Influence of Winter Rye and Preemergence Herbicides on Weed Control in No-tillage Zucchini Squash Production

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ADDITIONAL INDEX WORDS. *Amaranthus retroflexus*, clomazone, conservation tillage, *Cucurbita pepo*, *Digitaria ischaemum*, ethalfluralin, halosulfuron, vegetable production

SUMMARY. The influence of 'Elbon', 'Maton', and 'Wheeler' winter rye (*Secale cereale*) with or without herbicide treatments on weed control in no-tillage (NT) zucchini squash (*Cucurbita pepo*) was determined. 'Elbon' or 'Maton' produced higher residue biomass, greater soil coverage, and higher weed control compared with 'Wheeler'. Although winter rye alone did not provide sufficient weed control (generally <70%), it provided substantially greater redroot pigweed (*Amaranthus retroflexus*) and smooth crabgrass (*Digitaria ischaemum*) control (regardless of cultivar used) compared with no winter rye at both 28 and 56 days after transplanting (DAT). No effect ($P > 0.05$) of winter rye cultivar on early or total squash yield was detected. Although applying clomazone + ethalfluralin to winter rye residues improved redroot pigweed control compared with no herbicide, the level of control was generally not adequate (<85% control) by 56 DAT. Treatments that included halosulfuron provided greater control of redroot pigweed than clomazone + ethalfluralin, and redroot pigweed control from halosulfuron treatments was similar to the weed-free control.

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However, regardless of year or cover crop, any treatment with halosulfuron caused unacceptable injury to zucchini squash plants which lead to reduced squash yield (primarily early yields). Insignificant amounts of squash injury (<10% due to stunting) resulted from clomazone + ethalfluralin in no-tillage plots during either year. Treatments with clomazone + ethalfluralin had early and total yields that were similar to those of the weed-free control, although this herbicide combination provided less weed control compared with the weed-free control.

Although there was a 300% increase in no-tillage acreage in the midwestern U.S. during the 1990s (Conservation Tillage Information Center, 1999), vegetable growers have been reluctant to use no-tillage practices (NeSmith et al., 1994; Walters and Kindhart, 2002). Weeds are the major problem in no-tillage vegetable production systems and there are few herbicides available to control weeds in most vegetable crops, as the use and number of herbicides available are dependent on the specific vegetable grown (Egel et al., 2004). The adoption of no-tillage by commercial vegetable growers has been limited (Galloway and Weston, 1996) and improved weed management practices need to be developed before no-tillage systems in vegetable production will be readily adopted.

Approximately 2500 acres (1012 ha) of zucchini and yellow squash are grown in Illinois (M. Babadoost, personal communication), and many squash growers are interested in no-tillage production. In Illinois, most squash growers use transplants for the spring crop and this requires additional inputs compared with direct seeding. Growers apply preemergence herbicides regardless of whether conventional tillage or no-tillage is used, and squash is transplanted into the herbicide-treated soil. Squash growers complain that harvesters cannot locate fruit as easily on squash plants that are shaded by weeds compared with those growing in a weed-free field, and this contributes to reduced harvest efficiency and yield loss. Research has indicated that when weeds are sufficiently controlled, squash grown in no-tillage yield similarly to those grown in conventional tillage (Knave and Herron, 1986; NeSmith et al., 1994; Walters and Kindhart, 2002).

No-tillage, in conjunction with the use of winter cover crops, can become an important part of vegetable production by reducing soil erosion and aiding in weed control (Marr et al., 1998; Morse, 1999). Winter rye can suppress weed densities in no-tillage production systems (Barnes and Putnam, 1983; Teasdale et al., 1991; Weston, 1990; Zasada et al., 1997); however, small grain cover crops (e.g., winter rye) must be killed to minimize competition with the vegetable crop (Zandstra et al., 1998). Reberg-Horton et al. (2001) found differences between winter rye cultivars for allelochemical levels, which could influence weed suppression. 'Wheeler' winter rye had higher levels of the allelochemical, DIBOA [2,4-dihydroxy-1,4-(2*H*)-benzoxazine-3-one], compared with several other cultivars. The objective of this study was to evaluate the effectiveness of different winter rye cultivars ('Wheeler' as well as two others recommended for use in southern Illinois) along with various pretransplant herbicide treatments for weed control in no-tillage zucchini squash production.

