Not for publication.

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Long-term Tillage Study, ARC

T.D. West, T.J. Vyn and G.C. Steinhardt

Introduction

Early evaluation of reduced tillage systems in the Midwest centered on well-drained and/or erosive soils. Due to reduced water erosion and savings in soil moisture, systems leaving 70% or more of the soil surface covered with residue often increased yield potential on these soils. These findings could not be generalized, however, to the dark silty clay loam soils of the Eastern Corn Belt where soil moisture and erosion were less severe problems.

Beginning in 1975, a range of tillage systems have been compared annually on Chalmers silty clay loam soil (4% OM) at the Purdue Agronomy Research Center in West-central Indiana. Our goal is to determine long-term yield potential of the different systems and to determine changes in soil characteristics and crop growth that could be associated with yield differences. Plow, chisel, ridge, and no-till systems are compared for continuous corn, corn following soybeans, soybeans following corn, and continuous soybeans. There are 4 replications; individual plots are 30-feet wide and 150-feet long.

Soil and Crop Management

Cultural practices have been relatively consistent since the study began. Plowing and chiseling were done in the fall with 1 disking and 1 or 2 field cultivation passes for spring seedbed preparation. For the ridge system, ridges were made at cultivation in corn and after harvest in soybeans. Row width for corn is 30-inches. Row width for soybeans was 30-inches for soybeans from 1975 to 1994. Starting in 1995, soybeans were drilled in 7.5-inch rows for plow, chisel and no-till treatments. All 30-inch row treatments except no-till were inter-row cultivated once.

Starter fertilizer was used for all corn plots, but not for soybeans. Placement was two inches to the side and two inches below the seed. Nitrogen source for corn was anhydrous ammonia through 2000 and liquid UAN (28%) starting in 2001, either pre-plant or side-dress. Total nitrogen applied generally exceeded 180 lbs./acre of actual N. Phosphorus, potassium and lime were surface-applied as needed.

Corn planting dates ranged from April 25 to May 31 and soybean dates from May 3 to June 21; however, all tillage treatments were planted on the same day each year. One-inch fluted, 2-inch fluted or bubble coulters were used ahead of planter disk openers from 1975 to 1996. Starting in 1997, no coulters were used ahead of disk openers as per planter manufacturer recommendation; however, tined row cleaners were used in no-till corn treatments. For ridge-till planting, horizontal disks were used to scrape ridges at planting from 1980 to 1996 and then we switched to planter-mounted, double-vertical disks in 1997.

Burndown herbicides were applied to control existing vegetation when needed. Pre-emergence herbicides were applied with the planter pass from 1975 through 1996. Starting in 1997, pre-emergence herbicides were applied after planting in a separate operation. Post-applied herbicides were used for weed escapes. Where needed, plots were hand weeded to ensure that weed control did not limit yield. Insecticides were applied at planting for corn rootworm control. Chemical control for cutworms, stalk borers, bean leaf beetle, rodents, and spider mites was applied as needed.

Five corn hybrids and 9 soybean varieties have been used during the 27 years of this project.

Researchers Involved

Dr. Jerry V. Mannering, Harry Galloway and Donald R. Griffith initiated the experiment in 1975 and continued to direct it until their respective retirements in 1989, 1980, and 1995. Terry D. West has managed the experiment from 1979 until present. Dr. Tony J. Vyn became involved in 1998, after moving from Canada where he had been involved in tillage research for 20 years.

Numerous faculty and graduate students have conducted research on this experiment over the years. Most of the efforts were directed towards soil physical properties (Drs. Mannering, Kladivko and Steinhardt), soybean diseases (Dr. Abney), corn and soybean production (Griffith and Dr. Swearingin), agricultural engineering (Dr. Parsons), soil microbiology (Drs. Nakatsu, Turco and Brouder), soil fertility (Dr. Mengel) and entomology (Dr. Bledsoe).

Table 1. Planting dates for corn and soybean, Long-term Tillage Study, ARC.

	Year	Corn	Soybean		Year	Corn	Soybean
1	1975	5/2	5/6	15	1989	4/25	5/12
2	1976	4/29	5/10	16	1990	4/26	5/21
3	1977	5/10	5/6	17	1991	5/10	5/3
4	1978	5/3	5/19	18	1992	5/5	5/7
5	1979	5/9	5/17	19	1993	5/11	5/12
6	1980	5/5	5/15	20	1994	4/26	5/17
7	1981	5/22	5/28	21	1995	5/22	6/1
8	1982	4/30	5/11	22	1996	5/31	6/21
9	1983	5/10	5/12	23	1997	4/29	5/16
10	1984	5/2	5/14	24	1998	5/14	5/18
11	1985	4/25	5/16	25	1999	5/12	5/21
12	1986	4/29	5/28	26	2000	4/26	5/24
13	1987	5/5	5/7	27	2001	5/2	5/10
14	1988	4/26	5/12				

2001 Field Practices

Primary tillage included the use of an International Harvester 5 18-inch bottom semi-mounted moldboard plow on the plow treatments. A DMI 7-shank coulter-chisel plow equipped with 4-inch twisted chisel points on 15-inch centers and a Danish-tine sweep leveling bar was used for the chisel treatment. Secondary tillage for plow and chisel included the use of an International 15-foot pull type tandem disk and a Glencoe 10-foot field cultivator with rear-mounted, double-rolling baskets.

Nitrogen was sidedressed at a depth of 3 to 4 inches with a DMI NutriPlacr 2800 five-knife liquid nitrogen applicator equipped with 1 coulter per knife. The outside knives (#1 and #5) were equipped to deliver 1/2 rate and after the first pass through the plots, an outside knife was placed back in the previous outside knife track to give a full rate. This method of knife placement gives us a marker for guiding the equipment for uniform application.

Corn was planted in 30-inch rows with a Case-IH model 955 4-row planter. Ripple coulters opened a slot for starter fertilizer placement. When planting the ridge treatment, row-unit-mounted double vertical disks scraped less than 1 inch of soil off the ridge tops and stabilized the planter on the ridge tops. We planted the no-till continuous corn 6-inches beside the old row rather than on the old row. We also used unit-mounted row cleaners to clear the row area of residue when no-till planting into corn and soybean residue.

Soybeans were planted with a 10-foot John Deere 750 no-till drill in the plow, chisel and no-till treatments. In the ridge treatment, the soybeans were planted with the Case-IH 955 planter in 30-inch rows.

Herbicides were applied with a tractor mounted Century 30-foot sprayer. All herbicides were broadcast with flat fan 8006 nozzles at 30-psi and 30-gallons water/acre at 5-miles per hour.

All 30-inch row plots, except no-till, were cultivated with a 4-row Hiniker ridging cultivator to control weeds and aerate the soil. The ridging wings were raised (and inoperative for "level" cultivating) on the plow and chisel plots. Ridge-till soybean plots were re-ridged after harvest. All corn plots were harvested with a White model 7300 combine equipped with a 4-row corn head. All soybean plots were harvested with a John Deere model 3300 combine equipped with a 10-foot grain platform with pickup reel.

Summary of studies conducted on the tillage plots by researcher.

- Dr. Scott Abney, USDA-ARS, Botany and Plant Pathology.
  The overall objectives of the soybean pathology research in the Long-Term tillage plots are: 1) identify and describe incidence and severity of Phytophthora root rot in conventional vs. reduced-tillage soybean production systems; 2) characterize the role of selected fungicide and post-herbicide treatments associated with conventional and no-till systems on developmental progress of soybean diseases that will facilitate improved plant health; and, 3) continue identifying pathogenicity and virulence of *Phytophthora sojae* races and *Fusarium solani* strains isolated from soybeans with Phytophthora root rot and sudden death syndrome symptoms, respectively. This research is important to Indiana and the north central region agriculture and is an integral part of Abney's on-going soybean pathology research project which emphasizes maintaining improved plant health as a means of reducing yield losses caused by Phytophthora root rot, sudden death syndrome and late season diseases. During the 1990s, diseases caused by *P. sojae*

and *F. solani* have increased throughout the north central region. Research data from field sites with a history of disease caused by these important soybean pathogens are critical to the success of the above objectives. Diseases caused by both pathogens occur in the Long-Term tillage plots and this test site is one of the best locations at the Purdue Agriculture Research Center to evaluate Phytophthora damage on soybeans. This study will continue in 2002. *Dr. Scott Abney*

- Cindy H. Nakatsu and Sylvie M. Brouder, Agronomy: Diversity of the Rhizosphere Bacterial Community of Corn and Soybean
  This was the fifth year of collecting corn and soybean plants from the long-term tillage plots. Collections were made of the disturbed (plowed) and undisturbed (no-till) soils, of the corn and soybean crops, grown in monoculture or in a two crop annual rotation. We continued to concentrate our studies on the rhizosphere soils of corn and soybean. The rhizosphere is the soil region in contact with plant roots and exudates from the roots can promote microbial growth. Characteristic profiles of the communities were obtained by denaturing gradient gel electrophoresis (DGGE) of PCR amplified 16S rDNA from soil extracted DNA. Using this method PCR products with different sequences migrate different distances in the denaturing gel producing distinct "fingerprint" patterns. The method is able to show the dominant rhizosphere bacterial populations, as indicated by bands with greater intensity. Observations from previous years indicated there are distinct microbial communities associated with root type, plant growth stage, and agronomic treatment. Statistical analysis showed that the microbial community fingerprints group according to plant growth stages within each agronomic treatment. Plant analysis showed that soil treatments resulted in distinct shoot and root growth patterns with significant differences observed in morphological and architectural aspects of the rooting systems of corn. Preliminary comparison of data between years suggests that some of the same populations can be observed yearly, but yearly variables such as weather does impact community structure. This approach provides a means to understand factors influencing the microbial ecology of the rhizosphere and, conversely, the influence microbial ecology has on plant development. *Dr. Cindy H Nakatsu*
- Akilah Martin and Dr. C. J. Johannsen, Agronomy: Crop Residue Delineation
  During the Spring/Fall 2001 season, crop residue amounts were measured using the line-transect method. A 50-ft rope containing 100 tied knots at 6-inch increments was utilized. The rope was strategically placed diagonally across each plot, then two measurements were taken in each plot (from one end to the middle and from the other to the middle) in order to obtain an accurate crop residue percentage value. If there was residue directly below the knot in the rope, a residue count was taken. This procedure was done for all 100 knots and a tally was done when all knots were accounted for. It was found that the residue percentages ranged from 1-80%, which is representative of plow to no-till tillage systems.

  Remote sensed images were also taken over the long-term tillage plots throughout the growing season. An image dated May 25, 2001 flown by Agri-Visions was utilized to study crop residue spectral response patterns. It was found after close examination of the image that no-till plots have a greater spectral response and therefore appear bright to white on the image, while plow plots appear very dark to black. Chisel and ridge plots were not so easily deciphered. After further analyses with a spectrometer as verification, a conclusion may be drawn. It was also apparent that corn residue has a much higher spectral response than soybean residue. The figure below displays this phenomenon.

- Terry D. West, Tony Vyn, and Gary Steinhardt, Agronomy.
  T. West, T. Vyn and G. Steinhardt studied long-term affects of tillage and rotation by measuring plant population, growth, and yield of corn and soybeans.

Table 2. Soil test results based on composite samples, Long-term Tillage Study, ARC, Fall 2001.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Plow	CC	0-8	4.6	36 H	122 M	605 VH	2150 L	6.1	6.7	19.7
No-till	CC	0-4	5.7	75 VH	316 VH	720 VH	2100 L	6.3	6.7	20.9
No-till	CC	4-8	4.4	34 H	108 M	515 H	1800 L	5.4	6.5	19.6
Plow	CB	0-8	4.5	51 VH	144 M	735 VH	2600 M	6.7	6.9	20.7
No-till	CB	0-4	5.3	78 VH	249 H	760 VH	2600 M	6.8		20.6
No-till	CB	4-8	4.2	26 M	110 M	605 H	2450 L	5.6	6.5	23.6
Plow	BB	0-8	4.5	42 H	144 M	760 VH	2750 M	7.2		20.5
No-till	BB	0-4	4.2	73 VH	241 H	675 VH	2450 M	7.3		18.5
No-till	BB	4-8	4.1	26 M	109 M	690 VH	2650 M	6.5	6.8	21.7

CULTURAL PRACTICES USED 2001

Long-term Tillage Study, ARC, Purdue Univ.

Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/1 5/1	Disk once on plow and chisel treatments Field cultivate once on plow and chisel treatments	5/10	Field cultivate twice on plow and chisel treatments
Hybrid/Variety planted	5/2	Beck's 5322 (109-Day) Row cleaners on c/b and c/c no-till. Shifted no-till c/c to west. (Shift to east in 2002)	5/10	Pioneer 93B66
Seeding rate		30,000 seeds/a., Drum A, 24 pockets (variable rate controller)		Plow, chisel, no-till drilled: 200,000 seeds/a. Ridge 30-inch rows: 140,000 seeds/a. (variable rate controller)
Starter fertilizer/planter		34-0-0 @ 96 LB/a., 2-inches to the side and 2-inches below the seed (sprockets driver 36, driven 30)		None
Insecticide/planter		Force 3G, 5 oz/1000 row feet, banded over row (Insecticide setting 1-7)		None
Rodenticide/planter		Pro-Zap zinc phosphide pellets		
Weed control	5/2	Pre-emergence: Harness Extra 5.6L 5pt/a. Roundup Ultra 2 pt/a.	5/2 5/11	Burndown: Roundup Ultra 1.5 pt/a. on B/B no-till, B/C no-till and B/C ridge Pre-emergence: First Rate 0.75 oz/a. Dual II Magnum 1.67 pt/a.
Nitrogen fertilizer	5/30	200 lbs N as UAN (28%) @ 60 gallons/acre		None
Cultivation	6/13 6/13	Plow and chisel treatments Ridge treatment (re-ridge)	6/25 11/8	Ridge treatment only Ridge treatment (re-ridge)
Harvest	10/8	Center 4 of 12 rows, 150-feet	10/5	Center pass, 150-feet
Primary tillage	11/8 11/9	Fall plow on plow treatment Fall chisel on chisel treatment	11/8 11/9	Fall plow on plow treatment Fall chisel on chisel treatment
Phosphorous, Potassium	11/13	0-46-0 @ 200 LB/a and 0-0-60 @ 300 LB/a. blended	11/13	0-46-0 @ 200 LB/a and 0-0-60 @ 300 LB/a. blended
Lime	11/15	2 ton/a. Bulk spread	11/15	2 ton/a. Bulk spread

Stand, growth, and yield -- Corn.

In no-till continuous corn, establishing a uniform stand can be difficult. The corn residue is thickest on the old row and we had previously observed seeds planted in contact with residue, not in contact with soil. Variable seed depth and inconsistent contact with the soil can result in non-uniform germination, reducing yield potential. We have shifted no-till corn after corn rows 6-inches (enough to clear the planter gauge wheels) to the side of last year's rows. By shifting the new rows, we wanted to gain more uniform seeding depth, improve seed to soil contact, and achieve more uniform seedling emergence. This is the seventh year of shifting the new rows. In 6 of the 7 years, we achieved these goals.

Continuous corn. Plant emergence was erratic in the plow and chisel treatments due to a dry seedbed and inadequate rainfall for 2 weeks after planting. Although most seeds germinated shortly after planting, there were lengths of some rows that did not germinate until the rains occurred 2 weeks later. Plant emergence in the ridge treatment was more uniform than plow or chisel, but still suffered gaps as some seeds lay in dry soil until rains came (Table 3). We expected the no-till plots to have significantly higher plant stands than the other treatments due to adequate soil moisture at planting. Since we use row cleaners and plant beside last year's row, crop residues had little negative affect on seed placement. Plant stands were equal for all tillage systems when measured at 4 weeks after planting. There were no significant differences in plant height at 4 or 8 weeks after planting. There were also no significant differences in grain moisture at harvest. For the first time in many years, there were no significant differences in grain yield. No-till yielded 187.4 bushels/acre, which is the second highest no-till corn yield in the history of this study (highest was 188.8 bushels/acre in 1982). The plow, chisel and ridge corn yields may have been reduced by the delayed germination.

Corn following soybeans. Plant stands in the no-till treatment were significantly higher that plow, chisel and ridge. As in continuous corn, plant emergence was erratic in the plow, chisel and ridge treatments because of dry seedbed and inadequate rainfall for 2 weeks after planting. Soil conditions in the no-till plots were ideal at planting with adequate moisture for uniform seed germination. Although there were no significant differences in plant height at 4 and 8 weeks after planting, no-till plants tended to be taller than any of the other treatments. There were no significant differences in grain moisture at harvest. No-till yielded the most at 210.5 bushels/acre, but was not significantly different than plow or ridge. This no-till yield of 210.5 bushels/acre beats the previous no-till record of 208.9 bushels/acre set in 1982. The plow and chisel treatments likely were reduced by the non-uniform germination and uneven seedling emergence. This year points out that no-tilled corn in rotation with soybeans can compete successfully with full-width tillage systems when soil conditions at planting are right and weeds are controlled throughout the year. Overall rotation system effects were non-significant for all corn response parameters in 2001. There was almost no yield advantage for crop rotation in 2001 in plow, chisel, and ridge-till systems. The only obvious corn yield advantage for corn after soybeans occurred in the no-till system, but even that 12% improvement was less than the norm in this tillage system.

Table 3. Agronomic performance of corn as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ARC, Purdue Univ., 2001. †

Previous Crop	Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		%	ppa	in	in	%	Bu/a.
Corn	Plow	4d‡	27800	11.9	49.0	20.4	199.6
	Chisel	26c	28300	11.3	49.0	20.0	194.1
	Ridge	50b	28000	11.5	44.8	20.6	199.4
	No-till	74a	27500	12.7	48.2	20.6	187.4
Soybean	Plow	2c	28300b	12.0	48.5	20.0	202.3ab
	Chisel	7c	28200b	10.5	47.5	19.5	193.8b
	Ridge	25b	26800b	13.0	51.2	19.9	201.3ab
	No-till	58a	30200a	13.5	55.0	19.6	210.5a

†Average of 3 replications.
‡Within rotations, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Stand, growth, and yield -- Soybeans.

For the seventh consecutive year we drilled the plow, chisel, and no-till treatments at 7.5-inch row spacing, while the ridge treatment was planted at 30-inch row spacing. Seeding rates were set higher for the drilled treatments. Soil samples taken in 1999 confirmed the presence of Soybean Cyst Nematodes (SCN) in many of the plots. To reduce the negative impact of SCN on yield potential a SCN resistant variety was planted in 2000 and 2001.

Rotation soybean/corn: Ridge plant populations were significantly lower due to the reduced seeding rate at planting for 30-inch rows (Table 4). The no-till stand likely benefited from higher soil moisture. Plant growth was tallest in the plow and ridge treatments at 4 weeks and significantly so at 8 weeks after planting. Insect feeding on the leaves was noted, but not thought to be yield limiting. We did note some plants infected with Sudden Death Syndrome (SDS). These were more often found in chisel plots. This may have led to the reduced yields in the chisel treatment. The 30-inch row ridge plots were equal to the 7.5-inch drilled treatments. This points out the competitiveness of the ridge-till system to drilling soybeans in a full-width tillage system in this study. Rotation soybeans yielded about 15% more than continuous soybeans in 2001.

Continuous soybean: Plant populations in the ridge treatment were significantly lower due to the reduced seeding rate at planting for 30-inch rows. Continuous soybean plant height was shorter at the 8-week measurement than for soybeans in rotation in all treatments except no-till. The ridge treatment, which in the past several years suffered from extremely high populations of SCN in some plots, yielded competitively with full-width tillage systems. We suspect that yields in all continuous soybean plots are somewhat affected by SCN. We also observed some plants affected by Sudden Death Syndrome.

Table 4. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ARC, Purdue Univ., 2001. †

Previous Crop	Tillage	Residue cover after planting	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		%	ppa	in	in	%	Bu/a.
Corn	Plow	3d§	185000a	3.8ab	14.3a	10.6	61.0a
	Chisel	32c	190000a	3.3b	12.3b	10.6	53.2b
	Ridge	47b	125000b	4.1a	14.2a	10.5	59.3a
	No-till	91a	211000a	3.5ab	11.5b	10.6	59.2a
Soybean	Plow	2c	198000b	3.9ab	12.8	10.8	51.8
	Chisel	8bc	187000b	3.3b	12.2	10.6	51.2
	Ridge	20b	126000c	4.2a	13.7	10.6	49.5
	No-till	77a	235000a	4.1ab	13.4	10.7	50.6

†Average of 3 replications.
‡Plow, chisel, and no-till are 7.5-inch drilled, ridge is 30-inch rows.
§Within rotation, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Table 5. Analysis of variance summary, tillage data, Long-term Tillage Study, ARC, Purdue Univ., 2001.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield Bu/a.
	----------Significance Level----------					
				Corn		
Tillage	.01	NS	.08	NS	NS	NS
Previous crop	.01	NS	NS	NS	NS	NS
Tillage x previous crop	.10	NS	NS	NS	NS	.02
				Soybean		
Tillage	.01	.01	.01	.01	NS	.04
Previous crop	.01	NS	NS	NS	NS	.08
Tillage x previous crop	.01	NS	NS	.01	NS	.03

Long-term Yields

Results from this study provide insight into long-term yield potential of corn and soybean with different tillage systems on dark prairie soils of the Central and Northern Corn Belt. While equipment, cultivars, and seeding rates were changed periodically, tillage treatments were not altered during the 27 years of this continuing experiment.

Both tillage system and rotation influenced stand, growth and yield of corn and soybean in these studies. In continuous corn, tillage system also influenced grain moisture. With planting conditions similar to those in this study the following conclusions appear to be justified:

1. Both corn and soybean yields are greater in rotation than in continuous cropping for all tillage systems (Tables 6 and 7). The positive response to rotation is greatest for no-till corn. However, within the 3 tilled treatments (plow, chisel, and ridge) soybean yields increased more (percent basis) with rotation than did corn yields.
2. When corn follows corn, yields with chiseling and ridging may be reduced slightly (3% or less) compared with plowing. No-till continuous corn yield on dark, poorly drained soil is likely to be reduced, compared with yield with other systems, and the yield reduction may increase with time when planted on the old row (Fig. 2). Part, but not all, of the yield loss prior to 1995 may be due to reduced stand or non-uniform plant emergence. Since planting beside old row starting in 1995, the yield gap has been reduced.
3. When corn follows soybean, yields with plow and chisel are likely to be about the same. Yields from the ridge system may be slightly better (3%) than plow and chisel. No-till corn yields may be slightly reduced (3%) compared to plow and chisel, but the relative yields of no-till change little with time (Fig. 3). Yield reductions with no-till corn are not due to lower populations.
4. No-till soybean yields are likely to be reduced slightly, compared with plowing, but yield differences may be reduced with time (Fig. 4 and 5). No-till soybean yield reductions are likely to be less frequent when grown in narrow rows.

Table 6. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, ARC, 1975-01.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	175.7	- - -	167.5	- - -	5
Chisel	175.8	100	162.7	97	8
Ridge*	180.3	103	165.8	99	9
No-till	171.3	97	144.7	86	18

*Since 1980

Table 7. Soybean Yield Response to Tillage and Rotation, Long-term Tillage Study, ARC, 1975-01.

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	52.6	- - -	48.0	- - -	10
Chisel	51.1	97	45.5	95	12
Ridge*	50.7	96	44.5	93	14
No-till	49.9	95	45.8	95	9

*Since 1980

The Journal of Production Agriculture article titled "Effect of Tillage and Rotation on Agronomic Performance of Corn and Soybean: Twenty-Year Study on Dark Silty Clay Loam Soil" gives a detailed report of this research project. This article can be found in volume 9, no. 2, page 241 to 248, 1996. A reprint can be obtained by contacting Terry D. West, Agronomy Department.

Not for publication.

Feasibility of Fall Zone Tillage for Corn Production in Indiana, ARC

Melissa J. Arends, Tony J. Vyn, and Terry D. West, Dept. of Agronomy, Purdue University.

Introduction

Fall zone tillage can be considered as an alternative to intensive tillage systems when farmers are reluctant to initiate or continue with a pure no-till system. Fall zone tillage is a type of in-row loosening where only the intended row area for the subsequent crop is disturbed, leaving the interrow area covered with residue. Fall zone tillage allows for the option of planting row crops directly into the loosened area in the spring. Ideally, the fall zone-tilled strips will leave a mound in the fall approximately three to four inches high, which will mellow down to about one to two inches in spring. This slight ridge, plus the loosening and residue disturbance associated with the fall zone tillage may improve soil drying and warming in spring compared to regular no-till rows. Earlier planting could be another advantage. Fall zone tillage may result in corn yields, which are comparable to those with moldboard plow and disk systems, but superior to that after no-till alone. Biggest benefits are expected on poorly drained soils with high clay content. Ultimately, the adoption of fall zone-till would help to over come the challenges of planting corn in early spring on poorly drained fine-textured soils while still maintaining erosion control benefits, productivity, and profitability.

Objective

The objective of this research project was to evaluate the effects of fall zone tillage systems with varying depths and subsequent secondary tillage on (a) spring soil dry down, (b) soil physical properties in the seedbed, and (c) the response of corn compared to full-width and no-till systems. Ten different tillage treatments were evaluated to determine the optimum fall zone tillage depth and the need of subsequent secondary tillage. The purpose of this study was to introduce fall zone tillage as an alternative system to intensive tillage and pure no-till where needed.

Site Information

In the fall of 1998 the field experiment was established at the Agronomy Research Center (ARC). The soil type is a Drummer and Raub-Brenton Complex, which is somewhat poorly to poorly drained, silty clay loam to clay loam with 3-4.5% organic matter. The field had been in continuous no-till production for at least five years. The experiment was initiated after soybeans in a corn-soybean rotation for corn planted in 30-inch rows. Each year the experiment was shifted to new fields, which were previously in soybean; all fields were in continuous no-till for at least 5 years before the tillage treatments were imposed.

