Conventional vs. No-Till Corn Following Alfalfa/Grass: Timing of Vegetation Kill

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ABSTRACT

Producers who plant no-till corn (*Zea mays* L.) following hay or pasture are concerned about herbicide application timing and efficacy to kill perennial vegetation, plant residue effects on corn growth, and optimal corn planting date. A field study was conducted near Arlington, WI, from 1985 to 1988 to evaluate the influences of (i) conventional (CT) vs. no-till (NT), (ii) fall vs. spring kill of perennial vegetation, (iii) late-April vs. mid-May planting, and (iv) three hybrid maturities on corn following legume/grass sod. Parameters measured include residue cover, soil temperature, and soil moisture after planting; corn emergence percentage; days to emergence; days to silk; grain moisture; and grain yield. Tillage by time of vegetation kill interactions were important for corn development and grain yield. Few differences were observed between fall and spring plowing in CT. For NT, however, chemically killing perennials in the spring compared to in the fall resulted in greater residue cover after planting (60–90% vs. 40%), and cooler and drier soil in the seed zone after planting. Emergence was delayed 1.5 to 4.0 d with spring-kill NT and subsequent development was delayed throughout the growing season. Spring-kill NT resulted in lower grain yields (−10 to −50%) compared to fall-kill NT in 3 of 4 yr. For NT, when perennial vegetation was killed in the fall and corn was planted early, plant growth and grain yields were comparable to those for CT. Fall-kill NT produced consistent growth and yield responses during the study years, whereas spring-kill NT results were more variable, with poorest results in the drought of 1988.

About 35% of corn grown in northern U.S. dairy regions follows perennial forages (USDA, 1988), yet most information about no-till planting of corn in these areas is based on research for corn following corn (Al-Darby and Lowery, 1986; Swan et al., 1987) or soybean [*Glycine max* (L.) Merr.] (Meese et al., 1991). There are several interrelated concerns about planting no-till corn following mixed-species perennial hay or pasture which differ from those for no-till corn following grain crops. These include the timing and efficacy of herbicides to kill existing perennial species, plant residue effects on corn growth, and optimal corn planting time (Barnett, 1990; Buhler and Mercurio, 1988; Moomaw and Martin, 1990).

Hay fields targeted for rotation to corn in the northern USA typically consist of 3- to 5-yr-old stands of alfalfa (*Medicago sativa* L.) or red clover (*Trifolium pratense* L.), sometimes interseeded with orchardgrass (*Dactylis glomerata* L.) or bromegrass (*Bromus inermis* Leyss). Hay stands are also usually invaded by quackgrass [*Elytrigia repens* (L.) Nevski], dandelion (*Taraxacum officinale* Weber), and several winter annual weeds. Buhler and Mercurio (1988) found that with this type of sod, split herbicide treatments, either in the fall or early spring, plus at corn planting were needed to completely kill vegetation. Best vegetation control was achieved with fall glyphosate [*N*(phosphonomethyl)glycine] applications. Even so, most producers who plant corn no-till into sod apply herbicides in the spring to kill perennials. This allows producers to evaluate hay stands for winter survival before deciding whether or not to plant corn.

Alfalfa or mixed alfalfa/grass, when chemically killed, leaves less residue weight on the soil surface than does corn. In addition, because of lower fiber content, legume residues are less persistent than grain-crop residues (Triplett, 1986). Therefore, due to both less residue cover and more rapid decomposition, forage residues likely do not alter the soil environment to the same extent as corn residue. Forage residues do, however, reduce soil temperatures compared to bare soil (Buhler and Mercurio, 1988; Barnett, 1990), which can result in delayed, reduced crop emergence, or both with no-till systems in northern regions. And in some cases, soil moisture depletion before vegetation kill or by surviving perennials may limit corn growth when no-till planted into sod (Box et al., 1980).

Planting date response has not been evaluated for no-till corn planting into alfalfa/grass sod. Highest corn yields in the northern corn belt under conventional tillage (plow and disk) result when a full-season hybrid is planted in late April or early May (Carter, 1984; Hicks, 1977). Yields decline progressively as planting is delayed in the spring. For continuous corn, the response to planting date was similar for both no-till and conventional tillage in Ohio (Eckert, 1984) and Wisconsin (Imholte and Carter, 1987).

