TILLAGE REQUIREMENTS FOR VEGETABLES FOLLOWING WINTER ANNUAL GRAZING

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ABSTRACT

In Alabama, over 400,000 ac of winter annuals are grazed prior to planting summer row crops. Previous research indicates that cattle grazed on ryegrass (*Lolium multiflorum* L.) pastures over the winter months in Alabama can be profitable, but winter grazing creates excessive compaction, which can adversely affects yields of subsequent summer crops. We initiated a study to determine the optimal tillage system for sweet corn (*Zea mays*, L.), southern field pea (*Vigna unguiculata* L.), and watermelon (*Citrullus lanatus* L.) production on a Wynnville fine sandy loam (Fine-loamy, siliceous, subactive, thermic Glossic Fragiudults), in north central Alabama from 2001 to 2003. Three surface tillage treatments (chisel/disk/level, disk/level, no surface tillage) and three deep tillage treatments (no deep tillage, in-row subsoiling, paratill) were arranged in a factorial randomized complete block design with four replications. Each fall, all plots were planted to ryegrass and stocked with 3 cattle ac^{-1}. Southern field pea yields responded to surface tillage following winter annual grazing with disking comparable to chisel and disking. Sweet corn yields responded to a combination of surface and deep tillage, although deep tillage produced similar yields to surface tillage during one growing season. Watermelon yields were maximized following winter annual grazing with only deep tillage alone without any surface tillage.

INTRODUCTION

Growers who concentrate on vegetable production typically receive higher returns per land unit area than growers who produce only traditional summer field crops. Although the farm operations are much smaller, vegetables prices received are typically much higher. For example, Alabama's 2005 cotton crop was valued at $198 million across 550,000 acres ($360 ac^{-1}), but all vegetable crops were valued at over $12.5 million across only 6,300 acres (~$2000 ac^{-1}) during the same year (NASS, 2005). Despite the higher value that vegetable growers receive for their crops, the ability to diversify into other systems may further enhance potential economical benefits. One option involves the contract grazing of stocker cattle during the winter and early spring months.

In Alabama, Ball (1988) reported over 400,000 ac. of winter annuals are grazed prior to planting summer row crops. Bransby et al. (1999) reported profits of $70 to $224 ac^{-1} for cattle grazed on ryegrass pastures over the winter months in Alabama, while Siri-Prieto et al. (2007) reported profits of approximately $80 ac^{-1} for cattle winter grazed on ryegrass or oats (*Avena sativa* L.). These profits illustrate the potential that exists for vegetable growers to increase their income over the winter months following the summer growing season.

Unfortunately, winter grazing contributes to soil compaction problems, which negatively affects yields of subsequent summer crops (Touchton et al., 1989; Miller et al., 1997; Mullins and Burmester, 1997). Although vegetable growers can supplement their income and reduce economic risk by incorporating winter grazing into their operation, this increase in profitability over the winter months should not be at the expense of vegetable yields the following year. Therefore, the objective of this study was to compare vegetable yields in a sweet corn-watermelon-field pea rotation among various surface and deep tillage combinations following winter annual grazing of stocker cattle.

MATERIALS AND METHODS

This experiment was established at the Sand Mountain Research and Extension Center in Crossville, AL on a Wynnville fine sandy loam. Treatments were a factorial arrangement of three surface tillage treatments (chisel/disk/level, disk/level, no surface tillage) and three deep tillage treatments (no deep tillage, in-row subsoiling, paratill) in a randomized complete block design with four replications, established for each of three crops (sweet corn, southern pea, and watermelon) grown simultaneously. The crops were rotated each year in a southern pea-sweet corn-watermelon sequence for 3 yr. Plot dimensions were 11 ft. wide and 45 ft. long, allowing for a 1 ft. buffer between plots. Each replication of each crop phase was sampled separately for pH, P, and K to a depth of 8 inches by collecting 20 soil cores with a probe diameter of 0.75 inches. Initial soil pH, measured in a 1:1 soil/water extract, was 6.3, 6.2, and 6.2 for the watermelon, southern pea, and sweet corn phases. Phosphorus levels were ‘high’ and K levels were ‘medium’ for each phase based on the Mehlich I extractant (Mehlich, 1953) and the Auburn University Soil Testing Laboratory (Adams et al., 1994).

Ryegrass cv. ‘Marshall’ was planted at 25-30 lb ac^{-1} with a no-till drill that had row spacings of 7.5 inches on 14 Sept. 2000, 10 Sept. 2001, and 23 Sept. 2002. At planting, all plots received an average rate of 100 lb N ac^{-1}, 100 lb P_2O_5 ac^{-1}, and 100 lb K_2O ac^{-1}. In late February, ryegrass plots were fertilized with 62 lb N ac^{-1} in 2001, 60 lb N ac^{-1} in 2002, and 102 lb N ac^{-1} in 2003 to promote maximum vegetative growth for grazing. Sweet corn and watermelon received approximately 130 lb N ac^{-1} and 60 lb N ac^{-1} soon after planting, respectively.

