Title: *HPPD Herbicides for Weed Control in Sweet Corn*

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Introduction: Full season weed control is needed to prevent yield loss and maintain harvest efficiency in sweet corn production. Postemergence herbicide applications are often necessary to maintain full season control, even if soil-applied residual herbicides were used at planting. Postemergence herbicide use relies heavily on HPPD-herbicides (group 27). There are four HPPD-herbicides currently labeled for sweet corn: Callisto (mesotrione), Impact or Armezon (topramezone), Laudis (tembotrione), and Shieldex (tolpyralate). These HPPD herbicides are primarily tank-mixed with atrazine, which has been shown to improve weed control efficacy and broaden the weed control spectrum. They are similar in chemistry but can differ in herbicide efficacy, weed control spectrum, and label restrictions. For example, the newest HPPD in the sweet corn market, Shieldex, has a similar weed control spectrum to Callisto but has significantly shorter replant intervals than the other HPPD products. The rotation to most cucurbits, including pumpkins, is 9 months for Shieldex, while the rotation is 18 months for the other three herbicides. Consideration of rotation restrictions is one of the primary factors that limit use of postemergence HPPD herbicides in sweet corn production. Additional factors may include concerns for carryover injury to post-harvest seeded cover crops.

We conducted experiments to improve management recommendations for use of postemergence HPPD herbicides in sweet corn production. Our experiment was designed to evaluate how postemergence HPPD herbicides (1) differ in weed control efficacy; (2) differ in weed control efficacy and weed control spectrum when applied with and without atrazine; and (3) and impact establishment rate of various post-harvest seeded cover crop species.

Materials and Methods: Experiments were conducted at two locations: (1) the Russell E. Larson Agricultural Research Farm in Centre County and (2) the University of Delaware Research and Extension Center in Sussex County. Herbicide treatments included mesotrione (Callisto), tembotrione (Laudis), topramezone (Impact or Armezon) and tolpyralate (Shieldex) applied at a 1X rate with and without atrazine and a 2X rate to improve evaluations of carryover potential to post-harvest seeded cover crops (**Table 1**). Herbicides were applied with label-recommended adjuvants.

Herbicide treatments were evaluated in a randomized complete block design with three replications. The plots were four rows by 25 feet long and a representative sweet corn variety was used. Standard tillage and seed bed preparation was used followed by an application of a set-up pre-emergence herbicide program across the study site within 2 days of planting. Weed control and crop injury were visually evaluated 2 and 4 weeks after application of postemergence herbicide treatments and just prior to harvest. Following sweet corn harvest, plots were mowed and three cover crop species (cereal rye, crimson clover, forage radish) were be drill-seeded in each plot in separate rows by modifying seed boxes to direct individual cover crop species to different drill units. The same variety of cover crop species was used at both experiment locations. Cover crop establishment rate and injury were evaluated 4 and 8 weeks after application.

Table 1. Herbicide treatments

Treatment	**Rate (per ac)**
Callisto 4SC	3 fl oz
Callisto 4SC + atrazine	3 oz + 1 pt
Callisto 4SC (2X)	6 fl oz
Shieldex 400SC	1.25 fl oz
Shieldex 400SC + atrazine	1.25 oz + 1 pt
Shieldex 400SC (2X)	2.5 fl oz
Impact 2.8SC	1 fl oz
Impact 2.8SC + atrazine	1 oz + 1 pt
Impact 2.8SC (2X)	2 fl oz
Laudis	3 fl oz
Laudis + atrazine	3 oz + 1 pt
Laudis (2X)	6 fl oz
Untreated check	--
Weed-free check	--

Results. At the Delaware location, postemergence control of Palmer amaranth was higher in Shieldex, Impact and Laudis treatments compared to Callisto when averaged across treatments (**Table 1**). However, the opposite trend was observed for control of annual morningglory, where control levels were higher in Callisto treatments compared to other HPPD programs when averaged across treatments. Tank-mixing atrazine with each HPPD herbicide consistently increased broadleaf weed control levels compared to applying HPPDs alone at 1X rates and were comparable or greater than 2X rates applied alone. Annual grass control was generally poor across treatments, with Impact providing the greatest efficacy (63 – 76%) among HPPD herbicides.

Herbicide treatments significantly impacted post-harvest establishment of cover crops at the Georgetown DE location (**Table 2**). However, the range of observed levels of biomass reduction were low to moderate (< 15%) and unlikely to impact the conservation benefits produced by the cover crop. Forage radish biomass reduction was higher in Laudis treatments compared to other HPPDs and crimson clover biomass reduction was lower in Shieldex treatments compared to others. No differences in cereal rye biomass reduction were observed among HPPD herbicides. Tank-mixing atrazine with HPPD inhibitors did not significantly affect cover crop injury levels compared to HPPDs applied alone.

At the Pennsylvania location, Callisto and Shieldex resulted in higher levels of common lambsquarters control compared to Impact and Laudis when applied alone (**Table 3**). Tank-mixing with atrazine improve lambsquarters control for each HPPD herbicide.

Tank-mix combinations resulted in high levels of control (> 95 %) and did not differ among HPPD herbicides.

