EFFECT OF CHANGING THE ROTATION SEQUENCE IN A LONG TERM TILLAGE AND FERTILITY STUDY

E.C. Varsa, G. Kapusta, R.F. Krausz, J.L. Matthews, and T.D. Wyciskalla
Department of Plant, Soil, and General Agriculture
Southern Illinois University
Carbondale, IL, USA, 62901-4415

Abstract

A continuous experiment was conducted from 1970 to 1999 to determine the long term effects of fertilizer application and tillage practices on soil acidity, organic matter and nutrient changes, and crop responses. Four tillage treatments were evaluated: continuous conventional; alternate till (two years no-till: one year conventional); continuous chisel till; and continuous no-till. Five fertilizer treatments were also evaluated (lb ac^{-1} N-P_2O_5-K_2O): check, 0-0-0; 175-0-0 broadcast; 160-0-0 broadcast plus 15-80-120 row banded at planting; 175-80-180 broadcast; and 160-50-150 broadcast plus 15-30-30 row banded at planting. From 1970 to 1990 the fertilizer treatments were applied to continuously produced corn. During the final nine years, soybean was introduced and was alternated with corn in a rotation. Fertilizer treatments were applied only when corn was the crop in the rotation during that period, while tillage treatments remained unaltered from the interception.

For the 1970 to 1990 period, when the experiment was in continuous corn, yield increased steadily over the years. Under high fertility management very few differences in yield were observed among the four tillage methods. No-till yields tended to be somewhat lower in the initial 10 years of the study but the trend changed such that no-till yields were comparable to other tillage methods in latter years. There was no yield benefit resulting from alternate tillage compared to continuous no-tillage. In the 1991 to 1999 period when soybean was introduced and alternately grown with corn, corn yields increased markedly. Yield from the check plots nearly doubled and most fertilizer treatments increased 25 to 50 percent. Soybean also responded to the residual fertility, especially soybean produced in no-tillage.

In the initial 20 years of this study soil pH levels were reduced significantly on all fertilizer treatments compared to the control. For all tillages, irrespective of the fertilizer treatment, the most acidic soil was always in the surface 0 to 2 inch depth and the acidity was found to decrease in intensity to a depth of about 8 inches or to the depth of tillage. Soil levels of P, and to a lesser extent K, increased with P and K fertilization. Soil depletion of P and K occurred to the point of observable deficiency symptoms in the N only treatment and the depletion was most obvious in continuous no-till. Organic matter content increased to the greatest extent under no-till and was enhanced by complete fertilization. During the final nine years of time study when soybean was introduced and fertilizer treatments were applied only to corn, there was a general decline in soil test levels for P and K and the organic matter content also decreased. The patterns of acidity, nutrient, and organic matter stratification with depth in the surface soil became less pronounced.

Introduction

Significant shifts toward reduced tillage methods in corn production have occurred during the past 25 to 35 years. The recognition of the need to reduce soil losses by erosion and the AT by 2000" initiative by the Natural Resources Conservation Service (NRCS) have stimulated this trend. Improved herbicides and other pest control chemicals and the need for producers to become more labor, machinery, fuel, and time efficient have further accelerated the change.

The benefits of reduced tillage in decreasing soil erosion losses and improving soil physical properties have been given in several reports (Hill, 1990; Kladivko et al., 1986; Lal and Van Doren, 1990). Likewise, organic matter composition increases at the soil surface with no-tillage (Dick et al., 1991) and phosphorus and potassium stratification (Eckert and Johnson, 1985; Karathanasis and Wells, 1990) with reduced and no-tillage are other reported soil property changes.

A number of concerns and problems have arisen as reduced tillage has become rather common place. Perennial weeds, occasional greater insect and disease problems, and soil compaction are some of the difficulties encountered as soil tillage is reduced toward no-tillage. One of the most common concerns is that of selecting the optimum fertilizer placement and management system which should be utilized.

A long-term tillage x fertility experiment was initiated at the Belleville Research Center of Southern Illinois University Carbondale (SIUC) in 1970 by Dr. George Kapusta and continued through 1999. During the first 21 years, the combined effects of tillage treatments and annual fertilizer treatments were evaluated under a continuous corn (*Zea mays* L.) production system. Beginning in 1991 and continuing through 1999 soybean [*Glycine max* (L.) Merr.] was introduced and was alternated with corn in a rotation. During those years when soybean was grown no fertilizers were applied but the tillage treatments were unchanged and maintained.

