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Selectivity of fomesafen based systems for preemergence weed control in cucurbit crops

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ABSTRACT

Experiments at two sites during two years evaluated the selectivity of preemergence fomesafen in cucurbit crops of winter and summer squash, zucchini, cantaloupe, cucumber, and pumpkin. Cucumbers were the most sensitive of the cucurbit crops to fomesafen and produced little or no fruit in two out of three experiments when applied at 0.28 kg ai ha^{-1}. Fomesafen also reduced cantaloupe yield. Visual damage was noted on the other crops tested, but crop yield was not impacted by fomesafen at 0.28–0.35 kg ai ha^{-1}. With the exception of cucumbers, injury caused by fomesafen to cucurbit crops was transitory even when fomesafen-treated soil splashed onto the leaves of emerging cucurbits during a powerful thunderstorm at one of the test sites. Control of redroot pigweed (*Amaranthus retroflexus*), Powell amaranth (*Amaranthus powellii*) and other *Amaranthus* spp., lambsquarters (*Chenopodium album*), hairy nightshade (*Solanum physafolium*), common purslane (*Portulaca oleraceae*), and velvetleaf (*Abutilon theophrastii*) ranged from 92 to 100% with fomesafen applied at 0.28 kg ai ha^{-1}. The excellent efficacy on these difficult to control weed species suggests that lower rates of fomesafen may be appropriate and improve crop tolerance, particularly if fomesafen is tankmix-applied with other preemergence herbicides such as s-metolachlor or dimethenamid-p. Weed control with these combinations was excellent for all weed species in these experiments.

1. Introduction

A wide diversity of crops of the Cucurbitaceae family are grown in the US for fresh, processed, and ornamental markets. These crops include cucumbers (*Cucumis sativus*), zucchini and other summer squash (*Cucurbita pepo*), fall and winter squash (*Cucurbita maxima*), and pumpkins (*C. maxima, Cucurbita moschata, and C. pepo*) (Tapley et al., 1937). One of the most difficult pest management challenges in these crops is weed control. If left unchecked, weeds significantly compete for nutrients, water and light with low growing cucurbits (Friesen, 1978), interfere with pollinators, and impede harvest. Factors that exacerbate weed control difficulties in cucurbits are the length of the growing season for crops such as pumpkins and winter squash, the vining habit of many cucurbit crops that quickly envelops rows and precludes cultivation, a relatively low economic value that limits the potential to use alternate methods such as hand weeding, and the high level of weed control needed if crops are to be machine harvested. Only a few herbicides are currently labeled for use on cucurbits in the US. Uncertainty regarding crop tolerance is a major impediment to registration of new active ingredients.

Cucurbitaceous crops represent an abundance of types and cultivars with a large diversity of genetic backgrounds, and therefore, a wide range of potential tolerance to herbicides (Wills and Putman, 1986; Figueroa and Kogan, 2005). Seed size varies greatly between the cucurbit species, which influences planting depth and possibly tolerance of many cucurbits to soil-applied herbicides. Cucurbitaceous crops are sensitive to many herbicides that are typically used in major agronomic crops such as corn, soybeans, and small grains, and this greatly restricts the herbicides available for development. Cucurbits are extremely sensitive to most triazines, many growth regulator herbicides, and several sulfonylurea herbicides.

Of the few herbicides that are registered for use in cucurbits, most have major limitations including narrow weed control spectrums and long crop rotation intervals. Ethalfluralin is commonly used for preemergence weed control in cucurbit production, but control of important species such as *Solanum physafolium* (hairy nightshade) and *Solanum nigrum* (black nightshade) is poor (Tonks et al., 2000). Cucurbit crops are moderately tolerant to ethalfluralin

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(Grey et al., 2000a,b), but cold and wet conditions during and after emergence will often stunt the crop and greatly reduce yield potential. Halosulfuron is also registered for control of some broadleaf weeds, but halosulfuron residues persisting into the next planting season may damage sensitive crops such as beets, brassica crops, and in some cases, cucurbit crops (Webster and Culpepper, 2005). Clomazone is labeled for use in some cucurbits but may interfere with carotenoid synthesis, particularly if parentage includes NK530 types (FMC, 2005) and will sometimes slow development of the orange pigment and maturity in pumpkins or squash (Barth et al., 1995). Clomazone also is persistent in the soil with rotation intervals up to 16 mo for sensitive crops, is prone to volatilization that will whiten adjacent crops, and does not adequately control *Amaranthus* spp. (Al-Khatib et al., 1995).

Fomesafen is a diphenyl-ether with both root and shoot activity with potential for preemergence weed control in cucurbits. Fomesafen inhibits protoporphyrinogen oxidase (protox), an enzyme needed for biosynthesis of chlorophyll (Senseman, 2007). Fomesafen controls a wide range of broadleaved weeds that are important in cucurbits including *Amaranthus* spp., nightshades (*Solanum* spp.), common lambsquarters (*Chenopodium album*), ladysthumb (*Polygonum persicaria*), velvetleaf (*Abutilon theophrasti*), and common purslane (*Portulaca oleracea*) (Senseman, 2007). Johnson and Talbert (1992) indicated that cucurbits were less sensitive to fomesafen carryover than several other rotational vegetable crops. Preliminary experiments in 1997 demonstrated that cucurbits are relatively tolerant to fomesafen but that selectivity may not be consistent across crops of the family Cucurbitaceae, including cultivars within *C. maxima, C. moschata, Cucurbita mixta, C. pepo and C. sativus*. Fomesafen is primarily a broadleaf herbicide and may need to be tankmixed with other herbicides to provide broad spectrum weed control. The objectives of this research were to evaluate the selectivity of fomesafen when used in a variety of cucurbits with and without tankmix herbicides to control grass weeds.