Treatments

1) Fall Moldboard Plow
2) Fall Disk Only
3) Fall Zone-Till 13-inch Depth (John Deere 955 Deep Ripper)
4) Fall Zone-Till 8-inch Depth (DMI 2500 w/mole knife and berming disks)
5) No-till with 3 Coulters
6) No-till with Row Cleaners

Note: Treatments 3, 4, & 6 were compared with and without the Phillips Rotary Harrow in the spring. Treatment 2 was compared both with and without spring cultivation.

CULTURAL PRACTICES USED 2001 Feasibility of Fall Zone Tillage for Corn Production in Indiana, ARC, Purdue Univ.		
Field Operation	Date	Application Details
Fall Tillage	Oct. 2000	
Secondary tillage	4/25	Phillips Rotary Harrow
Secondary tillage	4/27	Glencoe Soil Finisher
Hybrid planted	4/27	Pioneer 33A14 (113 day)
Seeding rate		31,000 seeds/a.
Starter fertilizer/planter		170 LB/a. 11.5-11.5-30, 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G, 5 oz/1000 row feet.
Rodenticide/planter		Pro-Zap zinc phosphide pellets
Weed control	4/30	Pre-emergence
		Harness Extra 5.6 5 pt/a.
		Roundup Ultra 1.5 pt/a.
	5/24	Post-emergence
		Clarity 12 ounces/a.
		All broadcast with flat fan 8006 nozzles at
		30 psi and 30 gallons water/a., 5.0 mph.
Nitrogen fertilizer	5/15	UAN (28%) N @ 60 gallons/acre
Harvest		Hand harvest 15-meters of row per plot

Preliminary Results

Results are not available for 2001 until after statistical analysis have been completed.

Acknowledgements:

We are grateful for the in-kind support of (a) zone tillage equipment from Case-DMI (Goodfield, Illinois) and John Deere Ltd. (Des Moines, Iowa), (b) the Phillips Rotary Harrow from Precision Metal Fabrication (Saskatoon, Saskatchewan), and (c) corn seed from Pioneer Hi-Bred Ltd. (Tipton, Indiana).

Long-term Tillage Study, PPAC

T.D. West, G.C. Steinhardt, and T.J. Vyn

In this study we will be investigating crop residue/soil temperature/tillage relationships and their effects on crop growth and yield. In this northern Indiana location, cold soil temperatures limit no-till crop performance. Most farmers in this area use full-width primary tillage with 2 secondary tillage passes to prepare a suitable seedbed. Our plans are to use a wide variety of tillage equipment to determine if there is a level of tillage that will preserve crop residues on the soil surface for erosion control, yet give satisfactory yields. The practices are designed to leave crop residue levels ranging from none to as much as possible with a number of levels in between. We are looking for the most effective mix to insure both soil protection and production. This has been a frequently expressed concern in northern Indiana, and one in which farmers have real interest.

This study will be a good start toward addressing questions that area farmers have raised about reduced tillage. We feel this is finally going to provide the comparisons that farmers have been asking for on the soils that are most troublesome. This study was set up in the field in 1996 with proper row direction and cropping sequence.

Crop Rotations	Tillage Treatments	Data to be Collected
Continuous corn	Fall chisel, spring disk and combo-mulch-finisher	Soil compaction
Corn/soybean	Fall chisel, spring combo-mulch-finisher	Residue cover
Soybean/corn	Fall disk, spring combo-mulch-finisher	Soil temperatures
	Fall aerator, spring aerator (1997-2000)	Week 4 stand and height
	Fall strip-till (2001-?)	Week 8 height
	No-till	% Grain moisture at harvest
		Yield

Table 1. Soil test results based on composite sampling, Long-term Tillage Study, PPAC, Fall 2001

Tillage	**Crop**	**Depth**	**OM**	**Phos.**	**K**	**Mg**	**Ca**	**Soil pH**	**Buffer pH**	**CEC**
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	3.2	34 H	118 M	440 VH	1400 M	6.4	6.9	12.2
No-till	CC	0-4	3.1	37 H	209 H	435 VH	1400 L	6.2	6.8	13.6
No-till	CC	4-8	3.0	17 L	88 M	395 VH	1400 L	6.1	6.8	12.9
Chisel	CB	0-8	3.0	42 H	126 M	485 VH	1600 L	6.0	6.7	16.0
No-till	CB	0-4	3.4	44 H	181 H	455 H	1500 L	6.1	6.7	15.4
No-till	CB	4-8	2.7	24 M	89 M	460 H	1650 L	6.1	6.7	15.9

CULTURAL PRACTICES USED 2001

Long-term Tillage Study, Fields B3 & C3, Pinney Purdue Agricultural Center

Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/9	Disk.	5/9	Disk.
	5/9	Field cultivate.	5/9	Field cultivate.
Hybrid/Variety planted	5/9	Pioneer 34G13 (109 day).	5/9	Pioneer 93B01 Roundup Ready.
Seeding rate		29,900 seeds/a.		180,000 seeds/a.
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed.		None.
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.		None
Weed control	4/16	Burndown: Roundup Ultra 2 pt/a. on no-till and strip-till	4/16	Burndown: Roundup Ultra 2 pt/a. on no-till and strip-till
	5/11	Pre-emerge: Bicep II Magnum 4.2 pt/a. Extrazine II 1.5 LB/a.	6/17	Post-emerge: Roundup 2 pt/a. AMS 17 LB/a. *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.*
	6/15	Post-emerge: Accent SP 2/3 oz/a. Atrazine 4L 2pt/a. *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.*		
Nitrogen fertilizer	6/11	215 lbs N as UAN (28%) @ 65 gallons/acre		None.
Cultivation	6/20	Once as required by treatment.		None
Harvest	10/29	All 6 rows, 130-feet.	10/9	Whole plot, 130-feet.
P and K fertilizer	11/6	350 LB/a. of 0-15-40	11/6	350 LB/a. of 0-15-40
Lime				
Fall tillage	11/7	Fall chisel with leveling bar. Fall disk, no harrow. Fall strip-till 8-inch depth.	11/7	Fall chisel with leveling bar. Fall disk, no harrow. Fall strip-till 8-inch depth.

Soil temperatures:

Soil temperatures were measured from the day after planting through the next 4 weeks in the new row at 2-inches from soil surface in 1 of the 4 replications. Temperatures were recorded hourly with Spectrum Technologies WatchDog model 100 data loggers. No-till had the lowest average daily maximum soil temperature in both continuous corn and in rotation (Fig. 2). All levels of tillage increased the daily maximum soil temperature. Strip-tilling warmed the soil 1 to 2 degrees compared to no-till. Average minimum soil temperatures for all treatments were within a 2-degree range (Fig. 3). Fall disking tended to result in lower maximums and minimum temperatures since this treatment left more residue cover than chisel plowed treatments.

Stand, growth, and yield -- Corn.

Continuous corn. The planter was shifted 6-inches to the side of last year's old row in no-till. There were no significant differences for stand among treatments (Table 10). We used row cleaners on the planter for the strip-till and no-till treatments. Seed germination and seedling emergence was uniform across treatments. With favorable early season weather, all treatments were equal in plant height at 4 weeks after planting. Plant height at 8 weeks was tallest for treatments with some level of tillage. The chisel/disk/field cultivator, chisel/field cultivator, and strip-till yielded significantly higher that disk/field cultivator and the no-till treatments. This year's results suggest that a level of tillage that leaves less than 70% residue cover after planting is needed for maximum grain yields on this soil. Also note that the strip-till treatment, which not only reduces residue cover in a 10-inch band over the row, but also tills the soil to a depth of 8-inches, can significantly improve no-till corn yields in high residue conditions.

Rotation corn/soybeans. Soil surface residue cover levels of at least 30% are needed to reduce soil erosion by wind and water. Full-width tillage in the fragile soybean residue reduces levels below 30% (Table 2). Even the least aggressive full-width tillage treatment of disk/field cultivator resulted in 18% residue cover. Both strip-till and no-till left sufficient residue to reduce soil erosion. This was an excellent year for corn at this site. The crop was never stressed by too little or too much soil moisture. No significant diseases or insect problems were noted. Yields ranged from 218.9 to 226.8 bushels/acre with no significant yield differences among treatments. This fact illustrates that no-till corn can yield competitively with full-width tillage when planted in rotation. Average yield gains for rotation (11%) were near the long-term average at this site.

Table 2. Agronomic performance of corn as affected by tillage and rotation, Sebewa loam, Long-term Tillage Study, Pinney Purdue Agricultural Center, 2001. †

Previous crop	Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		%	ppa	in	in	%	Bu/a.
Corn	Chisel/disk/field cultivator	15c‡	28400	8.4	55.8a	21.0	204.0a
	Chisel/field cultivator	17c	28300	8.7	56.3a	19.9	206.6a
	Disk/field cultivator	70b	29300	7.9	53.6ab	21.3	194.2b
	Fall strip-till	61b	29000	8.7	54.4ab	19.4	201.5a
	No-till	91a	28800	8.3	50.5b	21.5	189.0b
Soybean	Chisel/disk/field cultivator	10c	28600c	8.9	55.9	20.6	220.8
	Chisel/field cultivator	13c	29200bc	8.8	57.0	21.0	222.6
	Disk/field cultivator	18c	28200c	8.7	57.6	21.2	218.9
	Fall strip-till	38b	31300a	8.9	60.3	21.2	226.8
	No-till	79a	30600ab	9.0	59.2	20.6	220.2

†Average of 4 replications.
‡Within rotation, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P = .05).

Table 3. Analysis of variance summary, tillage data, corn, Long-term Tillage Study, PPAC, 2001.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield Bu/a.
	----------Significance Level----------					
Tillage	.01	.02	NS	NS	NS	.01
Previous crop	.01	.03	.09	.06	NS	.01
Tillage x previous crop	.01	.03	NS	.01	.01	.01

Stand, growth, and yield -- Soybeans

There were no significant differences in stands at 4 weeks after planting (Table 4). The lower plant stands in the no-tilled plots may be from not having the drill set deep enough in the heavy residues. Plant growth was very slow through week 4 with heights of less that 2-inches. By week 8 after planting, those treatments with the most aggressive tillage exhibited taller plant height. Manganese deficiency symptoms appeared in a few plots, but was not related to tillage system.

Grain yields ranged from 55.5 to 60.0 bushels per acre with no significant differences. The trend in yields indicates that less tillage equaled greater yields.

Table 4. Agronomic performance of soybean as affected by tillage, Sebewa loam, rotation soybean/corn, Long-term Tillage Study, Pinney Purdue Agr Center, 2001. †

Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
	%	ppa	in	in	%	Bu/a.
Chisel/disk/field cultivator	21c‡	187000	1.8	12.2ab	11.4	55.5
Chisel/field cultivator	26c	198000	1.9	12.8a	11.2	57.5
Disk/field cultivator	54b	191000	1.7	11.0bc	11.2	57.6
No-till (Fall strip-till for corn)	86a	178000	1.7	10.9bc	11.2	60.0
No-till	92a	172000	1.8	10.4c	11.3	59.8
ANOV sig. level	.01	NS	NS	.01	NS	NS

†Average of 4 replications.
‡Data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Long-term Yields

Table 5. Yield summary by year, Bu/a., Sebewa loam, Long-term Tillage Study, PAC.†

Previous Crop	Tillage	1997	1998	1999	2000	2001	2002	97-01 Avg.
				Corn				
Corn	Fall chisel, disk, field cultivate	187.2	188.4	141.5	164.1	204.0		177.0
	Fall chisel, field cultivate	194.5	187.1	146.8	170.3	206.6		181.1
	Fall disk, field cultivate	184.3	180.4	133.5	165.9	194.2		171.7
	Fall aerate, spring aerate	181.4	157.2	123.9	162.0	----		----
	Fall strip-till	----	----	----	----	201.5		----
	No-till	184.9	156.0	124.4	153.4	189.0		161.5
	CC Average	186.5	173.8	134.0	163.11	199.1		172.8
Soybeans	Fall chisel, disk, field cultivate	206.9	195.6	166.7	174.8	220.8		193.0
	Fall chisel, field cultivate	211.3	186.6	171.2	177.8	222.6		193.9
	Fall disk, field cultivate	205.6	196.1	169.0	177.2	218.9		193.4
	Fall aerate, spring aerate	207.8	170.7	160.0	172.4	----		----
	Fall strip-till	----	----	----	----	226.8		----
	No-till	204.6	169.9	166.8	173.4	220.2		187.0
	CB Average	207.2	183.8	166.7	175.1	221.9		191.8
	Average	196.9	178.8	150.4	169.1	210.5		182.3
				Soybean				
Corn	Fall chisel, disk, field cultivate	60.4	48.6	46.8	50.0	55.5		52.3
	Fall chisel, field cultivate	61.9	48.3	49.5	52.8	57.5		54.0
	Fall disk, field cultivate	60.5	45.1	46.0	56.8	57.6		53.2
	Fall aerate, spring aerate	61.2	49.9	43.5	49.0	----		----
	Fall strip-till	----	----	----	----	60.0		----
	No-till	60.8	51.0	41.2	47.2	59.8		52.0
	BC Average	61.0	48.6	45.4	51.2	58.1		52.9

†Average of 4 replications.