Objectives

1. To evaluate the effect of different phosphorus (P) and potassium (K) placement methods and strategies under four tillage systems on continuous corn grain yields (1970-1990) and corn and soybean grain yields (1991-1999) in a long term fertility-tillage experiment.

2. To determine soil chemical property changes 21 and 30 years following experiment initiation that resulted from fertilizer and tillage treatment applications.

Materials and Methods

The experimental site was located at the Belleville Research Center of SIUC on an Ebbert silt loam soil (fine-silty, mixed, mesic Argiaquic Argialbolls) with a slope of 0-2 percent. Clay accumulation in the B horizon of this soil causes somewhat poor internal drainage and renders tiling non-feasible. Soil tests at the beginning of the experiment in 1970 were: pHw = 6.1, Bray P_1 = 30 lb P ac^{-1}, exchangeable K = 261 lb K ac^{-1}, organic matter = 1.5 percent, and cation exchanges capacity = 12 meq 100 gms $soil^{-1}$. Corn hybrids changed several times as higher-yielding selections became available. Herbicide combinations with superior weed control performance over a variety of tillages were used. Insecticides were needed on occasion mainly for black cutworm control. No phosphorus or potassium fertilizer was applied except as added according to the treatment plan. Limestone was applied over the whole experiment in 1975 and 1983, each time at a rate of 3 ton ac^{-1}. In 1991, lime was applied as needed on a plot by plot basis to increase the pH of all plots to 6.5.

Tillage and annual fertilizer treatments were as follows:

Tillage (1970 - 1999)

Continuous conventional (Conv.): moldboard plow, disc, harrow or cultimulch

Alternate Till (Alter.): 2 years no-till: 1 year conventional till (1972, 1975, 1978...1999)

Continuous chisel (Chisel): field cultivator with chisel points, disk, harrow or cultimulch

Continuous no-till (No-Till): the only disturbance of the soil was from coulters on the planter

Fertilizers (lb $N\text{-}P_2O_5\text{-}K_2O$ ac^{-1}): 1970-1990, 1992, 1994, 1996 and 1998

01 = no fertilizer check, 0-0-0 lb $N\text{-}P_2O_5\text{-}K_2O$ ac^{-1}
02 = nitrogen only, no P_2O_5 or K_2O (175-0-0)
03 = 160-0-0 broadcast (BC) plus 15-80-120 as a 2 in x 2 in row - band (Row)
04 = 175-80-180 broadcast (BC)
05 = 160-50-150 broadcast (BC) plus 15-30-30 as a 2 in x 2 in row - band (Row)

The experimental arrangement was a split-plot design with tillage as main plots and fertilizer treatments as subplots. Treatments were replicated four times giving a total of 80 plots in the experiment. Individual plots were 25 feet in length x 20 feet (or 8-30 inch rows) in width. Nitrogen was applied as ammonium nitrate, phosphorus as triple superphosphate and potassium as muriate of potash.

Corn was grown continuously on the study site from 1970 to 1990. No yield data was obtained in 1981 due a succession of planting failures. Fertilizers were broadcast applied each year prior to seedbed preparation and at planting for row treatments. Beginning in 1991 rotation with soybean was introduced and alternated each year with corn until the experiment concluded in 1999. During those years when soybean was grown (1991, 1993...1999) no fertilizer was applied.

Intensive soil sampling was done in the Fall of 1990 and 1999. Each plot was sampled in a diagonal transect across the center four rows in 2 inch increments from the surface to 10 inch depth. A total of 20 cores were collected per plot and composited per specific increment depth. Average fertility assessment was obtained by taking the mean of the test values in the three increments to 6 inches. Incremental assessment of the soil chemical properties to 10 inches will be presented in this paper only for fertilizer treatment 04: 175-80-180(BC).

Results and Discussion

Fertility and Tillage Effects on Corn Yield, 1970 to 1990

Using high fertility practices, corn grain yield increased steadily during the experiment. The average annual yield increase ranged from 0.8 bu ac^{-1} for the check treatment (01) to over 2.5 bu ac^{-1} for the fertilized treatments over the 20-year period. Periodic changes to improved, higher-yielding hybrids probably accounted for much of the increase. Yield was less with N only in all instances compared with NPK treatments (Table 1). Starter fertilizer, banded near the row, did not increase yield in any tillage system compared to all fertilizer broadcasted (04). Possibly the high rate of P and K application on an annual basis resulted in a fertility level in the soil so enriched that no starter response was observed.

