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Reduced Tillage Practices for Summer Squash Production in Southern Illinois

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ADDITIONAL INDEX WORDS. *Cucurbita pepo*, conservation tillage, vegetable production

SUMMARY. Various tillage systems were evaluated in summer squash (*Cucurbita pepo*) production in southern Illinois to observe the influence of these systems on yellow and zucchini squash production during 1998, 1999, and 2000. For squash production, suppression of a cover crop such as tall fescue (*Festuca arundinacea*) or winter ryegrass (*Secale cereale*) must be accomplished to obtain the greatest possible yields. However, once the cover crop is killed via herbicides, squash yields tend to be similar among tillage, strip tillage, and no-tillage treatments. Previous studies indicated that early yields may be reduced when using a no-tillage production system, especially if direct seeding is the method of planting and would not be beneficial to growers seeking early production. This study found that squash growers can use transplants in a no-tillage system and not compromise early yields. No differences were observed for soil bulk densities between tillage and no-tillage treatments and may partially explain why similar yields were obtained between these treatments. Effective systems for weed control must be developed in no-tillage squash production before wide acceptance will occur. Observations from this study indicated that the success of no-tillage squash production depends on the availability of effective herbicides; however, few herbicides are currently labeled for use in summer squash. Future studies need to address the problem of weed control in no-tillage squash production.

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Soil erosion is a major concern to many vegetable growers in southern Illinois as topsoil is being lost at a high rate due to current and past tillage practices. Reduced tillage practices are an effective and inexpensive means of suppressing soil erosion (Blevins et al., 1983). Many vegetable growers are interested in reduced tillage systems to suppress this problem. However, vegetable growers will only incorporate reduced tillage systems into their production practices if yield and quality are not compromised.

Reduced tillage practices provide several benefits including reduced soil erosion, increased soil organic matter, and increased water-holding capacity (Johnson and Hoyt, 1999). Research has shown that plants grown under no-tillage conditions have more water available and tend to grow with less stress (Blevins et al., 1971; Lal, 1976). This would aid vegetable growers in overcoming the hot, drought-prone months that typically occur in many vegetable production areas in the U.S. Additionally, research has indicated that no-tillage areas covered with an organic mulch will decrease soil temperatures during the day compared to tilled soils (Lal, 1976; Peterson et al., 1986). Lower soil temperatures reduce biological activity in the soil and inhibit nutrient uptake, as well as suppressing early crop growth that can result in delaying yields (Johnson and Hoyt, 1999).

Research on reduced tillage practices of summer squash is limited. Squash grown in no-tillage yielded similarly to

those grown in conventional tillage (Knavel and Herron, 1986; NeSmith et al., 1994). However, early-season squash yields tend to be lower when grown in reduced tillage systems (NeSmith et al., 1994) and are probably the result of soils remaining colder for a longer period in the spring compared to tilled soils. The objective of this study was to evaluate the effectiveness of reduced tillage production practices on yellow and zucchini squash production in southern Illinois.

Materials and methods

Experiments were conducted during 1998, 1999, and 2000 to determine the influence of reduced tillage systems on summer squash production in southern Illinois. Standard cultural practices for yellow and zucchini squash production in Illinois were used (Foster et al., 1998, 1999, 2000). Fifty lb/acre (56 kg·ha⁻¹) N, 28 lb/acre (31 kg·ha⁻¹) P₂O₅, and 54 lb/acre (60 kg·ha⁻¹) K₂O was applied to plots before planting; plots were side-dressed with 25 lb/acre (28 kg·ha⁻¹) of N 3 weeks after planting. Recommended pest control was used which consisted of spraying a tank mixture of esfenvalerate (Asana, du Pont, Wilmington, Del.) or carbaryl (Sevin, Rhone-Poulenc Ag Company, Research Triangle Park, N.C.) and chlorothalonil (Bravo, Zeneca, Inc., Wilmington, Del.) once a week for the duration of the test. Three squash rows were grown per plot, with center-to-center row spacings of 3 ft (0.9 m) and in-row spacings of 2 ft (0.6 m). Five plants were grown per row

for a total of 15 plants per plot. Harvest frequency was every 2 to 4 d and fruit at each harvest were graded into marketable [1.5 to 2.5 inches (3.8 to 6.4 cm) diameter], oversize (>2.5 inches diameter), cull (unmarketable-misshapened, off-color, or decaying fruit), and cull with symptoms of virus infection. Yields are reported as the number of 20-lb (9-kg) boxes per acre, which is the standard packaging unit for the industry.

