Effect of Rye (Secale cereale) Mulch on Weed Control and Soil Moisture in Soybean (Glycine max)

Effect of Rye (*Secale cereale*) Mulch on Weed Control and Soil Moisture in Soybean (*Glycine max*)[1]

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Abstract. A four-year experiment was conducted near Urbana, IL to evaluate the effect of a rye cover crop on weed control, soybean yield and soil moisture. Soybeans were planted into either a rye mulch or corn stubble (with and without spring tillage). Giant foxtail, velvetleaf, smooth pigweed and common lambsquarters control in the rye mulch plots was generally greater than 90% and better than the corn residue treatments five weeks after planting. Weed control was generally better, except for lambsquarters, in the corn residue without spring tillage plots compared to the spring-tilled plots. Herbicides improved weed control in the corn residue plots but not in the no-till rye treatment, due to the excellent control by the rye mulch. Soil water content was lowest during June under the late-killed (killed at planting) rye during dry periods due to water depletion caused by the growing rye. During wet periods the rye mulch resulted in a wetter soil profile compared to the corn residue treatments. Soybean yields were reduced in late-killed rye compared to early-killed rye (killed 2 wk prior to planting) due to soybean stand reductions in the late killed rye. Yields in early-killed rye and spring-tilled treatments were similar to or better than soybeans planted in corn residue without spring tillage. **Nomenclature:** Common lambsquarters, *Chenopodium album* L. #[3] CHEAL; giant foxtail, *Setaria faberi* Herrm. # SETFA; smooth pigweed, *Amaranthus hybridus* L. # AMACH; velvetleaf, *Abutilon theophrasti* Medik. # ABUTH; rye, *Secale cereale*; corn, *Zea mays* L.; soybean, *Glycine max* (L.) Merr. 'Hack'.

Additional index words: Cover crop, no-tillage, reduced tillage.

INTRODUCTION

Conservation tillage is a system of cultivation and crop residue management that maintains residue on the soil surface and minimizes soil disturbance. Benefits of this tillage system include reduction of soil erosion caused by wind and water, reduction in fuel consumption associated with tillage, and potential conservation of soil water.

One of the most striking changes associated with the adoption of conservation tillage has been in the area of weed control because preplant tillage and cultivation are severely reduced. Reduction in tillage may necessitate that herbicides be substituted for mechanical weed control. Another challenge posed by conservation tillage has been shifting weed spectrums. The adoption of conservation-tillage cropping systems has been reported to increase populations of annual grasses and perennial broadleaf weeds and decrease densities of annual broadleaf weeds. Systems with limited tillage maximize the potential for weed growth from seed at or near the soil surface (24). Annual grass weed populations have been found to be higher in no-till compared to conventional tillage (5, 20, 24). Buhler and Daniel (5) reported giant foxtail densities eight times higher in no-till compared to conventionally tilled plots. Decreased populations of velvetleaf (5), morningglory (*Ipomoea lacunosa* L. and *I. purpurea* L.), common ragweed (*Ambrosia artemisiifolia* L.), lambsquarters (19), and other dicotyledonous weeds (9) have been associated with the adoption of no-till primarily due to reduced soil mixing.

Conservation tillage impacts numerous soil factors and environmental conditions that influence weed seed germination. Two important factors responsible for the reduction of weed populations are chemical and physical suppression by crop residues and the elimination of soil disturbance. In reduced tillage systems where a fall seeded cover crop is killed in the spring, decomposition of plant residues result in the production or release of phytotoxic compounds that are allelopathic to weed growth (2, 3, 13, 19). Rye mulch suppressed above ground biomass of redroot pigweed (*Amaranthus retroflexus* L.), common lambsquarters, and common ragweed (19). Two benzoxazinones isolated from rye

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

shoots suppressed seed germination and seedling growth in three dicot species that were 30% more sensitive than monocots (2). Additional allelochemicals may result from microbially transformed compounds originally from rye residues (16). Surface residues also reduce weed seed germination and seedling growth by shading, lowering soil temperature, and acting as a physical barrier (8). Eliminating tillage reduces broadleaf weed densities presumably because weed seed are isolated from germination stimuli that can overcome dormancy forces. In no-tillage pea (*Pisum sativum* L.) production, the weed density was reduced 60% by eliminating primary and secondary tillage (17). In Iowa, Vincent et al. (22) attributed the increased velvetleaf density that was associated with increased tillage to the fact that tillage provided velvetleaf with a better seedbed for germination, establishment and growth. Morningglory and ragweed populations also were increased by tillage (19). Soil disturbance improves soil aeration, releases volatile inhibitors, enhances seed-soil contact, and exposes weed seed to light (9, 11). Without tillage, weed seed do not receive proper germination stimuli and remain dormant. Tillage may also increase weed seed germination by bringing more viable seed to the soil surface. Seed survivability is often improved with deeper soil burial due to the reduced amplitude in seasonal temperature and water content changes associated with soil depth and, therefore, increased stability of the temperature and water content (11).

