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Effect of Winter Cover Crop Residue on No-till Pumpkin Yield

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***Abstract*. Throughout the southeastern United States, vegetable growers have successfully cultivated pumpkins (*Cucurbita pepo*) using conventional tillage. No-till pumpkin production has not been pursued by many growers as a result of the lack of herbicides, no-till planting equipment, and knowledge in conservation tillage methods. All of these conservation production aids are now present for successful no-till vegetable production. The primary reasons to use no-till technologies for pumpkins include reduced erosion, improved soil moisture conservation, long-term improvement in soil chemical and microbial properties, and better fruit appearance while maintaining similar yields compared with conventionally produced pumpkins. Cover crop utilization varies in no-till production, whereas residue from different cover crops can affect yields. The objective of these experiments was to evaluate the influence of surface residue type on no-till pumpkin yield and fruit quality. Results from these experiments showed all cover crop residues produced acceptable no-till pumpkin yields and fruit size. Field location, weather conditions, soil type, and other factors probably affected pumpkin yields more than surface residue. Vegetable growers should expect to successfully grow no-till pumpkins using any of the winter cover crop residues tested over a wide range in residue biomass rates.**

Vegetable producers commonly use conventional tillage practices to prepare a seedbed that optimizes vegetable seed placement, crop germination, and emergence resulting from increased contact with loose, moist soil (Coolman and Hoyt, 1993; Sprague, 1986). Incorporating surface residues also can reduce potential weed, disease, and insect pests. Conventional tillage also facilitates incorporation of surface-applied nutrients to improve nutrient availability to crop roots. As a result of these benefits, conventional tillage has been the standard cultural practice for hundreds of years (Sprague, 1986).

With its introduction in the 1950s, conservation tillage systems have been increasingly adopted for many row crops as a result of distinct advantages in soil erosion control, soil water conservation, reduced energy and labor requirements, and enhanced crop performance (Frye et al., 1981; Phillips, 1984; Sprague, 1986). In addition, contemporary no-till planting equipment can provide for optimum seed placement, germination and emergence of most agronomic crops. Advantages and disadvantages of conservation tillage systems with agronomic crops have been well documented (Gallaher and Ferrer, 1987; Rice, 1983). An undesirable consequence of conservation tillage for vegetables includes lower soil temperature in spring resulting from surface crop residue cover that can reduce emergence and seedling vigor (Hoyt and Konsler, 1988).

In addition, increased potential for weed and pest infestations can occur with conservation tillage, requiring application of preemergence or postemergence pesticides (Hoyt et al., 1996; Hoyt and Monks, 1996). Currently, many pesticides are available for use in conservation tillage systems. Pest problems can also be minimized by fall tillage of crop debris and establishment of a grass or legume winter cover crop (Phatak et al., 1991).

Early adoption of conservation tillage systems was primarily related to concerns for soil erosion. A substantial reduction in soil loss through water and wind erosion occurs with the maintenance of surface crop residues (Follett and Stewart, 1985; Griffith et al., 1986). The use of previous summer crop and winter cover crop residues for conservation tillage planting protects the soil surface from erosion by absorbing the impact energy of raindrops, thus reducing soil particle detachment and decreasing the acceleration of surface runoff. In addition, increased water infiltration and reduced soil water evaporation under conservation tillage generally increases plant-available water and subsequent crop yield potential (Griffith et al., 1986). This increased available water is particularly important in dry land cropping systems in arid and semiarid regions where plant water availability is the most limiting factor to crop yield potential. Increased surface residue can also improve nutrient availability through increased organic matter and nutrient cycling (Doran, 1980).

With increased urbanization in rural areas and decreased availability of prime nonerodible farmland in the southeastern United States, the advantages of conservation tillage are very important to profitable crop production. Many soils available for producing farm commodities in these regions are highly erodible, especially in the Piedmont region of the southeast. In addition, much of the remaining farmland is marginal for plant growth without substantial inputs resulting from steep slopes and variable growing season conditions. Increasing surface residue cover by using conservation tillage in this region can enhance crop yield potential through protection of nutrient-rich surface soil from erosion and increased plant-available soil moisture resulting from increased infiltration and decreased evaporation (Coolman and Hoyt, 1993). The objectives of these experiments were to evaluate the yield potential and fruit quality of no-till pumpkins grown with various winter cover crop surface residues.

Materials and Methods

No-till pumpkin experiments were conducted in 2001 at the Mountain Research Station (MRS) near Waynesville and the Mountain Horticultural Crops Research Station (MHCRS) near Fletcher, NC. In 2002, no-till pumpkin experiments were conducted at the MRS near Waynesville, the Upper Mountain Research Station (UMRS) near Laurel Springs, the MHCRS near Fletcher, and the Piedmont Research Station (PRS) near Salisbury, NC. Pumpkin cultivars in 2001 were 'Magic Lantern', a large (7.3 to 10.8 kg), powdery mildew-resistant cultivar,

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and 'Oz', a small (1.4 to 2.3 kg) cultivar. The pumpkin cultivars used in 2002 were 'Magic Lantern' and 'Mystic Plus', a small (2.3 to 3.2 kg) cultivar. Soils were a Toxaway loam (a fine-loamy, mixed, nonacid, mesic Cumulic Humaquept) at UMRS, French loam (a fine-loamy, over sandy or sandy skeletal, mixed, mesic Fluaquentic Dystrochrepts) at MRS, Comus fine sandy loam (a course-loamy, mixed, mesic Fluventic Dystrochrepts) at MHCRS, and Hiwassee clay loam (clayey, kaolintic, thermic Rhodic Kanhapludults) at PRS.