Farmers tend to delay planting corn no-till into sod, waiting for enough spring growth to assess legume winter survival. Other reasons for late planting of no-till corn into sod include (i) time for increased vegetation growth to enhance preplant herbicide interception and uptake and (ii) the perception that corn productivity will be increased by a warmer soil seed zone to enhance corn seedling emergence and early growth rates. Whether these factors will balance the expected disadvantages of late corn planting into sod is unknown.

When planting is delayed for no-till corn into sod, full-season maturity hybrids which are normally recommended for early planting may not produce the greatest yields. Also, even with early planting in northern regions where length of growing season is limiting, slower growth under no-till can limit the yield potential of full-season hybrids by shortening the grain-filling period (Carter and Barnett, 1987). Shorter-season maturity hybrids may be better suited to these situations.

The objective of this study was to evaluate the influence of tillage system and time of perennial vegetation kill on corn emergence, development, and yield for two planting dates and three corn hybrid maturities when grown following alfalfa/grass. Other research

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Abbreviations: CT, conventional-till; and NT, no-till.

has evaluated specific herbicides and rates for efficacy of perennial vegetation control with no-till corn planting (Buhler and Mercurio, 1988), whereas our primary interest was in the time of vegetation kill and possible interaction with corn planting date.

MATERIALS AND METHODS

Corn was grown following mixed alfalfa/grass in a field study conducted for 4 yr, 1985 to 1988, at the Arlington Agricultural Research Station near Madison, WI on a Plano silt loam (fine, mixed, mesic Typic Argiudoll) soil. Three corn hybrids were evaluated under two tillage systems, with two times of vegetation kill and two planting dates. The study was conducted in a split, split-plot arrangement in a randomized complete block design with three replicates. Tillage systems were whole plots, time of vegetation kill/planting date combinations composed four subplots, and hybrids were sub subplots. Sub subplots were eight rows (0.76-m row spacing) wide and 7.5 m long.

Corn was planted in late April (29 Apr. 1985 and 1988, 24 Apr. 1986, and 27 Apr. 1987) and except for 1985, in mid May (20 May 1986, 13 May 1987, and 12 May 1988). Hybrids, ranging from short- to full-season for southern Wisconsin, were FR23 x CM105, 95-d Relative Maturity (RM); Pioneer 3747, 100-d RM; and Agripro 680, 110-d RM. Relative maturities were based on the Minnesota Relative Maturity Rating System (Peterson & Hicks, 1973).

Conventional tillage (CT) plots were plowed in the fall or spring just before planting and no-till (NT) plots were treated with herbicides to kill vegetation at the same times. Conventional tillage was moldboard plowed 18 cm deep either in the fall or spring depending on the time-of-vegetation-kill treatment, followed by two spring diskings. No-till was planted into undisturbed forage residues. Corn was planted 5 cm deep in both tillage systems at a rate of 110 000 kernels ha^{-1}, using cone seeders on a four-row no-till planter (Kinze Manufacturing Inc., Williamsburg, IA). The planter was equipped with non-powered rippled coulters, heavy-duty down-pressure springs, double-disk openers, and cast-iron press wheels.

Vegetation varied at the different sites each yr. Sward composition was estimated visually in the fall before treatments were applied, with species expressed as a percentage of total vegetation. In 1985, the stand contained 40% alfalfa, 40% orchardgrass, and 20% dandelions. In 1986, the stand was composed of 60% alfalfa, 30% dandelions, and 10% other weedy species. In 1987 and 1988 stands were 30% alfalfa, 30% orchardgrass, 20% bromegrass, 10% dandelions, and 10% other weedy species.

Fall-kill NT treatments were sprayed with 1.7 to 2.7 kg a.e. ha^{-1} glyphosate in mid-October to early November, depending on the yr. Spring-kill NT treatments received the same rates of glyphosate a few d before each planting date in 1985, 1987, and 1988. In 1986, spring-kill NT was treated with dicamba (3,6-dichloro-2 methoxy-benzoic acid) at 0.6 kg a.e. ha^{-1} and diethanolamine salt of 2,4-D [(2,4-D-dichlorophenoxy) acetic acid] at 1.1 kg a.e. ha^{-1} before planting. Conventional tillage treatments were plowed at the same time glyphosate or dicamba was applied to NT plots.