Materials and methods

Experiments were conducted during 2002 and 2003 at the Southern Illinois University Horticulture and Forestry Research and Education Laboratory in Carbondale. The experiment was designed as a split-plot with four replications. The four main plots were: 1) 'Elbon' winter rye, 2) 'Maton' winter rye, 3) 'Wheeler' winter rye, and 4) no winter rye. Subplots consisted of six herbicide treatments (on active ingredient basis): 1) cultivation with 0.31 lb/acre (0.347 kg·ha⁻¹) clomazone and 1.0 lb/acre (1.12 kg·ha⁻¹) ethalfluralin; 2) no-tillage with 0.31 lb/acre clomazone and 1.0 lb/acre ethalfluralin; 3) no-tillage with 0.031 lb/acre (0.035 kg·ha⁻¹) halosulfuron; 4) no-tillage with 0.31 lb/acre clomazone and 1.0 lb/acre ethalfluralin + 0.031 lb/acre halosulfuron; 5) no-tillage that was not weeded (no-herbicide); and 6) no-tillage with hand-weeding (weed-free).

Plots were 10 ft (3.0 m) long with 3-ft-wide (0.9 m) alleys between them. Center-to-center row spacing was 3 ft with two rows per plot and in-row spacings of 2 ft (0.6 m). Ten plants per plot were evaluated. The field soil was a Hosmer silt loam (fine-silty, mixed, mesic Typic Fragiudalfs;

Herman, 1979) with a 1.5% organic matter content and 6.5 pH.

Winter rye was planted 20 Oct. each year (2001 and 2002) at a broadcast seeding rate of 120 lb/acre (134.5 kg·ha⁻¹) (Samples and Sule, 2000) and fertilized 25 Feb. with 35 lb/acre (39.2 kg·ha⁻¹) N. Winter rye was killed 20 Apr. with 0.78 lb/acre (0.874 kg·ha⁻¹) acid equivalent glyphosate (Monsanto, St. Louis) and mowed with a rotary mower to a height of 2.5 inches (6.35 cm) approximately 3 weeks later. Herbicide treatments were applied to the soil 2 to 3 d after mowing. 'Independence II' zucchini squash seedlings were grown in 72-cell plastic trays [6.6 inch³ (108.15 cm³) individual cell volume] containing a soilless medium consisting of 2 peat-moss:1 vermiculite:1 perlite. Squash transplants were planted with a bulb transplanter having a 2.5-inch-diameter opening within 3 d of herbicide application (mid-May). Herbicide treatments were applied with a carbon dioxide-pressurized backpack sprayer using 8003 flat-fan spray tips (TeeJet; Spraying Systems Co., Wheaton, Ill.) at 40 psi (275.8 kPa) in 20 gal/acre (187.1 L·ha⁻¹) water.

Standard cultural practices for squash in Illinois were used (Egel et al., 2003; Foster et al., 2002). Before transplanting, 30 lb/acre (33.6 kg·ha⁻¹) N, 36 lb/acre (40.3 kg·ha⁻¹) P, and 66 lb/acre (73.9 kg·ha⁻¹) K were broadcast. Plots were sidedressed with 40 lb/acre (44.8 kg·ha⁻¹) N 4 weeks after transplanting. Overhead sprinkler irrigation was utilized to activate the preemergence herbicides and to ensure that the experiment received at least 1 inch (2.5 cm) water weekly throughout the growing season. Diseases and insects were controlled by spraying recommended rates of esfenvalerate (Asana; E.I. du Pont de Nemours and Co., Wilmington, Del.) or carbaryl (Sevin; Rhone-Poulenc Ag Company, Research Triangle Park, N.C.) and chlorothalonil (Bravo; Zeneca, Inc., Wilmington, Del.) twice per week for the duration of the experiment. Once flowering commenced, a honeybee (*Apis mellifera*) hive was placed in the field adjacent to the experimental site.