Plots were grazed, beginning in late November to early December, at a stocking rate of 2.7 cattle ac^{-1} and removed by early to mid-April to facilitate vegetable planting. Cattle performance was determined each year by weighing each animal prior to grazing and again at the time of removal from grazing. Biomass samples were collected after cattle removal and prior to tillage operations. Ryegrass was chemically terminated and tillage treatments were administered to corresponding plots. Typical cultural practices recommended for each crop by the Alabama Cooperative Extension System for fertilizer and to control weeds and insects were utilized throughout the season to maximize yields. Agronomic practices related to specific cultivars, planting dates, seeding rates and harvest dates for each crop are presented in Table 1. Yields of each crop were measured by hand-harvesting mature vegetables from the two center rows of each plot and summing the weights from each harvest date.

Yields were analyzed using the MIXED procedure (Littell et al., 1996) and the LSMEANS PDIFF option to distinguish between treatment means (release 9.1; SAS Institute Inc.; Cary, NC). Data were analyzed with year as a fixed effect in the model, and there were significant year X treatment interactions for yield. Therefore, yields were analyzed within each year, with yield and discussion presented by year. Surface and deep tillage treatments were considered fixed effects, while rep was considered random. Treatment differences were considered significant if $P \leq 0.05$.

Table 1. Planting dates, cultivar, seeding rate, and harvest dates for sweet corn, southern field pea, and watermelon grown at the Sand Mountain Substation near Crossville, AL during 2001-2003.

Crop	Planting dates†	Cultivar	Seeding rate	Harvest dates 2001	2002	2003
			--plants ac^{-1}--			
	4-26-2001	Silver	26,000	7-19	7-12	7-25
Sweet corn	4-18-2002	Queen		7-26	7-19	7-28
	4-15-2003			8-6	7-24	7-31
				7-24	7-26	8-1
	5-16-2001	Pinkeye	2600	7-29	7-30	8-4
Southern field pea	5-15-2002	Purplehull		8-2	8-2	8-6
	5-29-2003			8-7	8-7	
	5-16-2001	AU	870	8-24	8-16	8-29
Watermelon	5-15-2002	Producer		8-30	8-23	9-5
	5-29-2003					

† Planting dates represent original planting dates. In 2001, a portion of the sweet corn plots (new plant date; 5-8-2001) and all the southern field pea and watermelon plots (new plant date; 5-25-2001) had to be re-planted due to dry weather. In 2003, sweet corn plots had to be re-planted (new plant date; 5-2-2003) due to poor seed germination.

RESULTS AND DISCUSSION

Cattle performance measured over three grazing periods indicated that the average gain was 925 lb ac^{-1}, which generated an average net return of \$169 ac^{-1} (Table 2). After cattle were removed, surface residue was minimal. Ryegrass biomass production was low due to intensive grazing by the cattle. In 2001, ryegrass was heavily grazed, so no biomass measurements were collected; however, prior to the initiation of tillage treatments, ryegrass biomass averaged 360 lb ac^{-1} in 2002 and 870 lb ac^{-1} in 2003.

Table 2. Cattle performance measured during three grazing periods at the Sand Mountain Research Station in Crossville, AL.

	2000-2001	2001-2002	2002-2003	Mean
Grazing period, days	129	129	138	132
Average daily gain, lb day^{-1}	2.5	2.9	2.4	2.6
Total gain, lb ac^{-1}†	871	1010	894	925
Gross income, \$ ac^{-1}‡	314	364	322	333
Net returns, \$ ac^{-1}§	150	200	158	169
Cost per gain. \$ lb^{-1}	0.19	0.16	0.18	0.18

† Stocking rate of 2.7 cattle ac^{-1}.
‡ Contract price of \$0.36 lb^{-1}
§ Average variable cost of \$164 ac^{-1}, excluding fences, water facilities, and rent.

In 2001, both surface tillage treatments produced superior sweet corn yields when compared to no surface tillage (Table 3). Sweet corn yields following deep tillage were not different in 2001, but numerically higher yields were measured following either deep tillage operation (Table 3). A significant interaction was observed between surface tillage and deep tillage in 2002 and 2003. In 2002, both deep tillage operations required some form of surface tillage to maximize sweet corn yields (Fig. 1). However, the surface tillage operation was not consistent for each deep tillage operation. In-row subsoiling produced higher yields when the disk/level treatment was applied, while the paratill treatment produced higher yields in combination with the chisel/disk/level treatment. Sweet corn yields across all treatments were lower in 2003 due to wind damage from a tropical storm (Table 3). Surface tillage was required to maximize sweet corn yields when no deep tillage was performed, however there was no yield increase by including either form of surface tillage following in-row subsoiling or the paratill treatment (Fig. 1).