Herbicides that are effective in conventional tillage systems may not always be successful in conservation tillage systems with surface residues (5, 21). Crop residues in conservation tillage can intercept herbicide sprays before they reach the soil, reducing their effectiveness at the site of weed germination (1). Koppatschek et al. (12) reported that corn residues reduced the amount of metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one] reaching the underlying soil in no-till soybeans, resulting in diminished herbicide effectiveness.

Studies have not compared the effects of a rye cover crop and kill date on soil water use, weed suppression, and soybean yield. The objectives of this research were to compare the effects of non-selective herbicide application timing and crop herbicide application method on subsequent weed control and soybean yield within corn and rye residue systems.

MATERIALS AND METHODS

A four-year field study beginning in 1986 was conducted on a Flanagan silt loam (Aquic Argiudolls; fine, montmorillonitic, mesic with 4% organic matter and a pH of 6.0) at the Agronomy South Farm in Urbana, IL. The previous year's crop during each of the four years was corn. Following corn harvest in the year prior to each experiment the entire plot was tilled in the fall with one pass of a straight-shank chisel plow running to a depth of 15 cm, equipped with 5-cm points. The area was then disked to a depth of 7 cm to smooth the area for planting the following spring. Approximately 8000 kg ha^{-1} of corn residue covering 40% of the soil surface remained following fall tillage. Rye was seeded with a conventional International Harvester grain drill in 20-cm wide rows. Common winter rye seed were drilled to a depth of 3 cm and at a rate of 84 kg ha^{-1}.

A split-plot design with four replications was used during all years of the study, with main plots consisting of residue management (5 levels) and subplots consisting of herbicide (3 levels). The residue management main plots, 3.1 by 45.7 m, consisted of (a) rye killed 2 wk before planting (RE)[4], (b) rye killed at planting (RL)[4], (c) corn residue with vegetation killed 2 wk before planting (CE)[4], (d) corn residue with vegetation killed at planting (CL)[4], and (e) conventionally tilled (CON)[4]. Prior to soybean planting, a combination secondary tillage tool with cultivator shovels, spike tooth harrows, and rolling baskets was used for seedbed preparation in the conventional treatment; the RE, RL, CE, and CL plots did not receive additional tillage. Rye and other vegetation in the corn residue plots were killed with 0.75 kg ae ha^{-1} glyphosate [*N*-(phosphonomethyl)glycine]. Herbicide application and planting dates are presented in Table 1.

The three herbicide subplots were designated as follows: PRE, POST, and no herbicide. The no herbicide treatment was not included in 1986. The PRE treatment consisted of a tank-mix of metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] at 2.2 kg ai ha^{-1} and metribuzin at 0.43 kg ai ha^{-1}. The POST treatment was a tank mixture of bentazon [3-(-1-methylethyl)-(1*H*)-2,1,3-ben-

[4]Abbreviations: RE, rye killed 2 wk before planting; RL, rye killed at planting; CE, existing vegetation in fall chisel plowed corn stalks killed 2 wk before planting; CL, existing vegetation in fall chisel plowed corn stalks killed planting; CON, cornstalks fall chisel plowed, secondary tillage at planting in spring.

Table 1. Planting and herbicide application dates for soybean and rye cover crop.

Year	Vegetative kill		Herbicide application		Planting	
	Early	Late	Pre	Post	Rye[a]	Soybean
1986	25 April	9 May	9 May	2 June	15 Oct	9 May
1987	28 April	7 May	8 May	1 June	1 Oct	7 May
1988	25 April	11 May	11 May	7 June	28 Sept	11 May
1989	25 April	16 May	17 May	7 June	3 Oct	16 May

[a]Rye planting dates are for the previous calendar year.

zothiadiazin-4(3*H*)-one 2,2-dioxide] at 0.56 kg ai ha^{-1}, acifluorfen {5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid} at 0.28 kg ai ha^{-1}, and sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one} at 0.17 kg ai ha^{-1} plus crop oil concentrate[5] at 1% of the spray volume. The no herbicide treatment did not include herbicides for weeds emerging after planting. Plots received tillage (CON) or glyphosate (RE, RL, CE, CL) to control vegetation prior to planting. Herbicides were applied with a CO_2 backpack sprayer in 187 L ha^{-1} with 8003 (PRE) or 8002 (POST) flat fan nozzles[6].