All plots were treated after planting with atrazine [6-chloro-*N*-ethyl-*N*′-(1-methylethyl)-1,3,5-triazine-2,4-diamine] and metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide], both at rates of 3.4 kg a.i. ha^{-1}, for annual weed control. Paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) was applied separately at 0.6 kg a.i. ha^{-1} with surfactant to NT treatments as needed for burndown of living plants before corn emergence when glyphosate did not completely kill vegetation. Dicamba at 0.6 kg a.e. ha^{-1} and 2,4-D at 1.1 kg a.e. ha^{-1} were applied in both CT and NT when needed to control perennial broadleaves not killed by glyphosate. Common stalkborer (*Papaipema nebris* Guenee), identified only in spring-kill NT plots in 1987 and 1988, was controlled with fenvalerate [cyano(3-phenoxyphenyl)methyl 4-chloro-α-(1-methyl ethyl) benzeneacetate] applied postemergence at 0.17 kg a.i. ha^{-1}.

Table 1. Mean air temperature and precipitation for the 1985 to 1988 corn growing seasons at Arlington, WI.

Month	1985	1986	1987	1988
	Air temperature†			
	°C			
April	10.9 (+2.6)‡	10.2 (+1.9)	10.3 (+2.0)	12.8 (+4.5)
May	16.9 (+2.2)	15.0 (+0.3)	15.9 (+1.2)	17.0 (+2.3)
June	17.8 (−1.5)	19.0 (−0.3)	21.4 (+1.1)	22.0 (+1.7)
July	21.3 (−0.8)	22.1 (0)	23.6 (+1.5)	23.9 (+1.8)
August	18.7 (−2.1)	17.8 (−3.0)	20.2 (−0.6)	23.7 (+2.9)
September	16.5 (+0.2)	16.5 (+0.2)	16.4 (+0.1)	18.0 (+1.7)
Six-month mean	17.0 (+0.1)	16.8 (−0.3)	18.0 (+0.9)	19.6 (+2.5)
	Precipitation			
	mm			
April	60 (−18)	69 (−8)	67 (−11)	83 (+5)
May	63 (−15)	53 (−25)	119 (+41)	25 (−53)
June	89 (−3)	106 (+14)	16 (−86)	39 (−53)
July	149 (+58)	118 (+27)	102 (+11)	39 (−52)
August	92 (−18)	126 (+16)	126 (+16)	74 (−36)
September	174 (+71)	272 (+169)	125 (+22)	99 (−4)
Season total	627 (+75)	746 (+194)	555 (+3)	359 (−193)

† Recorded at 1.5 m above a grassy surface.
‡ Number in parentheses is the deviation from the 20-yr average.

Soil test ranges for the four site-year were pH 6.4 to 6.6, 65 to 134 kg P ha^{-1}, and 175 to 435 kg K ha^{-1}. All plots received 10+19+34 kg ha^{-1} of N+P+K as row-applied starter fertilizer and 168 kg ha^{-1} of N (NH_4NO_3) broadcast on all treatments each yr before the first planting date. Based on Wisconsin soil test recommendations, nutrient levels were adequate for corn growth (Kelling et al., 1991). Terbufos {S-[(1,1-dimethylethyl)thio]-methyl]-*O*-*O*-diethyl phosphorodithioate} at 1.5 kg a.i. ha^{-1} was banded with the planter to control soil-borne insects.

Residue cover was measured once after planting with the line intersect method (Laflen et al., 1981) in 1987 and 1988. Mid-day in-row soil temperatures (5 cm deep) were recorded with a hand-held soil temperature probe daily in both tillage systems for 7 d after planting. In 1987 and 1988 only, gravimetric soil moisture was determined 1 d after planting at 0 to 7.5 cm, 7.5 to 15 cm, and 15 to 30 cm depths to measure relative soil moisture depletion by perennials. Emerged seedlings were counted daily until full emergence, and expressed as the number of seedlings emerged as a percentage of kernels planted. Days to emergence was calculated as d after planting until 75% of final stand was achieved.

When corn under CT reached the V6 stage (Ritchie and Hanway, 1984), plots were hand thinned to 60 000 plants ha^{-1}. At that time, 10 plants from each sub subplot were randomly selected and harvested at ground level, dried at 60 °C in a forced-air drier, and weighed. Days from planting to silking were determined by the date when 50% of corn plants had silks emerged.

Before harvest, final stand and mature plant height (centimeters to the flag leaf collar) were measured. Grain moisture (g H_2O kg $^{-1}$, wet basis) and yield were determined from two interior rows of each sub subplot with a plot combine. Harvest dates were 30 Oct. 1985, 25 Oct. 1986, 12 Oct. 1987, and 8 Oct. 1988.