Residue treatments were arranged in a randomized block experimental design with four replications at all locations. Plots were 6.1 m wide by 13 m long. For both the 2001 and 2002 experiments, various varieties of rye (*Secale cereale*), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), triticale (*Triticosecale*), ryegrass (*Lolium multiflorum*), oats (*Avena sativa*), and crimson clover (*Trifolium incarnatum*) were fall-planted at 134 kg·ha^{-1} for small grain, 33 kg·ha^{-1} for ryegrass, and 25 kg·ha^{-1} for crimson clover using conventional tillage to prepare the experimental areas. Winter cover crops were killed with paraquat (1,1′-dimethyl-4, 4-bipyridinium dichloride) herbicide at 3.5 L·ha^{-1} or glyphosate [N-(phosphonomethyl) glycine] at 3.5 L·ha^{-1} between 2 and 4 weeks before pumpkin planting. Winter cover biomass samples (0.25 m^2) were collected from each treatment at planting, oven-dried at 65 °C, then weighed to determine the amount of residue present at planting. Pumpkins were no-till-planted into the winter cover crop treatments during the third week of June for each location and year. A John Deere (Moline, IL) Maxi-merge no-till corn planter (no pumpkin seed was used) was used to open the furrows and simulate the use of a no-till planter within the plots. Two to three seeds were hand-seeded at 0.91 m in-row spacing and thinned to one plant per seeding location after seedling emergence. Between-row spacing was 1.83 m, resulting in 12 plants per pumpkin cultivar (two rows of six plants long) per plot with 1.66 m^2 per plant. The small pumpkin cultivar (six plants) was planted in the front half of the plot and 'Magic Lantern' (six plants) planted at the back half of the plot.

Nitrogen fertilizer as ammonium nitrate (100 kg·ha^{-1} N) was surface band-applied 15 cm beside the row 2 weeks after planting. A single application of ethalfluralin [n-ethyl-N-(2methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl benzeneamine)] and clomazone [2-(2-chlorophenyl) methyl-4, 4-dimethyl-3-isoxazolidinone] herbicides was applied at 4.6 L·ha^{-1} after planting to control weeds. Esfenvalerate [(s)-cyano (3-phenoxyphenyl) methyl (s)-4-chloro-alpha-(1-methylethyl) benzeneacetate] was applied for insect control at 0.43 L·ha^{-1} once a week after fruit emergence. Fungicides azoxystrobin [methyl (E)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4-yloxy] phenyl}-3-methoxyacrylate] applied at 0.86 L·ha^{-1} and chlorothalonil (tetrachloroisophthalonitrile) applied at 2.29 L·ha^{-1} were rotated between applications weekly starting mid-July.

Pumpkin fruit were harvested at all locations between the third week of September and the second week of October. Fruit were classified as marketable or nonmarketable (cull) and then individually counted and weighed. Analysis of variance (PROC GLM) was performed with SAS version 6.12 (SAS Institute, Cary, NC). Least significant difference tests were preformed on each yield parameter at all locations.

Results and Discussion

Residue biomass

Winter cover residue treatments just before pumpkin planting in 2001 ranged from 4156 to 11,867 kg·ha^{-1} over locations, cover crop species, and varieties (Table 1). At each location in 2001, wheat produced more residue biomass than rye, triticale, or ryegrass. The highest yielding wheat cultivar at both locations was Patton with 11,867 kg·ha^{-1} at MHCRS and 10,573 kg·ha^{-1} at MRS. The lowest yielding residue treatment was Gulf ryegrass at MRS with 4165 kg·ha^{-1} and Wheeler rye at MHCRS with 6242 kg·ha^{-1}. All winter cover species and varieties for these two locations provided at least 75% surface cover for no-till pumpkins.

In 2002, Arcia triticale produced the greatest residue (12,226 kg·ha^{-1}) at MRS among all locations and cover residue treatments (Table 2). Like in 2001, all wheat varieties produced similar biomass within each location with an average of 10,365 kg·ha^{-1}. At MHCRS, the highest yielding cover crop residue was Wrens Abruzzi rye (5844 kg·ha^{-1}), whereas the lowest yielding residue treatment was Arcia triticale (2377 kg·ha^{-1}). Compared with 2001 at MHCRS, small grain residue treatments were lower in 2002 as a result of poor winter and early spring growth.

Wheat was the highest yielding residue species at PRS and UMRS, with 'Pioneer 26R24' being the highest yielding wheat cultivar. Crimson clover yielded the least amount of residue at PRS (3763 kg·ha^{-1}) and UMRS (1577 kg·ha^{-1}), respectively.

Rye, triticale, wheat, or barley varieties included in these studies have provided excellent residue cover for no-till summer crops when cover crops were planted at recommended fall planting dates and grown under normal winter weather conditions. These winter cover crops were allowed to grow through May, increasing the amount of residue biomass and providing excellent surface residue cover for no-till pumpkin production. Some ryegrass varieties produced residue cover that completely covered the soil surface, but in general, ryegrass cover residues resulted in lower no-till vegetable yields compared with small grain selections (Hoyt, 1999).

Pumpkin yield

Small pumpkin cultivar.