Corn yield was less in no-till compared to conventional, chisel, or alternate till where no fertilizer or where N only was applied (Table 1). There was no difference in yield among tillage systems where NPK was applied broadcast. Corn yield was 5 to 7 percent less in no-till compared to conventional or chisel till where a starter was applied. Possibly the annual tillage redistributed the banded fertilizers of the starters and enhanced the uptake volume of nutrients (Barber, 1995) compared to when no-tillage was employed. Alternate till did not influence corn yield compared to continuous no-till with NPK broadcast. Similar results have been reported by Dickey et al. (1983). Any negative effects of continuous no-till, if present, were not modified by a periodic conventional tillage. Likewise, if soil physical properties were improved by long term no-tillage, then periodic tillage had no apparent negative effect on yield although physical properties were likely altered. A more detailed report of this segment of the research may be found in a report by Kapusta et al. (1996).

Fertility and Tillage Effects on Corn Yield (1992, 1994, 1996 and 1998)

During this period corn was alternated with soybean in a rotation. Most evident is the dramatic increase in yield for all fertility treatments regardless of tillage (Table 2). Compared to the 1970 to 1990 period, when continuous corn was grown, yield increases of 30 to 45 bu ac^{-1} were obtained during the 1992-1998 period. This was achieved across all fertility treatments, even the check plots. The synergistic benefit or Arotational effect@ of soybean likely contributed to the large increase in yields across tillages and fertility treatments.

Fertilizer treatments with P and K whether split with row banding or all broadcast continued to result in significant yield increases over the N only treatment. No-till was no different than any of the other tillages when complete fertilizers were applied but yielded lower than other tillages when receiving no fertilizer (check) or N only. It must be noted that the growing seasons were excellent when this segment of the research was conducted.

Fertility and Tillage Effects on Soybean Yield (1991, 1993, 1995, 1997, and 1999)

Just like the corn in rotation reported above, soybean also was very responsive to the residual fertilizers applied to the preceding corn crop (Table 3). In all tillages a greater soybean yield was obtained with the treatments receiving NPK than the N only treatment or the non-fertilized check.

Soybean yield was reduced to the greatest extent in the no-till plots that received N only or no fertilizer. Residual bands of P and K appeared to have no effect in enhancing soybeans compared to where the P and K was broadcast.

Fertility and Tillage Effects on Soil Properties

Soil pH was affected differently by fertility treatment applications within the various tillages (Tables 4 and 5). Application of 175 lb N ac^{-1} resulted in the average soil pH being 0.7 to 0.9 pH unit less than the check treatment in the 1990 sampling. Because limestone to correct acidity was added plot by plot in 1991 (lime rate ranging from 0 to some plots to 5.5 tons ac^{-1} to those most acidic) the variability among treatments was mostly removed by the 1999 sampling (Table 5). The acidity resulting from nitrification of the ammonium nitrate fertilizer and the increased yield and grain removal of base-forming cations probably resulted in most of the acidity differences observed in the1990 sampling. Strong acidity formation at the soil surface for the 1990 sampling of fertility treatment 04 (Figure 1) probably was a result of the annual fertilizer applications made during the first 20 years of the study. By 1999 (Figure 2) large soil pH differences in the upper soil profile had largely disappeared.

Bray P_1 extractable P levels were significantly affected by fertility treatments in the 1990 and 1999 samplings (Tables 6 and 7). Throughout the study, the lowest soil tests for P were observed for the N only treatment where no P or K was applied (Tmt 02). The reduced soil P reflects the uptake and crop removal of P without replenishment from any P fertilizer. The soil level of P for the check treatment decreased from an initial test of 30 lb P ac^{-1} in 1970 to 29 and 24 lb P ac^{-1} in the 1990 and 1999 samplings. The application of 80 lb P_2O_5 ac^{-1} as fertilizer annually for 20 consecutive years (1970-1990) led to large soil test increases (Table 6). But when rotation was introduced, and fertilizer P was applied only biennially to corn, large reductions in the soil test P occurred (Table 7). Incremental distribution of soil P levels for fertility treatment 04 (Figures 3 and 4) showed the very large increase in P stratification usually observed with reduced tillage. By the 1999 sampling, the high degree of stratification at the soil surface had decreased except that higher P levels usually associated with no-tillage persisted.