Soybeans were planted at 33 seeds per m at a depth of 4 cm with an International Harvester 185 planter preceded by 3-cm fluted, no-till coulters. Subplots were 3.1 by 15.2 m with four soybean rows 76 cm apart. Entire plots were harvested with a plot combine and grain yields were adjusted to 13% moisture.

Weed control was estimated visually at 4 and 10 wk after PRE and POST applications. Control was evaluated on a scale of 0 (no control) to 99 (complete control). Densities of individual weeds by species were obtained in a 3.1 by 0.8 m area randomly selected between the two center rows of each plot approximately five weeks after planting. Crop stand was determined by counting soybean plants in random 2-m sections in each of the middle two rows. Treatment means were separated using Fisher's Least Significant Difference Test at the 5% level. Data transformed by arcsin were also analyzed. Since results were similar, untransformed means and LSDs are presented.

Soil water measurements were made on June 8 and 28 in 1988, and June 7 and July 7 in 1989 by taking three 1.9-cm-diam cores per plot with a hand-held probe to a depth of 60 cm, 10 cm from the crop row. The cores were divided into four 7.5-cm segments to a depth of 30 cm and two 15-cm segments from 30 to 60 cm. The three segments were then composited for each plot and placed in aluminum soil moisture cans. Gravimetric water contents were converted to volumetric water contents by using bulk density values determined by extracting 7.5-cm-diam undisturbed cores (4). Soil profile volumetric water changes were then calculated for the periods of interest.

[5]Prime Oil, Riverside/Terra Corp., Terra Center, 600 Fourth Street, Sioux City, IA 51101.

[6]Spraying Systems, Wheaton, IL 60188.

RESULTS AND DISCUSSION

Cumulative rainfall for the period Apr. 1 through Sept. 30 in 1986, 1987, and 1989 was similar to or greater than the 30-yr average (Table 2). During these three years August of 1986 and July of 1989 were the only months during the growing season that received less than 50% of the 30-yr average rainfall. Cumulative rainfall from April through June in 1988 was only 30% of the 30-yr average. June of 1988 was extremely droughty. These seasonal differences in precipitation contributed to differences in weed control and soybean yield between years.

Weed control. Both residue management and herbicide treatments affected weed control and soybean yield (Table 3). Because of significant year by treatment interactions, results were separated by years. Evaluations based on weed counts were similar to visual ratings; therefore, only visual ratings are reported. Because the 4- and 10-wk evaluations of weed control were similar, the data from both evaluations were combined for presentation.

Weed control in the RL treatments (94% ± 8) was equal to or better than in the other tillage treatments (Figure 1). The rye was equally inhibitory to all the weed species. The rye treatments (RE and RL) provided better weed control than the conventional treatment in 1987, 1988, and 1989 with the exception of pigweed in 1989 which was equivalent. And except for 1986, when few differences in weed control occurred among the

Table 2. Rainfall amounts received during crop season for 1986–1989 for selected periods at Urbana, IL.

Month	1986	1987	1988	1989	30-Yr average
	cm				
April	2.8	9.0	3.8	14.6	9.8
May	10.9	8.0	3.8	14.7	9.1
June	11.0	11.1	0.8	12.8	10.0
July	12.1	20.0	9.3	4.5	11.1
August	3.6	12.7	3.3	10.9	9.3
September	20.0	3.2	8.5	11.6	7.7
Total	60.4	64.0	29.5	69.1	57.0