2001 experiment with 'Oz'. At both of the locations in 2001, there was considerable variability in pumpkin fruit yields among the various residue treatments (Tables 3 and 4). The 'Oz' (Harris Moran Seed Company, Modesto, CA, pumpkin Guide) cultivar ranged from 10,262 to 18,060 kg·ha^{-1} of pumpkin fruit yield over both locations. Residue treatments generally had no consistent effect on pumpkin yield. The Wrens Abruzzi rye residue treatment produced the highest pumpkin fruit yield (18,060 kg·ha^{-1}) at MHCRS and Gulf ryegrass residue treatment produced the highest pumpkin fruit yield (15,080 kg·ha^{-1}) at MRS. The lowest pumpkin fruit yielding residue treatment at MRS was Rio ryegrass and the 'Pioneer 24R26' wheat cultivar treatment at MHCRS. Pumpkin fruit at both locations were within the recommended size for 'Oz' ranging from 1.28 to 1.71 kg/fruit (Table 3). Residue treatment influenced fruit size at MHCRS, but not at MRS (Tables 3 and 4). Residue treatment had no effect on the number of fruit or total yield per hectare at either location.

Table 1. Winter cover residue for the no-till pumpkin experiments in 2001.

	Location	
	MRS[z]	MHCRS[y]
Winter cover residue	biomass, kg·ha^{-1}	
Bare soil	0	0
Rye Wrens Abruzzi	9455	8007
Rye Wheeler	8232	6242
Wheat Roane	10,175	10,325
Wheat Patton	10,573	11,867
Wheat Coker 9663	9683	9859
Wheat Pioneer 26R24	9667	10,495
Wheat SS 566	9614	9599
Ryegrass Marshall	8721	9073
Ryegrass Rio	6883	8918
Ryegrass Gulf	4165	7512
Triticale Trical 498	7894	8973
Triticale Trical 10308-B1	7186	8041
Triticale Trical 102	6784	8140
$LSD_{0.05}$	1450	1475

[z]MRS = Mountain Research Station, Waynesville.
[y]MHCRS = Mountain Horticultural Crops Research Station, Fletcher.
Planting rates were 134 kg·ha^{-1} for small grain and 33 kg·ha^{-1} for ryegrass.
LSD = least significant difference.

2002 experiments with 'Mystic Plus'. At MRS, no-till pumpkin fruit total yield ranged from 40,333 kg·ha^{-1} in the Marshall ryegrass residue treatment to 66,774 kg·ha^{-1} in the Patton wheat residue treatment (Table 5). Overall, wheat, rye, triticale, and barley residue treatments had greater no-till pumpkin yields than ryegrass, oats, crimson clover, and bare soil treatments, although some varieties of wheat did result in poor pumpkin total yield.

Marketable fruit size at MRS varied between 2.46 and 3.0 kg/fruit (Table 5). The ryegrass residue treatments at MRS yielded the smallest size fruit of any treatments, whereas wheat, barley, and crimson clover residue and bare soil treatments yielded the largest no-till pumpkin fruit. The number of marketable fruit ranged from 13,948 (Coker 9663) to 21,666 fruit/ha ('Pioneer 26R24') and was influenced by residue treatment (Table 5). Pumpkin cull yields at

Table 2. Winter cover residue for the no-till pumpkin experiments in 2002.

	Location[z]			
	MRS	MHCRS	PRS	UMRS
Winter cover residue	biomass, kg·ha^{-1}			
Bare soil	0	0	—[y]	0
Rye Wrens Abruzzi	6168	5844	6514	3423
Rye Wheeler	10,770	4170	5635	4381
Barley Nomini	7278	2572	7297	4418
Wheat Roane	10,999	3178	8324	3759
Wheat Patton	10,825	3637	7829	5105
Wheat Coker 9663	10,554	3341	6735	4087
Wheat Pioneer 26R24	9800	3325	9056	5448
Wheat SS 566	8547	2552	7342	4530
Wheat Vigoro RC 904	11,462	2545	6611	4178
Ryegrass Marshall	7468	3528	6740	4450
Ryegrass Rio	6512	3574	7218	3685
Ryegrass Big Daddy	6393	3740	6263	2758
Triticale Trical 498	10,146	2953	6408	4047
Triticale Arcia	12,226	2377	8274	4417
Triticale Trical 308	9920	3165	7681	1774
Crimson Clover	8568	3917	3763	1577
Oats	9810	4448	5962	3620
$LSD_{0.05}$	1432	1475	840	1202

[z]MRS = Mountain Research Station, Waynesville; MHCRS = Mountain Horticultural Crops Research Station, Fletcher; PRS = Piedmont Research Station, Salisbury; UMRS = Upper Mountain Research Station, Laurel Springs.
[y]Bare soil treatment was not included at this location.
Planting rates were 134 kg·ha^{-1} for small grain, 33 kg·ha^{-1} for ryegrass, and 25 kg·ha^{-1} for crimson clover.
LSD = least significant difference.

Table 3. The effect of winter cover residue on no-till pumpkin yield at the MHCRS[z], 2001.

	Oz	Magic Lantern	Oz	Magic Lantern	Oz	Magic Lantern
Winter cover residue	kg/fruit		kg·ha^{-1}		no. fruit/ha	
Bare soil	1.50	7.66	15,102	48,848	9465	6476
Wheat Coker 9663	1.49	6.71	12,570	34,731	8217	4981
Wheat Pioneer 26R24	1.71	6.44	10,397	41,454	5977	6476
Wheat Roane	1.56	7.71	17,993	52,658	11,206	6725
Wheat Patton	1.45	7.07	12,055	49,969	8217	6972
Wheat FFR566	1.46	6.21	12,951	35,404	8716	5727
Rye Wrens Abruzzi	1.54	6.75	18,060	43,470	11,705	6476
Rye Wheeler	1.35	7.16	14,161	39,885	10,460	6476
Triticale Trical 498	1.50	6.62	17,948	46,383	11,455	6972
Triticale Trical 102	1.48	6.53	13,511	42,798	8716	6725
Triticale Trical 10308-B	1.64	8.70	13,444	56,915	7970	6725
Ryegrass Marshall	1.60	7.34	14,878	44,143	9465	6226
Ryegrass Rio	1.54	6.80	16,290	47,056	10,460	6972
Ryegrass Gulf	1.46	6.62	14,206	40,782	9465	6226
$LSD_{0.05}$	0.28	NS	NS	NS	NS	NS

[z]MHCRS = Mountain Horticultural Crops Research Station, Fletcher.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
LSD = least significant difference.