Soil test K in the 1990 and 1999 samplings was affected differently when K fertilizers were applied to the various tillages (Tables 8 and 9). Higher soil test K values were usually observed under no-till throughout the study for those treatments receiving K. When no K was applied, no-till had some of the lowest soil test K values. There was a progressive increase in the average soil test value when K was applied at 180 lb K_2O ac^{-1}. Row banding of K at 120 lb K_2O ac^{-1} led to intermediate levels of soil K. Following only biennial application of fertilizers beginning in 1991, there was a dramatic decrease in soil test K values. For fertility treatment 03 which received 120 lb K_2O ac^{-1} in the row to corn but not soybean, levels of exchangeable K had decreased to below desired test values and replenishment with K was insufficient to meet crop removal. The incremental pattern of K distribution in the upper soil profile of fertility treatment 04, observed in Figures 7 and 8, also reflects the influence of strong K stratification from 20 consecutive years of annual fertilization in the 1990 sampling but less pronounced stratification following biennial fertilization during the 1991 to 1999 period.

The organic matter content of the soil changed as a function of both fertility and tillage treatments

(Tables 10 and 11). Continuous corn production and no-tillage for 20 years has led to a significantly higher organic content compared to the other three tillage methods. This probably occurred because of the slower rate of raw organic matter decomposition as tillage was reduced. The organic matter content under alternate till was no different from that observed with continuous conventional or chisel tillage. Higher organic matter levels were also observed when fertilizers were applied, especially in treatments 03, 04, and 05 which received the full compliment of N, P and K. The higher soil organic matter levels with these fertility treatments were probably a result of greater amounts of crop residues remaining following harvest. The organic matter content in samples collected in 1999 (Table 11) were lower than those of 1990 (Table 10) mainly because of less raw organic matter being returned after soybean and a more favorable C:N ratio offered by soybean in encouraging microbial decomposition. Even with the introduction of alternating soybean in the rotation, the organic matter content remained the highest in the surface soil for the no-till and chisel tillage systems. Details regarding other phases of this study may be found in an earlier report by Kapusta and Varsa (1990).

References

Barber, S. A., 1995. Soil nutrient bioavailability: A mechanistic approach. 2nd ed. John Wiley and Sons, Inc., New York, NY.

Dick, W. A., E. L. McCoy, W. M. Edwards, and R. Lal. 1991. Continuous application of no-tillage to Ohio soils. Agron. J. 83: 65-73.

Dickey, E. C., T. R. Peterson, J. R. Gilley, and L. N. Miekle. 1983. Yield comparisons between continuous no-till and tillage rotations. Trans. ASAE 26: 1682-1686.

Eckert, D. J., and J. W. Johnson. 1985. Phosphorus fertilization in no-tillage corn production. Agron. J. 77: 789-792.

Hill, R. L. 1990. Long-term conventional and no-tillage effects on selected soil physical properties. Soil Sci. Soc. Am. J. 54: 161-166.

Kapusta, G., R. F. Krausz, and J. L. Matthews. 1996. Corn yield is equal with conventional, reduced, and no tillage after 20 years. Agron. J. 88: 812-817.

Kapusta, G., and E. C. Varsa. 1990. Long term tillage and fertility effects on corn. Proceedings of the Twentieth North Central Extension - Industry Soil Fertility Conference. Pp. 70-80. Nov. 14-15, 1990. St. Louis, MO.

Karathanasis, A. D., and K. L. Wells. 1990. Conservation tillage effects on the potassium status of some Kentucky soils. Soil Sci. Soc. Am. J. 54: 800-806.

Karlen, D. L., E. C. Berry, T. S. Colvin, and R. S. Kanwar. 1991. Twelve-year tillage and crop rotation effects on yield and soil chemical properties in northeast Iowa. Commun. Soil Sci. Plant Anal. 22: 1985-2003.

Kladivko, E. J., D. R. Griffith, J. V. Mannering. 1986. Conservation tillage effects on soil properties and yield of corn and soybeans in Indiana. Soil Tillage Res. 8: 277-287.

Lal, R., and D. M. Van Doren, Jr. 1990. Influence of 25 years of continuous corn production by three tillage methods on water infiltration for the soils in Ohio. Soil and Tillage Res. 16: 71-84.