residue management treatments (possibly attributable to the lack of a no herbicide treatment 1986), both RE and RL provided better control of all weeds in 1987, lambsquarters in 1988, and foxtail and velvetleaf in 1989 than the CE and CL treatments. The RL treatment was slightly more effective for weed control than RE in some years. In 1986, overall weed control in the RE treatments was approximately 10% lower than RL, and there was a decrease in common lambsquarters control in 1988 when the rye was killed early rather than at planting. In the CE, CL, and CON treatments, weed control was species dependent. Foxtail, velvetleaf, and pigweed control were greater in CE and CL (especially CL) compared with CON. Since an important difference between the corn residue and conventional treatments was tillage, an undisturbed seedbed may be a more favorable environment for control of these weeds than a conventional one. Without a rye mulch, lambsquarters control is best with spring tillage; control was equal to or greater in the conventional compared with the CE and CL treatments. Control of lambsquarters in the corn residue plots was better two out of three years when glyphosate was applied at planting compared to two weeks before. Lambsquarters control was greatly improved when a rye mulch was also included in the reduced-till system. Pigweed control was improved by rye mulch in 1987 and independent of residue management and poor in 1989.

In the absence of herbicides, the combination of notillage and a rye mulch provided good to excellent weed control (Table 4). Late treatments (RL and CL) were omitted from Table 4 since weed control was similar for late and early timings. There was only one species by year combination (velvetleaf in 1987) in which herbicides improved the weed control in no-till rye. Even when the overall weed control was low, such as velvetleaf in 1988 and pigweed in 1989, the inclusion of herbicides did not significantly improve the weed control in the no-till rye. Surface residues will intercept herbicides, decreasing initial soil-herbicide contact and possibly rendering them unavailable for weed control (1). Ghadiri et al. (10) showed that wheat (*Triticum aestivum* L.) stubble intercepted 60% of an atrazine application.

The excellent weed control observed in the rye residue treatments, regardless of herbicide treatment, may be attributable to the allelopathic effect of the rye and physical presence of the mulch on the soil surface. Decomposing rye residues associated with no-till cropping systems are a potential source of allelopathic chemicals capable of reducing weed biomass (3, 19). Shading, lower temperatures, and the physical obstruction provided by the rye mulch could have also played a role in reducing weed growth in the RE and RL plots (7). The exceptional weed control in the rye residue

Table 3. Analysis of variance of weed control, soybean stand, and soybean yield[a] as affected by residue management.

Year	Source	Giant foxtail	Velvetleaf	Common lambsquarters	Smooth pigweed	Soybean stand	Soybean yield
1986	Residue management	**	**	**	–[b]	**	**
	Herbicide	**	**	**	–	NS	**
	RM × Herbicide	**	**	**	–	*	**
1987	Residue management	**	**	**	**	*	**
	Herbicide	**	**	**	**	NS	**
	RM × Herbicide	**	**	**	**	*	**
1988	Residue management	**	**	**	**	**	**
	Herbicide	**	**	**	**	NS	*
	RM × Herbicide	**	**	**	**	**	**
1989	Residue management	**	**	–	NS	**	*
	Herbicide	**	**	–	**	NS	**
	RM × Herbicide	**	**	–	**	NS	**

[a] *,**Significance at the 0.05 and 0.01 probability levels, respectively.
[b] Infestation insufficient to evaluate.