Data were subjected to analysis of variance procedures appropriate for a randomized complete block experimental design to determine the effects of tillage. Fisher's least significant difference (LSD) tests were used to separate differences among means at $P \leq 0.05$.

1998 EVALUATIONS. Three experiments were conducted in established tall fescue sod during the fall of 1998 to evaluate the influence of the following four tillage treatments on 'Multipik' yellow or 'Dividend' zucchini squash yields: 1) no-tillage with 1-ft (0.3-m) wide sections in plots sprayed with glyphosate, 2) no-tillage with complete areas in plots sprayed with glyphosate, 3) strip tillage with 1 ft sections in plots tilled with the rest of the plot area sprayed with glyphosate, and 4) a conventional tillage control. Experiments were set up as a factorial treatment arrangement in a randomized complete block design with four replications.

The first experiment was conducted at Rendleman Orchards in Alto Pass, Ill., and consisted of evaluating 'Dividend' zucchini in an Alford silty clay loam soil, which is a fine-silty, mixed,

Table 1. Yellow and zucchini squash yield in number of 20-lb (9-kg) boxes per acre at Dixon Springs Agricultural Research Center in Simpson, Ill., during Fall 1998.^z

Treatment	Early-season			Total		
	Marketable	Culls	Total	Marketable	Culls	Total
'Multipik' yellow squash						
Tillage	742	60	802	3890	279	4169
No-tillage ^y	139	45	184	1645	67	1712
No-tillage ^x	493	82	575	3835	172	4007
Strip tillage ^w	493	50	520	3803	132	3935
LSD _(0.05)	174	NS	199	712	NS	958
'Dividend' zucchini squash						
Tillage	849	12	864	3365	159	3524
No-tillage ^y	483	62	548	3054	87	3141
No-tillage ^x	1080	85	1165	4223	182	4405
Strip tillage ^w	821	112	936	3768	246	4014
LSD _(0.05)	234	NS	174	702	NS	796

^zData are means of four replications. Early harvest is the sum of the first six harvests; and total is the sum of all 20 harvests. Cultivars are ranked according to total marketable yield. Total yields are the sum of marketable, oversize, and cull grade fruit. Transplanting was used as the method of planting.

^yGlyphosate was sprayed in 1-ft (0.3-m) strips in plots.

^xGlyphosate was sprayed over entire plot area.

^wGlyphosate was sprayed over entire plot area after strips were tilled.

mesic typic Hapludalf (Miles, 1979). Two-week-old squash transplants were planted into field soil on 1 Aug., and harvest began on 14 Sept. [44 d after transplanting (DAT)] and ended on 20 Oct. (80 DAT) with a total of 12 harvests. No supplemental irrigation was provided. Plants received little moisture as southern Illinois was experiencing drought conditions [less than 1 inch (25 mm) rainfall for the first 4 weeks after transplanting], which delayed the time to harvest.

The second and third experiments were conducted at the University of Illinois-Dixon Springs Agricultural Center (DSAC) in Simpson, Ill. ‘Multipik’ yellow and ‘Dividend’ zucchini squash were evaluated in a Grantsburg silt loam soil type, a fine-silty, mixed, mesic, typic Fragiudalf (Parks, 1975). Three-week-old transplants were planted 8 Aug., and harvest began on 10 Sept. (33 DAT) and ended 20 Oct. (73 DAT) with a total of 20 harvests. Due to drought conditions [less than 1 inch rainfall for the first 4 weeks after transplanting], supplemental irrigation was provided via drip tubing placed on the soil surface in the row. About 1.5 inches (38 mm) of water was applied weekly via trickle irrigation.