Southern field pea yields only responded to surface tillage treatments 2 out of 3 years compared to no surface tillage, while deep tillage had no effect on yields following winter annual grazing (Table 3). A single disking operation was equivalent to a chisel and disking operation, however, numerical field pea yields were greater in 2001 following the chisel and disking operation.

Watermelon yields responded to a combination of surface and deep tillage treatments during the 2001 and 2002 growing seasons (Table 3). Although not significant, there was a trend ($P<0.12$) the last year of the experiment that also indicated a combination of surface and deep tillage treatments were required to maximize yields. In 2001 and 2002, watermelon yields responded to surface tillage in the absence of deep tillage, which were equivalent to yields obtained when surface tillage was combined with deep tillage (Fig. 2). The difference was not significant, but watermelon yields responded greater to in-row subsoiling compared to the paratill operation, either alone or combined with surface tillage (Fig. 2).

CONCLUSIONS

Sweet corn yields responded to a combination of surface and deep tillage, although deep tillage produced similar yields to surface tillage during one growing season. Southern field pea yields only responded to surface tillage following winter annual grazing with disking comparable to chisel and disking. Watermelon yields following winter annual grazing with only deep tillage alone were maximized without any additional surface tillage. The results of this study confirm that vegetable growers who complement their operations with winter annual grazing should be aware of potential soil compaction problems, but the tillage system required to correct the problem varies with the vegetable grown.

Table 3. Sweet corn, southern field pea, and watermelon yields measured following winter annual grazing of stocker cattle and combinations of surface and deep tillage for the 2001, 2002, and 2003 growing seasons at the Sand Mountain Research Station in Crossville, AL.

	Sweet corn			Southern field pea			Watermelon		
Tillage system	2001	2002	2003	2001	2002	2003	2001	2002	2003
	---cwt ac^{-1}†---								
Surface tillage									
Chisel/disk/level	195.5	175.9	97.3	60.7	36.6	52.7	631.3	384.8	357.1
Disk/level	185.7	166.1	93.8	57.1	36.6	55.4	621.4	393.8	407.1
None	92.9	127.7	74.1	48.2	39.3	44.6	520.5	350.9	326.8
$LSD_{0.05}$	25.0	16.1	15.2	6.3	NS‡	7.1	NS	NS	NS
Deep tillage									
In-row subsoil	175.0	152.7	93.8	55.4	39.3	51.8	655.4	480.4	360.7
None	144.6	153.6	75.9	53.6	36.6	51.8	470.5	304.5	364.3
Paratill	154.5	163.4	96.4	58.0	36.6	49.1	647.3	343.8	365.2
$LSD_{0.05}$	25.0	NS	15.2	NS	NS	NS	100.9	108.0	NS
	Analysis of variance ($P > F$)								
Surface tillage	<0.0001	<0.0001	0.0090	0.0011	0.5597	0.0145	0.0626	0.6905	0.1702
Deep tillage	0.0564	0.3024	0.0241	0.4154	0.6530	0.7230	0.0010	0.0068	0.9922
Surface X Deep	0.3843	0.0135	0.0152	0.1208	0.9858	0.5202	0.0002	0.0172	0.1252

† Yields are the totals of all the harvest dates within each year.

‡ Not significant at the 0.05 level of probability.