The effect of herbicide treatments on cover crop establishment at the Pennsylvania location was species specific. No injury or biomass reduction was observed in post-harvest established cereal rye and forage radish. Standard rates of Callisto, Shieldex and Laudis applied alone or combination with atrazine resulted in minimal injury to crimson clover establishment, whereas Impact treatments resulted in crimson clover biomass reduction levels (18 – 22%) that may impact cover crop performance.

Summary & Conclusions: Results demonstrate that HPPD herbicides available for postemergence use in sweet corn differ in their selectivity. Each HPPD herbicide provided acceptable control of small seeded broadleaf species but varied in control of large seeded (annual morningglory) and annual grass (fall panicum) species. Importantly, tank-mixing atrazine improved total weed control levels for each HPPD herbicide and at each location, which demonstrates the utility and value of HPPD + atrazine combinations.

The effects of HPPD herbicides on establishment of cover crop species varied across locations, with minimal impacts observed on the establishment of cereal rye and forage radish. The use of Impact reduced crimson clover establishment at one location. Carryover potential of HPPD herbicides is mediated by soil type, rainfall after application, and the duration to cover crop seeding. Additional field trials will be needed to fine tune recommendations for cover crop establishment following post emergent use of HPPDs in sweet corn but results of these field trials suggest that post-harvest cover crop seeding is compatible with HPPD post emergence use.

Table 1. Herbicide treatment effects on weed species 30 days after application (30 DAA) at the Georgetown, DE location. Means followed by the same letter are not significantly different ($P > 0.05$).

Treatment	Palmer amaranth	Annual morningglory	Fall panicum
	---------- % control (30 DAA) ----------		
Callisto 4SC	66 c	50 de	33
Callisto 4SC + atrazine	94 a	88 a	40
Callisto 4SC (2X)	73 bc	80 ab	40
Shieldex 400SC	87 ab	33 f	50
Shieldex 400SC + atrazine	94 a	71 bc	56
Shieldex 400SC (2X)	95 a	40 ef	68
Impact 2.8SC	88 ab	47 def	63
Impact 2.8SC + atrazine	97 a	68 bc	71
Impact 2.8SC (2X)	98 a	60 cd	76
Laudis	84 ab	43 ef	20
Laudis + atrazine	98 a	93 a	33
Laudis (2X)	87 ab	60 cd	43

Table 2. Herbicide treatment effects on cover crop establishment and visual reduction biomass 60 days after planting (DAP) at the Georgetown, DE location. Means followed by the same letter are not significantly different (P > 0.05).

Treatment	Cereal rye	Forage radish	Crimson clover
	----- % biomass reduction (60 DAP) -----		
Callisto 4SC	7 bc	2 bc	2 b
Callisto 4SC + atrazine	11 ab	2 bc	12 a
Callisto 4SC (2X)	13 a	9 a	10 a
Shieldex 400SC	3 cd	7 ab	0 b
Shieldex 400SC + atrazine	0 d	2 bc	2 b
Shieldex 400SC (2X)	12 ab	12 a	0 b
Impact 2.8SC	11 ab	0 c	0 b
Impact 2.8SC + atrazine	3 cd	2 bc	9 a
Impact 2.8SC (2X)	0 d	12 a	9 a
Laudis	15 a	10 a	9 a
Laudis + atrazine	13 a	9 c	2 b
Laudis (2X)	9 ab	0 c	2 b

Table 3. Herbicide treatment effects on weed species 30 days after application (30 DAA) at the Rock Springs, PA location. Means followed by the same letter are not significantly different (P > 0.05).

Treatment	Common lambsquarters	Common dandelion
	---------- % control (30 DAA) ----------	
Callisto 4SC	92 bc	75 bcd
Callisto 4SC + atrazine	99 a	84 a
Callisto 4SC (2X)	96 ab	80 ab
Shieldex 400SC	94 ab	79 abc
Shieldex 400SC + atrazine	99 a	83 a
Shieldex 400SC (2X)	98 ab	82 a
Impact 2.8SC	83 de	63 f
Impact 2.8SC + atrazine	95 ab	70 de
Impact 2.8SC (2X)	82 e	62 f
Laudis	79 e	66 ef
Laudis + atrazine	98 ab	74 cd
Laudis (2X)	88 cd	66 ef

Table 4. Herbicide treatment effects on cover crop establishment and visual reduction biomass 60 days after planting (DAP) at the Rock Springs, PA location. Means followed by the same letter are not significantly different (P > 0.05).

Treatment	Cereal rye	Forage radish	Crimson clover
	----- % biomass reduction (60 DAP) -----		
Callisto 4SC	0	0	3 cd
Callisto 4SC + atrazine	0	0	10 c
Callisto 4SC (2X)	0	0	7 cd
Shieldex 400SC	0	0	3 cd
Shieldex 400SC + atrazine	0	0	4 cd
Shieldex 400SC (2X)	0	0	20 b
Impact 2.8SC	0	0	18 b
Impact 2.8SC + atrazine	0	0	22 b
Impact 2.8SC (2X)	0	0	45 a
Laudis	0	0	5 cd
Laudis + atrazine	0	0	2 d
Laudis (2X)	0	0	2 d