Analyses of variance were computed each year, for data

Table 2. Significance of main effects and selected interactions for tillage systems (*T*), time of vegetation kill (*K*), and planting date (*D*) for measurements taken in 1987 and 1988 at Arlington, WI.

	Main Effects			Interactions				
	Tillage system (*T*)	Time of vegetation kill (*K*)	Planting date (*D*)	*T*×*K*	*T*×*D*	*K*×*D*	*T*×*K*×*D*	CV
	$P > F$†							%
1987								
Residue cover	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	17.2
Soil temperature	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.4
Soil moisture								
0 to 7.5 cm	NS	<0.01	NS	NS	NS	0.02	NS	6.3
7.5 to 15 cm	NS	<0.01	<0.01	NS	NS	<0.01	NS	3.6
15 to 30 cm	NS	NS	NS	NS	NS	NS	NS	5.7
Emergence %	NS	NS	<0.01	NS	NS	NS	NS	6.0
Days to 75% emergence	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	4.1
Veg. dry wt.	NS	NS	<0.01	0.05	NS	NS	NS	15.5
Days to 50% silk	NS	NS	<0.01	<0.01	NS	NS	NS	0.8
Mature plant ht.	NS	NS	0.03	NS	0.03	NS	NS	2.8
Final stand	NS	NS	NS	NS	NS	NS	NS	3.2
Grain moisture	NS	NS	<0.01	<0.01	NS	NS	NS	2.5
1988								
Residue cover	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11.7
Soil temperature	0.01	NS	<0.01	<0.01	<0.01	NS	<0.01	1.8
Soil moisture								
0 to 7.5 cm	NS	NS	<0.01	NS	NS	<0.01	NS	13.1
7.5 to 15 cm	NS	NS	<0.01	NS	NS	<0.01	NS	23.9
15 to 30 cm	NS	<0.01	<0.01	NS	NS	0.04	NS	8.0
Emergence %	NS	<0.01	<0.01	NS	NS	0.04	NS	10.4
Days to 75% emergence	0.02	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	3.8
Veg. dry wt.	NS	<0.01	—	<0.01	—	—	—	10.9
Days to 50% silk	0.02	<0.01	<0.01	<0.01	NS	<0.01	NS	2.6
Mature plant ht.	NS	<0.01	<0.01	<0.01	NS	NS	NS	6.1
Final stand	NS	NS	NS	NS	NS	NS	NS	6.8
Grain moisture	NS	<0.01	0.02	NS	NS	NS	NS	8.5

† *P* values for main effects and interactions: Tillage system (*T*) × Time of vegetation kill (*K*), Tillage system (*T*) × Planting date (*D*), Time of vegetation kill (*K*) × Planting date (*D*), and Tillage system (*T*) × Time of vegetation kill (*K*) × Planting date (*D*).

combined over years, and for variables measured in only 1987 and 1988, on data combined over those years. All factors, other than replicates, were considered fixed effects.

RESULTS AND DISCUSSION

Seasonal precipitation and air temperatures for the growing seasons of 1985, 1986, and 1987 were nearly average (Table 1). April and May air temperatures were at least 1.0 °C warmer than average each year except for May of 1986. Septembers of 1985 and 1986 were wetter than average and June 1987 was much drier than average. Precipitation during the 1988 growing season was only 67% of the 20-yr average, while air temperatures averaged 2.5 °C warmer than average. The resulting drought produced corn yields less than half those in 1985, 1986, and 1987.

Soil and corn growth data will be discussed only for 1987 and 1988. Data for 1987 were representative of 1985 and 1986, and 1988 provided an extreme growth environment. Yield data for all 4 yr of the experiment are presented.

Seedbed Environment

Plowing in either the fall or spring adequately controlled alfalfa/grass. Chemical vegetation kill in NT was most effective with fall glyphosate treatment and additional herbicides applied pre-emergence. For fall-kill treatments, less than 10% live ground cover remained at corn emergence. Spring-kill NT, with glyphosate applied just before planting and additional herbicides applied pre-emergence, required supplemental herbicides to completely kill vegetation. Although full kill was ultimately achieved, 20 to 40% live ground cover remained at corn emergence in 1986 and 1988 and competed with corn seedlings for 1 to 2 wk following corn emergence.