Table 6. Agronomic performance of corn as affected by tillage and rotation, Sebewa loam, Long-term Tillage Study, Pinney Purdue Agricultural Center, 1997-2001. †‡

Previous crop	Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		%	ppa	in	in	%	Bu/a.
Corn	Chisel/disk/field cultivator	20	26850	12.1	53.3	19.7	177.0
	Chisel/field cultivator	24	26500	12.5	54.4	19.3	181.1
	Disk/field cultivator	60	26700	11.3	51.0	19.8	171.7
	No-till	85	27300	10.9	46.7	20.6	161.5
Soybean	Chisel/disk/field cultivator	6	27100	13.2	57.8	19.4	192.9
	Chisel/field cultivator	8	27600	12.6	57.9	19.5	193.9
	Disk/field cultivator	12	27500	12.5	57.0	19.6	193.3
	No-till	62	28500	11.8	54.3	19.6	187.0

†Average of 4 replications.
‡No statistics run on data.

Table 7. Agronomic performance of soybean as affected by tillage, Sebewa loam, rotation soybean/corn, Long-term Tillage Study, Pinney Purdue Agr Center, 1997-2001.†

Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
	%	ppa	in	in	%	Bu/a.
Chisel/disk/field cultivator	22c‡	161000	2.9	12.1a	11.7	52.3
Chisel/field cultivator	28c	161000	3.0	12.5a	11.6	54.0
Disk/field cultivator	52b	161000	2.9	11.2b	11.6	53.2
No-till	83a	170000	3.0	10.8b	11.8	52.1
ANOV sig. level	.01	NS	NS	.01	NS	NS

†Average of 4 replications.
‡Data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Table 8. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, PPAC, 1997-2001.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of c/d/fc yield	Bu/ac	% of c/d/fc yield	%
Chisel/disk/field cultivator	193.0	- - -	177.0	- - -	9
Chisel/field cultivator	193.9	100	181.1	102	7
Disk/field cultivator	193.4	100	171.7	97	13
No-till	187.0	97	161.5	91	16

Feasibility of One Pass Tillage in Northern Indiana, PPAC

Principal Investigators: Terry D. West, Tony J. Vyn and Gary C. Steinhardt.

Objectives

1 To determine the feasibility of a new single-pass mulch tillage tool for corn and soybean production relative to no-till and conventional tillage systems.
2 To compare surface residue cover and soil physical properties left after a single pass mulch tillage system (in either fall or spring) relative to other conservation tillage alternatives.
3 To upgrade the current secondary tillage equipment at the Pinney Purdue Agricultural Center to permit timely operations, fuel savings, less residue bunching, and more satisfactory seedbed conditions than are currently possible.

Duration: Research plots: 1999 to 2004

Justification and Relevance:

Reduced tillage has many advantages in terms of efficiency, erosion control and cost savings. These have been documented in numerous studies. There is a continuing perception that, in cooler climates, no-till leads to delayed planting, reduced plant stands and reduced yields in corn. These perceptions have resulted in a reduction in no-till corn acreage in Indiana, particularly in the northern part of the state. The Conservation Technology Information Center estimates that, for Indiana as a whole, only 21% of the corn acreage was planted with no-till in 2000.

Chisel plowing is the most common tillage system prior to corn in Indiana. Since soybeans leave little residue cover to begin with, and because farmers who chisel usually perform two passes of secondary tillage, essentially no residue cover remains after planting. There have been very few investigations of single-pass tillage systems which in fall (stale seedbed) or spring (without any prior primary tillage) might permit sufficient residue cover for erosion control while resulting in yields superior to no-till.

Long-term research (1975-01) in west central Indiana (Agronomy Research Center) has documented significant corn yield reductions with no-till when corn followed corn, but not when corn followed soybeans. Average corn yields were only 3% lower with no-till compared to moldboard plowing after soybeans. Soil temperatures with no-till were significantly lower than moldboard, chisel and ridge-till systems in the first month after planting. Spring temperatures are even colder at locations farther north. Thus, planting delays and potential yield reductions with no-till corn may be even greater on poorly drained soils in Northern Indiana.

To fully explore a range of tillage system/crop residue relationships, a "one-pass" high clearance tillage implement is used in this study. Current two-pass or three-pass tillage treatments could be replaced with the one-pass treatment that - if proven successful - could save farmers machinery, fuel and labor costs. Single-pass concepts that need more investigation are those in the fall followed by spring no-till planting (i.e. stale seedbed) or those just before planting in spring. Preliminary indications are that some new implements can do this single-pass, full-width tillage while maintaining 30% residue cover (the minimum level to be rated as conservation tillage).

This research project is very important if we are to provide farmers with timely and vital information. There are insufficient replicated studies, and too many farmers are not making valid comparisons between full-width tillage, reduced tillage and no-till. These plots can help show the possibilities for reduced tillage on the colder soils, and possibly affect the way that farmers think about reduced tillage and no-till planting of corn. This may not solve the problem of no-till planting of corn but it will, with more years of data, show farmers the relative risk and rewards so more informed decisions could be made.

Site Information

These field experiments were established in the spring of 1999 in field "D" and in the fall of 1999 in field "F" at the Pinney Purdue Agricultural Center near Wanatah, IN. The soil type is Sebewa loam. "This nearly level or depressional, deep, very poorly drained soil is on broad flats or in slight depressions where it is intermingled with poorly drained or very poorly drained soils" according to the Soil Survey of Porter County, 1981.

Table 1. Soil test results based on composite sampling, Field D, Fall 2001.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	5.8	23 M	155 M	640 H	2550	6.0	6.6	23.3
No-till	CC	0-4	5.6	22 M	213 H	625 H	2350	6.1	6.7	21.1
No-till	CC	4-8	5.5	14 L	103 M	635 H	2550	5.9	6.5	24.3
Chisel	CB	0-8	5.4	22 M	142 M	575 H	2400	5.8	6.6	22.0
No-till	CB	0-4	4.7	25 M	184 H	520 H	1950	6.0	6.7	18.2
No-till	CB	4-8	4.2	9 VL	81 L	545 H	2050	6.1	6.7	18.6

Table 2. Soil test results based on composite sampling, Field F, Fall 2001.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CB	0-8	3.1	14 L	127 M	430 H	1550 L	5.8	6.7	15.3
No-till	CB	0-4	3.6	15 L	137 M	460 VH	1600 L	6.2	6.8	14.6
No-till	CB	4-8	3.5	17 L	85 M	430 H	1500 L	5.9	6.7	14.9

Equipment Description for 2001

Conventional chisel plow: Glencoe Soil Saver, front disk gang, 7-shank, 4-inch twisted points, soil leveler on rear.
One pass tillage tool (See photo): 18-foot Case-IH Combo-Mulch Finisher 4400, front disk gangs with adjustable depth and angle.

- Equipped with Vibra®Chisel or Vibra®Edge shanks as per treatment (VC, VE).
- Equipped with 3 bar spike tooth harrow/double rolling baskets as per treatment (3BDR).
- Equipped with 5 bar spike tooth harrow/single rolling basket as per treatment (5BSR).

Strip-till: Remlinger 6-row Precision Strip-Till unit.
Disk: International Harvester 22-foot tandem disk.
Planter used in corn after corn: 6-row John Deere 7000 equipped with Dawn spike tooth row cleaners.
Planter used in corn after soybeans: 6-row John Deere 7000 equipped with Dawn spike tooth row cleaners.
Drill used in soybeans after corn: 15-foot John Deere 1560.
N application: DMI NutriPlacr 2800.
Harvester: Case-IH 1640

Table 3. Equipment abbreviation table

Equipment	Abbreviation
Shank type	
Vibra®Edge	VE
Vibra®Chisel	VC
Spike tooth harrow type	
3 bar	3B
5 bar	5B
Rolling basket type	
Single	SR
Double	DR
Example: VE3BDR = Vibra®Edge + 3 bar spike tooth harrow + double rolling basket	

Case-IH 4400 Combo-mulch Finisher

Continuous Corn, 2001

CULTURAL PRACTICES USED 2001
Feasibility of One Pass Tillage in Northern Indiana, Continuous Corn

Item	Date	Application Details
Spring tillage	3/21	Combo-mulch Finisher 4400: Vibra®Chisel + 5 bar + single roller
	5/14	One pass treatments as required
Hybrid planted	5/30	Pioneer 34F80Bt (109 day)
Seeding rate		29,900 seeds/ac. JD 7000 planter equipped with row cleaners.
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.
Weed control	5/14	Pre-emerge:
		Bicep II Magnum 4.2 pt/a.
		Extrazine II 1.5 LB/a.
		Roundup 1.5 pt/a.
	6/15	Post-emerge:
		Accent Sp 2/3 oz/a.
		Atrazine 4L 2 pt/a.
		Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.
Nitrogen fertilizer	6/11	215 lbs N as UAN (28%) @ 65 gallons/acre
Cultivation	6/28	As required by treatment
Harvest	10/30	Center 6 of 12 rows
P and K fertilizer	11/6	350 LB/a. of 0-15-40
Lime		None applied
Tillage	11/6	Fall chisel with ridge leveling sweeps
		Fall Combo-mulch Finisher 4400 with VC3BDR
		Fall strip-prep
	11/14	Fall disk-ripper-disk (DRD)

Eight of the 10 tillage systems left enough residue cover for adequate soil erosion protection. Only the 2-pass system of conventional chisel plus VE3BDR and the Fall VC5BSR treatments resulted in less that the desirable 30% cover (Table 4). No-till had significantly more residue cover than the other treatments. There were significant differences in plant week 4 stand, week 4 height, and week 8 height and grain moisture at harvest. No-till had the slowest plant growth through 8 weeks after planting and the highest grain moisture at harvest. The yields ranged from a high of 158.7 bushels/acre to a low of 125.6 bushels/acre. Considering the late planting date of May 30, we expected the no-till corn to grow, mature and yield competitively with the tilled treatments. Soil temperature reductions with no-till tend to be more of a factor in early, as opposed to late, planting dates. The lower no-till yields could be attributed, in part, to increased insect feeding on the silks of no-till plants whose silks may have emerged later than those in tilled plots. leading to poorer pollination as compared to the tilled treatments.

Plant spacing standard deviation this year was approximately 1-inch greater than previous years. We noted many doubles and triples when counting plants at 4-weeks after planting. This can be attributed to worn planter parts and planting too fast.

Table 4. Feasibility of One Pass Tillage in Northern Indiana Study, Continuous Corn, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 2001.†

Tillage Treatment (ranked by yield)	Residue cover after planting	Plant spacing S.Dev.	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Inches	Plants/a.	Inches	Inches	%	Bu/a.
1. Conv. chisel, VE3BDR	18e‡	4.0a	25700ab	19.6a	88.6a	28.4b	158.7a
3. VE3BDR	39bcd	3.7ab	26200ab	19.5a	88.4ab	29.0b	156.8ab
9. Spring VC5BSR, stale seedbed	34cd	4.0a	25500ab	18.6ab	85.4abc	28.2b	156.1ab
10. Fall VC5BSR	28de	3.7ab	26200ab	19.2a	86.4abc	29.4b	155.9ab
8. VE3BDR, minimal disk	31de	3.5ab	24200b	17.5bc	83.8c	28.7b	154.8ab
4. VE5BSR	46bc	3.6ab	26600a	19.2a	85.1bc	28.9b	153.7ab
6. VE (no attachments)	34cd	3.8ab	26100ab	18.9ab	83.9c	28.6b	151.6ab
7. VE3BDR, aggressive disk	38bcd	3.2b	26600a	18.4ab	84.3c	29.1b	151.5ab
5. VE5B	50b	3.8ab	25400ab	18.7ab	86.6abc	29.0b	149.3b
2. No-till	81a	4.0a	25600ab	16.4c	80.2d	31.8a	125.6c
LSD (5%)	14	0.6	2038	1.7	3.5	1.6	7.9

† Average of 4 replications.
‡ Means with the same letter are not significantly different.

Corn following Soybean, 2001

CULTURAL PRACTICES USED 2001 Feasibility of One Pass Tillage in Northern Indiana, Corn Following Soybeans		
Item	Date	Application Details
Spring tillage	3/21	Combo-mulch Finisher 4400: Vibra®Chisel + 5 bar + single roller
	5/14	One pass treatments as required
Hybrid planted	5/30	Pioneer 34F80Bt (109 day)
Seeding rate		29,900 seeds/ac. JD7000 planter equipped with row cleaners.
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.
Weed control	5/14	Pre-emerge: Bicep II Magnum 4.2 pt/a.; Extrazine II 1.5 LB/a.; Roundup 1.5 pt/a. Post-emerge: Accent Sp 2/3 oz/a.; Atrazine 4L 2 pt/a. *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.*
Nitrogen fertilizer	6/11	215 lbs N as UAN (28%) @ 65 gallons/acre
Cultivation	6/28	As required by treatment
Harvest	10/29	Center 6 of 12 rows, 150 feet
P and K fertilizer	11/6	350 LB/a. of 0-15-40
Lime		None applied
Tillage	11/6	Fall chisel with ridge leveling sweeps
		Fall Combo-mulch Finisher 4400 with VC3BDR
		Fall strip-prep
	11/14	Fall DRD

Only no-till and strip-till left enough residue cover to adequately protect the soil from erosion (Table 5). There were no significant differences in plant stands at 4 weeks. Although there were significant differences in plant height at 4 and 8 weeks after planting, plant growth was satisfactory in all treatments. Both treatments with the Vibra®Chisel and the strip-till treatment yielded significantly higher than no-till. If the objective is to reduce soil erosion and yet maintain satisfactory yields, then the strip-till treatment was the best tillage system.