Table 4. The effect of winter cover residue on no-till pumpkin yield at the MRS[z], 2001.

	Oz	Magic Lantern	Oz	Magic Lantern	Oz	Magic Lantern
Winter cover residue	kg/fruit		kg·ha^{-1}		no. fruit/ha	
Bare soil	1.31	6.30	13,130	34,283	9862	5478
Wheat Coker 9663	1.40	6.44	12,660	47,280	8916	7296
Wheat Pioneer 26R24	1.34	6.16	12,234	33,835	8966	5429
Wheat Roane	1.34	5.76	12,548	33,163	9163	5727
Wheat Patton	1.34	5.98	14,072	38,765	10,312	6575
Wheat FFR566	1.31	6.30	11,315	39,885	8667	6276
Rye Wrens Abruzzi	1.40	6.30	13,399	40,557	9465	6473
Rye Wheeler	1.48	6.30	15,080	43,246	10,087	6723
Triticale Trical 498	1.42	6.16	14,228	41,230	10,309	6473
Triticale Trical 102	1.37	6.39	12,167	38,765	8716	5977
Triticale Trical 10308-B	1.48	5.89	14,654	37,196	9862	6276
Ryegrass Marshall	1.28	5.98	11,965	32,715	9264	5478
Ryegrass Rio	1.43	5.85	10,262	41,006	7222	6898
Ryegrass Gulf	1.37	6.98	15,416	41,454	11,307	5977
$LSD_{0.05}$	NS	NS	NS	NS	NS	1862

[z]MRS = Mountain Research Station, Waynesville.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
LSD = least significant difference.

the MRS location showed no statistical differences among treatments (Table 5).

At MHCRS, pumpkin total yield ranged from 27,416 to 62,067 kg·ha^{-1} and was influenced by residue treatment (Table 6). Arcia triticale produced the greatest no-till pumpkin total yield and number of marketable fruit/ha. The residue treatment producing the lowest no-till pumpkin total yield was Patton wheat. Cull no-till pumpkin fruit size and number of fruit ha^{-1} showed no differences among treatments (Table 6). Cull pumpkin yield had high variability with treatments producing from 0 to 1852 kg·ha^{-1} cull pumpkin fruit (Table 6). The largest amount of cull pumpkins was produced by the Marshal ryegrass residue treatment. Several treatments yielded no cull pumpkin fruit at this location.

At PRS, the greatest no-till pumpkin total yield (47,280 kg·ha^{-1}) and marketable fruit number/ha (24,408 fruit/ha) was planted into Wheeler rye residue (Table 7). The other rye residue (Wrens Abruzzi) also produced a high no-till pumpkin yield (43,695 kg·ha^{-1}). Triticale residue treatments had similar high yields with an average of 42,051 kg·ha^{-1}. Although some wheat, ryegrass, barley, and crimson clover residue treatments produced lower no-till pumpkin total yields, all treatments had good yields. Cull pumpkin yields (kg/fruit, kg·ha^{-1}, number of fruit/ha) at PRS showed no differences among treatments (Table 7). The marketable size fruit produced at this location also showed no differences among treatments (Table 7).

At UMRS, the greatest no-till pumpkin total yield (51,761 kg·ha^{-1}) and number of marketable fruit (17,433 fruit/ha) were measured in the Trical 308 triticale residue treatment (Table 8). Residue treatments from the other varieties of triticale also produced high no-till pumpkin total yields with an average of 43,097 kg·ha^{-1}. The lowest no-till pumpkin total yield was 28,989 kg·ha^{-1}, which was planted into Patton wheat residue (Table 8). Although residue from this cultivar of wheat produced the lowest no-till pumpkin total yields, other varieties of wheat residues produced good pumpkin yields (average 41,364 kg·ha^{-1}). The lowest number of marketable fruit at this location was 11,954 fruit/ha produced by the Marshall ryegrass treatment (Table 8).

Cull fruit yield and fruit size were highly variable at this location, where cull yield ranged from 1120 to 11,427 kg·ha^{-1} and the cull fruit size ranged from 0.60- to 3.01-kg/fruit (Table 8). The wheat residue treatments (except for Vigoro RC 904) produced the greatest amount of cull pumpkins. The bare soil treatment also had high cull pumpkin yields. The lowest weight and number of cull pumpkins produced came from the Arcia triticale residue and Vigoro RC 904 wheat residue treatments, both with a 1120-kg·ha^{-1} cull pumpkin yield (Table 8). Marketable pumpkin fruit size varied from 2.10- to 2.65-kg fruit (Table 8). The overall pumpkin yields from the residue treatments at this location were good considering this location has the highest elevation of the four with the