For percent residue cover, results did not differ in 1987 and 1988 (Table 2), so values are averaged (Fig. 1A). Percent residue cover after planting for CT was about 5% regardless of planting date (Fig. 1A), but under NT, residue cover varied with planting date and time of vegetation kill. Residue cover after NT planting into sod following fall vegetation kill was near 40% for both planting dates (Fig. 1A). When vegetation was spring-killed before late-April planting, residue cover averaged 59%, but more plant growth before the mid-May planting date resulted in 94% ground cover (Fig. 1A).

Soil temperature responses were not different in 1987 and 1988, therefore the values were averaged (Fig. 1B). At late-April planting, soil temperatures did not differ for CT and NT, regardless of time of perennial vegetation kill (Fig. 1B). With mid-May planting, soil temperatures were not influenced by tillage systems for fall vegetation kill, but when vegetation was killed in the spring, soil temperatures were reduced 3.3 °C under NT compared to CT. Although there was greater residue cover in NT compared to CT at both planting dates and times of vegetation kill (Fig. 1A), increased

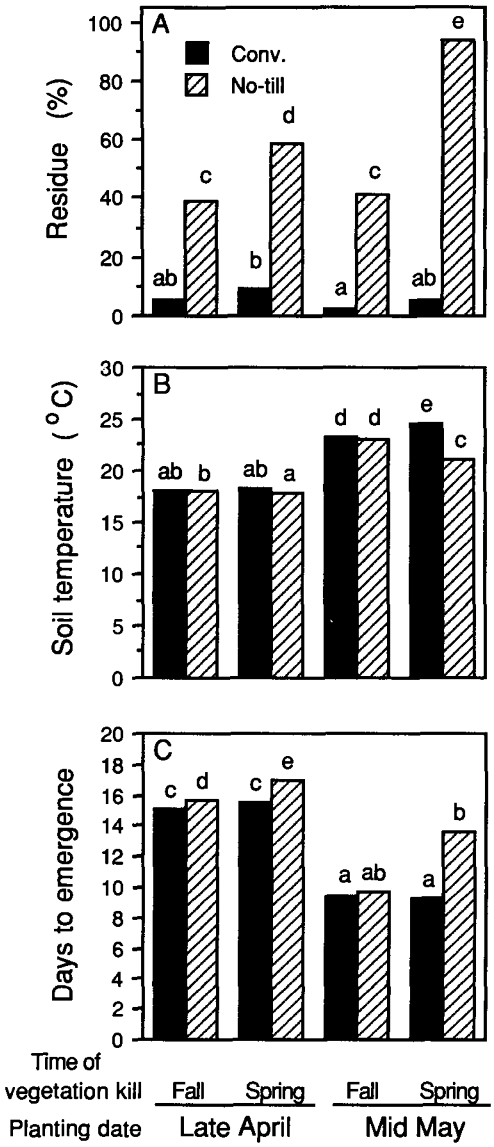

Fig. 1. Residue % cover (A), mid-days, in-row, soil temperature at seeding depth averaged over 7 d after planting (B), and days to emergence (C) for corn under conventional tillage and no-till with two times of vegetation kill (fall vs. spring) and two planting dates (late-April vs. mid-May). Values are averaged over three hybrids and 2 yr, 1987 and 1988. Means are different according to Fischer's LSD ($P < 0.05$) if different letters appear above bars.

residue was only related to decreased soil temperature for NT in mid May with spring kill when residue cover approached 100% (Fig. 1B). In contrast, Swan et al. (1987) in Minnesota and Wisconsin observed a linear inverse relationship between percent corn residue cover and soil temperature. Sloneker and Moldenhauer (1977) found that 40% corn residue cover weighed 1.3 Mg ha^{-1}, while 40% oat (*Avena sativa* L.) residue weighed only 0.4 Mg ha^{-1}. Because alfalfa and grass forage species produce less biomass than corn, soil temperature relationships with percent residue cover from forage species may not correspond to research with corn residue.

Soil in the 0- to 30-cm zone contained markedly less moisture after planting in 1988 than in 1987 due to low rainfall and high temperatures (Table 1, Fig. 2). In both years, soil moisture at all depths was lowest with mid-May vegetation kill (Fig. 2A and 2B) due to additional alfalfa/grass growth between planting dates.

