THE IMPACT OF GRAZING WINTER ANNUALS ON SOIL COMPACTION AND NO-TILL CORN AND SOYBEAN YIELD

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Feeding hay during the winter months in Missouri is expensive. Winter rye and ryegrass have been cost-effective options to feeding hay or stockpiled tall fescue (Bishop-Hurley and Kallenbach, 2001). Winter rye (Blevins et al. 1971) and ryegrass (Jung et al., 1991; Sollenberger et al., 1984) have also been used as cover crops to reduce soil erosion (Griffith et al. 1986), improve soil structure and organic matter, suppress weeds (Barnes and Putnam 1981; Barnes and Putnam 1986; Creamer et al. 1996;), reduce nitrate leaching, and alter physical and chemical soil characteristics (Lal et al. 1991; Mitchell and Teel 1977; Worshman 1990). Since farmers in the Midwest often experience winter annual weed problems, these producers may be missing an opportunity to integrate winter annual forages into their production system.

Soils in Northern Missouri do not remain frozen throughout the winter months. These soils may be wet during the spring. This moisture provides conditions for excellent spring growth of winter annual forage grasses. However, grazing cattle during these conditions may increase soil compaction and require spring tillage to remedy compaction problems. Limited research has quantified the impact of grazing on claypan soil compaction and the subsequent impact on grain crop yields. This research was initiated to determine the effect of grazing winter annuals on soil compaction and no-till corn and soybean yield compared with non-grazed winter annual treatments.

Research was conducted at the Greenley Research Center near Novelty, MO from 2003 to 2008. A split-split plot design with grazed and non-grazed winter annuals as the main plot, corn and soybean as the sub-plot, and winter annual forages (Forage Master winter rye, P25R37 winter wheat, King annual ryegrass, Marshall annual ryegrass, and non-treated winter annual weeds) as the sub-sub plot. Treatments were 10 by 50 ft with four replications. Four to eleven open cows or cow-calf pairs were used to spring flash graze the plot area for two to five days to simulate a management intensive grazing system. Forage samples were harvested from the non-grazed plots and mowed. Samples were dried and dry weights recorded to calculate forage dry weight yield. All residue was left on the soil surface of the non-grazed plots to prevent nutrient removal. Winter annual forages were harvested once the winter annual forages reached 8 to 10 inch heights.

Soil penetrometer readings were recorded during mid-July at seven, two-inch depth intervals and three to ten subsamples/plot. No penetrometer evaluations were recorded in 2005 and 2007 due to drought conditions throughout the summer. Corn and soybean plots were harvested with a small plot combine and moisture adjusted to 15 and 13%, respectively, prior to an analysis. All

data were subjected to analysis of variance and means separated using Fisher's Protected LSD at p=0.05. Main effects were presented when there was an absence of interactions.

Forage yields were similar following corn or soybean residue in 2003 and ranged from 1.35 to 2.73 ton/acre (Table 1). Corn grain yield was 7 to 15 bu/a greater in the non-seeded winter annual weed only treatment when compared to winter annual forage grasses in 2003 while soybean grain yield was similar amongst winter rye, annual ryegrass, and the non-seeded control. Penetrometer resistance to the 6 inch depth was greater in the corn and soybean grazed treatments when compared to the non-grazed treatments (Table 2). Corn grain yield was 12 bu/a greater in the non-grazed treatment while soybean grain yield was 3 bu/a greater in grazed treatment in 2003.

Winter annual forages were harvested four times in 2004 (Table 3). Winter annual dry weight yield was similar following corn and soybean residue except for wheat. Dry weight yields ranged from 0.68 to 1.62 ton/acre. Winter annual weeds produced as much dry matter as some of the winter annual forages evaluated in this research. Penetrometer resistance was greater in the grazed than non-grazed treatments to the 4 inch depth in soybean following the winter annuals (Table 4). Corn grain yield was similar for the non-treated, wheat, and Marshall annual ryegrass; however soybean grain yields with winter rye and King annual ryegrass were similar to the non-treated control. Grazing reduced soybean yield9 bu/acre in 2004.

Winter annual forages were grazed two times in 2005 with dry weight yields ranging from 0.31 to 0.82 ton/acre (Table 5). King and Marshall ryegrass had poor establishment in standing soybean in 2005. This was probably due to the prolonged drought followed by relatively cold, wet weather. There was no difference in corn or soybean grain yield following the winter annual forages and the non-treated control. Similarly, there was no effect of grazing on corn or soybean grain yields in 2005 (Table 6).

In 2006, winter annual forages were grazed three times (Table 7); however, annual ryegrass survival was limited. Wheat and winter rye dry weights ranged from 2.5 to 3.7 ton/acre. Corn grain yield was 9 to 11 bu/a greater following wheat and King annual ryegrass, respectively. Soybean yields were similar or less than the non-seeded control. Penetrometer resistance was greater in the grazed than the non-grazed area, but no effect on corn or soybean yield was observed (Table 8).