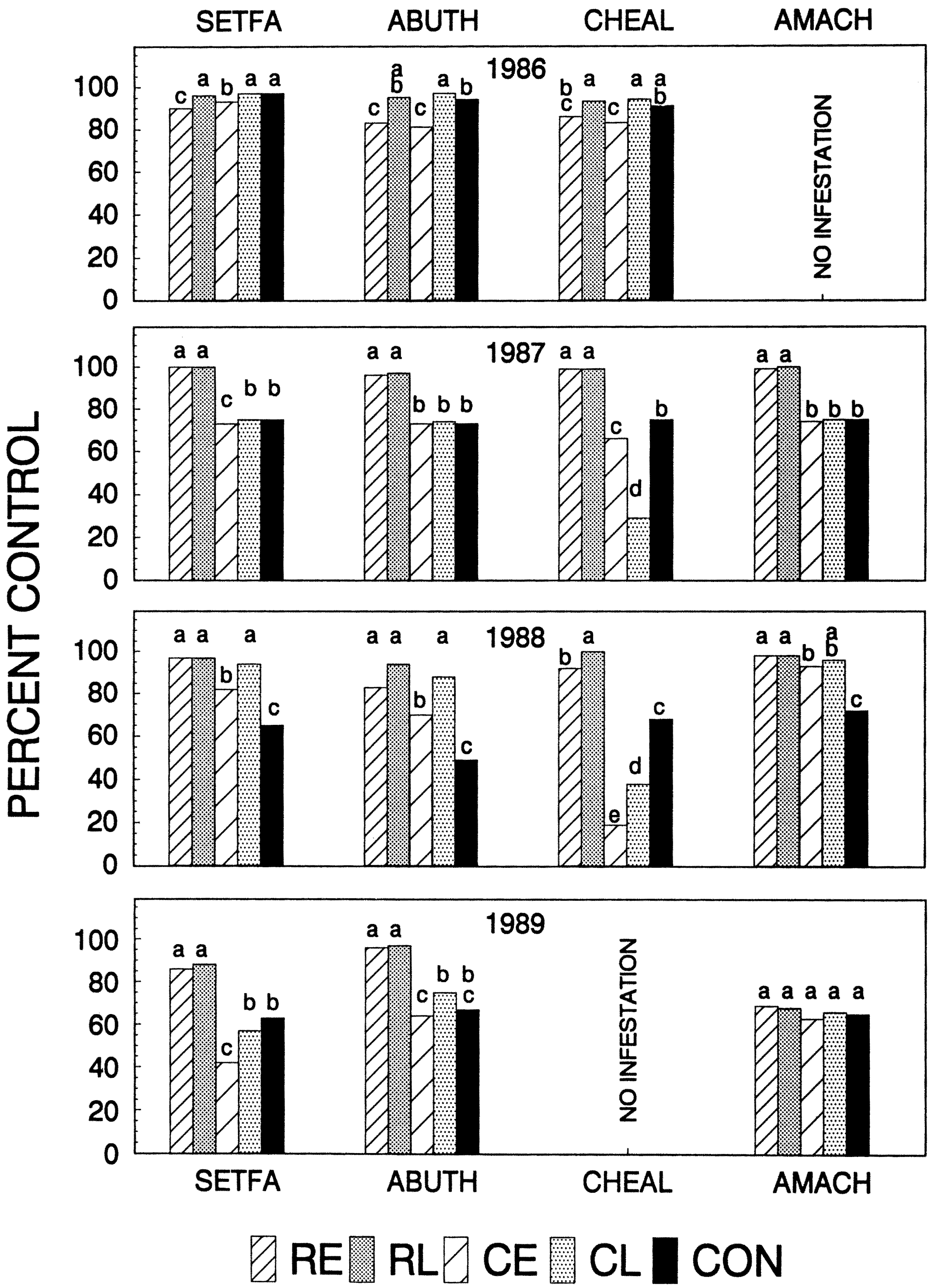

Figure 1. The effect of residue management on weed control. Data are averaged over the three herbicide treatments. RE, rye killed 2 wk before planting; RL, rye killed at planting; CE, existing vegetation in fall chisel plowed corn stalks killed 2 wk before planting; CL, existing vegetation in fall chisel plowed corn stalks killed at planting; CON, corn stalks fall chisel plowed, secondary tillage at planting in spring. Means within each year plus species combination followed by the same letter are not significantly different at the 0.05 level as determined by Fisher's Protected LSD test.

Table 4. Effect of residue management and herbicides on weed control and yield components in soybeans. Weed control ratings are the average of 4- and 10-wk ratings.

Year	Residue management	Herbicide	Weed control: Giant foxtail	Velvetleaf	Common lambsquarters	Smooth pigweed	Soybean stand	Soybean yield
			%				plants per m	kg ha^{-1}
1986	Conventional	PRE	99	96	95	–[a]	23	2810
		POST	95	90	85	–	23	2680
	Corn residue early[b]	PRE	97	95	93	–	24	3000
		POST	85	52	61	–	24	2530
	Rye early	PRE	99	97	97	–	22	2870
		POST	72	54	64	–	22	2130
		LSD (0.05)	5	6	8		4	310
1987	Conventional	Check	0	0	0	0	25	1580
		PRE	99	99	99	99	25	3320
		POST	99	98	99	98	25	2820
	Corn residue early	Check	0	0	0	0	24	1610
		PRE	95	99	86	99	26	3050
		POST	99	95	88	98	24	2920
	Rye early	Check	99	88	98	98	23	2230
		PRE	99	98	99	99	20	2670
		POST	99	99	99	99	26	2660
		LSD (0.05)	2	6	8	3	5	680
1988	Conventional	Check	0	0	0	0	9	110
		PRE	89	62	89	97	14	730
		POST	85	68	90	92	12	660
	Corn residue early	Check	83	44	20	84	13	130
		PRE	70	81	31	93	13	240
		POST	82	75	9	99	12	10
	Rye early	Check	93	77	88	94	14	280
		PRE	99	86	96	99	9	100
		POST	96	85	89	99	10	160
		LSD (0.05)	11	25	14	11	4	NS
1989	Conventional	Check	0	0	–	0	24	650
		PRE	89	92	–	96	24	3010
		POST	82	64	–	55	24	2230
	Corn residue early	Check	0	10	–	5	22	310
		PRE	65	89	–	94	28	2880
		POST	54	74	–	65	30	1450
	Rye early	Check	90	93	–	65	20	2430
		PRE	92	95	–	56	22	2260
		POST	81	97	–	74	22	2480
		LSD (0.05)	18	19	–	27	4	900