Table 1. Corn yield as influenced by seedbed tillage and fertilizer treatment, Belleville Research Center, 1970 - 1990 (less 1981), pooled.

Fertilizer Treatment lb ac^{-1} $N\text{-}P_2O_5\text{-}K_2O$	Seedbed Tillage Treatment[1] Continuous Conventional	Alternate (2-1-2 years) No-Till/Conv	Continuous Chisel	Continuous No-Till
	--------------------(bu ac^{-1})--------------------			
0-0-0	47	44	52	36
175-0-0(BC)	125	118	121	106
160-0-0(BC) +15-80-120(Row)	141	136	142	132
175-80-180(BC)	142	141	140	137
160-50-150(BC) +15-30-30(Row)	143	138	142	135
LSD (0.05)[2]		4 or 6		

[1]Continuous conventional = moldboard plow, disc, plus cultimulch; Alternate was No-Till in 1970-1971, 1973-1974, 1976-1977, 1979-1980, 1982-1983, 1985-1986 and 1988-1989, conventional till in 1972, 1975, 1978, 1981, 1984, 1987, 1990. Continuous chisel = field cultivator with chisel points, disk, cultimulch; Continuous no-till = coulters only disturbance of the soil. Yield average over years is presented.

[2]Mainplot tillage, subplot fertilizer and the interaction of tillage with fertilizer were significant. Year interactions with tillage, fertilizer and tillage by fertilizer were significant. Comparisons of tillages can be made within each fertilizer using LSD (0.05) = 4, 6, 4 and 4 for fertilizers 0-0-0, 175-0-0(BC), 160-0-0(BC)+15-80-120(Row) and 160-50-150(BC)+15-30-30(Row), respectively. Tillage was not significant within the 175-80-180(BC) fertilizer treatment when years were pooled. Comparisons of fertilizers can be made within each tillage using LSD (0.05) = 6.

Table 2. Corn yield as influenced by seedbed tillage and fertilizer treatment, Belleville Research Center, 1992, 1994, 1996 and 1998, pooled.

Fertilizer Treatment lb ac^{-1} N-P_2O_5-K_2O	Seedbed Tillage Treatment[1] Continuous Conventional	Alternate (2-1-2 years) No-Till/Conv	Continuous Chisel	Continuous No-Till
	(bu ac^{-1})			
0-0-0	96	95	96	92
175-0-0(BC)	185	177	180	152
160-0-0(BC) +15-80-120(Row)	199	196	191	195
175-80-180(BC)	201	200	195	205
160-50-150(BC) +15-30-30(Row)	198	187	195	198
LSD (0.05)[2]		11		

[1]Continuous conventional = moldboard plow, disc, plus cultimulch; Alternate was No-Till in 1991-1992, 1994-1995 and 1997-1998, conventional till in 1990, 1993, 1996, and 1999; Continuous chisel = field cultivator with chisel points, disc, cultimulch; Continuous no-till = coulters only disturbance of the soil. Yield average over years is presented.

[2]Mainplot tillage probability of F was 0.066; subplot fertilizer and the interaction of tillage with fertilizer were highly significant. Year interactions with tillage and fertilizer were significant. Year interactions with tillage by fertilizer were not significant.

Table 3. Soybean grain yield as influenced by seedbed tillage and fertilizer treatment, Belleville Research Center, 1991, 1993, 1995, 1997 and 1999, pooled.

Fertilizer Treatment lb ac^{-1} N-P_2O_5-K_2O	Seedbed Tillage Treatment[1] Continuous Conventional	Alternate (2-1-2 years) No-Till/Conv	Continuous Chisel	Continuous No-Till
	(bu ac^{-1})			
0-0-0	53	49	52	46
175-0-0(BC)	51	51	52	43
160-0-0(BC) +15-80-120(Row)	55	56	55	54
175-80-180(BC)	56	56	56	56
160-50-150(BC) +15-30-30(Row)	55	56	56	55
LSD (0.05)[3]		2		

[1]Continuous conventional = moldboard plow, disc, plus cultimulch; Alternate was No-Till in 1991-1992, 1994-1995 and 1997-1998, conventional till in 1993, 1996, and 1999; Continuous chisel = field cultivator with chisel points, disc, and cultimulch; continuous no-till = coulters only disturbance of the soil. Yield average over years is presented.

[2]No fertilizer applied in 1991, 1993, 1995, 1997, or 1999, only in alternate years when corn was in these plots.

