EVALUATION OF FERTILIZER MANAGEMENT IN STRIP-TILL AND NO-TILL CORN PRODUCTION

L. J. Ferdinand, R.E. Lamond, W.B. Gordon, K.A. Janssen and C.B. Godsey
Kansas State University, Manhattan, KS

Abstract

Strip-tillage for corn production may have advantages over no-till, particularly in areas with heavy soils and/or high rainfall during spring months. With these conditions in no-till systems, planting delays and/or slow, uneven emergence are common. Strip-tillage creates a narrow tilled area for the seedbed while maintaining the inter-row residue cover, allowing for the erosion protection associated with no-till, yet providing an area in the row where the soil will dry out and warm up earlier in the season. Objectives for this study were to evaluate strip-till and no-till for early planted corn and to compare various fertilizer management options for these tillage systems, including time of fertilizer application and nitrogen rates. Field studies were conducted at three locations in Kansas in 2003 and at the North Agronomy Farm in Manhattan, KS in 2004. Nitrogen rates included 40, 80, and 120 lbs N acre^{-1} applied with 30 lbs P_2O_5 acre^{-1}, 5 lbs K_20 acre^{-1} and 5 lbs S acre^{-1}. Nutrients were applied either with fall strip-till, at planting after fall strip-till, or at planting with no-till. Soil temperature measurements were taken at two locations from selected treatments in each tillage system at 4 cm depth. Results indicate that strip-till provides for warmer soil temperatures early in the season, resulting in better early season growth, and higher grain yields than no-till. Fertilizer applied during the fall strip-till performed similarly to fertilizer applied at planting where fall strip-tillage was done.

Introduction

Conservation tillage practices leave residue from the previous crops on the soil surface, reduce soil erosion, and decrease trips across the field with heavy tillage equipment. Although no-till provides soil and water conservation benefits to producers, the cooler, wetter soil conditions found in no-till systems result in potential problems for planting and establishing crops. Crop residues affect the soil surface energy balance by providing insulation and reflective properties. Thus, covered and bare surfaces have different energy balances with soil under a residue staying cooler and wetter in comparison to bare soil (Horton et al., 1996). The inherent residue layer associated with no-till contributes to cooler temperatures in the seed zone at spring planting (Al-Darby and Lowery, 1987). Lower soil temperatures negatively affect seedling emergence and early season growth, especially with early planting dates. Corn root growth increased five-fold when soil temperature increased from 18 °C to 25 °C (Mackay and Barber, 1984). If no-till systems are limited by crop residues on the soil surface, then seed-row residue removal should lead to corn growth similar to that of tilled systems (Kaspar et al., 1990). Strip-tillage provides an ideal combination of no-till with conventional tillage. Residue removal from within the row should allow for crop development rates similar to that of conventional tillage. Maintaining residue cover in the inter-row will allow the no-till advantages of lower soil water evaporation and reduced runoff (Fortin, 1993). Strip-till also offers the option of applying fertilizer nutrients during the fall strip-till operation. A second option is to apply nutrients in the spring at planting after creating the strip-till in the fall. The overall objective for this research is to compare strip-till and no-till as options for early planted corn in Kansas by evaluating i) seed row temperature differences between strip-till and no-till and effects on emergence, early season growth, and grain yield; and ii) management options for rates and timing of fertilizer application.