Table 5. Feasibility of One Pass Tillage in Northern Indiana Study, Corn Following Soybeans, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 2001.†

Tillage Treatment (ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
4. Fall VC5BSR, spring VE5BSR	11de‡	29100	19.8a	94.4a	29.4b	162.6a
9. Fall strip-till 8 inches deep	30b	30000	19.2a	93.7ab	29.5b	162.1ab
3. Fall VC5BSR, spring SS*	21bc	29500	19.9a	94.0ab	30.3ab	158.7abc
1. Fall Conv. chisel, spring VE5BSR	10e	29300	19.8a	91.2ab	30.0ab	158.0abcd
5. Fall disk, spring SS	18cde	28500	19.0ab	94.2a	30.0ab	156.5bcd
6. Fall disk, spring VE5BSR	18cde	29300	19.8a	91.0ab	30.1ab	156.0cd
8. Spring VE5BSR	19cd	28900	19.5a	94.3a	30.4ab	155.1cd
7. Spring VE5BSR (raised disk)	14cde	29100	19.8a	90.6b	30.0ab	154.8cd
2. No-till with row cleaners	79a	28300	17.0b	94.2ab	31.1a	152.7d
LSD (5%)	8.9	NS	2.0	3.6	1.3	5.8

† Average of 4 replications.
‡ Means with the same letter are not significantly different.
*SS = Stale seedbed.

Soybean following Corn, 2001

CULTURAL PRACTICES USED 2001 Feasibility of One Pass Tillage in Northern Indiana, Soybeans following Corn		
Item	Date	Application Details
Spring tillage	3/21	Combo-mulch Finisher 4400: Vibra®Chisel + 5 bar + single roller
	5/14	One pass treatments as required
Variety planted	5/30	Pioneer 93B01 Roundup Ready
Seeding rate		180,000 seeds/ac. John Deere model 1560 drill
Weed control	7/6	Post-emerge: Roundup 2 pt/a. 17 LB/100 gallons of water AMS 5% chelated manganese 1 gallon/a. *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.*
Nitrogen fertilizer		None
Manganese		5% celated manganese 1 gallon/a.
Cultivation		None
Harvest	10/9	Center 15 feet of 30-foot plot.
P and K fertilizer	11/6	350 LB/a. of 0-15-40
Lime		None applied
Tillage	11/6	Fall chisel with ridge leveling sweeps
		Fall Combo-mulch Finisher 4400 with VC3BDR
		Fall strip-prep
	11/14	Fall DRD

All Combo-mulch Finisher 4400 tillage systems left adequate residue cover for soil erosion protection (Table 6). The single pass system left up to double the residue cover left after the conventional tillage option, but about one-half less than that left with no-till alone. Significant differences were found in plant stands, plant height at 4-weeks, plant height at 8-weeks, grain moisture at harvest and grain yield. If tillage is warranted for soybeans after corn, there is no apparent advantage for chisel plowing prior to a cultivation pass with the Combo-mulch Finisher 4400. The 3BDR attachment resulted in almost 5 more bushels of soybeans per acre than the 5BSR. Soybean populations were lowest with the 5BSR attachment.

Table 6. Feasibility of One Pass Tillage in Northern Indiana Study, Soybeans Following Corn, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 2001.†

Tillage Treatment (ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
3. VE3BDR	37b	125100ab	4.2abc	17.6bc	12.5a	53.8a
1. Conv. chisel, VE3BDR	17c	114000b	4.5ab	18.0ab	12.4a	52.4ab
6. VE (no attachments)	36b	105000b	4.5abc	16.8bcd	11.8b	50.4ab
9. Spring VC5BSR	30bc	141000a	4.7a	19.0a	12.2ab	50.4ab
7. VE3BDR, aggressive disk	38b	106000b	3.9c	16.1d	12.2ab	50.3ab
8. VE3BDR, minimal disk	30bc	111000b	4.3abc	17.6bc	11.9ab	50.0ab
5. VE + 5 bar	31b	108000b	4.0bc	17.3bcd	12.2ab	49.2ab
4. VE5BSR	35b	107000b	4.1bc	16.5cd	12.3ab	48.9b
2. No-till	66a	108000b	4.1bc	16.2d	12.1ab	48.4b
LSD (5%)	14	21500	0.6	1.3	0.6	4.8

† Average of 4 replications.
‡ Means with the same letter are not significantly different.

Study Summary of 2 and 3 Year Data

Considering the three-year averages for continuous corn production (Table 7), some trends are noticeable:

- Single pass cultivation systems are successful in continuous corn.
- There appears to be no corn plant population or grain yield advantage for primary tillage before the Combo-mulch Finisher 4400. The key advantages for using the Combo-mulch Finisher 4400 without prior chiseling include higher residue cover, fewer passes and less cost.
- All one-pass configurations of the Combo-mulch Finisher 4400 left sufficient residue to reduce soil erosion.
- A single pass of the Combo-mulch Finisher 4400 with the VibraChisel shanks in the fall followed by stale seedbed planting was at least as good as the same single pass system in spring.
- There was a significant 12-17 bushel/acre yield advantage with Combo-mulch Finisher 4400 relative to no-till in continuous corn.
- Overall, the attachments used on the Combo-mulch Finisher 4400 did not result in substantial differences in residue cover or corn response.
- Aggressive disk settings on the Combo-mulch Finisher 4400 did not reduce residue cover in corn after corn, and appeared to reduce seed spacing variability somewhat.

Table 7. Feasibility of One Pass Tillage in Northern Indiana Study, Continuous Corn, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 1999-2001.†

Tillage Treatment (ranked by yield)	Residue cover after planting	Plant spacing S.Dev.	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Inches	Plants/a.	Inches	Inches	%	Bu/a.
10. Fall VC5BSR	47bc‡	3.2abc	27500a	15.3a	64.5abc	22.8a	150.6a
8. VE3BDR, minimal disk	41c	3.2abc	26300d	14.1bc	62.3de	21.3bc	148.2ab
1. Conv. chisel, VE3BDR	27d	3.4ab	26400cd	15.2a	65.1ab	21.3bc	148.0ab
5. VE5B	48bc	3.4ab	26400d	14.8ab	63.0bcd	21.3bc	147.3ab
4. VE5BSR	48b	3.3abc	26800abcd	15.5a	62.6cde	21.7b	146.8ab
9. Spring VC5BSR, stale seedbed	47bc	3.2abc	27300abc	15.0ab	65.3a	21.4bc	146.8ab
3. VE3BDR	46bc	3.2abc	27000abcd	15.3a	65.4a	20.6c	145.7b
6. VE (no attachments)	43bc	3.3ab	26600bcd	14.6ab	62.4cde	21.9ab	145.5b
7. VE3BDR, aggressive disk	47bc	3.0c	27400ab	14.9ab	63.7abcd	21.0bc	145.2b
2. No-till	82a	3.5a	27300abc	13.6c	61.5e	22.8a	133.2c
LSD (5%)	7	0.3	914	0.9	2.3	1.0	4.9

† Average of 4 replications.
‡ Means with the same letter are not significantly different.

Some trends are also evident in the 2-year results for corn following soybeans (Table 8):

- Single pass cultivation systems are successful in corn following soybeans for grain production, but do not leave enough residue cover to adequately protect the soil from erosion.
- Strip-till not only yielded higher than no-till, but also left enough residue to protect the soil from erosion.
- There appears to be no advantage for primary tillage before the Combo-mulch Finisher 4400.
- There was a significant 5-6 bu/a advantage with Combo-mulch Finisher 4400 with Vibra®Chisel relative to no-till.
- Presence or absence of disk with VibraEdge treatment did not influence corn response following soybeans.
- In the stale seedbed systems the Combo-mulch Finisher 4400 with VibraChisel shanks resulted in a 5 bu/a yield advantage relative to tandem disking. Therefore the Combo-mulch Finisher 4400 may be preferable to disking in fall.
- Fall operation of Combo-mulch Finisher 4400 was superior to spring operations of Combo-mulch Finisher 4400 in single pass systems following soybeans.
- No-till grain yields were 3.5% lower than the highest full-width tillage system. This echoes our findings in the Pinney PAC Long-term Tillage Study.

Table 8. Feasibility of One Pass Tillage in Northern Indiana Study, Corn Following Soybeans, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 2000-2001.†

Tillage Treatment	Residue cover after	Week 4	Week 4	Week 8	Grain moisture	Grain yield at

(ranked by yield)	planting	stand	height	height	at harvest	15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
3. Fall VC5BSR, spring SS*	23c	29400a	16.3a	76.7a	24.1ab	159.9a
4. Fall VC5BSR, spring VE5BSR	13de	29000ab	15.2bc	76.1ab	23.7b	159.6ab
9. Fall strip-till 8 inches deep	36b	29600a	15.3abc	75.0ab	23.8ab	158.9abc
1. Fall Conv. chisel, spring VE5BSR	10e	28800ab	15.2bc	72.5b	24.5ab	157.4abc
6. Fall disk, spring VE5BSR	17cd	29300ab	15.8ab	73.8ab	24.1ab	156.8abc
7. Spring VE5BSR (raised disk)	18cd	28900ab	15.9ab	74.8ab	23.9ab	155.4abc
5. Fall disk, spring SS	19c	28400b	15.6ab	75.5ab	24.2ab	155.1bc
8. Spring VE5BSR	22c	29200ab	16.0ab	76.8a	24.0ab	154.6c
2. No-till with row cleaners	67a	28800ab	14.6c	75.4ab	24.7a	154.2c
LSD (5%)	6	924	1.0	4.0	0.9	4.8

† Average of 4 replications.
‡ Means with the same letter are not significantly different.
*SS = Stale seedbed.

The two-year average results for soybeans following corn (Table 9) suggest the following:

- Some form of tillage improved no-till soybean yields, although not all were significantly better.
- There appears to be no advantage for primary tillage before the Combo-mulch Finisher 4400.
- All one-pass configurations of the Combo-mulch Finisher 4400 left sufficient residue to reduce soil erosion.
- There was a significant 5 bushel/acre advantage with 2 configurations of the Combo-mulch Finisher 4400 relative to no-till in 2 treatments. The VE3BDR treatment and the conventional chisel followed by VE3BDR treatment, with perhaps the best seedbeds, yielded the highest.

Table 9. Feasibility of One Pass Tillage in Northern Indiana Study, Soybeans Following Corn, Sebewa loam, Pinney Purdue Agr Center, Wanatah, IN, 2000-2001.†

Tillage Treatment (ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
3. VE3BDR	45.6b‡	156000	4.0ab	14.9a	11.8a	55.5a
1. Conv. chisel, VE3BDR	23.5c	143000	4.1a	15.0a	11.8a	55.0ab
7. VE3BDR, aggressive disk	45.0b	145000	3.7b	13.8bc	11.7ab	53.2abc
6. VE (no attachments)	43.3b	142000	4.0ab	14.2ab	11.5b	53.0abc
8. VE3BDR, minimal disk	38.6b	146000	4.0ab	14.6ab	11.6ab	52.8abc
9. Spring VC5BSR	43.2b	155000	4.1a	15.1a	11.7ab	52.6abc
5. VE + 5 bar	40.9b	145000	3.9ab	14.4ab	11.8ab	51.4abc
4. VE5BSR	43.7b	140000	3.7b	13.6bc	11.8ab	50.5bc
2. No-till	74.3a	145000	3.9ab	13.1c	11.7ab	49.2c
LSD (5%)	11	20000	0.3	1.1	0.4	4.7

† Average of 4 replications.
‡ Means with the same letter are not significantly different.

Overall conclusions for Case Combo-mulch Finisher 4400 experiments:

- Of the shank alternatives investigated, the VibraChisel resulted in consistently higher levels of surface residue cover, and a tendency to higher yields of both corn and soybeans than the VibraEdge shanks.
- Single pass cultivation was as good as or slightly better than a 2-pass system (where chisel plowing preceded cultivation) in terms of yield, and superior in terms of residue cover.

- Single pass with Combo-mulch Finisher 4400 in fall followed by spring no-till planting may be as good as conventional tillage for corn, and leave more residue cover. The Combo-mulch Finisher 4400 may also prove to be superior to fall disking for stale-seedbed planting systems.
- No significant differences in residue cover were observed among harrow attachments (whether 5BSR or 3BDR) or in disk settings on the Combo-mulch Finisher 4400.
- Fall operation of the Combo-mulch Finisher was consistently as good as, or superior, to a single pass in spring.