1999 EVALUATION. Three tillage treatments were evaluated at Rendleman

Orchards in Alto Pass, Ill. during the spring growing season: 1) no-tillage using transplants; 2) strip tillage using transplants with 1-ft sections in center of plots tilled; 3) tillage using direct seeding; and 4) tillage using transplants. Winter rye was established during the fall of 1998 following disk tillage. Winter rye was mowed 2.5 to 4 inches (6 to 10 cm) above the soil surface the following spring and then killed with paraquat [2.3 qt/acre (0.5 L·ha⁻¹)] about 4 to 5 weeks before transplanting squash. The experiment was set up as a factorial treatment arrangement in a randomized complete block design with four replications using ‘Dividend’ zucchini squash in an Alford silty clay loam soil. Seed or transplants were planted 30 Apr., and harvest began on 3 June (34 DAT) and ended 2 July (63 DAT) with a total of 12 harvests. No supplemental irrigation was provided.

2000 EVALUATION. Two tillage treatments were evaluated at Rendleman Orchards in Alto Pass, Ill during the spring growing season: 1) no-tillage and 2) a tillage control. ‘Independence II’ zucchini squash was transplanted into winter rye as discussed previously. The experiment was set up as a factorial treatment arrangement in a randomized complete block design with five

replications in an Alford silty clay loam soil. Transplants were planted 27 Apr. and harvest began on 31 May (34 DAT) and ended 30 June (64 DAT) with a total of 12 harvests. No supplemental irrigation was provided.

Squash are sensitive to root restriction (NeSmith, 1993) and soil compaction can attribute to yield loss. Soil bulk densities were taken to determine soil compaction levels. Soil bulk density samples were taken in the harvested row after the completion of harvest at 5-inch (12.6-cm) depths. Soil bulk density samples were also taken from the grower’s field at 5-inch depths comparing a no-tillage area with a tilled area in which ‘Independence II’ zucchini squash was grown. Three replications were used.

Results

1998 EVALUATIONS. Yields of ‘Multipik’ yellow and ‘Dividend’ zucchini squash at DSAC (Table 1) were similar to those obtained for ‘Dividend’ squash at Rendleman Orchards in Alto Pass, Ill. (Table 2). The no-tillage treatment in which glyphosate was sprayed only in 1 ft strips suppressed early and total season yields compared to the other treatments evaluated. At DSAC, there was no differences ($P \leq 0.05$) between the tillage, no-tillage (with glyphosate

Table 2. Zucchini squash yield in number of 20-lb (9-kg) boxes per acre grown in reduced tillage systems at Alto Pass, Ill. during Fall 1998, Spring 1999, and Spring 2000.^z

Year/cover crop/ squash cultivar/ tillage system	Early-season			Total		
	Marketable	Culls	Total	Marketable	Culls	Total
1998/Tall fescue/‘Dividend’						
Tillage	864	159	1023	2633	214	2847
No-tillage ^y	425	100	525	1239	319	1558
No-tillage ^x	794	162	956	2334	276	2610
Strip tillage ^x	1297	112	1409	3840	221	4061
LSD _(0.05)	607	NS	560	814	NS	1147
1999/Winter ryegrass/‘Dividend’						
Tillage-direct seeded ^w	44	15	59	909	765	1917
Tillage ^w	462	97	793	1379	1273	3112
No-tillage ^w	385	119	811	1442	1031	3262
Strip tillage ^w	409	157	922	1623	1002	3560
LSD _(0.05)	231	34	292	422	256	828
2000/Winter ryegrass/‘Independence II’						
Tillage ^w	430	19	476	1330	189	1806
No-tillage ^w	436	24	460	1358	162	1919
LSD _(0.05)	NS	NS	NS	NS	NS	NS

^zData are means of four replications, with 12 harvests taken in 1998 and 1999. For 2000, 12 harvests were taken and data are means of five replications. Early harvest is the sum of the first four harvests, and total is the sum of all harvests. Total fruit is the sum of marketable, oversize, and cull grade fruit. Transplanting was used as the method of planting unless otherwise noted.

^yGlyphosate was sprayed in 1-ft (0.3-m) strips.