Squash plant injury was rated from 0% = no squash injury (discoloration or stunting) to 100% = squash plant mortality and weed control was rated from 0% = no weed control to 100%

= complete weed control at 14, 28, and 56 d after transplanting (DAT) squash. Percent soil coverage of winter rye residues was rated from 0% (no residues) to 100% (soil completely covered with residues). Winter rye dry biomass per square foot of soil area was also determined. Weed counts per 1-ft² area were determined in the no-herbicide treatments to obtain the effect of winter rye on weed suppression. Zucchini squash were harvested between mid-June and the first week of July, every 2 to 3 d with a total of 12 harvests. The fruit were graded into marketable [1.5–2.5 inches (3.81–6.35 cm) diameter], oversize (>2.5 inches diameter), or cull (misshapened, off-color, or decaying fruit). Harvests were combined and squash yields were evaluated as either early (first six harvests) or total-season (all 12 harvests).

Data were subjected to analysis of variance procedures using general linear models procedure of SAS (SAS Institute, Cary, N.C.) appropriate for a split plot experimental design to determine the effects of winter rye and preemergence herbicide treatments on squash plant injury, weed control and squash yields. Linear contrasts were used to make comparisons between rye cultivars and herbicide treatments where F-tests were significant.

Results and discussion

WINTER RYE. The winter rye cultivar had a significant effect on percent soil coverage and biomass production (Table 1). Over the 2002 and 2003 growing seasons, 'Elbon' and 'Maton' produced greater residue biomass and had greater soil coverage compared with 'Wheeler'. All cultivated plots had ~10% to 15% residue coverage on soil regardless of the cover crop used (data not shown).

ZUCCHINI SQUASH INJURY. Squash injury did not occur at 14 DAT in both years. Halosulfuron caused injury to squash at 56 DAT with ~25% and 10% injury observed for 2002 and 2003, respectively (data not presented). However, significant amounts of squash injury was observed at 28 DAT in both years. At 28 DAT, the year × cover crop and year × herbicide interactions were significant ($P \leq 0.05$). The analysis also indicated an interaction ($P \leq 0.01$) of herbicide with cover crop. Therefore, squash injury data at 28 DAT are presented by year, cover crop, and herbicide treatment (Table 2).

Table 1. Percent winter rye coverage over soil and winter rye biomass after mowing, and weed densities [redroot pigweed (RRPW) and smooth crabgrass (SMCG)] taken approximately 28 and 56 d after transplanting (DAT) combined over the 2002 and 2003 growing seasons.^z

Cover crop	Soil coverage (%) ^x	Dry biomass (oz/ft ²) ^w	Weed density (plants/ft ²) ^y			
			RRPW (DAT)		SMCG (DAT)	
			28	56	28	56
No winter rye	0	0.0	5.9	11.4	16.3	36.4
Wheeler winter rye	49	1.6	2.5	5.5	11.5	29.8
Elbon winter rye	93	7.5	0.8	2.6	4.3	15.1
Maton winter rye	89	7.8	0.7	2.6	4.8	16.5
Contrasts						
No winter rye						
- vs. winter rye	***	***	***	***	**	*
Elbon vs. Maton	NS	NS	NS	NS	NS	NS
Elbon, Maton vs. Wheeler	**	***	**	**	***	**

^zResults are from the no-herbicide, no-tillage treatment.

^x1.0 plant/ft² = 10.76 plants/m².

^yWinter rye biomass soil coverage is rated from 0 to 100%, with 0% = no coverage of soil to 100% = complete soil coverage.

^wDry biomass is the amount of dry winter rye residue biomass per square foot of soil area; 1.0 oz/ft² = 305.17 g·m⁻².

^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.0001, respectively.

Table 2. Ratings of 'Independence II' zucchini squash injury at 28 d after transplanting (DAT) as influenced by various winter rye cultivars and preemergence herbicide treatments during Spring 2002 and 2003.

Cover crop/herbicide-tillage	Squash injury (%) ^z	
	2002	2003
No cover crop (NCC)		
Clom ^y + Ethal ^v -T	5	0
Clom + Ethal-NT	5	0
Halo ^y -NT	11	12
Halo + Clom + Ethal-NT	23	10
Wheeler winter rye (WR)		
Clom + Ethal-T	40	0
Clom + Ethal-NT	9	4
Halo-NT	33	13
Halo + Clom + Ethal-NT	20	16
Elbon winter rye (WR)		
Clom + Ethal-T	54	0
Clom + Ethal-NT	0	0
Halo -NT	38	15
Halo + Clom + Ethal-NT	46	13
Maton winter rye (WR)		
Clom + Ethal-T	45	0
Clom + Ethal-NT	0	1
Halo-NT	26	16
Halo + Clom + Ethal-NT	24	14
Contrasts		
NCC vs. WR	**	NS
Ethal + Clom-T vs. Ethal + Clom-NT	***	NS
Halo-NT vs. Ethal + Clom-NT, T	***	***
Halo-NT vs. Halo + Ethal + Clom-NT	NS	NS
No-herbicide-NT, weed-free-NT vs. Ethal + Clom-NT	NS	NS
No-herbicide-NT, weed-free-NT vs. Halo-NT,		
Ethal + Clom + Halo-NT	***	***