Table 5. The effect of winter cover residue on no-till Mystic Plus pumpkin yield at the MRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	2.96	47,056	16,936	1.66	2913	1244	49,969	18,181
Wheat Coker 9663	2.82	38,989	13,948	1.47	1568	748	40,557	14,696
Wheat Pioneer 26R24	2.56	36,748	13,948	2.49	4033	1743	40,782	15,691
Wheat Roane	2.93	62,517	21,419	0.52	448	249	62,965	21,669
Wheat Patton	2.98	62,965	21,170	1.41	3809	1244	66,774	22,415
Wheat FFR566	2.54	41,230	16,188	0.71	2240	748	43,470	16,936
Wheat Vigoro RC 904	2.94	56,019	18,927	1.13	3585	1494	59,604	20,421
Rye Wrens Abruzzi	2.73	52,209	19,177	1.41	2464	1743	54,674	20,920
Rye Wheeler	2.85	52,658	18,181	0.51	1120	498	53,778	18,680
Triticale Trical 498	2.76	59,828	21,666	0.96	2016	995	61,845	22,662
Triticale Trical 308	2.75	49,072	17,932	0.83	3137	1743	52,209	19,676
Triticale Arcia	2.72	53,106	19,426	0.53	1344	3238	54,450	22,664
Ryegrass Marshall	2.49	37,869	15,442	0.62	2464	995	40,333	16,437
Ryegrass Rio	2.46	49,072	19,925	1.13	2240	995	51,313	20,920
Ryegrass Big Daddy	2.71	47,056	17,183	0.34	672	498	47,728	17,682
Barley Nomini	2.96	60,276	20,421	2.06	4033	1993	64,310	22,415
Oats	2.87	48,176	16,687	1.19	3585	1494	51,761	18,181
Clover Crimson	3.00	48,400	16,188	1.21	3585	1494	51,985	17,682
$LSD_{0.05}$	0.41	18,598	6669	1.59	NS	2591	19,718	7587

[z]MRS = Mountain Research Station, Waynesville, NC.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

Table 6. The effect of winter cover residue on no-till Mystic Plus pumpkin yield at the MHCRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	3.01	32,631	10,560	0	0	0	32,631	10,560
Wheat Coker 9663	2.96	44,330	14,196	0.44	1310	747	45,641	14,943
Wheat Pioneer 26R24	2.55	42,740	16,537	0	0	0	42,740	16,537
Wheat Roane	2.58	44,140	16,737	1.04	1039	498	45,180	17,235
Wheat Patton	2.32	27,100	8518	0.32	316	249	27,416	8767
Wheat FFR566	3.26	55,853	17,559	0.34	338	249	56,192	17,808
Wheat Vigoro RC 904	3.06	49,143	15,990	0	0	0	49,143	15,990
Rye Wrens Abruzzi	2.95	38,603	13,200	0.70	700	498	39,303	13,698
Rye Wheeler	3.08	28,367	9340	0	0	0	28,367	9340
Triticale Trical 498	3.03	51,933	17,085	0.34	338	249	52,272	17,334
Triticale Trical 308	2.96	48,268	16,737	0.43	429	249	48,697	16,986
Triticale Arcia	2.69	61,954	21,519	0.11	113	249	62,067	21,768
Ryegrass Marshall	2.86	50,442	18,206	0.62	1852	747	52,295	18,953
Ryegrass Rio	3.05	48,702	16,089	0	0	0	48,702	16,089
Ryegrass Big Daddy	2.88	48,266	17,036	0	0	0	48,266	17,036
Barley Nomini	2.65	40,792	15,442	0.57	564	249	41,357	15,691
Oats	2.64	32,405	12,752	0.37	745	498	33,151	13,250
Clover Crimson	2.69	44,296	16,537	0.57	564	249	44,861	16,787
$LSD_{0.05}$	0.73	25,347	8301	NS	1818	NS	25,222	8244

[z]MHCRS = Mountain Horticultural Crops Research Station, Fletcher.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

shortest growing season and lowest average soil temperature.

Large pumpkin cultivar.

2001 experiments with 'Magic Lantern'. No-till 'Magic Lantern' pumpkin total yields at MHCRS ranged from 34,731 to 56,915 kg·ha^{-1} (Table 3). The winter cover residue treatments had no significant effects on yield, fruit size, or fruit number at this site.

At MRS, no-till 'Magic Lantern' pumpkin total yield ranged from 32,715 to 47,280 kg·ha^{-1} (Table 4). Residue treatments had no significant effect on yield and fruit size, but residue cover did affect number of fruit produced, which ranged from 5429 to 7296 fruit/ha (Table 4). Results from MRS and MHCRS in 2001 indicated that all winter cover residue treatments produced excellent no-till pumpkin yields.

2002 experiments with 'Magic Lantern'. At MRS, no-till pumpkin total yield ranged from 105,540 (Patton wheat residue treatment) to 144,081 kg·ha^{-1} (oat residue treatment) (Table 9). Although the oat residue treatment had the greatest no-till pumpkin total yield for this location, a high percentage of the total were cull fruit. The residue treatments that yielded the largest and smallest marketable fruit size were bare soil (9.34-kg/fruit) and Rio ryegrass (6.66-kg/fruit), respectively (Table 9). All treatments yielded excellent pumpkin fruit weights at this location.