Winter annual forage production was low in 2007, and was grazed only two times. Forage production was similar following corn and soybean. Annual ryegrass winter kill was extensive. Corn grain yield was reduced 12 to 27 bu/acre when corn followed winter wheat or rye. Soybean grain yields following winter annual forages were ranked winter rye = King annual ryegrass = Marshall annual ryegrass $\geq$ non-seeded > wheat. Corn grain yield following non-grazed soybean was 6 bu/acre greater than grazed stubble; however, soybean yields were slightly greater in the grazed compared to the non-grazed treatments. A dry summer prevented recording of penetrometer resistance among treatments.

Winter annual weeds were prolific in 2008. Annual ryegrass experienced extensive winter kill and winter annual weeds (henbit) were the primary contributor to forage dry weights. Winter

annual forages were grazed three times in saturated soil conditions which resulted in extensive tracking of the grazed areas. Forage production was greater following soybean residue than corn residue. Forage production was ranked winter wheat = winter rye > annual ryegrass. Penetrometer resistance was greater in the grazed than the non-grazed area 8 inches into the soil profile (Table 12). Visual inspection of corn height and stand indicated a substantial impact of grazing when compared to non-grazed areas.

In summary, grazed winter annuals have resulted in increased penetrometer resistance in the top 6 to 8 inches of soil. This has resulted in a reduction in corn grain yield in three of five years of research and a variable effect on soybean grain yields. There was no increase in corn grain yield following ryegrass, wheat, or winter rye when compared to the non-treated control except when corn followed wheat and King annual ryegrass in 2006. A reduction in corn grain yield has been observed following winter rye depending on the year. Soybean grain yields following winter annual forages have usually been similar to or less than the non-treated control. An economic analysis needs to evaluate the forage and crop yields of grazed winter annuals compared with non-treated non-grazed crop production land.

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Table 1. Winter annual forage, corn, and soybean yields in 2003.

Winter annual treatment	Forage yield[a] following		Grain yield[b]	
	corn residue	soybean residue	Corn	Soybean
	ton/acre		bu/acre	
Wheat (P25R37)	1.78	2.14	134	41
Winter rye (Forage master)	2.33	2.73	134	44
Annual ryegrass (Marshall)	1.39	1.66	141	44
Annual ryegrass (King)	1.35	1.56	142	46
Non-seeded (winter annual weeds)	1.56	1.89	149	44
LSD (p=0.05)	0.64		5	2

[a]Harvested April 5, April 18, and April 29. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged over grazing treatments.

Table 2. The effect of grazing winter annual forages on penetrometer resistance and subsequent grain crop yields in 2003.[a]

Cropping system	Penetrometer resistance				Grain yield[b]	
	0-2 in.	2-4 in.	4-6 in.	6-8 in.	Corn	Soybean
	psi				bu/acre	
Soybean following grazed winter annuals	231	519	512	525		45
Soybean following non-grazed winter annuals	162	313	371	416		42
Corn following grazed winter annuals	268	493	533	587	134	
Corn following non-grazed winter annuals	177	320	408	482	146	
LSD (p=0.05)	65	90	122	NS	5	2

[a]Grazed three to four days starting on April 5, April 18, and April 29. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.

Table 3. Winter annual forage, corn, and soybean yields in 2004.

Winter annual treatment	Forage yield[a] following		Grain yield[b]	
	corn residue	soybean residue	Corn	Soybean
	ton/acre		bu/acre	
Wheat (P25R37)	0.68	1.20	218	46
Winter rye (Forage master)	1.07	1.28	169	54
Annual ryegrass (Marshall)	1.17	1.62	208	53
Annual ryegrass (King)	1.30	1.56	182	55
Non-seeded (winter annual weeds)	1.13	0.91	214	56
LSD (p=0.05)	0.48		18	2

[a]Harvested January 20, April 6, April 21, and May 4, 2004. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged over grazing treatments.

Table 4. The effect of grazing winter annual forages on penetrometer resistance and subsequent grain crop yields in 2004.[a]

Cropping system	Penetrometer resistance				Grain yield[b]	
	0-2 in.	2-4 in.	4-6 in.	6-8 in.	Corn	Soybean
	psi				bu/acre	
Soybean following grazed winter annuals	278	276	255	260		48
Soybean following non-grazed winter annuals	220	220	221	236		57
Corn following grazed winter annuals	240	252	251	270	197	
Corn following non-grazed winter annuals	196	230	247	273	200	
LSD (p=0.05)	45	37	NS	NS	NS	2

[a]Grazed three to four days starting on January 20, April 6, April 21, and May 4, 2004. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.

Table 5. Winter annual forage, corn, and soybean yields in 2005.

Winter annual treatment	Forage yield[a] following		Grain yield[b]	
	corn residue	soybean residue	Corn	Soybean
	ton/acre		bu/acre	
Wheat (P25R37)	0.64	0.66	97	52
Winter rye (Forage master)	0.58	0.82	100	53
Annual ryegrass (Marshall)	0.31	0	104	54
Annual ryegrass (King)	0.62	0	104	53
Non-seeded (winter annual weeds)	0	0	106	54
LSD (p=0.05)	0.42		NS	NS

[a]Harvested April 19 and May 2, 2005. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged over grazing treatments.