[a]Infestation insufficient to evaluate.

[b]Corn residue late and rye late treatments are not shown.

plots without PRE or POST herbicides coupled with limited effectiveness of herbicides in these plots is likely responsible for the tillage × herbicide interaction (Table 3). The corn residue and killed annual weed residue in CE and CL had little effect on weed control. Except for 1988, weed control in CE and CL without herbicides was similar to the conventional control. In 1988, the corn residue without herbicides provided good foxtail and pigweed control. Koppatschek et al. (12) reported that increasing corn residue in no-till soybeans did not improve weed control. Weed control provided by herbicides in the conventional plots was good to excellent and comparable with the RE and RL check plots. Overall, herbicide performance with the PRE treatment was generally equal to or better than the POST treatment. This result suggests that PRE herbicides were not inactivated by surface residues. POST treatments may have been sprayed when the weeds were too large. Additionally, there may have been a better herbicide activity match between the weeds and PRE herbicides as opposed to the POST herbicides. Differences between the PRE and POST treatments

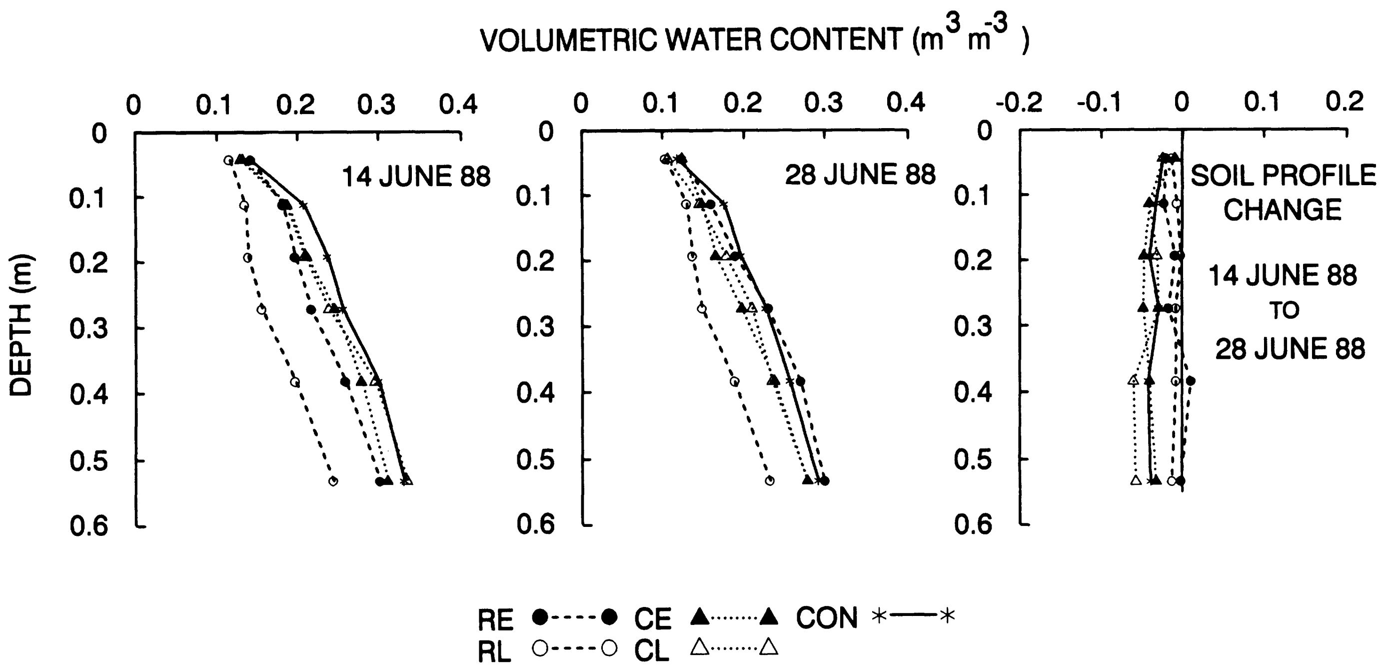

Figure 2. Soil water content profiles for two dates in 1988 and the resultant change in soil water content for the period. See Figure 1 for a description of tillage treatments.

were particularly apparent in the rye residue plots in 1986.