Methods and Materials

Field experiments were conducted in 2003 at three Kansas State University Research and Extension Fields in eastern Kansas (Belleville, Crete silty clay loam; Manhattan, Reading silt loam; Ottawa, Woodson silty clay loam). The study was conducted at Manhattan again in 2004. Tillage treatments included no-tillage and strip-tillage. A four-row strip-till rig was used in the fall at each site to create a 4-5" wide strip of residue free soil, disturbed to a depth of approximately 6 inches, over the row. Inter-row regions were left undisturbed. Previous crops from the 2003 growing season included wheat (Belleville) and soybean (Manhattan and Ottawa). The 2004 study was evaluated in a corn-corn rotation and in corn following soybean rotation. Fertilizer treatments included 40, 80, and 120 lbs N $acre^{-1}$ applied with 30 lbs P_2O_5 $acre^{-1}$, 5 lbs K_2O $acre^{-1}$, and 5 lbs S $acre^{-1}$. No-fertilizer check plots were included for both strip-till and no-till at each site. Fertilizer was applied to strip-till either in the fall during the strip-till operation or at planting time. One strip-till fertilizer treatment consisted of a split application on the 120 lbs $acre^{-1}$ rate with 2/3 applied during fall strip-till and the balance at planting time. No-tillage plots received fertilizer applications during the planting operation. Fertilizer was placed approximately 5-6" deep with the strip-till operation or in a 2x2 placement with the planter on no-till plots. Fertilizer combinations were made using UAN, 10-34-0 and potassium thiosulfate. Corn was planted in early April. At the Manhattan site (2003, 2004) and the Belleville site (2003), Cu-constantan thermocouples were installed at the seeding depth in selected no-till and strip-till plots to measure soil temperature. Daily temperature data were taken at in-row positions in each of the selected plots during the early part of the growing season. At the V6 growth stage, plants were randomly selected from non-harvest rows in each plot to determine dry matter yield and analyzed for nutrient concentration. Ear leaf samples were collected for nutrient analysis at the VT growth stage. Whole plant samples were taken at physiological maturity at the Manhattan site in 2003 to determine total biomass and nutrient analysis. Grain yields were determined by either hand harvest or machine harvest, depending on location.

Results and Discussion

2003

Although there were no differences in final plant stands due to tillage, corn in the strip-till treatments emerged quicker and more uniformly than no-till, likely due to higher soil temperatures. Average daily soil temperatures in at both Manhattan and Belleville through April and May were higher in strip-till compared to no-till. The effect of higher soil temperatures in strip-till was reflected in the increased V6 dry matter production compared to no-till at all locations (Tables 1, 2, 3). In addition to the greater early growth, the use of strip-till significantly increased corn yields in comparison to no-till at all locations in 2003 (Tables 1, 2, 3). Grain yields were excellent in 2003 at the Manhattan site for dryland corn due to early planting and timely rains through mid-July. Strip-till provided significantly increased early season growth over no-till and a 28 bu/ac grain yield advantage over no-till at the Manhattan site (Table 3). Grain yields at Belleville were reduced due to dry conditions. But even with lower yields, strip-till yields were 12 bu/ac higher than no-till yields at Belleville (Table 3). Advantages in early season dry matter production and grain yield were also observed for strip-till at the Ottawa field site. No significant difference existed between fertilizer applications made in the fall with the strip-till operation as compared to applying fertilizer in the spring after fall strip-till (Table 2). Results suggest that under similar conditions fertilizer can be applied during fall strip-till without concern of yield reduction. Nitrogen rate effects varied by location and previous crop, but increasing N rates generally increased grain yields.

2004
Manhattan

Corn after Soybean

Averaged across treatments receiving fertilizer at planting time, the final plant population was not significantly different between the two tillage systems (Table 4). However, the rate of emergence was more rapid in strip-till, providing an advantage over no-till in terms of the length of time required to achieve 50% of final plant population (Table 4). No significant difference in soil temperature at the 4 cm depth existed between strip-till and no-till. Although soil temperatures were significantly greater in strip-till at Manhattan in 2003 on corn ground after soybean, the 2004 corn after soybean study was located on a field that had not been in long-term no-till as the 2003 study had been. Less accumulated residue cover could have been a contributing factor to the similar soil temperatures found in the two tillage systems in 2004. Early season dry matter production at the V6 growth stage and grain yield were not significantly affected by the tillage system used (Table 4). Grain yield was also not significantly different between the two types of tillage systems. Considering strip-till treatments, no significant difference in dry matter production at V6 or grain yield was found between fertilizer applications made in the fall with the strip-till operation or at planting time (Table 6). Under similar conditions, producers could potentially apply fertilizer in the fall and obtain the same grain yield as that of fertilizer applications made at planting time.