Studies for 2002

Title: Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana

Objectives:

1. To expand feasibility studies of various reduced tillage systems for corn and soybean production relative to no-till and conventional tillage systems.
2. To compare grain production for fall strip tillage, deep tillage (Case-IH MRX690 Mulch-till Ripper), single-pass mulch tillage (Case-IH Combo-mulch Finisher 4400), and no-tillage for corn after corn, corn after soybeans, and soybeans after corn.
3. To compare surface residue cover and soil physical properties left after various tillage systems and single-pass mulch tillage systems (in either fall or spring) relative to other conservation tillage alternatives.

Duration: October 2001 to October 2004.

Locations:
Pinney Purdue Agricultural Center near Wanatah, Indiana

- Continuous Corn: Field D.
- Corn following Soybeans: Field F.
- Soybeans following corn. Field D.

Agronomy Research Center near West Lafayette, Indiana

- Corn following soybeans: Field 117

Principal Investigators: Terry D. West, Tony J. Vyn, and Gary C. Steinhardt
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Soybean Yield and Quality Responses to Potassium Management Alternatives Following Long-Term No-Till

Xinhua Yin and Tony J. Vyn

Summary

Surface broadcasting is still the predominant mode of potassium (K) fertilizer application for soybeans in conservation tillage systems even though significant soil K stratification has been observed in fields after long-term no-till. Soybean seed yield and quality in conservation tillage systems may be improved by band placement alternatives of K fertilizer to surface broadcasting. The goal of this research was to investigate K nutrition, yield, and quality response of soybeans resulting from alternate K fertilizer placements (band placement in fall or spring, direct applied to soybeans or to the previous corn crop) in various tillage (such as zone-till (ZT), fall disk (FD), and continuos NT etc.) and row-width systems imposed after long-term NT. All 17 experimental sites in Ontario, Canada had a minimum 5-year NT history prior to treatment initiations.

Soybean responses to K placement (100 kg K ha-1) were generally unaffected by tillage systems (ZT, FD and continuous NT) and row widths (from 18 to 76 cm) on soils with a wide range in exchangeable K concentrations. Trifoliate leaf K concentrations were usually increased 2 to 7 g kg–1 by K fertilizer on soils with K levels from low to high. Despite vertical soil K stratification on all experimental sites, deep-banded K increased soybean yield, relative to broadcast applied K, only on fields with low soil K and only when most soybean rows were in close proximity to fertilizer bands. On low-testing K soils, leaf K concentration and yield gains of NT soybeans planted over previous corn rows exceeded 10%, compared to those between rows, even when corn received no K fertilizer. Soybean seed K concentrations increased up to 3 g kg-1 in response to both direct and residual K fertilization.

Potassium fertilization increased daidzein, genistein, and total isoflavone concentrations in soybean seeds on low to high K soils. Isoflavone concentrations were positively correlated to yield as well as seed K and oil concentrations.

In our studies, K application to increase NT soybean yield improved certain attributes of seed quality. There was no apparent yield or seed quality benefit from banded versus broadcast K applications except on low K soils. Furthermore, banding K fertilizers for corn on low- to medium-testing soils might be detrimental to the productivity of narrow-row, no-till soybeans that follow corn in sequence (especially when K fertilizer is only applied before corn in rotation).

Publications

1. Yin, X. H. and T. J. Vyn. Soybean responses to potassium placement and tillage alternatives following long-term no-till. Submitted to Agron. J. in Oct. 2001.
2. Yin, X. H. and T. J. Vyn. Potassium placement effects on yield and quality of no-till soybeans in alternate row widths. Submitted to Agron. J. in Oct., 2001.
3. Vyn T. J., X. H. Yin, T. W. Bruulsema, C-J. C. Jackson, I. Rajcan, and S. M. Brouder. Potassium fertilization effects on isoflavone concentrations in soybeans. Submitted to J. of Agric. and Food Chemistry in January 2002.
4. Yin, X. H. and T. J. Vyn. Residual effects of potassium placement and tillage systems for corn on subsequent no-till soybeans. Submitted to Agron. J. in August, 2001.
5. Yin, X. H. and T. J. Vyn. Previous corn row effects on potassium nutrition and yields of subsequent no-till narrow-row soybeans. Commun. in Soil Testing and Plant Analysis. In preparation.
6. Yin, X. H. and T. J. Vyn. Residual effects of potassium application and tillage practices in spring for corn on subsequent no-till soybeans. Soil and Tillage Research. In preparation.

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Zone Tillage Systems for High Oil Corn Production, DPAC

Brian J. Ball, Tony J. Vyn, Terry D. West, and Dirk Maier

Introduction

Conservation tillage systems (no-till in particular) have generally been discouraged in the production of high oil corn due to the concerns with inconsistent stand establishment which might lead to unsuccessful pollination, reduced grain yields and inconsistent grain quality. Contract producers of high oil corn are specifically encouraged to select their most productive fields and prepare fine seedbeds. Zone (strip) tillage systems may offer a suitable alternative for high oil corn producers desiring a reduced tillage alternative to no-till. Zone tillage permits a wider planting window in spring (a result of faster in-row soil drying) and it often allows for deep banding of essential fertilizer nutrients like potassium (K). Deep banding of K might be particularly beneficial if the field has been in no-tillage production recently, and if significant stratification in soil-test K levels has occurred. This research is examining the feasibility of zone tillage and K fertility treatments relative to the current (encouraged) conventional tillage practice and the present (discouraged) practice of no-till for high oil corn production.

CULTURAL PRACTICES USED AT DPAC FIELD W, 2000-2001

Field Operation	Date	Application Details
Spread fertilizer (K)	12/5/2000	Broadcast with DMI strip tillage unit driven with shanks out of the ground at rates varying from 0 lbs./ac to 150 lbs./ac
Primary tillage	3/28/2001	Fall (spring) field cultivation on chisel plow plots and also the DMI strip tillage plots
Secondary tillage	4/30/2001	Spring secondary cultivation (packer) was only done on the chisel plots and
Planting	5/01/2001	Pioneer Optimum High Oil Corn 34B25 (Topcross^R) at 31,000 plants/ac into 30" rows Planter set at 20-28
Starter fertilizer	5/01/2001	N rate of 50 lbs./ac was applied on all plots. The fall plus spring plots also received an extra 50 lbs./ac of K. Fertilizer settings were: 28-14 and 26-36
Weed control	5/02/2001	Surpass 100 (2.8 qt), Roundup Ultra (1qt), AMS (1.7 qt), 2-4D (1pt)
Rootworm control	6/14/2001	Furadan 4F (44 oz)
Hand harvest	10/01/2001	Picked the hand harvest area and shelled them Oct 3
Plot harvest	11/08/2001 11/12/2001	Harvested from the west to east, was rained out at plot 506. Finished harvest

Table 1. High oil plant parameters, corn grain yields and quality as affected by tillage system and K fertility in 2001.

	No-till	Fall Chisel	Fall DMI	No K	Fall K	F&S K
Soil K 0-2" (ppm)	189	177	171	169	178	189
Soil K 2-6" (ppm)	107	117	101	109	107	109
Soil K 6-10" (ppm)	103	109	99	105	102	103
Population (plts/ac)	26.4	26.8	26.8	26.5	26.7	26.8
Early Height (inches)	17.5	17.1	16.7	16.5	16.6	18.2
Earleaf K (%)	1.33	1.47	1.41	1.29	1.44	1.48
Final Height (inches)	107	106	105	103	106	108
Grain Yield (bu/ac)*	180	180	185	176	183	186
Grain Oil (%)	8.16	8.15	8.22	8.18	8.19	8.16
Grain Protein (%)	8.30	8.27	8.37	8.28	8.31	8.36
Grain Starch (%)	68.09	68.19	68.02	68.10	68.13	68.07
Kernel K(%)	0.40	0.40	0.39	0.39	0.40	0.40

Grain yields are from the hand-harvested areas of consistently populated areas through out the field.

Results and Discussion

1. **Soil Potassium Concentrations**

Soil-test K levels for the western side field W (plot area in 2001) averaged 179 ppm (0-6" depth) with a standard deviation of 41 ppm. Table 2 shows the distribution of the exchangeable K values (NH_4OAC test) as they spatially fall within the randomized plots at the three sampling depths. This does not show, however, the variability of the spatial distribution of actual values, which ranged between 112 and 283 ppm in the top 2” of soil. Unfortunately, the straight linear analysis also does not consider the stratification that was evident within the plots themselves. One can obtain an idea of the extent of stratification by comparing the mean values in the top 2” of the soil with the lower 4” increments that were sampled. The deeper 4” samples tended to have similar (although slightly lower) soil K concentrations than those at the 2-6” sample depth just above it.

2. **Plant Population**

Consistent corn plant populations were obtained with the moderate spring weather conditions in 2001. We did not experience the high intensity spring rainfalls that caused a reduction in the overall population in 2000 (especially in low-lying areas of slow drainage). Table 2 indicates that our actual average populations were near 27,000 plants per acre. The overall plant populations were not affected by either tillage or K treatments. The percent of male pollinators did not seem to be affected by the differences in tillage or K treatments (data not shown). Plant establishment was not negatively affected in reduced tillage treatments.

3. **Plant and Kernel K Concentrations**

Ear-leaf K concentrations at R1 (silking) ranged from 1.18 to 1.58 percent. These values are lower relative to values in 2000, and are somewhat surprising given the generally adequate soil-test values. Leaf K concentrations responded positively to K fertility applications in all 3 tillage systems. The overall mean kernel K value was 0.389 % with a standard deviation of 0.032 %. We did not observe any significant treatment effects associated with K fertilization, or any differences due to tillage system.

4. **Grain Yields**

The overall mean grain yield was 182 bu/ac with a standard deviation of 13 bu/ac. These yields are based on hand-harvested areas in areas throughout the field that had relatively consistent plant populations. Our yield monitor data for the whole plot areas has not currently been analyzed. However, within the hand-harvested regions, corn yields were lowest with the control (no K) plots in all tillage systems.

5. **Oil concentrations**

Determination of the oil concentration was done using a near infrared (NIR) grain analyzer, and subsequently adjusted to 0% moisture. The overall mean was 8.18 percent with a standard deviation of 0.20 percent (Table 2). No significant differences or trends arose in the linear analyses due to the treatments imposed.

Summary

Good growing conditions throughout the growing season in 2001 resulted in more uniform final plant stands than were achieved in 2000. Both corn plant heights and grain yields responded positively to K fertility application in all tillage treatments in 2001. Oil concentrations were not affected by tillage or fertility treatments. Spatial variability in corn response to treatments must still be analyzed. However, both no-till and strip-till were apparently appropriate tillage systems for high oil corn since neither yield nor quality was negatively affected by these tillage systems.

Acknowledgements

We are grateful for the assistance from the Davis Purdue Agriculture Center. The project was funded through a USDA NRI grant and Pioneer (Dupont). The Andersons supplied the starter fertilizer and Case DMI provided the strip tillage implement.

Poster Publications

Ball B.J., T.J. Vyn, T. West, and D.E. Maier. 2001. Tillage and Potassium Fertilizer
Effects on High Oil Corn. 16th Annual Soil/Plant Analyst's Workshop. Nov. 13-14. Des Moines, Iowa.

Ball B.J., T.J. Vyn, T. West, and D.E. Maier. 2001. Tillage and Potassium Fertilizer Effects on High Oil Corn. ASA Annual Meeting. Oct 24. Charlotte, NC. Poster no. 514.

Ball B.J., T.J. Vyn, and T. West. 2001. Tillage and Potassium Fertilizer System Effects in High Oil Corn Production. ASA North Central Branch Meeting. March 14-15, Peoria, IL. The same poster was also presented at AG INFO in Indianapolis on Aug.7, 2001.

Effect of Temperature-activated Polymer Seed Coatings on the Feasibility of Early Plant Corn

Mercedes Murua, Tony J. Vyn, and Terry D. West

Introduction

Recently patented, temperature-activated polymers can be used as seed coatings to enable earlier planting, but delayed emergence, of hybrid corn seed. Relative to uncoated seeds, these polymers could improve emergence uniformity, final population and grain yield when corn is planted early. This benefit could be even more evident as stress increases (whether because of cool soil temperatures, stress-susceptible hybrids, or conservation tillage). The possibility of using seed coatings would allow corn producers to minimize risks associated with early planting, and take more advantage of conservation tillage systems for corn.

Objectives

The objectives of this study are: a) to determine the average corn emergence delay resulting from temperature-sensitive polymers for multiple planting dates and hybrids, b) to determine whether temperature-sensitive polymers applied to the seed coats of selected corn hybrids will improve uniformity of emergence, relative to uncoated seed, when corn is planted early, c) to evaluate if final plant populations and overall grain yields will increase in response to the application of the temperature-activated polymers, relative to uncoated corn seed, and d) to understand the possible interacting effects of polymer treatments, hybrid treatments, and planting date treatments on plant-to-plant variability and final grain yields.