In reduced tillage, numerous soil factors are changed which could affect the germination and growth of weeds. The adoption of no-till can result in the decrease of certain weeds, particularly annual broadleaf species. Wallace and Bellinder (23) reported lower populations of common lambsquarters in reduced tillage potato (*Solanum tuberosum* L.) production compared with conventional. Even when the effect of surface residues is removed, the elimination of tillage has been shown to reduce populations of morningglory, common ragweed, and common lambsquarters (19). In the present study, foxtail, velvetleaf, and pigweed populations in the CE and CL plots (soil undisturbed at planting) were often less than in conventional plots, whereas lambsquarters populations were reduced in the conventional seedbed. However, the excellent weed control observed in RE and RL suggests the rye cover crop also had a significant impact on control since the rye and corn residue plots received similar amounts of tillage. Froud-Williams et al. (9) proposed that reduced tillage limits weed populations because seeds are isolated from favorable conditions for germination. A major result of soil disturbance is that it provides the seed with proper stimuli for germination. No-till systems are also known to affect soil moisture, pH, and temperature, all of which affect the emergence and growth of both crops and weeds.

Soil moisture. Soil water content (0 to 60-cm depth) was lowest for RL compared with other treatments on June 14, 1988. Because soybean canopy was limited at

Table 5. Effect of residue management systems, averaged over herbicide treatments, on soybean stand and yield.[a]

Residue management	Yield 1986	Yield 1987	Yield 1988	Yield 1989	Stand 1986	Stand 1987	Stand 1988	Stand 1989
	kg ha^{-1}				plants per m of row			
Conventional	2720 b	2720 a	500 a	2280 a	23 a	25 a	11 b	24 bc
Corn residue early	2720 b	2670 a	110 b	1780 b	24 a	24 a	13 a	27 ab
Corn residue late	2900 a	1760 b	240 b	1890 b	24 a	23 b	14 a	28 a
Rye early	2630 b	2530 a	150 b	2420 a	23 a	23 b	11 b	21 c
Rye late	2330 c	1870 b	40 c	1890 b	19 b	17 c	6 c	15 d

[a]Means within years followed by the same letter are not significantly different at the 0.05 level as determined by a Fisher's Protected LSD test.