Corn after Corn

Averaged across treatments receiving fertilizer applications at planting time, the final plant population was not significantly different between the two tillage systems (Table 7). The rate of emergence was more rapid in strip-till, providing an advantage over no-till in terms of the length of time required to achieve 50% of final plant population (Table 7). Soil temperature at the 4 cm (seeding) depth was significantly greater in strip-till (Table 8). The effect of higher soil temperatures in strip-till was reflected in increased V6 dry matter production as compared to no-till (Table 7). Averaged across treatments receiving fertilizer at planting time, early season dry matter production at the V6 growth stage was significantly greater in strip-till treatments. Among strip-till treatments, V6 dry matter production was significantly greater in treatments receiving fertilizer at planting time (Table 9). Averaged across treatments receiving fertilizer applications at planting time, strip-till provided a significant yield advantage to no-till (Table 7). Increasing nitrogen rates generally resulted in increased grain yield, regardless of the type of tillage system used. Considering strip-till treatments solely, the time of fertilizer application had no significant affect on final grain yield (Table 9).

Summary

Fall strip-till significantly increased corn grain yields over no-till corn yields in 2003. Application of nutrients during the fall strip-till operation resulted in similar yields to that of spring applied fertilizer, thus indicating that fall application of nutrients with strip-till is an effective way to implement a fertilizer program into the system. Additionally, soil temperatures were higher in strip-till the early part of the season, providing an emergence and early season growth advantage in strip-till. Overall, fall strip-till seems to be a viable option for producers who want to utilize conservation tillage practices and spread the work load while increasing grain yield.

References

Al-Darby, A.M., and B. Lowery. 1987. Seed zone soil temperature and early corn growth with three conservation tillage systems. Soil Sci. Soc. Am. J. 51:768-774.

Fortin, M.-C. 1993. Soil temperature, soil water, and no-till corn development following in-row residue removal. Agron. J. 85:571-576.

Horton, R., K.L. Bristow, G.J. Kluitenberg, and T.J. Sauer. 1996. Crop residue effects on surface radiation and energy balance – Review. Theor. Appl. Climatol. 54, 27-37.

Mackay, A.D., and S.A. Barber. 1984. Soil temperature effects on root growth and phosphorus uptake by corn. Soil Sci. Soc. Am. J. 48:818-823.

Kaspar, T.C., D.C. Erbach, and R.M. Cruse. 1990. Corn response to seed-row residue removal. Soil Sci. Soc. Am. J. 54:1112-1117.

Table 1. Effects of tillage, time of fertilizer application and N rate on corn, 2003.

Tillage	Time of Fertilizer Application	Fertilizer Rate N	P	K	S	Manhattan V6 dry weight	Manhattan Grain yield	Belleville V6 dry weight	Belleville Grain yield	Ottawa V6 dry weight	Ottawa Grain yield
		------ lbs $acre^{-1}$ ------				lbs $acre^{-1}$	bu/a	lbs $acre^{-1}$	bu/a	g/plant	bu/a
Strip-till	--	0	0	0	0	339	170	155	42	2.6	78
Strip-till	Fall	40	30	5	5	417	182	276	56	6.6	86
Strip-till	Fall	80	30	5	5	450	193	284	58	7.1	96
Strip-till	Fall	120	30	5	5	452	205	361	67	7.2	91
Strip-till	2/3 Fall 1/3 Planting	120	30	5	5	493	193	406	75	7.8	89
Strip-till	Planting	40	30	5	5	468	185	263	52	9.1	90
Strip-till	Planting	80	30	5	5	485	187	283	60	7.6	88
Strip-till	Planting	120	30	5	5	424	187	353	71	6.7	78
No-till	Planting	40	30	5	5	366	152	178	45	6.2	80
No-till	Planting	80	30	5	5	360	167	189	48	5.4	90
No-till	Planting	120	30	5	5	310	174	198	51	4.8	86
No-till	--	0	0	0	0	263	121	105	36	2.4	66
LSD (0.05)						**76**	**25**	**34**	**12**	**1.7**	**9**

Table 2. Effects of time of fertilizer application and N rate on strip-till corn, 2003.