The number of marketable fruit/ha produced at MRS was comparable with the other locations. 'Pioneer 26R24' wheat residue treatment had the highest number of marketable fruit (16,437 fruit/ha), whereas the lowest number of marketable fruit produced (11,954 fruit/ha) occurred with Vigoro RC 904 wheat residue and bare soil treatments (Table 9). The yields and size of cull pumpkin fruit produced at this location varied considerably. The highest cull yield produced was 22,631 kg·ha^{-1} (oat residue), whereas the lowest cull yield (4481 kg·ha^{-1}) was observed

Table 7. The effect of winter cover residue on no-till Mystic Plus pumpkin yield at the PRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Wheat Coker 9663	2.01	28,457	15,192	1.09	3361	2242	31,818	17,435
Wheat Pioneer 26R24	1.79	34,059	19,824	0.64	2913	2489	36,972	22,313
Wheat Roane	1.80	33,611	18,678	0.83	1120	748	34,731	19,426
Wheat Patton	1.90	38,093	19,426	1.39	3361	1244	41,454	20,671
Wheat FFR566	1.93	28,233	14,943	0.56	1568	1244	29,802	16,188
Wheat Vigoro RC 904	1.97	30,698	15,938	0.72	1120	748	31,818	16,687
Rye Wrens Abruzzi	2.00	42,126	21,792	0.80	1568	1244	43,695	23,037
Rye Wheeler	1.75	43,246	24,408	0.93	4033	1993	47,280	26,401
Triticale Trical 498	1.96	36,524	18,628	1.34	4705	2440	41,230	21,069
Triticale Trical 308	1.90	39,885	21,419	0.74	1344	995	41,230	22,415
Triticale Arcia	1.97	40,333	20,920	0.86	3361	1993	43,695	22,914
Ryegrass Marshall	1.94	32,043	16,687	1.63	1568	748	33,611	17,435
Ryegrass Rio	1.93	38,765	20,720	1.14	3137	1943	41,902	22,664
Ryegrass Big Daddy	1.99	34,059	16,936	1.11	1344	622	35,404	17,559
Barley Nomini	1.89	29,130	15,938	0.92	1344	748	30,474	16,687
Oats	1.91	33,163	17,433	0.87	2016	1244	35,180	18,678
Clover Crimson	1.82	30,698	17,285	0.70	1792	1244	32,491	18,529
$LSD_{0.05}$	NS	11,203	6478	NS	NS	NS	11,203	6478

[z]PRS = Piedmont Research Station, Salisbury, NC.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

Table 8. The effect of winter cover residue on no-till Mystic Plus pumpkin yield at the UMRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	2.52	34,956	13,948	2.43	10,979	4233	45,935	18,181
Wheat Coker 9663	2.30	34,731	14,943	1.89	6050	2489	40,782	17,433
Wheat Pioneer 26R24	2.30	38,989	17,183	2.25	8066	2739	47,056	19,923
Wheat Roane	2.53	36,076	14,296	3.01	6050	2092	42,126	16,388
Wheat Patton	2.32	33,611	14,444	2.26	5377	2489	28,989	16,934
Wheat FFR566	2.40	31,594	13,199	2.41	11,427	4732	43,022	17,932
Wheat Vigoro RC 904	2.26	32,715	14,444	0.60	1120	498	33,835	14,943
Rye Wrens Abruzzi	2.60	32,043	12,453	2.43	6274	2739	38,317	15,192
Rye Wheeler	2.47	39,885	16,089	2.29	7394	3188	47,280	19,278
Triticale Trical 498	2.47	35,852	14,496	1.93	6498	2637	42,350	17,134
Triticale Trical 308	2.74	48,176	17,433	1.12	3585	1494	51,761	18,927
Triticale Arcia	2.14	34,059	15,938	1.13	1120	498	35,180	16,437
Ryegrass Marshall	2.65	31,370	11,954	1.72	4481	2739	35,852	14,694
Ryegrass Rio	2.53	36,748	14,943	2.24	7394	3235	44,143	18,179
Ryegrass Big Daddy	2.48	35,180	14,197	1.91	3585	1743	38,765	15,941
Barley Nomini	2.64	38,317	14,444	2.60	4481	1743	42,798	16,188
Oats	2.10	28,233	14,046	1.94	4033	2042	32,267	16,089
Clover Crimson	2.16	30,250	13,948	1.58	4257	1993	34,507	15,941
$LSD_{0.05}$	0.42	10,083	4050	1.35	6274	2583	12,324	4774

[z]UMRS = Upper Mountain Research Station, Laurel Springs.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

with Wrens Abruzzi rye residue (Table 9). Pumpkin cull fruit size ranged from 3.31- to 7.03-kg/fruit (Table 9).

At MHCRS, no-till pumpkin total yield varied from 60,248 (crimson clover residue) to 100,798 kg·ha^{-1} (Wrens Abruzzi rye residue) (Table 10). Residue treatments influenced both total and marketable fruit yield. Marketable pumpkin size and numbers of fruit·ha^{-1} ranged from 4.59- to 9.70-kg fruit and from 4,632 to 14,171 fruit/ha, respectively (Table 10).

The cull fruit size and yield also were highly variable among treatments with some treatments producing no cull fruit. The greatest no-till pumpkin cull yield was 5513 kg·ha^{-1} from the Patton wheat residue treatment and the lowest cull pumpkin yield was zero and was produced by several residue treatments (Table 10). Overall yields were lower than those at MRS, probably as a result of landscape position, with the MHCRS field site in a river bottom landscape position that had visual wet conditions during summer, whereas the MRS field site was on an upland terrace.