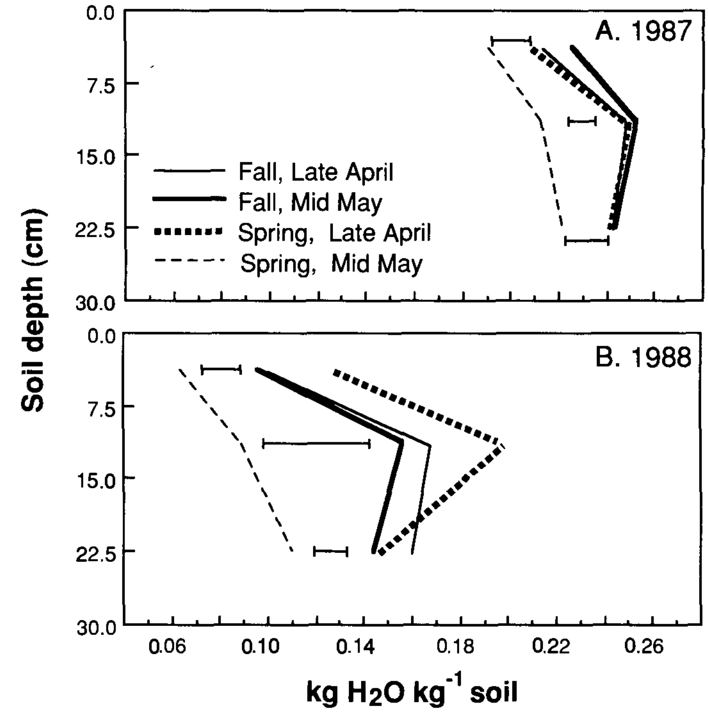

Fig. 2. Mean gravimetric soil moisture for 0 to 7.5, 7.5 to 15, and 15 to 30 cm depths following corn planting for two times of vegetation kill (fall vs. spring) and two planting dates (late-April vs. mid-May) in 1987 (A) and 1988 (B). Values are averaged over tillage systems. Horizontal bars indicate Fischer's LSD at $P < 0.05$.

Table 3. Corn growth means for tillage system by time of vegetation kill interactions during 1987 and 1988. Values are averaged over two planting dates and three hybrids.

	Tillage System				
	Conventional tillage		No-till		
	Fall kill	Spring kill	Fall kill	Spring kill	LSD† (0.05)
1987					
Veg. dry wt. (g plant^{-1})	10.4	10.6	11.3	9.0	1.7
Days to 50% silk	72.1	71.4	72.0	73.1	0.7
Grain moisture (g H_2O kg^{-1})	218	216	217	224	4
1988					
Veg. dry wt. (g plant^{-1})‡	5.5	5.5	4.6	1.7	1.1
Days to 50% silk	72.7	75.7	75.4	88.9	2.7
Mature plant ht. (cm)	158	156	159	124	7

† LSD for comparisons across tillage systems and times of vegetation kill.
‡ Values for the early planting date only.

Corn Growth, Development, and Grain Yields

For growth parameters measured, there were few hybrid–by–tillage, hybrid–by–planting–date, or hy-

Table 4. Summary of statistical significance from analyses of variance for grain yield from 1985 to 1988 for corn following alfalfa/grass sod.

Source	df	1985	1986	1987	1988
		Year			
		$P > F$			
Blocks (*B*)	2	NS	NS	NS	NS
Tillage (*T*)	1	0.04	NS	NS	NS
error a	2				
Time of Vegetation Kill (*K*)	1	NS	<0.01	NS	<0.01
T × *K*	1	0.03	<0.01	NS	<0.01
Planting date (*D*)	1 (–)†	–	<0.01	<0.01	NS
T × *D*	1 (–)	–	NS	NS	NS
K × *D*	1 (–)	–	NS	NS	NS
T × *K* × *D*	1 (–)	–	NS	0.03	NS
error b	12 (4)				
Hybrid maturity	2	<0.01	<0.01	<0.01	0.02
T × *H*	2	NS	NS	<0.01	NS
K × *H*	2	NS	NS	NS	NS
T × *K* × *H*	2	NS	NS	NS	NS
D × *H*	2 (–)	–	<0.01	0.02	NS
T × *D* × *H*	2 (–)	–	NS	NS	NS
K × *D* × *H*	2 (–)	–	NS	NS	NS
T × *K* × *D* × *H*	2 (–)	–	NS	NS	NS
error c	32 (16)				
Total	71 (35)				
CV %		4.0	5.2	5.4	20.9

† Degrees of freedom which differ for 1985, when there was just one planting date.

brid–by–time–of–vegetation–kill interactions. Therefore, subsequent growth data were averaged over the three hybrids.