^zSquash injury rated from 0% (no injury) to 100% (plant mortality).

^yClom = 0.31 lb/acre a.i. clomazone; Ethal = 1.0 lb/acre a.i. ethalfluralin; and Halo = 0.031 lb/acre a.i. halosulfuron. T = tillage and NT = no-tillage. No crop injury was observed in the handweed or no-herbicide treatments; 1 lb/acre = 1.12 kg·ha⁻¹.

^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.01$ or 0.0001, respectively.

Table 3. Percent control of smooth crabgrass (SMCG) and redroot pigweed (RRPW) in ‘Independence II’ zucchini squash at 28 and 56 d after transplanting (DAT) as influenced by various winter rye cultivars and preemergence herbicide treatments during Spring 2002 and 2003.

Cover crop/ herbicide-tillage	SMCG control ^z				RRPW control ^z			
	28 DAT		56 DAT		28 DAT		56 DAT	
	2002	2003	2002	2003	2002	2003	2002	2003
No cover crop (NCC)								
Clom ^y + Ethal ^y -T	95	95	58	70	76	65	73	20
Clom + Ethal-NT	91	95	84	83	76	63	85	30
Halo ^z -NT	40	14	20	0	88	90	88	91
Halo + Clom + Ethal-NT	68	90	45	59	81	95	75	91
Wheeler winter rye (WR)								
Clom + Ethal-T	96	99	74	90	78	85	70	55
Clom + Ethal-NT	93	95	92	86	90	84	84	68
Halo-NT	65	53	70	21	94	96	91	93
Halo + Clom + Ethal-NT	91	98	78	79	94	99	90	91
Elbon winter rye (WR)								
Clom + Ethal-T	91	95	70	91	82	85	71	64
Clom + Ethal-NT	99	94	95	88	99	91	95	80
Halo-NT	75	80	70	66	97	95	95	90
Halo + Clom + Ethal-NT	95	90	88	79	95	97	89	91
Maton winter rye (WR)								
Clom + Ethal-T	95	98	61	90	83	86	66	58
Clom + Ethal-NT	99	90	88	88	99	93	81	74
Halo-NT	80	81	69	69	97	95	93	88
Halo + Clom + Ethal-NT	95	95	90	88	99	97	91	91
Contrasts								
NCC vs. WR	NS	*	**	**	**	*	NS	**
Clom + Ethal-T vs. Clom + Ethal -NT	NS	NS	**	NS	NS	NS	**	NS
Clom + Ethal-NT, T vs. Halo-NT	***	***	*	***	**	**	*	***
Halo-NT vs. Halo + Clom + Ethal-NT	*	**	**	***	NS	NS	NS	NS
Clom + Ethal-NT, T vs. Halo + Clom + Ethal-NT	NS	NS	NS	NS	NS	NS	*	***
Weed-free-NT vs. Clom + Ethal-NT	NS	NS	*	*	NS	*	***	***
Weed-free-NT vs. Halo-NT	**	***	***	***	NS	NS	NS	NS
Weed-free-NT vs. Halo + Clom + Ethal-NT	NS	NS	*	**	NS	NS	NS	NS

^zRated from 0% (no control) to 100% (complete control).

^yClom = 0.31/acre a.i. clomazone; Ethal = 1.0 lb/acre a.i. ethalfluralin; Halo = 0.031 lb/acre a.i. halosulfuron; 1 lb/acre = 1.12 kg·ha⁻¹; T = tillage; and NT = no-tillage.

^{ns}, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.0001, respectively.

Squash injury was more severe in 2002 than 2003, likely due to the different weather conditions over the 2 years. In 2002, the spring was very wet (which may have caused more herbicide leaching and squash injury) compared to 2003.