Total and marketable no-till pumpkin yields were not influenced by residue treatment at the PRS location (Table 11). No-till pumpkin total yield ranged from 58,484 (Roane wheat residue treatment) to 90,975 kg·ha^{-1} (Wrens Abruzzi rye residue treatment). The Rio and Big Daddy ryegrass residue treatments also produced relatively high yields and marketable fruit size. Fruit size ranged from 4.89 ('Pioneer 26R24' wheat treatment) to 7.03-kg/fruit (Rio ryegrass treatment) (Table 11). Pumpkin cull yields ranged from 448 to 13,220 kg·ha^{-1} at PRS (Table 11). The Roane wheat residue treatment produced the lowest cull pumpkin yield (448 kg·ha^{-1}) and also produced the smallest cull size (0.43 kg) (Table 11). The highest cull pumpkin yield (13,220 kg·ha^{-1}) was produced by the Patton wheat treatment (Table 11). The largest cull fruit size was 5.21 kg and was produced by the Wrens Abruzzi rye residue treatment (Table 11), which also produced the greatest total yield in both weight and number of fruit.

At the UMRS location, no-till pumpkin total yield varied from 51,313 (Crimson clover residue treatment) to 85,373 kg·ha^{-1} (Nomini barley residue treatment) (Table 12).

Table 9. The effect of winter cover residue on no-till Magic lantern pumpkin yield at the MRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	9.34	109,797	11,954	7.03	10,083	1494	119,881	13,449
Wheat Coker 9663	7.98	101,730	12,703	3.40	6498	1494	108,229	14,197
Wheat Pioneer 26R24	7.03	114,503	16,437	3.31	8066	1993	122,570	18,431
Wheat Roane	8.30	109,797	13,199	4.71	13,220	2242	123,018	15,442
Wheat Patton	8.07	96,801	12,154	4.67	8739	1793	105,540	13,948
Wheat FFR566	6.94	112,038	16,188	4.71	8739	1993	120,777	18,181
Wheat Vigoro RC 904	7.93	94,112	11,954	6.25	21,959	3487	116,071	15,442
Rye Wrens Abruzzi	8.07	115,399	14,197	4.53	4481	748	119,881	14,945
Rye Wheeler	7.43	112,710	15,091	5.80	16,581	3038	129,292	18,129
Triticale Trical 498	7.07	105,540	14,943	4.49	8290	1494	113,831	16,437
Triticale Trical 308	8.02	108,005	13,498	3.44	9187	1842	117,192	15,347
Triticale Arcia	7.62	110,694	14,694	4.98	14,340	2739	125,034	17,433
Ryegrass Marshall	6.84	102,627	14,943	5.76	17,253	2988	119,881	17,932
Ryegrass Rio	6.66	107,108	16,040	3.40	5377	1294	112,486	17,334
Ryegrass Big Daddy	7.57	109,573	14,545	4.44	12,100	2541	121,673	17,087
Barley Nomini	8.43	116,520	13,846	4.03	9187	1494	125,707	15,341
Oats	8.48	121,449	14,444	5.66	22,631	3737	144,081	18,181
Clover Crimson	7.84	107,332	13,698	4.26	7394	995	114,727	14,694
$LSD_{0.05}$	1.13	23,752	3161	3.62	12,996	2050	24,872	3522

[z]MRS = Mountain Research Station, Laurel Springs.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

Table 10. The effect of winter cover residue on no-till Magic Lantern pumpkin yield for the MHCRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	7.27	69,704	9464	1.76	1853	547	71,557	10,012
Wheat Coker 9663	7.93	94,727	12,827	0.49	994	498	95,721	13,325
Wheat Pioneer 26R24	9.70	79,103	8219	0	0	0	79,103	8219
Wheat Roane	7.83	93,421	11,930	0.38	576	373	93,997	12,303
Wheat Patton	8.28	87,983	11,332	2.77	5513	996	93,496	12,328
Wheat FFR566	6.57	61,973	10,988	0	0	0	61,973	10,988
Wheat Vigoro RC 904	6.63	76,652	11,037	1.47	3841	1245	80,493	12,282
Rye Wrens Abruzzi	6.98	58,847	8593	1.40	1401	249	60,248	8842
Rye Wheeler	8.06	68,836	9165	1.86	2223	298	71,059	9464
Triticale Trical 498	7.14	79,483	10,819	0.41	610	373	80,093	11,192
Triticale Trical 308	4.59	42,500	4632	0	0	0	42,500	4632
Triticale Arcia	7.86	63,991	9464	0.47	712	373	64,702	9838
Ryegrass Marshall	7.20	90,796	13,200	0.74	746	249	91,541	13,449
Ryegrass Rio	6.45	89,881	14,171	3.96	4067	547	93,948	14,719
Ryegrass Big Daddy	6.15	80,922	13,698	0	0	0	80,922	13,698
Barley Nomini	7.99	70,983	9340	3.12	5366	1220	76,349	10,560
Oats	7.07	78,956	11,581	1.81	3276	747	82,232	12,328
Clover Crimson	8.11	100,798	12,577	0	0	0	100,798	12,577
$LSD_{0.05}$	2.55	42,643	7016	3.39	4946	1045	43,545	7319

[z]MHCRS = Mountain Horticultural Crops Research Station, Fletcher.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

At this location, the rye, ryegrass, and wheat residue treatments also resulted in good pumpkin total yields. Residue treatment also influenced yield, fruit size, and numbers of fruit for marketable and cull pumpkins parameters. 'Pioneer 26R24' wheat treatment produced the highest marketable fruit number (12,404 fruit/ha), whereas the Oat residue treatment produced the lowest number of marketable fruit (8220 fruit/ha) (Table 12). Marketable fruit size was generally high for this location, considering cool nighttime summer temperatures for this high elevation location, ranging from 4.67- (Crimson clover residue treatment) to 7.62-kg/fruit (Wrens Abruzzi and Wheeler rye residue treatments) (Table 12). The cull pumpkin fruit yield varied from 448 (Vigoro RC 904 wheat residue treatment) to 20,615 kg·ha^{-1} (bare soil treatment) (Table 12). The bare soil treatment had considerably more cull fruit than the residue treatments. The Vigoro RC 904 wheat residue treatment produced the smallest cull pumpkin fruit size (0.36 kg) and the FFR566 wheat treatment produced the largest cull pumpkin fruit size (5.39 kg) (Table 12).