[3]Interaction of tillage with fertility was highly significant.

Table 4. Effect of fertility and tillage on soil pH in the surface 0-6 inches of soil in the 1990 sampling.

Fertility		Soil pH				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	7.0	7.0	7.2	7.3	7.1
02	175-0-0 (BC)	6.2	5.6	6.3	6.7	6.2
03	160-0-0 (BC) +15-80-120 (Row)	6.3	6.6	6.2	6.4	6.3
04	175-80-180 (BC)	6.6	6.2	6.5	6.0	6.3
05	160-50-150 (BC) +15-30-30 (Row)	6.5	6.3	6.8	6.2	6.4
	Mean	6.5	6.3	6.6	6.5	
	$LSD_{0.05}$ Tillage	0.13				
	Fertility	0.17				
	Tillage*Fertility	0.34				

Table 5. Effect of fertility and tillage on soil pH in the surface 0-6 inches of soil in the 1999 sampling.

Fertility		Soil pH				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	6.4	6.6	6.5	6.9	6.6
02	175-0-0 (BC)	6.4	6.8	6.2	5.7	6.3
03	160-0-0 (BC) +15-80-120 (Row)	6.4	5.8	6.1	6.0	6.1
04	175-80-180 (BC)	6.1	6.3	6.2	6.5	6.3
05	160-50-150 (BC) +15-30-30 (Row)	6.3	6.2	6.1	6.2	6.2
	Mean	6.3	6.3	6.2	6.3	
	$LSD_{0.05}$ Tillage	0.11				
	Fertility	0.13				
	Tillage*Fertility	0.25				

Table 6. Effect of fertility and tillage on Bray P_1 extractable P in the surface 0-6 inches of soil in the 1990 sampling.

Fertility Tmt. No.	Treatment (lb ac^{-1} $N-P_2O_5-K_2O$)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
		Bray P_1 Phosphorus (lb ac^{-1})				
01	0-0-0	47	28	37	20	33
02	175-0-0 (BC)	15	26	20	10	18
03	160-0-0 (BC) +15-80-120 (Row)	87	86	86	82	85
04	175-80-180 (BC)	115	108	92	108	106
05	160-50-150 (BC) +15-30-30 (Row)	116	122	95	109	111
	Mean	76	74	66	66	
	$LSD_{0.05}$ Tillage	NS				
	Fertility	9				
	Tillage*Fertility	NS				

Table 7. Effect of fertility and tillage on Bray P_1 extractable P in the surface 0-6 inches of soil in the 1999 sampling.

Fertility Tmt. No.	Treatment (lb ac^{-1} $N-P_2O_5-K_2O$)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
		Bray P_1 Phosphorus (lb ac^{-1})				
01	0-0-0	44	20	27	17	27
02	175-0-0 (BC)	18	24	29	20	23
03	160-0-0 (BC) +15-80-120 (Row)	66	78	74	65	71
04	175-80-180 (BC)	73	68	69	77	72
05	160-50-150 (BC) +15-30-30 (Row)	82	82	68	80	78
	Mean	58	55	54	52	
	$LSD_{0.05}$ Tillage	7				
	Fertility	8				
	Tillage*Fertility	16				

Table 8. Effect of fertility and tillage on soil exchangeable K in the surface 0-6 inches of soil in the 1990 sampling.

Fertility		Exchangeable Potassium (lb ac^{-1})				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	252	230	241	188	227
02	175-0-0 (BC)	213	224	224	174	208
03	160-0-0 (BC) +15-80-120 (Row)	334	328	334	339	334
04	175-80-180 (BC)	482	493	448	549	493
05	160-50-150 (BC) +15-30-30 (Row)	459	515	414	560	487
	Mean	348	358	333	362	
	$LSD_{0.05}$ Tillage		NS			
	Fertility		25			
	Tillage*Fertility		50			

Table 9. Effect of fertility and tillage on soil exchangeable K in the surface 0-6 inches of soil in the 1999 sampling.

Fertility		Exchangeable Potassium (lb ac^{-1})				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	156	140	158	123	144
02	175-0-0 (BC)	149	148	155	140	148
03	160-0-0 (BC) +15-80-120 (Row)	199	183	200	213	199
04	175-80-180 (BC)	273	283	318	334	302
05	160-50-150 (BC) +15-30-30 (Row)	288	339	282	340	312
	Mean	213	218	223	230	
	$LSD_{0.05}$ Tillage		28			
	Fertility		31			
	Tillage*Fertility		63			

Table 10. Effect of fertility and tillage on the soil organic matter content in the surface 0-6 inches of soil in the 1990 sampling.