Halosulfuron and clomazone + ethalfluralin + halosulfuron resulted in excessive squash injury (>10% due to plant stunting) regardless of year or cover crop (Table 2). Clomazone + ethalfluralin caused growth reduction in cultivation treatments that included winter rye in 2002, but not in 2003. Clomazone + ethalfluralin provided minor squash injury (<10% due to

plant stunting) in no-tillage plots during both years.

WEED CONTROL. In the absence of herbicides, all winter rye cultivars reduced redroot pigweed and smooth crabgrass densities compared with no winter rye at both 28 and 56 DAT (Table 1). ‘Elbon’ and ‘Maton’ provided better weed suppression than ‘Wheeler’, probably due to their higher biomass production and greater soil coverage with residues. ‘Elbon’ and ‘Maton’ produced almost five times more dry residue biomass [7.5 and 7.8 oz/ft² (2.29 and 2.38 kg·m⁻²), respectively] compared with ‘Wheeler’ [1.6 oz/ft² (0.49 kg·m⁻²)], and this

increased biomass equated to almost doubling the percent soil coverage by ‘Elbon’ and ‘Maton’ residues (93% and 89%, respectively) compared with ‘Wheeler’ (49%). ‘Elbon’ and ‘Maton’ provided similar weed control, with both reducing redroot pigweed and smooth crabgrass densities more than ‘Wheeler’.

Generally, redroot pigweed and smooth crabgrass control was greater in plots with a winter rye cover crop compared with no cover crop (Table 3). Season-long smooth crabgrass control (56 DAT) in no-tillage plots was aided by the inclusion of winter rye residues. Clomazone + ethalfluralin provided

similar control of redroot pigweed and smooth crabgrass regardless of tillage treatment in both years except at 56 DAT in 2002. Although clomazone + ethalfluralin did not adequately control smooth crabgrass at 56 DAT compared with the weed-free control, it provided greater smooth crabgrass control than halosulfuron at 28 and 56 DAT in both 2002 and 2003. Treatments that included halosulfuron provided greater control of redroot pigweed than clomazone + ethalfluralin in both years. Redroot pigweed control from halosulfuron and halosulfuron + clomazone + ethalfluralin was similar to the weed-free control in both years.

ZUCCHINI YIELD. There were significant ($P \leq 0.05$) year by herbicide treatment and year by cover crop interactions for marketable early and total squash yields. However, no herbicide by cover crop interaction ($P > 0.05$) was detected (data not presented). Generally, herbicide and cover crop main effects were significant ($P \leq 0.05$) for marketable squash yields.

Depending on the growing season, the use of winter rye enhanced (2002) or suppressed (2003) squash yields (Table 4). Prolonged low temperatures during spring 2003 reduced the growth and productivity of zucchini squash and the effect was exacerbated with the winter rye organic mulch. The three winter rye cultivars had similar effects on early and total squash yields.

There were no differences detected between no-tillage and cultivation for squash yields when clomazone + ethalfluralin were used (Table 5). In 2002, the no-tillage clomazone + ethalfluralin and weed-free treatments tended to have the greatest squash yields; whereas in 2003, both tillage systems using clomazone + ethalfluralin provided the greatest yields along with the weed-free treatment. Early and total squash yields were similar in the clomazone + ethalfluralin and weed-free treatments (Table 5), although this herbicide combination provided less weed control compared with the weed-free treatment (Table 3). In both years, the no-herbicide treatment had high early-season yields; however, weed emergence and competition increased in this treatment over the production season and caused a yield decrease compared with the clomazone + ethalfluralin treatments. Treatments with halosulfuron resulted in less squash yield (primarily early yields) compared

Table 4. 'Independence II' squash marketable early and total yield (lb/acre) as influenced by various winter rye cultivars (over all herbicide and cultivation treatments) during Spring 2002 and 2003.

Cover crop	2002 yields (lb/acre) ^z		2003 yields (lb/acre) ^z	
	Early	Total	Early	Total
No winter rye	4,906	14,071	5,616	17,152
Elbon	7,245	18,468	2,862	11,584
Maton	7,038	17,389	2,733	12,382
Wheeler	5,521	16,653	4,455	15,213
Contrasts				
No winter rye vs. winter rye	**	*	*	**
Elbon vs. Maton	NS	NS	NS	NS
Elbon, Maton vs. Wheeler	NS	NS	NS	NS

^zEarly is the sum of the first six harvests, and total is the sum of all 12 harvests; 1 lb/acre = 1.12 kg·ha⁻¹.

