting herbicides. Laudis killed Merit whereas Callisto stunted Merit by at least 20% at each location. Stunting by Laudis of the other five hybrids was significantly less than the stunting of Merit. Laudis had less than 1% stunting at Arlington, WI and stunting was less than 10% among the five other hybrids at Waseca, MN. Other than with Merit, Callisto caused less stunting than either Laudis or Impact. Impact caused less than 10% stunting of any hybrid at each location.

Table 5. Hybrid injury from three HPPD-inhibiting herbicides when applied with atrazine at 7 days after treatment. Ratings are the mean of the 1x and 2x rates of each herbicide.

		Arlington, WI		Waseca, MN	
Treatment	Hybrid	Stunting	Chlorosis	Stunting	Chlorosis
		----------------------%	----------------------		
Laudis + atrazine	Cahill	0	1	4	3
	Dynamo	0	1	7	2
	GH 2042	0	1	7	7
	GH 2547	0	1	5	4
	GH 9597	0	1	8	3
	Merit	95	3	94	80
Callisto + atrazine	Cahill	0	9	2	1
	Dynamo	1	25	4	8
	GH 2042	0	11	4	6
	GH 2547	0	2	2	0
	GH 9597	0	3	1	2
	Merit	22	62	23	40
Impact + atrazine	Cahill	0	1	5	4
	Dynamo	0	3	9	5
	GH 2042	0	3	5	3
	GH 2547	0	1	4	3
	GH 9597	0	1	4	3
	Merit	0	2	7	3

Merit had the greatest chlorosis with the Laudis and Callisto treatments. The discrepancies between locations for chlorosis with Laudis are meaningless because Merit was nearly dead at this rating date (Table 5). Callisto caused greater chlorosis of Merit than Impact. Dynamo had the most chlorosis with Callisto at both locations of the five remaining hybrids. Dynamo and GH 2042 at Arlington, WI were the only herbicide by hybrid combinations with greater than 10% chlorosis. GH 2547 and GH 9597 had less than 5% chlorosis for all three herbicides at both locations.

GH 2547 and GH 9597 yielded less when treated with the 2x rate of Laudis than with the 1x rate at Waseca, MN (Table 6). Callisto reduced the yield of Merit when comparing the 1x and 2x rates to the control at Arlington, WI, but hybrid yields were similar at Waseca after 1x and 2x rates of Callisto. Dynamo, GH 2042, and Merit had lower yields with 2x rates of Impact at Arlington, WI while GH 2547 and GH 9597 had lower yields at 2x Impact rates at Waseca, MN. Excluding Merit and averaging across the other five hybrids, Laudis and Impact reduced sweet corn yields with the 2x rate as compared with the 1x rate at Waseca, MN (Table 7). There were no differences in yield among the herbicides at Arlington, WI when averaging the yields of these five hybrids.

Table 6. Hybrid yield following treatment with three HPPD-inhibiting herbicides when applied with atrazine at 1x and 2x rates.

		Arlington, WI			Waseca, MN		
Treatment	Hybrid	Control	1x rate	2x rate	Control	1x rate	2x rate
		Tons/acre					
Laudis + atrazine	Cahill	4.7	5.2	5.1	- †	7.9	7.2
	Dynamo	7.9	8.4	8.8	-	11.9	11.2
	GH 2042	5.6	5.2	5.5	-	9.3	8.4
	GH 2547	6.5	6.6	6.5	-	11.5	10.3
	GH 9597	5.1	6.4	6.4	-	9.3	7.8
	Merit	6.3	0.1	0	-	0.5	0.1
Callisto + atrazine	Cahill	4.6	4.4	5.2	-	8.1	7.1
	Dynamo	6.5	6.4	6.5	-	9.8	9.4
	GH 2042	5.8	4.8	5.4	-	6.9	7.5
	GH 2547	6.3	6.6	5.9	-	11.0	10.5
	GH 9597	6.1	6.7	5.7	-	9.2	8.9
	Merit	5.7	4.4	4.1	-	8.7	8.0
Impact + atrazine	Cahill	5.4	5.5	5.2	-	7.3	7.1
	Dynamo	7.7	7.0	6.2	-	9.8	8.9
	GH 2042	6.2	6.7	5.1	-	8.8	8.4
	GH 2547	5.9	6.1	5.5	-	10.7	8.7
	GH 9597	6.0	6.5	6.4	-	9.0	7.0
	Merit	5.9	7.5	4.5	-	8.9	8.2
			$LSD_{0.05}$ = 1.4			$LSD_{0.05}$ = 1.0	

† The control plots were not harvested because partial weed competition reduced yields.

Table 7. Mean yield of Cahill, Dynamo, GH 2042, GH 2547, and GH 9597 following treatment with three HPPD-inhibiting herbicides when applied with atrazine at 1x and 2x rates.

	Arlington, WI			Waseca, MN		
Treatment	Control	1x rate	2x rate	Control	1x rate	2x rate
	Tons/acre					
Laudis + atrazine	5.9	6.4	6.5	- †	10.0	9.0
Callisto + atrazine	5.9	5.8	5.8	-	9.0	8.7
Impact + atrazine	6.2	6.4	5.7	-	9.1	8.0
		$LSD_{0.05}$ = 0.7			$LSD_{0.05}$ = 0.7	

† The control plots were not harvested because partial weed competition reduced yields.

HPPD-Inhibiting Herbicide Conclusions

Impact provides better giant foxtail control than Callisto. Impact provided excellent control of the broadleaf weeds evaluated when tank-mixed with atrazine. The sweet corn hybrids that were tested for tolerance to Impact displayed minimal visual injury. However, sweet corn yields were less when treated with the 2x rate than with the 1x rate at Waseca, MN. Additional research is warranted to validate the potential effect of Impact on sweet corn yield.

Laudis provided better giant foxtail control than Callisto. Laudis provided excellent giant foxtail control when tank-mixed with atrazine and good to excellent control of the broadleaf weeds evaluated even without atrazine. Laudis killed the hybrid Merit, which is homozygous sensitive for the *nsf*1 gene. Excluding Merit, the sweet corn hybrids that were tested for tolerance to Laudis displayed minor visual injury. However, sweet corn yields were less when treated with the 2x rate than with the 1x rate at Waseca, MN. Additional research is warranted to validate the potential effect of Laudis on sweet corn yield.

Callisto provided less giant foxtail control than Impact or Laudis. Callisto provided good to excellent control of the broadleaf weeds evaluated. A wide range of visual injury was observed for Callisto, but yields were only reduced with the highly sensitive hybrid Merit.