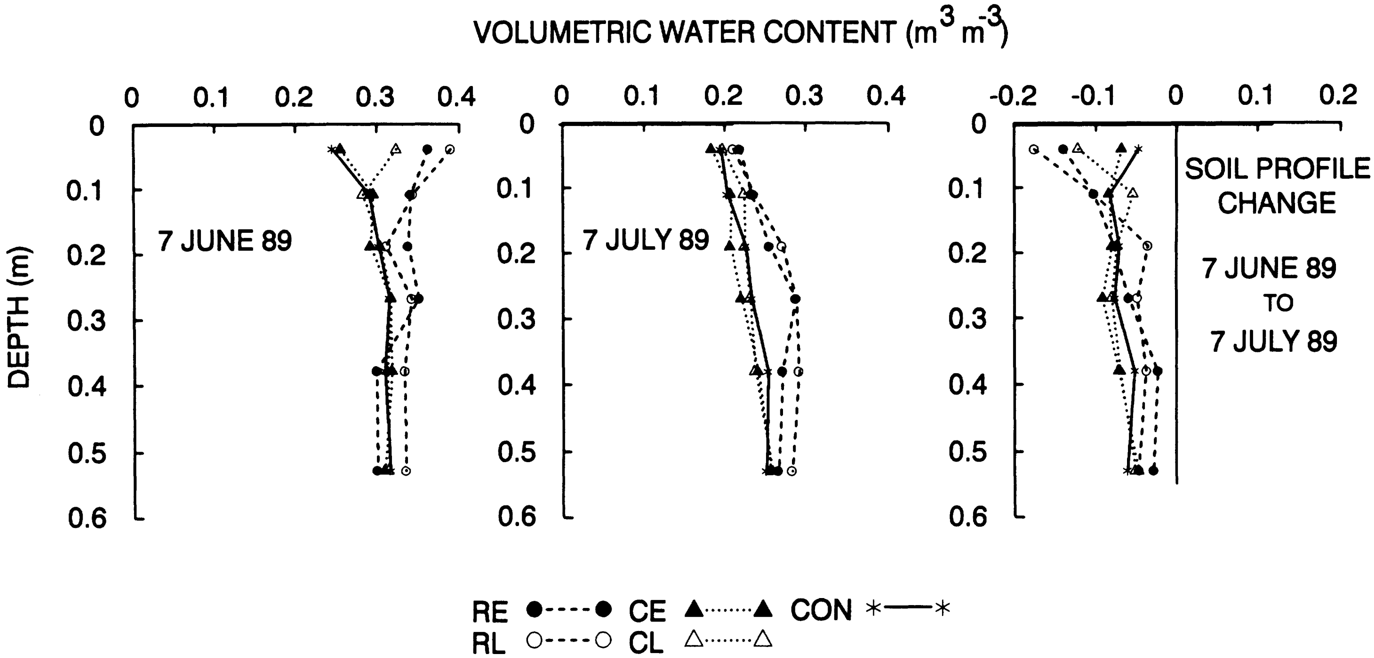

Figure 3. Soil water content profiles for two dates in 1989 and the resultant change in soil water content for the period. See Figure 1 for a description of tillage treatments.

that time the soil water profile reflects depletion by the rye cover prior to planting (Figure 2). The sampled depth contained 4 to 6 cm less total water than other treatments and the differences between RL and other treatments at 55-cm depth indicate that the influence of the transpiring rye crop undoubtedly went deeper. The two sampling times bracket a rainless period and were preceded by low rainfall amounts (Table 2). Total soil water use from 14 to 28 June was greater in CE, CL and CON than both of the RE and RL treatments demonstrating that the higher water contents in these treatments at the beginning of the period were exploited by the soybeans. Munawar et al. (15) attributed differences in soil water depletion under early- and late-killed rye to canopy structure of the rye residue. Mature late-killed rye tended to stand whereas early-killed rye formed an evaporation reducing mat. In this study we observed similar residue behavior between kill dates and ascribe the early season soil water content differences to the soil depletion caused by growing rye. Moschler et al. (14) observed a similar soil water depletion in late-killed rye.

In 1989, ample rain preceded and occurred during the sampling period (Table 2). The effects of a surface mulch are demonstrated by the wetter upper 25 cm under the RE and RL treatments on 7 June (Figure 3). The CL treatment also provided enough surface cover to increase water content in the 0 to 15-cm zone compared to the bare CE and CON treatments. The soil profile in RE and RL stayed wetter below the 15-cm depth through one month of rain and crop water use, suggesting that in wetter years the rye cover may provide increased water supply to the crop. Soil water content changes from 7 June to 7 July show water use in the RE and RL plots was greatest in the top 20 cm while the CE, CL, and CON had deeper profile water extraction.

Yield. Soybean yields were greatly affected by cover crop kill date in the rye residue; yields were substantially higher in the RE compared with the RL treatments for all years (Table 5). Soybean stand in the RL treatment was 32 to 45% lower than the conventional treatment and resulted in lower yields in these treatments. The large amount of residue in the RL plot adversely affected soybean planting leading to a lower stand. Stand counts in the RE, CE, CL, and CON were similar. Yields in the RE plots were similar to conventional plots during the 4-yr study (Table 3). Soybean yields in the CE and CL plots were similar to or lower than the conventional treatment (Table 5) and could not be related to stand or weed control. Koppatschek et al. (12) attributed low soybean yields in the second year of a 2-yr study to the accumulated corn residue in the no-till production system used in that study. Allelopathic compounds from decomposing crop residue in no-till cropping systems have been reported to decrease both crop and weed growth. Compounds inhibitory to plant growth have been isolated from both decomposing rye and corn residues (3, 6, 18).

Herbicides generally improved soybean yields in the conventional and corn residue tillage systems in 1987 and 1989 (yields in 1988 were essentially zero) (Table 4). Yields were usually higher where PRE herbicides were used compared with POST treatments. Weed control, particularly for common lambsquarters, was best with the PRE herbicide program. Herbicides did not improve soybean yield in the RE. The RE check yields were comparable with the conventional or the corn residue plus herbicides treatments.

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