NS, *, ** Nonsignificant or significant at $P \leq 0.05$ and 0.01, respectively.

Table 5. 'Independence II' squash early and total yield as influenced by preemergence herbicide treatments (over all cover crop treatments) during Spring 2002 and 2003.

Herbicide-tillage	2002 yields (lb/acre) ^z		2003 yields (lb/acre) ^z	
	Early	Total	Early	Total
Herbicides				
Clom ^y + Ethal ^y -T	5,462	15,302	4,563	17,009
Clom + Ethal-NT	8,319	20,502	5,037	17,046
Halo ^y -NT	5,059	13,461	1,483	7,200
Halo + Clom + Ethal-NT	4,802	14,255	1,679	11,147
No-herbicide-NT	5,816	15,072	5,823	14,974
Weed-free-NT	8,606	23,277	5,066	17,731
Contrasts ^x				
Halo + Clom + Ethal-NT, Halo-NT vs. Clom + Ethal-NT, T	*	**	***	***
No-herbicide-NT vs. Clom + Ethal-NT, T	NS	*	NS	*
Weed-free-NT vs. Halo + Clom + Ethal-NT, Halo-NT	*	**	***	**
No-herbicide-NT vs. Halo + Clom + Ethal-NT, Halo-NT	NS	NS	***	***

^zEarly is the sum of the first six harvests, and total is the sum of all 12 harvests.

^yClom = 0.31 lb/acre a.i. clomazone; Ethal = 1.0 lb/acre a.i. ethalfluralin; and Halo = 0.031 lb/acre a.i. halosulfuron; 1 lb/acre = 1.12 kg·ha⁻¹; T = tillage; and NT = no-tillage.

^xOther contrasts evaluated that were found nonsignificant ($P > 0.05$) for early and total yields in 2002 and 2003 were: Clom + Ethal-T vs. Clom + Ethal-NT, Halo-NT vs. Halo + Clom + Ethal-NT, and Weed-free-NT vs. Clom + Ethal-NT, T.

NS, *, **, *** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.0001, respectively.

with other treatments evaluated (Table 5) due to squash plant injury caused by this herbicide (Table 2).

Adequate weed control systems must be developed before no-tillage production systems will be widely adapted for zucchini squash. Similar to Zasada et al. (1997), this study indicated that a winter rye cover crop alone will not provide sufficient weed control for zucchini squash grown under no-tillage conditions. Densities of redroot pigweed were reduced

early in the season with only a winter rye cover crop (Table 1), but reductions were not consistent and were not sustained throughout the growing season. Although broadleaf weed control is improved, winter rye that is herbicide killed and then mowed will not sufficiently control (<85%) many broadleaved weeds in no-tillage squash production even if used in conjunction with clomazone + ethalfluralin (Table 3). However, winter rye residues over the soil surface tended to improve weed

control with clomazone + ethalfluralin (Table 3).

Although clomazone + ethalfluralin is the herbicide mixture most often utilized by squash growers, it generally provides poor control of pigweed species (Walters et al., 2004). Despite insufficient pigweed control at 56 DAT (< 85%) in no-tillage using clomazone + ethalfluralin (Table 3), early and total yields were similar to the weed-free control (Table 5). This herbicide mixture also provided greater end-of-season weed control when used in conjunction with a winter rye cover crop (Table 3). All treatments with halosulfuron caused significant injury and yield reduction to zucchini squash, similar to results observed by Webster et al. (2003). Clomazone + ethalfluralin treatments resulted in the best overall weed control without having a detrimental influence on zucchini squash growth or yields in a no-tillage production system. However, clomazone + ethalfluralin does not provide sufficient season-long weed control; and, harvest laborers cannot locate fruit as easily on squash plants that are shaded by weeds compared to those growing under weed-free conditions thereby contributing to yield loss due to decreased harvest efficiency.

Due to the limited number of registered herbicides for summer squash and their inadequate weed control (Egel et al., 2004), future research should evaluate various cover crops along with other herbicides that have potential registrations for squash production to facilitate the implementation of no-tillage zucchini squash production.

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