Fertility		Soil Organic Matter (%)				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	1.78	1.67	1.80	1.87	1.78
02	175-0-0 (BC)	1.90	1.86	2.01	1.98	1.94
03	160-0-0 (BC) +15-80-120 (Row)	2.11	2.00	1.93	2.23	2.07
04	175-80-180 (BC)	1.84	2.01	1.95	2.20	2.00
05	160-50-150 (BC) +15-30-30 (Row)	2.17	2.04	1.98	2.37	2.14
	Mean	1.96	1.92	1.93	2.13	
	$LSD_{0.05}$ Tillage	0.14				
	Fertility	0.12				
	Tillage*Fertility	NS				

Table 11. Effect of fertility and tillage on the soil organic matter content in the surface 0-6 inches of soil in the 1999 sampling.

Fertility		Soil Organic Matter (%)				
Tmt. No.	Treatment (lb ac^{-1} N-P_2O_5-K_2O)	Cont. Conv.	Alt. Till	Cont. Chisel	Cont. No-Till	Mean
01	0-0-0	1.44	1.37	1.48	1.45	1.44
02	175-0-0 (BC)	1.36	1.47	1.55	1.62	1.50
03	160-0-0 (BC) +15-80-120 (Row)	1.43	1.56	1.63	1.93	1.64
04	175-80-180 (BC)	1.49	1.52	1.74	2.04	1.70
05	160-50-150 (BC) +15-30-30 (Row)	1.59	1.53	1.56	1.99	1.67
	Mean	1.46	1.49	1.59	1.81	
	$LSD_{0.05}$ Tillage	0.14				
	Fertility	0.16				
	Tillage*Fertility	0.32				

Figure 1. Incremental pH of the soil as influenced by tillage in the 1990 sampling of fertility treatment 04.

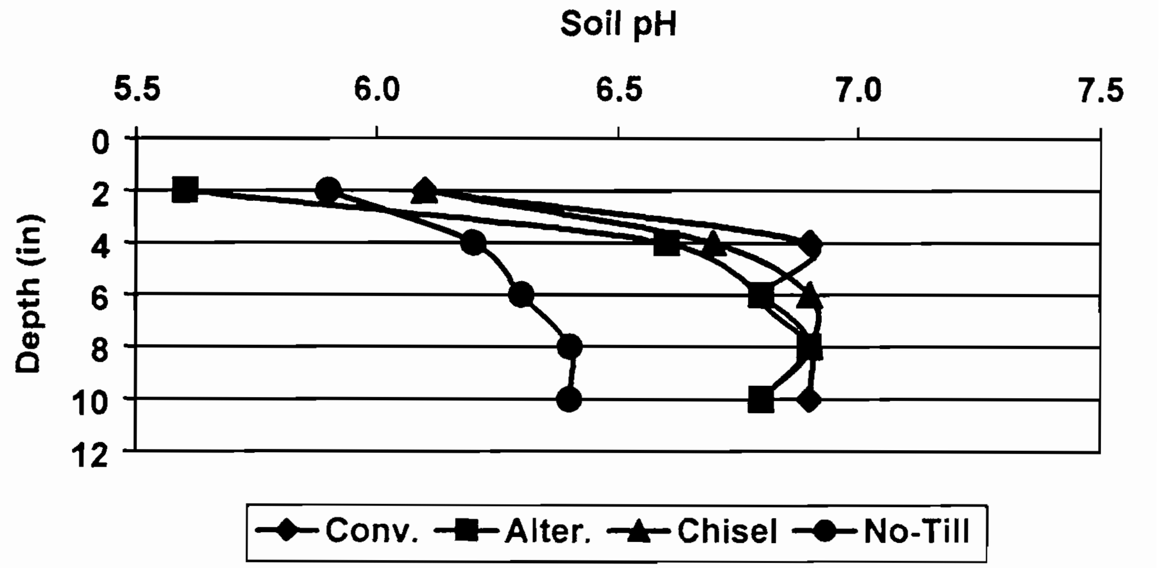


Figure 2. Incremental pH of the soil as influenced by tillage in the 1999 sampling of fertility treatment 04.