Conclusions

All residue treatments produced good no-till pumpkin yields at one location per year or another. With any of the winter cover residue types used, we did not see any residue treatments that had potential detrimental effect on pumpkin growth or yield. Because locations varied as a result of elevation, soil type, and weather conditions, these studies should represent conditions for typical pumpkin production for much of the southeastern United States. Although we did measure lower yields for some types of residue on occasion, we not see any consistent detrimental factors or yield reductions resulting from type of residue. This study did not evaluate ease of planting in these residue types. All seed were planted by hand after a no-till planter was run through the plots, so that each plant would have a 0.91-m spacing in-row. Seed placement in

Table 11. The effect of winter cover residue on no-till Magic lantern pumpkin yield for the PRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Wheat Coker 9663	5.03	60,948	12,453	1.63	3809	995	64,758	13,449
Wheat Pioneer 26R24	4.89	59,604	12,453	1.81	4481	995	64,086	13,449
Wheat Roane	5.89	58,035	9712	0.43	448	249	58,484	9961
Wheat Patton	5.66	72,825	13,698	2.54	13,220	3386	86,045	17,084
Wheat FFR566	5.66	77,082	13,698	4.39	4257	995	81,339	14,694
Wheat Vigoro RC 904	5.21	73,721	14,694	2.72	7618	1993	81,339	16,687
Rye Wrens Abruzzi	5.57	81,339	15,442	5.21	9635	2242	90,975	17,685
Rye Wheeler	5.35	73,273	14,694	2.99	5377	1743	78,651	16,437
Triticale Trical 498	5.35	69,463	13,449	2.67	6498	1743	75,962	15,192
Triticale Trical 308	5.35	67,671	13,199	3.40	6722	1993	74,393	15,192
Triticale Arcia	5.66	68,791	13,199	3.08	12,772	2988	81,564	16,188
Ryegrass Marshall	5.80	60,948	10,959	0.77	2240	748	63,189	11,707
Ryegrass Rio	7.03	79,099	12,103	2.85	7170	1993	86,269	14,096
Ryegrass Big Daddy	6.48	79,099	12,601	3.17	8963	2092	88,062	14,694
Barley Nomini	5.98	67,671	11,455	1.99	6722	1244	74,393	12,700
Oats	5.48	73,945	14,195	2.76	5377	1993	79,323	16,188
Clover Crimson	5.53	65,654	12,453	1.49	3585	1244	69,239	13,698
$LSD_{0.05}$	1.04	NS	5434	2.81	8514	2097	NS	5434

[z]PRS = Piedmont Research Station, Salisbury, NC.
NS = not significant at $a = 0.05$.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

Table 12. The effect of winter cover residue on no-till Magic Lantern pumpkin yield for the UMRS[z], 2002.

	Marketable yield			Cull yield			Total yield	
Winter cover residue	kg/fruit	kg· ha^{-1}	no. fruit/ha	kg/fruit	kg·ha^{-1}	no. fruit/ha	kg·ha^{-1}	no. fruit/ha
Bare soil	6.48	62,069	9662	4.30	20,615	4732	82,684	14,395
Wheat Coker 9663	6.84	71,480	10,460	1.95	6274	2242	77,754	12,703
Wheat Pioneer 26R24	5.94	72,152	12,404	2.85	12,772	3139	84,925	15,543
Wheat Roane	7.34	70,808	9662	3.17	8514	2042	79,323	11,705
Wheat Patton	6.57	69,015	10,460	2.67	10,370	2489	79,323	12,950
Wheat FFR566	6.98	66,550	9961	5.39	10,755	1494	77,306	11,455
Wheat Vigoro RC 904	6.35	62,069	9862	0.36	448	249	62,517	10,112
Rye Wrens Abruzzi	7.62	77,306	10,210	4.85	6274	1494	83,580	11,705
Rye Wheeler	7.62	75,962	9961	3.53	6498	1244	82,460	11,206
Triticale Trical 498	7.52	55,795	7471	4.53	10,979	2242	66,774	9714
Triticale Trical 308	6.53	56,691	8716	3.62	11,652	2739	68,343	11,455
Triticale Arcia	7.07	65,430	9215	2.35	6050	1993	71,480	11,208
Ryegrass Marshall	7.52	75,065	9912	3.76	6050	1543	81,115	11,455
Ryegrass Rio	7.71	75,289	9862	2.08	6946	1543	82,236	11,406
Ryegrass Big Daddy	7.12	68,567	9714	3.99	10,307	1743	78,875	11,458
Barley Nomini	7.34	69,463	9215	4.26	15,909	3737	85,373	12,952
Oats	6.21	50,865	8220	2.99	4705	995	55,571	9215
Clover Crimson	4.67	39,437	8269	5.17	11,876	2788	51,313	11,058
$LSD_{0.05}$	1.17	21,735	3166	3.17	11,427	2358	25,320	4122

[x]UMRS = Upper Mountain Research Station, Laurel Springs.
Pumpkins were planted on 1.82-m between-row and 0.91-m in-row spacing.
100 kg N ha^{-1} applied at planting.
LSD = least significant difference.

the soil may be an additional factor affecting no-till pumpkin yield with type of residue affecting correct seed depth.

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