Table 6. The effect of grazing winter annual forages on penetrometer resistance and subsequent grain crop yields in 2005.[a]

Cropping system	Penetrometer resistance				Grain yield[b]	
	0-2 in.	2-4 in.	4-6 in.	6-8 in.	Corn	Soybean
	psi				bu/acre	
Soybean following grazed winter annuals	—[c]	—	—	—		53
Soybean following non-grazed winter annuals	—	—	—	—		53
Corn following grazed winter annuals	—	—	—	—	102	
Corn following non-grazed winter annuals	—	—	—	—	103	
LSD (p=0.05)					NS	NS

[a]Grazed three to four days starting on April 19 and May 2, 2005. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.
[c]Unable to collect penetrometer data due to dry conditions throughout the summer.

Table 7. Winter annual forage, corn, and soybean yields in 2006.

Winter annual treatment	Forage yield[a] following		Grain yield[b]	
	corn residue	soybean residue	Corn	Soybean
	ton/acre		bu/acre	
Wheat (P25R37)	3.2	3.3	147	64
Winter rye (Forage master)	3.7	2.5	138	69
Annual ryegrass (Marshall)	0.3	0.5	143	69
Annual ryegrass (King)	0.1	0.3	149	72
Non-seeded (winter annual weeds)	1.3	1.7	138	71
LSD (p=0.05)	0.6		8	3

[a]Harvested April 4, April 21, and May 2, 2006. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged over grazing treatments.

Table 8. The effect of grazing winter annual forages on penetrometer resistance and subsequent grain crop yields in 2006.[a]

Cropping system	Penetrometer resistance				Grain yield[b]	
	0-2 in.	2-4 in.	4-6 in.	6-8 in.	Corn	Soybean
	psi				bu/acre	
Soybean following grazed winter annuals	153	283	277	247		69
Soybean following non-grazed winter annuals	93	196	207	224		69
Corn following grazed winter annuals	147	267	255	240	142	
Corn following non-grazed winter annuals	97	208	229	239	144	
LSD (p=0.05)	41	39	27	18	NS	NS

[a]Grazed three to four days starting on April 4, April 21, and May 2, 2006. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.

Table 9. Winter annual forage, corn, and soybean yields in 2007.

Winter annual treatment	Forage yield[a] following		Grain yield[b]	
	corn residue	soybean residue	Corn	Soybean
	ton/acre		bu/acre	
Wheat (P25R37)	0.7	1.0	113	49
Winter rye (Forage master)	1.2	1.6	112	53
Annual ryegrass (Marshall)	0.9	0.6	125	52
Annual ryegrass (King)	0.6	0.9	127	53
Non-seeded (winter annual weeds)	0.2	0.7	129	51
LSD (p=0.05)	0.3		8	2

[a]Harvested April 2 and April 18, 2007. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged over grazing treatments.

Table 10. The effect of grazing winter annual forages on penetrometer resistance and subsequent grain crop yields in 2005.[a]

Cropping system	Penetrometer resistance				Grain yield[b]	
	0-2 in.	2-4 in.	4-6 in.	6-8 in.	Corn	Soybean
	psi				bu/acre	
Soybean following grazed winter annuals	—[c]	—	—	—		52
Soybean following non-grazed winter annuals	—	—	—	—		50
Corn following grazed winter annuals	—	—	—	—	118	
Corn following non-grazed winter annuals	—	—	—	—	124	
LSD (p=0.05)					6	1

[a]Grazed four to six days starting on April 2 and April 18, 2007. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.
[c]Unable to collect penetrometer data due to dry conditions throughout the summer.

Table 11. Winter annual forage yields in 2008.

Winter annual treatment	Forage yield[a] following corn residue	Forage yield[a] following soybean residue
	ton/acre	
Wheat (P25R37)	0.7	2.6
Winter rye (Forage master)	1.0	2.5
Annual ryegrass (Marshall)	0.4	1.8
Annual ryegrass (King)	0.3	1.4
Non-seeded (winter annual weeds)	0	1.7
LSD (p=0.05)	0.7	

[a]Harvested April 7, April 23, and May 7, 2008. Grazing timings were determined based on mowed plot regrowth.

Table 12. The effect of grazing winter annual forages on penetrometer resistance in 2008.[a]

Cropping system	Penetrometer resistance 0-2 in.	2-4 in.	4-6 in.	6-8 in.
	psi			
Soybean following grazed winter annuals	135	238	246	252
Soybean following non-grazed winter annuals	102	162	191	210
Corn following grazed winter annuals	178	250	243	244
Corn following non-grazed winter annuals	109	171	172	187
LSD (p=0.05)	31	37	26	29

[a]Grazed four to six days starting on April 7, April 23, and May 7, 2008. Grazing timings were determined based on mowed plot regrowth.
[b]Grain yield was reported as a main effect and was averaged winter annual forage treatments.