Variable		Manhattan		Belleville	
		V6 dry weight	Grain yield	V6 dry weight	Grain yield
		lbs acre^{-1}	bu acre^{-1}	lbs acre^{-1}	bu acre^{-1}
Time of fertilizer Application:	During strip-till (fall)	440	193	307	60
	Planting time	459	186	300	61
	LSD (0.05)	**NS**	**NS**	**NS**	**NS**
N Rate: lb/a	40	443	184	269	54
	80	468	190	283	59
	120	438	196	357	69
	LSD (0.05)	**NS**	**NS**	**24**	**6**

Table 3. Effects of tillage and N rate on corn[1], 2003.

Variable		Manhattan		Belleville	
		V6 dry weight	Grain yield	V6 dry weight	Grain yield
		lbs acre^{-1}	bu acre^{-1}	lbs acre^{-1}	bu acre^{-1}
Tillage:	Strip-till	429	182	264	57
	No-till	325	154	168	45
	LSD (0.05)	**37**	**15**	**17**	**7**
N Rate: lb/a	0	301	146	130	40
	40	417	169	221	49
	80	423	177	236	54
	120	367	181	276	61
	LSD (0.05)	**52**	**21**	**25**	**10**

[1] Averaged across treatments receiving fertilizer at planting time.

Table 4. Effects of tillage and nitrogen rate on corn[1], 2004.

Variable		Plant population	V6 dry weight	Grain yield	Time to 50% emergence
		1000 plants acre^{-1}	lbs acre^{-1}	bu acre^{-1}	days
Tillage:	Strip-till	23.1	356	188	14.9
	No-till	22.5	320	180	16.8
	LSD (0.10)	**NS**	**NS**	**NS**	**0.73**

[1]Averaged across treatments receiving fertilizer at planting time – corn after soybean, Manhattan.

Table 5. Effects of time of fertilizer application and nitrogen rate on strip-till corn after soybean, Manhattan, KS. 2004.

		Plant population	V6 dry weight	Grain yield
		1000 plants acre^{-1}	lbs acre^{-1}	bu acre^{-1}
Time of fertilizer application:	With strip-till (fall)	25.0	346	215
	Planting time	22.4	335	209
	LSD (0.10)	**1.6**	**NS**	**NS**

Table 6. Effects of tillage and nitrogen rate on corn[1], 2004.

Variable		Plant population	V6 dry weight	Grain yield	Time to 50% emergence
		1000 plants acre^{-1}	lbs acre^{-1}	bu acre^{-1}	days
Tillage:	Strip-till	22.6	277	155	17
	No-till	23.1	231	134	20
	LSD (0.10)	**NS**	**46**	**14**	**1.5**

[1]Averaged across treatments receiving fertilizer at planting time – corn after corn, Manhattan.

Table 7. Effects of time of fertilizer application and nitrogen rate on strip-till corn after corn, Manhattan, KS. 2004.

		Plant population	V6 dry weight	Grain yield
		1000 plants acre^{-1}	lbs acre^{-1}	bu acre^{-1}
Time of fertilizer application:	With strip-till (fall)	22.5	247	162
	Planting time	22.2	310	166
	LSD (0.10)	**NS**	**47**	**NS**

PROCEEDINGS OF THE

THIRTY-FOURTH NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 20

November 17-18, 2004
Holiday Inn Airport
Des Moines, IA

Program Chair:
Bob Hoeft
University of Illinois
Urbana, IL 61801
(217) 333-9480

Published by:
Potash & Phosphate Institute
772 – 22nd Avenue South
Brookings, SD 57006
(605) 692-6280
Web page: www.ppi-ppic.org