Low soil moisture in 1988 resulted in average corn emergence of only 76% compared to 88% in 1987. In 1987, percent emergence was increased from 86 to 91% by delayed planting and not influenced by tillage system or time of perennial vegetation kill (Table 2). In 1988, when vegetation was killed in the fall, planting date had no effect on percent emergence. But with spring kill just before corn planting, emergence decreased from 76% for late-April planting to 59% for mid-May planting, likely due to soil moisture depletion by perennial vegetation growth between planting dates (Fig. 2B).

Responses for days to emergence were not different in 1987 and 1988 (Table 2), so values are averaged (Fig. 1C). Differences in days to emergence between CT and NT were relatively small with fall vegetation kill, but increased with spring kill, especially with mid-May compared to late-April planting (Fig. 1C). With mid-May planting and spring kill, emergence was delayed nearly 5 d under NT compared to CT (Fig. 1C), likely due to increased residue cover (Fig. 1A) and decreased soil temperature (Fig. 1B).

For vegetative dry weight, days to silk, and harvest grain moisture, general responses were similar to those for days to emergence, with small differences between CT and NT with fall vegetation kill, but slower development under spring-kill NT (Tables 2 and 3).

Under CT, early vegetative dry weights were not affected by time of plowing, but with NT dry weights were 2.3 to 2.9 g $plant^{-1}$ lower when vegetation was killed before planting compared to the previous fall (Table 3). In 1987, days to silk were the same for fall and spring CT and fall-kill NT, but were 1 d later under spring-kill NT (Table 3). In 1988, silking was delayed 3 d for spring compared to fall CT and 13 d with spring-kill compared to fall-kill NT.

In 1988, plants were about 30 cm shorter under spring-kill NT than for fall-kill NT and both fall and spring CT (Table 3).

In 1987, CT and fall-kill NT resulted in comparable grain moistures, but spring-kill NT resulted in greater moisture by 7 g H_2O kg^{-1} (Table 3). In 1988, grain moisture at harvest did not differ due to tillage system, but was affected by time of vegetation kill (data not shown). Grain contained 302 g H_2O kg^{-1} with spring vegetation kill compared to 247 g H_2O kg^{-1} when perennials were killed in the fall.

Grain yields generally increased as hybrid maturity increased from short- to full-season (data not shown). Hybrid maturities interacted with tillage only in 1987, when yields for CT ranged from 6.6 to 9.2 Mg ha^{-1} for short- to full-season hybrids while yields for short-season hybrids were higher for NT, with a range from 7.1 to 9.1 Mg ha^{-1}. Hybrids did not interact with time of vegetation kill (Table 4).

In 1986, average yields were lower by 10% for short-season, 15% for medium-season, and 19% for full-season maturity hybrids with mid-May compared to late-April planting, but in 1987 yields for mid-May planting were lower by 8, 15, and 1%. In 1988, there was no planting date effect on yield (Table 4). Based on long-term planting date results at this site, the 1986 planting date response was near average (Carter, 1984). Tillage–by–planting–date interactions for grain yield did not occur in the 3 yr (1986 to 1988) when there were two planting dates (Table 4, Fig. 3). There was no advantage to delayed NT corn planting into sod; therefore, similar to NT planting for corn following corn (Imholte and Carter, 1987), late-April planting was optimum for NT following alfalfa/grass.

For grain yield there was a tillage–by–time–of–vegetation–kill interaction in 1985, 1986, and 1988 (Table 4, Fig. 3). Yields for fall and spring CT and fall-kill NT were similar, but were reduced an average of 10% in 1985 and 1986 and 50% in 1988 by spring-kill NT. In 1987, for fall CT and spring-kill NT, yields were reduced about 10% when planting was delayed from late April to mid May, but for spring CT and fall-kill NT, yields were not influenced by planting date (Fig. 3). For all 4 yr, lowest overall yields were for corn planted NT in mid May following spring vegetation kill. In contrast, NT corn planted in late April following fall vegetation kill resulted in yields equal to, or greater than highest yields obtained from other treatments all 4 yr.