^xGlyphosate was sprayed over entire plot area.

^wParaquat was sprayed over entire plot area.

Table 3. Soil bulk densities at 5-inch (12.6-cm) depths of 'Independence II' zucchini squash grown in reduced tillage systems at Alto Pass, Ill. during Spring 2000.^z

Treatment	Test location	Grower field
Tillage	1.49	1.40
No-tillage	1.47	1.47
LSD _(0.05)	NS	NS

^zData are means of three replications.

sprayed over the entire plot area) and strip-tillage treatments for total-season marketable yields for 'Multipik' (Table 1). However, a trend was observed for 'Dividend' to produce greater marketable yields in the no-tillage (with glyphosate sprayed over the entire plot area) treatment compared to the tillage and strip-tillage treatments during both early-season and total season harvests. Strip tillage was superior to the other treatments for total marketable yields of 'Dividend' squash at Rendleman Orchards (Table 2) in 1998. The tillage and no-tillage treatment produced similar early and total season marketable yields.

1999 EVALUATION. Considering all harvests, 'Dividend' tended to produce greater marketable yields under strip-tillage conditions (Table 2), although differences among treatments in which transplants were used were nonsignificant ($P \leq 0.05$). When direct seeding was used in plots that were tilled, squash yields were lower ($P \leq 0.05$) compared to the other treatments in which transplants were used. Early-season and total harvests for all grades were less ($P \leq 0.05$) in the direct seeded tillage treatment compared to the other treatments. Comparing those treatments in which transplants were used, early-season marketable yields tended to be greater in the tillage treatment, although total yields had a tendency to be greater in the strip-tillage treatment. Total cull yields were much greater compared to 1998 due to watermelon mosaic virus (WMV) (Walters et al., 2000) that rendered almost half of the harvested fruit unmarketable.

2000 EVALUATION. In most instances in 1998 and 1999, yields from strip tillage were not significantly greater than from no-tillage treatments; since strip tillage is initially more expensive, this treatment was omitted from the 2000 evaluation. Also, a change was made to the WMV-resistant transgenic cultivar 'Independence II', as yields of

'Dividend' were severely reduced due to WMV infection in 1999. There were no differences between the tillage and no-tillage treatments for early- and total-season marketable yields in 2000 (Table 2).

No differences were observed for soil bulk densities between the tillage and no-tillage treatments for either the test location or the adjoining grower's field location (Table 3).

Discussion

Suppression of cover crops such as fescue or winter ryegrass must be accomplished to obtain the greatest possible summer squash yields in reduced tillage production systems. However, once the cover crop is killed via herbicides then summer squash yields tend to be similar among tillage, strip tillage, and no-tillage treatments.

Squash growers in southern Illinois obtain the greatest profits in squash production from early-season yields (i.e., the first 3 to 6 harvests). Early yields may be reduced when using no-till especially if direct seeding is the method of planting, and a no-tillage production system would not be beneficial to growers seeking early production (NeSmith et al., 1994). Summer squash can be produced with no-tillage production systems in southern Illinois without compromising early- or total-season yields if transplants are used. Most growers in southern Illinois use squash transplants for the spring growing season. If squash growers depend on early yields to obtain the greatest profits, no-tillage using transplants will provide similar returns as transplants in a tillage production system. Soil bulk density data indicated that soil compaction should not develop into a problem in no-tillage squash production in southern Illinois as growers tend to use shallow tillage in the fall prior to seeding the winter cover crop.

Before wide acceptance of no-tillage squash production will occur, effective systems for weed control must be developed. To obtain high yields in no-tillage summer squash production, weed control is essential. Growers complain that during harvest laborers cannot find fruit as easily on squash plants that are shaded by weeds compared to squash growing in a weed free field, and this contributes to yield loss. Our studies indicated that the success of no-tillage squash production depends on the availability of effective herbicides as poor weed control was observed in all reduced tillage studies (data not shown);

however, few herbicides are currently labeled for use in summer squash in Illinois (Foster et al., 2001). Future studies need to be directed at controlling weeds in reduced tillage squash production.

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