Site Information and Treatments

The study was conducted at the Agronomy Research Center (ARC), IN, on Drummers silty clay loam soil in 2000 and 2001. Two corn hybrids (Fielder's Choice 9307 and 8509, 107 to 109 day RM) were no-till planted on three dates representing early (28 March 2000, 2 April 2001), intermediate (14 April 2000, 19 April 2001) and late (16 May 2000, 11 May 2001) planting times. Each hybrid had the following coating treatments in Year 2000: the control (UTC), coating A (2 % of seed weight), coating B (3 % of seed weight), and in 2001: the control (UTC), coating C (slightly different polymer than in 2000, 2 % of seed weight), coating D (same polymer as in 2000, 2.5 % of seed weight).

<u>CULTURAL PRACTICES USED AT 5 LOCATIONS IN 2000-01</u>

Field Operation	Date	Application Details
Seeding rate	April-May	30,000 seed/a.
Starter fertilizer		95 LB/ac 34-0-0
Nitrogen fertilizer	May	180 N LB/ac as NH_3 sidedress
Weed control	April	Harness Extra 5 pt/a.
(Pre-emergence)		Roundup Ultra 1.5 pt/a.
		Gramoxone Extra 3 pt/a.
		All broadcast with flat fan 8006 nozzles at 30 psi and 30 gallons of water/a., 5.0 mph
Harvest	Sept.-Dec.	Hand harvest 15-20 meters of row per plot

Preliminary Results

Preliminary results for days from planting to 50 % emergence, days from 10 to 90 % emergence and plant populations are summarize in Tables 1 & 2.

Table 1. Coating treatment effects on days to 50 % emergence, days from 10 to 90 % emergence for different planting dates, and hybrids in years 2000 and 2001.

Treatment	Mean Days to 50 % Emergence			Days from 10-90 % Emergence		
	Planting Date			Planting Date		
Year 2000	**3/28**	**4/14**	**5/16**	**3/28**	**4/14**	**5/16**
9307/UTC	28.2 c	16.4 b	10.2	5.5	4.3	4.6
9307/A	31.1 b	18.5 a	11.2	6.4	4.0	4.0
9307/B	33.3 a	19.2 a	11.1	6.9	4.4	4.4
8509/UTC	29.7 b	16.3 b	9.8	9.3 a	2.8	4.0
8509/A	30.3 b	18.4 a	10.8	5.0 b	4.1	3.4
8509/B	31.5 a	18.7 a	10.9	5.6 b	3.4	2.8
Year 2001	**4/2**	**4/19**	**5/11**	**4/2**	**4/19**	**5/11**
9307/UTC	10.94 b	10.19 b	8 c	4.0 b	2.5	3.4 b
9307/C	15.81 a	13.56 a	12.44 a	8.1 a	4.4	8.9 a
9307/D	16.31 a	13.06 a	10.25 b	8.8 a	3.3	4.1 b
8509/UTC	10.75 b	10.69 b	8.06 b	3.5 b	2.9	2.9
8509/D	15.13 a	13.19 a	10.13 a	6.8 a	3.4	2.6

Means separation within planting date and hybrid by Duncan range test, 5% level.
Treatment code: UTC, control, A, coating A, B, coting B, C, coatging C, D, coating D.

Table 2. Coating treatment effects on final plant populations in 2000 and 2001.

Plant Population (Plants/acre)							
Treatment	**Planting Date**			**Treatment**	**Planting Date**		
Year 2000	**3/28**	**4/14**	**5/16**	**Year 2001**	**4/2**	**4/19**	**5/11**
9307/UTC	27200	28700	26600	**9307/UTC**	17400 b	28500 a	30500 a
9307/A	28700	28700	27400	**9307/C**	24300 a	26000 b	28400 b
9307/B	29000	28200	26900	**9307/D**	23300 a	28200 a	30600 a
8509/UTC	31300	31600	30500	**8509/UTC**	25000 b	25700	30000
8509/A	30900	31900	29600	**8509/D**	29100 a	27400	30400
8509/B	30400	31700	30400				

Means separation within planting date and hybrid by Duncan range test, 5% level.
Treatment code: UTC, control, A, coating A, B, coting B, C, coatging C, D, coating D.

Preliminary conclusions

Polymer coatings resulted in emergence delays for early, intermediate and late planting dates for both hybrids and in both years. Uncoated seeds generally emerged 1 to 4 days before the coated seeds (coating treatments A, B, C or D), and the emergence period from initial to final emergence was longer for coated treatments than for uncoated seeds. In terms of emergence uniformity, coated treatments resulted in additional days from 10 to 90 % emergence for the early planting date in 2001, but not in 2000. Final plant populations were never lower with polymer-coated seeds than uncoated seeds in FC-8509. In 2001, coated seeds resulted in significantly higher plant populations of both hybrids for the early planting date. Potential treatment differences in developmental stages, height, silking, plant spacing as well as grain yield are not certain because all data are yet to be statistically analyzed.

The potential for utilization of these polymers on hybrid corn production is obvious if producers can be assured that yields associated with early planting would be at least equal to those planted uncoated hybrid corn seed during the optimum period. Analysis of this research data will further contribute to the assessment of whether temperature-sensitive polymers will reduce the traditional risks associated with early planting.

Acknowledgements

We appreciate funding provided by Landec Ag of Monticello and the Purdue Agricultural Research Program (graduate student assistantship).

Publications

Vyn, T. J. and M. Murua. 2002. Polymer seed coatings: sufficient reduction for early plant corn? Proceedings of the 56 annual corn & sorghum research conference. In press.

Not for publication.

Effects of Fertility Placement in High Yield Corn Situations

Ann M. Kline, Tony J. Vyn, and Sylvie Brouder

Introduction

Fertilizer rates and placement are important considerations to farmers hoping to raise high yielding corn. Because of the relative immobility of phosphorus (P) and potassium (K) in the soil, different techniques for placing these fertilizers have been studied for average yield corn grown with conservation tillage systems. Although the traditional method of nutrient placement is broadcasting, it may be that a deeper placement of these nutrients would allow corn roots to better utilize the fertilizers applied. Corn yields might also increase if available P and exchangeable K were more uniformly distributed in the corn rooting zone. The purpose of this research is to investigate the effects of the depth of P and K placement on corn response specifically in a high yield environment. Better understanding of processes involved might permit improved fertility recommendations to farmers as yields continue to increase.

Two studies were initiated in 2001 to pursue this research. Both studies are being conducted on dark prairie soils at the Agronomy Research Center or Animal Sciences Research and Education Center near West Lafayette, Indiana.

The first experiment looks specifically at effects of the depth of placement for P and K together. The treatments include two hybrids (Pioneer 24B24 and 34M95), two populations (32,000 and 42,000 plants per acre), and five fertility treatments. The fertility treatments include a control, broadcast P & K, 6 inch banded P & K, 12 inch banded P & K and a 6 and 12 inch banded P & K. The fertilizer was banded directly beneath the intended row area before planting took place.

CULTURAL PRACTICES USED FOR STUDY 1 IN 2000-2001

Field Operation	Date	Application Details
Primary Tillage	Fall 2000	Fall Moldboard Plow
Lime Application	Spring 2001	4 tons/acre
Secondary Tillage	4/04/01	JD Field Cultivator with rolling baskets
Fertilizer Application	5/02/01	192 lbs 0-45-0 and 0-0-60 applied with DMI Nutriplacr 2500
Planting	5/03/01	34,000 and 44,000 plants per acre seeding rates with JD 1780 planter, hybrids Pioneer 34B24 and Pioneer 34M95
Starter fertilizer	5/03/01	20 gal/ acre 9-18-9 plus zinc
Nitrogen Applications	5/14/01	135 lbs/acre N applied as UAN
	6/12/01	75 lbs/acre N applied as UAN
	6/19/01	90 lbs/acre N applied as UAN
Herbicide Application	5/07/01	3.75 pt/acre of Harness Extra and 1.25 pt/acre of Atrazine 4L
	6/14/01	0.76 oz/acre Beacon
Insecticide Application	7/10/01	3.8 oz/acre Warrior
	8/02/01	3.8 oz/acre Warrior
Harvest	11/08/01-11/13/01	Hand harvest 16 m row length per plot

The second experiment investigates corn response to placement when either P or K is applied without the other, or in combination. Measurements in this second experiment are also more focused on the effects to the roots. The treatments include two hybrids (Pioneer 34B24 and 34M95) and five fertility applications including a control, broadcast P & K, band P & K, band P alone, and band K alone. Banding depth is 6 inches in the intended row area. The rates of P and K for all treatments except the control are 135 pounds P_2O_5 and 138 pounds K_2O for both studies. P was applied as 0-46-0 and K was applied as muriate of potash (0-0-60).

CULTURAL PRACTICES USED FOR STUDY 2 IN 2000-2001

Field Operation	Date	Application Details
Tillage	4/04/01	Tilled twice using JD Field Cultivator with rolling baskets
Fertilizer Application	5/04/01	192 lbs 0-45-0 and 0-0-60 applied with DMI Nutriplacr 2500
Planting	5/03/01	32,000 plants per acre seeding rate with JD 1780 planter, hybrids Pioneer 34B24 and Pioneer 34M95
Starter fertilizer	5/03/01	20 gal/ acre 9-18-9 plus zinc
Nitrogen Applications	Spring 2001	180 lbs. N / acre as NH_3
	6/12/01	75 lbs/acre N applied as UAN
Herbicide Application	5/07/01	3.75 pt/acre of Harness Extra and 1.25 pt/acre of Atrazine 4L
	6/14/01	0.76 oz/acre Beacon
Insecticide Application	7/10/01 8/01/01	3.8 oz/acre Warrior, applied aerially 3.8 oz/acre Warrior, applied aerially
Harvest	10/30/01	Hand harvest 16 m row length per plot

Measurements

Several measurements have been taken throughout the past growing season. In the first study, shoot samples were taken as well as leaf area measurements at both V6 and R1 growth stages. Early height measurements and chlorophyll readings were taken for both studies. The second study looked more intensively at the roots. Measurements included Root:Shoot ratio, root scanning for whole roots at V4 and root scanning for root cores at V10.

Preliminary Conclusions

In both studies, grain yields were typically lower for Pioneer 34M95 than for 34B24; however, if this is statistically different has yet to be determined. Further analysis will be done to statistically analyze the fertility treatments as well as hybrid and population responses.

Acknowledgements

We are grateful for the cooperation received from the Agronomy Research Center supervisor (Jim Beaty) and the staff. We also appreciate the Animal Sciences Research and Education Center for allowing us to use their land for one study. The project was funded by the Foundation for Agronomic Research (FAR) and the Potash and Phosphate Institute (PPI). Fertilizer application equipment was donated by Case New Holland and John Deere Ltd. provided the planter. Pioneer Hi-Bred International, Inc. supplied us with seed of both corn hybrids.

Effect of Acrylic Polymer Seed Coatings on the Feasibility of Relay Intercropping in Indiana

Scott M. McCoy, Tony J. Vyn, Terry D. West, and Ellsworth P. Christmas

Introduction

In 1998, research on relay intercropping was initiated at Purdue to study the effects of polymer coatings have on soybean growth and yield. These polymers may have the potential to increase the profitability of relay intercropping in this state. This would allow producers in Northern Indiana to harvest two crops in a single growing season. Up to this point, multiple cropping has been restricted to more Southerly areas because there is usually insufficient time to produce a second crop after wheat harvest. Over the past three years, fifteen site years of data have been collected. Wheat was planted in wide rows (15 inches) to accommodate interplanting of soybeans in the spring. Soybeans were planted between the wheat rows using a mounted grain drill and a tractor with narrow tires. Soybean planting time was determined by wheat growth stage, with wheat ranging from Feekes stage 8 to 10.5 when planting was accomplished. The wheat was harvested as early as possible to reduce stress on and damage to the soybeans. The wheat was cut high (12-15 inches) to minimize damage to upper soybean nodes.