CONCLUSIONS

Under CT, only small differences in corn performance were observed due to the time of plowing to kill perennial vegetation. With NT, however, killing perennials in the spring before planting compared to in the fall resulted in reduced grain yields in 3 of 4 yr. Several factors may have contributed to these yield reductions, including (i) increased residue cover which often was associated with cooler soil temperatures after planting and with delayed plant development, and (ii) increased early-season competition for water and light from delayed kill of perennials. When perennial veg-

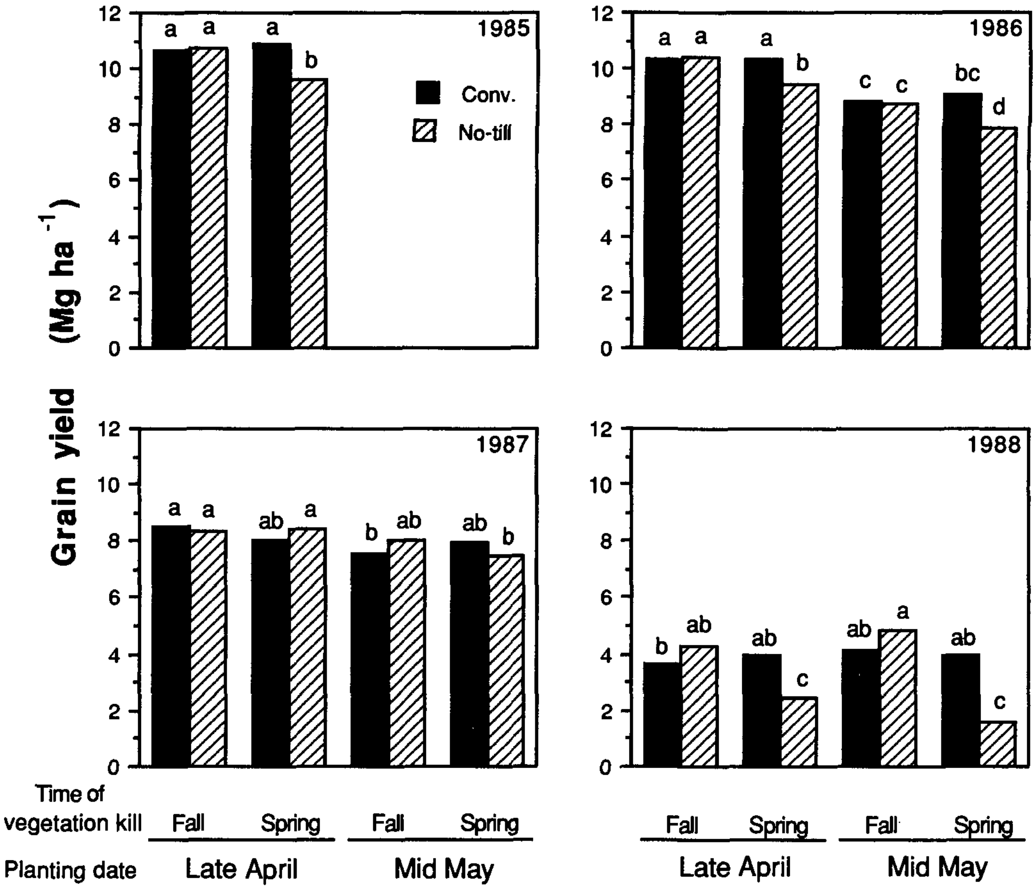

Fig. 3. Corn grain yield response to tillage (conventional vs. no-till), time of vegetation kill (fall vs. spring), and planting date (late-April vs. mid-May) for 4 yr. Values are averaged over three hybrids. Means within each year are different if different letters appear above bars ($P < 0.05$).

etation was killed in the fall and corn was planted early, NT grain yields were comparable to those for CT. For best yield performance with NT corn planted into sod, planting should be early, at the same dates and using full-season hybrid maturities as for CT.

No-till for corn following hay or pasture should not be evaluated or adopted merely based on agronomic performance. Farmers need to also consider economics and soil conservation benefits of the system. Based on ease of sod vegetation kill and corn yield potential, fall-kill NT presents the superior NT option. With this system, however, the need to chemically kill vegetation the previous fall requires producers to adopt a fixed rotation schedule, rather than waiting until spring to decide where to plant corn based on assessments of winter survival of perennials. In addition, on some slopes residue cover of 40% after planting with fall-kill NT may not fulfill government requirements for soil conservation compliance. Further research is needed to measure and compare the level of erosion control provided with NT corn planting using fall vs. spring perennial vegetation kill.

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