2. Methods and materials

Four studies were conducted at two sites over two years on silt loam soils to evaluate selectivity of fomesafen in cucurbit crops. Crops chosen for the study were economically significant to the study regions in Western Oregon and northcentral Ohio and included cucumbers, zucchini, cantaloupe, summer and winter squash, and pumpkin. The experiment near Corvallis was on the Oregon State University Vegetable Research Farm with soils of the 'Chehalis' series (fine-silty, mixed, mesic Cumulic Ultic Haploxeroll) comprised of 30% sand, 50% silt, and 20% clay. The experiments near Wooster were at the Ohio Agricultural Research and Development Center (OARDC) on a Wooster silt loam (fine-loamy, mixed, mesic Oxyaquic Fragiudalf) comprised of 11% sand, 75% silt, and 14% clay. The crops evaluated, site characteristics, and methodologies unique to each crop and situation are described in Tables 1 and 2.

The experimental design used to evaluate selectivity of fomesafen was a split-plot with main effects of herbicide treatment and cucurbit crop with each herbicide treatment replicated 4 times in a randomized complete block design. Herbicide treatments were applied preemergence (PRE) to main plots (A) and cucurbits seeded in subplots (B) except at Corvallis in 2008, where cucurbit crops were seeded to main plots (A) and herbicide treatments applied to subplots (B). Cucurbits were planted in mid-May through mid-July depending on crop and seasonal weather (Table 2). Herbicides were applied with backpack CO_2 sprayers set at 172–206 kPa and delivering 187–234 l/ha. Approximately 1.3 cm of water was applied with overhead irrigation within one day of applying the herbicides.

Emerged crop seedlings were counted at 2 weeks after treatment (WAT). Crop injury and weed control were evaluated visually at 2 WAT (approximately 7–10 days after cucurbit crops began to emerge) and again at 4 WAT. Crop injury was visually evaluated for each plot and rated on a scale of 0 (no injury or growth reduction compared to the untreated check plot) to 100% injury (complete death). Percent weed control was evaluated for the predominate weed species present at each site at 3 and 6 WAT. After the last crop and weed evaluation, plots were cultivated between rows. The weed-free plots were hand-weeded throughout the season. Crops were harvested and marketable yield determined. Cucumber and zucchini were picked 4 times and graded to industry standards. Maturity in pumpkin and summer and winter squash was determined by color.

Analysis of variance was completed with the PROC Mixed procedure of SAS (2008) using a model for split-plot designs where the RANDOM statement included effects of BLOCK and

Table 1
Crops and planting methods.

Site-year	Genus and species	Type	Cultivar	Planting method	Planting depth (cm)	Seed spacing within row (no m of row^{-1})	Number of harvests reported	Plot width and length (m)	Crop rows per plot and row spacing (cm)	Area harvested (m of row)
Corvallis-08	*Cucumis sativus*	Cucumber	Speedway	Belt planter	2.5	2.2	0[a]	2.4 × 7.6	1	–
Corvallis-08	*Cucurbita maxima*	Hubbard winter squash	Golden Delicious	JD Max Emerge	3.8	3.3	1	4.9 × 7.6	2–76	7.6
Corvallis-08	*Cucurbita pepo*	Zucchini	Tigress	Belt planter	2.5	1.6	1	2.4 × 7.6	1	4.5
Wooster-08	*Cucurbita pepo*	Cantaloupe	104 SE	Hand	1.3	2.2	1	2.4 × 9.1	1	9.1
Wooster-08	*Cucumis sativus*	Cucumber	Eureka	Hand	1.3	2.2	4	2.4 × 9.1	1	9.1
Wooster-08	*Cucurbita pepo*	Pumpkin	Chucky (157)	Hand	2.5	2.2	1	2.4 × 9.1	1	9.1
Corvallis-09	*Cucurbita moschata*	Butternut winter squash	Ultra	Belt planter	3.2	3.3	1	2.8 × 6.1	2–76	6.1
Corvallis-09	*Cucurbita maxima*	Hubbard winter squash	Golden Delicious	Belt planter	3.2	3.3	1	2.8 × 6.1	2–76	6.1
Corvallis-09	*Cucurbita moschata*	Pumpkin	Dickinson	Belt planter	3.2	3.3	1	2.8 × 6.1	2–76	6.1
Corvallis-09	*Cucurbita pepo*	Zucchini	Elite	Belt planter	3.2	3.3	4[b]	2.8 × 6.1	2–76	6.1
Wooster-09	*Cucumis sativus*	Cucumber	Improved Long green	Hand	2.5	3.3	4	2.4 × 7.6	1	7.6
Wooster-09	*Cucurbita pepo*	Pumpkin	Small Sugar	Hand	2.5	3.3	1	2.4 × 7.6	1	7.6
Wooster-09	*Cucurbita pepo*	Summer squash	Yellow Crookneck	Hand	2.5	3.3	1[b]	2.4 × 7.6	1	7.6

[a] Yield data not reported because of poor emergence and unrepresentative yields.
[b] Harvest of summer squash reported until treatment effects dissipated.