Research Locations In 2000-2001

Name	Location	Region
Ag Alumni Seeds	Romney	Central
Agronomy Research Center	West Lafayette	Central
Pinney Purdue Ag Center	Wanatah	Northern
Southeast Purdue Ag Center	Butlerville	Southern

Cultural Practices Used at 4 Locations in 2000-2001

Field Operation	Date	Application Details
Primary tillage	10/00	Fall field cultivation at most locations
Wheat planting	10/00	Ag Alumni 9811(1.7 million seeds/acre in 7.5-inch rows)
Soybean variety		Group 2.8 (Northern Indiana), 3.5 (Central Indiana), or 4.1 (Southern Indiana)
Soybean seeding date	5/7/01-6/12/01	225,000 seeds/ac in 15-inch rows (Sunflower 9412 grain drill).
Starter fertilizer	10/00	30-40 lb N/ac + P and K for both crops
Nitrogen fertilizer	2/01	60-90 lb N/ac
Weed control	4/01	Buctril in wheat
	7/01-8/01	Roundup in soybeans
Insecticide application	6/01	Warrior T 3.8 oz/ac
Wheat harvest	6/26/01-7/11/01	Entire plot
Double crop planting	6/26/01-7/12/01	250,000 seeds/ac in 7.5-inch rows
Soybean harvest	10/01-11/01	Entire plot

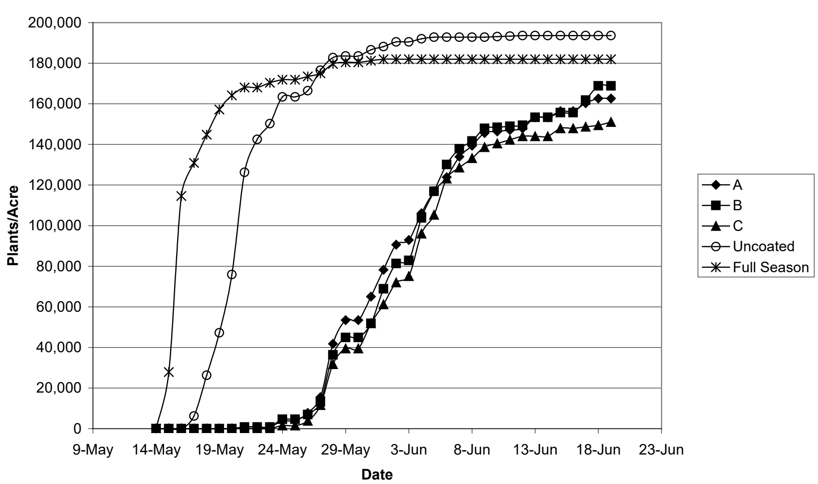
Table 1: 2001 Wheat Yields

Treatment	Central Indiana bu/ac	Northern Indiana bu/ac	Southern Indiana bu/ac
7.5” Monocrop Wheat	84.1	102.9	81.0
15” Monocrop Wheat	75.0	87.6	72.3
15” Relay Crop Wheat	69.4	86.4	70.2

Table 2: 2001 Soybean Yields

Treatment	Central Indiana bu/ac	Northern Indiana bu/ac	Southern Indiana bu/ac
Full-Season	52.2	58.9	71.2
Double Crop	11.4	14.3	43.1
Intercrop Coating A	21.6	20.5	55.8
Intercrop Coating B	21.2	24.8	54.1
Intercrop Coating C	22.5	24.1	58.4
Intercrop Uncoated	19.5	27.1	59.2

Figure 1: 2001 Relay Crop Soybean Emergence - Romney



Winter Wheat Yield

Table 1 illustrates that wheat yields in 15-inch rows averaged between 82 and 89 percent of 7.5” wheat when monocropped. Wheat yield losses associated with soybean interseeding itself were negligible, since yields of intercropped wheat were between 93 and 97 percent of monocropped 15” wheat.

Soybean Emergence

As Figure 1 above illustrates, the coatings applied to the soybean were successful in delaying emergence at the Romney location. Based on these data, there does not appear to be as much difference among the coatings as there had been in the previous two years of research. Delays induced by the coatings, when compared to full-season uncoated soybeans, averaged from 16 to 17 days. Uncoated, intercropped soybeans took 4 days longer to emerge than full-season soybeans, mostly due to limited moisture where wheat was present. Coated soybeans also emerged at a slower rate once emergence started. Coated soybeans took between 12 and 16 days to progress from 10% to 90% emergence, while conventional soybeans took only 6 days. Uncoated soybeans in a relay intercropping situation went from 10% to 90% emergence in 9 days. Emergence data presented here is for only for the Romney site. Therefore, one must be careful when drawing conclusions from it.

Soybean Yield

Intercropped soybeans yielded between 35 and 46 percent of monocropped soybeans in Northern and Central Indiana, while doublecrop soybeans in the same areas ranged from 22 to 24 percent of full -season soybeans. In Southern Indiana, relay cropped soybeans yielded between 76 and 83 percent of full-season soybeans, while doublecrop soybeans yielded only 60 percent of monocropped soybeans. Intercropped soybeans therefore yielded 25-97% more then doublecrop soybeans. The coatings tested in these trials only improved intercropped soybean yields in Central Indiana when compared to uncoated soybeans. Interseeded soybean yields were even higher in Northern and Central Indiana when we harvested between the wheel tracks left from the wheat combine.

Preliminary Conclusions

The results of this experiment showed that the coatings tested delayed emergence of intercropped soybeans up to approximately 16 days and that winter wheat yields were reduced by 11 to 18% in 15-inch row widths versus the standard 7.5-inch rows. Equipment damage added little yield loss beyond that associated with row width. At this time it is not clear if these emergence delays consistently translate into soybean yield gains versus uncoated soybeans. In years with above normal precipitation during the growing season, there may be little advantage to using coated seed because soybeans encounter less stress. In moisture limited years, polymer coatings have increased yields for relay cropped soybeans, but such increases may not have been large enough to improve profitability when the added expense of coated seed is taken into consideration.

Acknowledgements

We would like to thank the farm supervisors and workers at the Agronomy Research Center (ARC), Northeast Purdue Ag Center (NEPAC), Southeast Purdue Ag Center (SEPAC), and Pinney Purdue Ag Center (PPAC) for the labor and equipment they provided for this research. Land and wheat planting help was provided by Ag Alumni Seeds for the Romney location. The project was primarily funded by Landec Ag of Oxford, IN. Landec also provided both the coated and uncoated soybean seed, as well as the wheat seed. We would also like to thank the Purdue University Crop Diagnostic Training and Research Center (DTC) and Bayer Agriculture Division for providing spray equipment for this project.

Landec Ag Wheat Variety Evaluations for Relay Cropping in 2001

Scott M. McCoy and Tony J. Vyn

Wheat yields averaged almost 80 bushels per acre in 15” rows. Furthermore, average winter wheat yields for the 27 varieties were reduced by only 10% with 15” versus 7.5” row spacing. Some of the economic penalty of that yield reduction to producers may be compensated by lower seed costs, since the seeding rate in 15” rows was just 50% of that in 7.5” rows. Wheat varieties varied considerably in their canopy architecture and, therefore, their suitability for relay cropping to soybeans.

In selecting a suitable winter wheat variety for relay intercropping system, there are several characteristics that need to be considered. A balance of characteristics is necessary to ensure good yield for both wheat and soybeans. We believe a desirable wheat variety should have the following characteristics: high yield in 15" rows, low harvest moisture (preferably an early maturing variety), high test weight, short to moderate height (<34 inches), and a somewhat open canopy architecture (with relatively erect tillers). Based on these criteria, and results from this year's trials at two Indiana locations, we think six varieties are most suitable for this system. They are listed below in no particular order. Relay crop producers should also consider the disease characteristics and winter survival ratings of the wheat varieties they select for conditions prevalent in their location.

Treatment mean differences (based on a protected LSD) are given only where the overall ANOVA was significant at P=0.05. The results are averaged for the 2 locations (Agronomy Research Center near West Lafayette, and Pinney Purdue Agricultural Center near Wanatah). Both experiments had 3 replications in a split plot design (varieties as main plots), but one rep at the Agronomy Research Center was dropped from yield analysis because of variable stand. Plots were 7.5’ wide and 50’ long, but only the center 5’ width and 40’ length of each plot was harvested with a small plot combine to obtain a properly bordered yield estimate. The order of the varieties listed for all parameters reported was based on the respective yield ranking in 15” rows.

The canopy ratings were developed based on a scale from 1.0 (closed canopy with wide tiller formation) to 5.0 (very open canopy with erect tillers). They proved to be more beneficial in separating variety differences than light bar measurements on the soil surface between the wheat rows. The latter measurements were taken at solar noon, and thus in a period of most direct sunlight interception by the light meter between the wheat rows.

Most Suitable Varieties:

W-301
SR 01488J
Ag Alumni AGX 2012
Agripro Mitchell
Ohm 92145 (not commercially available)
Ohm 92201D5-2-80 (To be renamed Ag Alumni INW 0102)

Cultural Practices used in Wheat Variety Trials:

	ARC	Pinney
Planting Date	October 11, 2000	October 2, 2000
Fall Broadcast Nitrogen (Pre-plant)	30 lb/ac	30 lb/ac
Spring Nitrogen (~March 1)	90 lb/ac	90lb/ac
15" Seeding Rate	850,000 seeds/ac	850,000 seeds/ac
7.5" Seeding Rate	1,700,000 seeds/ac	1,700,000 seeds/ac
Tillage	Conventional	Conventional
Previous Crop	Soybeans	Soybeans

Table 1. Wheat Variety Trial Results, 2001. Varieties sorted by 15” yields.

Variety	15" Yield		7.5" Yield		Overall Yield		15" Yield Reduction
	Bu/ac		Bu/ac		Bu/ac		%
951067	87.90	a	97.42	ab	92.66	a	9.78
Shurgro 1530	86.62	ab	94.44	abcd	90.53	ab	8.45
Honey	86.58	ab	96.86	ab	91.72	ab	10.49
Ohm 92145	86.56	ab	99.06	a	92.81	a	12.78
Stine 455	85.82	ab	90.28	abcdef	88.05	abcd	4.50
W-301	84.54	abc	95.78	abc	90.16	ab	11.68
DEI 685	84.06	abc	89.42	bcdefg	86.74	abcde	6.21
Pioneer 25R37	82.82	abcd	93.86	abcde	88.34	abc	11.67
JGL 144J	81.40	abcde	92.22	abcdef	86.81	abcde	11.35
Wellman W-101	81.14	abcde	90.68	abcdef	85.91	bcdef	10.14
SR 01488J	80.36	abcdef	86.50	defghi	83.43	cdefgh	7.06
Agripro Gibson	80.28	abcdef	86.44	defghi	83.36	cdefgh	7.08
AGI 540	79.28	abcdef	87.36	cdefghi	83.32	cdefgh	9.20
Ag Alumni AGX 2012	78.52	bcdef	80.98	ghi	79.75	fghij	2.93
Ohm 92201	77.76	bcdef	87.06	cdefghi	82.41	cdefghi	10.55
Agripro Mitchell	77.70	bcdef	90.16	bcdef	83.93	cdefg	13.68
Croplan 527W	77.66	bcdef	86.42	defghi	82.04	defghi	9.91
Vicar	76.48	cdef	87.58	cdefgh	82.03	defghi	12.75
Beck's 104	75.02	def	86.78	defghi	80.90	efghij	13.33
Lisbo	74.88	def	88.72	bcdefg	81.80	defghi	14.73
BW 244	74.76	def	86.66	defghi	80.71	efghij	13.45
Ohm 88204	74.68	def	83.59	fghi	79.14	ghij	10.59
Ag Alumni 9811	74.54	def	84.50	fghi	79.52	ghij	11.79
Zorro	74.42	def	85.64	efghi	80.03	fghij	13.13
Coker 9474	74.18	def	79.70	hi	76.94	ij	6.92
PSL 9903	73.80	ef	80.80	ghi	77.30	hij	8.57
Ohm 9346	72.12	f	78.74	I	75.43	j	8.34
	79.40	A	88.43	B	83.92		10.04
	CV = 8.35		CV = 6.78		CV = 10.16		CV = 41.92

With in columns, data followed by the same letter are not significantly different by Fisher's Protected LSD.
Within lines, averages followed by the same letter are not significantly different.

Table 2. Wheat Variety Trial Results, 2001. Varieties sorted by 15” yields.

Variety	15" Height (Inches)		15" Canopy Rating		Log 15" Light
	Inches				
951067	32.8	abcd	1.8	gh	1.275
Shurgro 1530	31.0	bcde	1.6	hi	1.329
Honey	31.6	bcde	1.8	gh	1.453
Ohm 92145	28.2	ef	3.2	bc	1.483
Stine 455	33.4	abcd	2.2	efgh	1.247
W-301	32.0	bcde	2.4	defg	1.308
DEI 685	32.8	abcd	1.8	gh	1.387
Pioneer 25R37	31.0	bcde	3.6	ab	1.426
JGL 144J	30.6	bcde	1.0	i	1.471
Wellman W-101	29.8	def	1.8	gh	1.478
SR 01488J	32.6	abcd	2.6	cdef	1.344
Agripro Gibson	30.8	bcde	2.0	fgh	1.233
AGI 540	34.8	ab	2.4	defg	1.389
Ag Alumni AGX 2012	33.4	abcd	3.0	bcd	1.270
Ohm 92201	31.2	bcde	2.6	cdef	1.311
Agripro Mitchell	33.0	abcd	2.4	defg	1.333
Croplan 527W	34.6	ab	1.0	i	1.330
Vicar	29.6	def	3.0	bcd	1.427
Beck's 104	36.4	a	1.8	gh	1.291
Lisbo	30.2	cde	2.8	cde	1.460
BW 244	34.2	abc	1.8	gh	1.369
Ohm 88204	32.8	abcd	3.6	ab	1.383
Ag Alumni 9811	29.4	def	2.4	defg	1.523
Zorro	30.8	bcde	4.2	a	1.443
Coker 9474	30.8	bcde	2.8	cde	1.326
PSL 9903	34.2	abc	1.6	hi	1.433
Ohm 9346	25.6	f	2.6	cdef	1.339
	31.8		2.4		1.373
	CV = 2.60		CV = 16.88		CV = 210.23

With in columns, data followed by the same letter are not significantly different by Fisher’s Protected LSD.
Within lines, averages followed by the same letter are not significantly different.

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