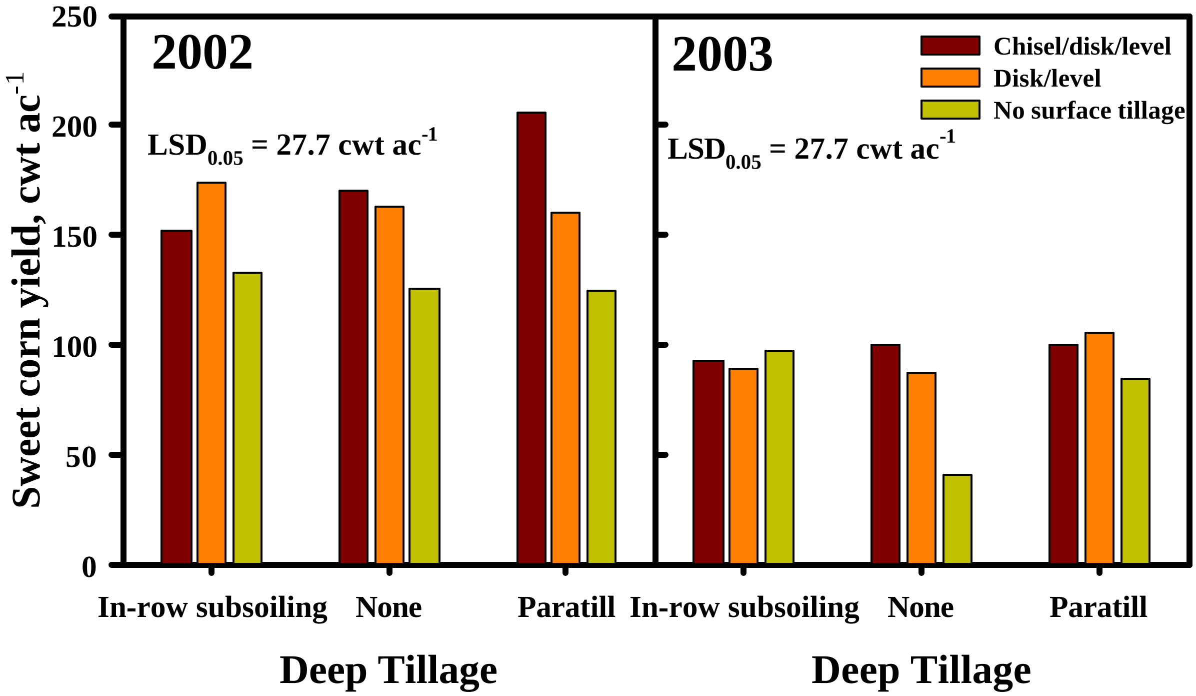

Figure 1. Sweet corn yields measured following winter annual grazing of stocker cattle and combinations of surface tillage and deep tillage treatments during the 2002 and 2003 growing seasons at the Sand Mountain Research and Extension Center in Crossville, AL

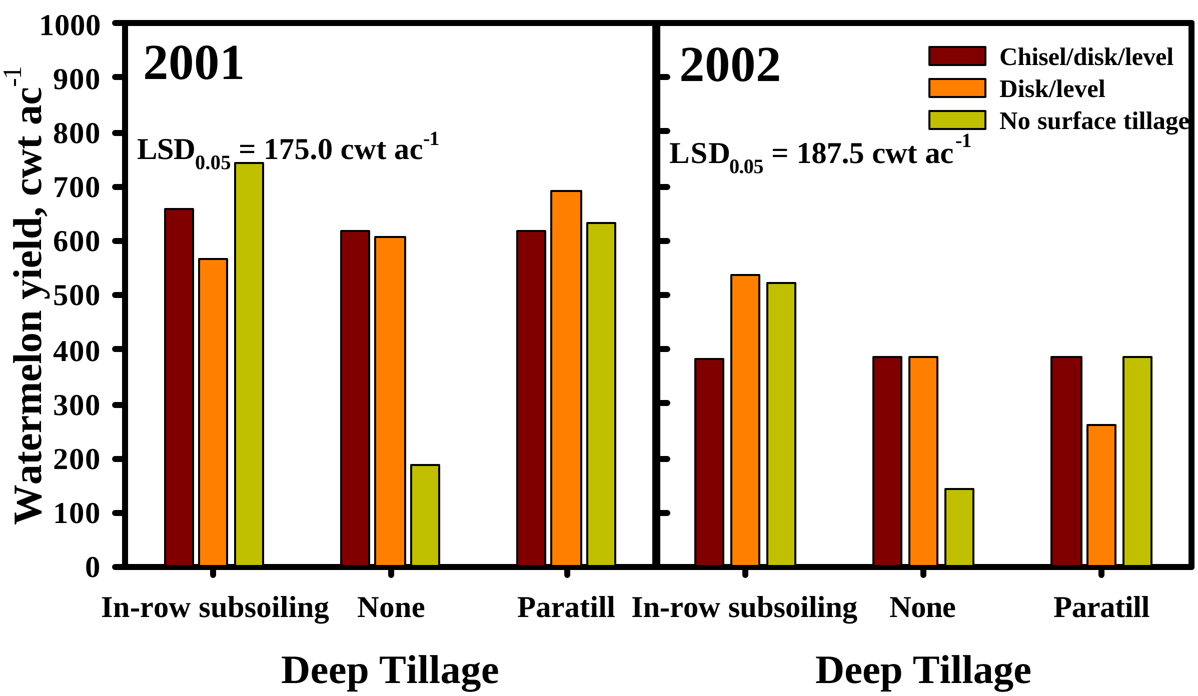

Figure 2. Watermelon yields measured following winter annual grazing of stocker cattle and combinations of surface tillage and deep tillage treatments during the 2001 and 2002 growing seasons at the Sand Mountain Research and Extension Center in Crossville, AL

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