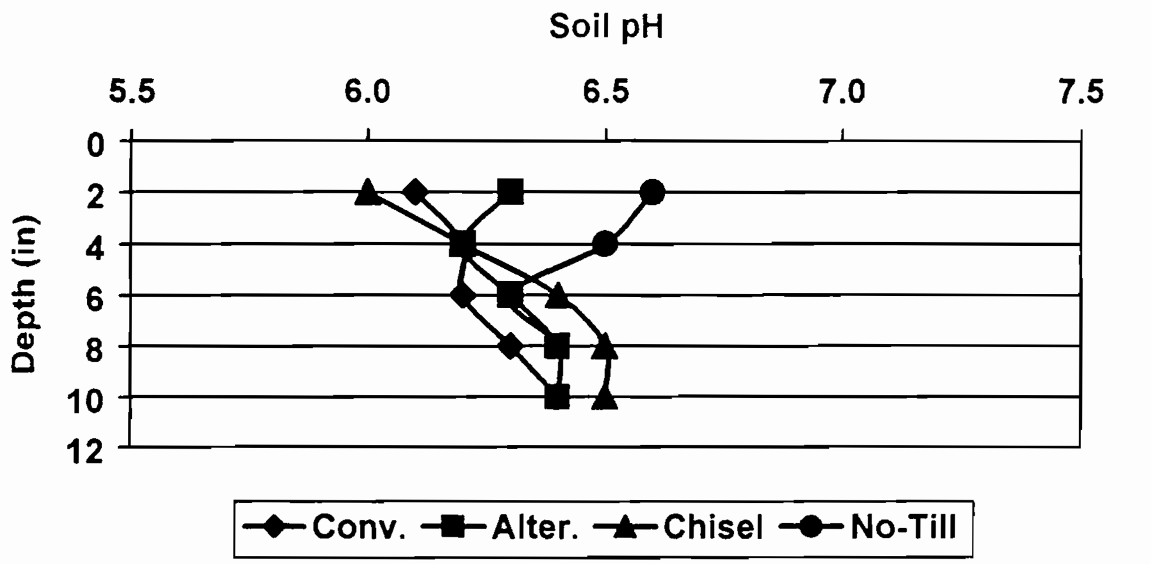


Figure 3. Incremental Bray P1 extractable P of the soil as influenced by tillage in the 1990 sampling of fertility treatment 04.

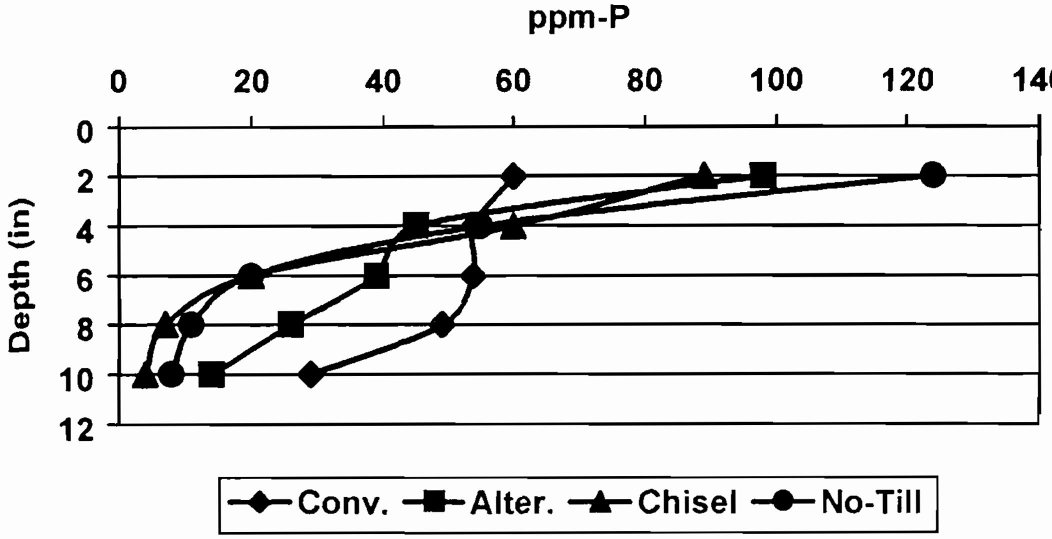


Figure 4. Incremental Bray P1 extractable P of the soil as influenced by tillage in the 1999 sampling of fertility treatment 04.

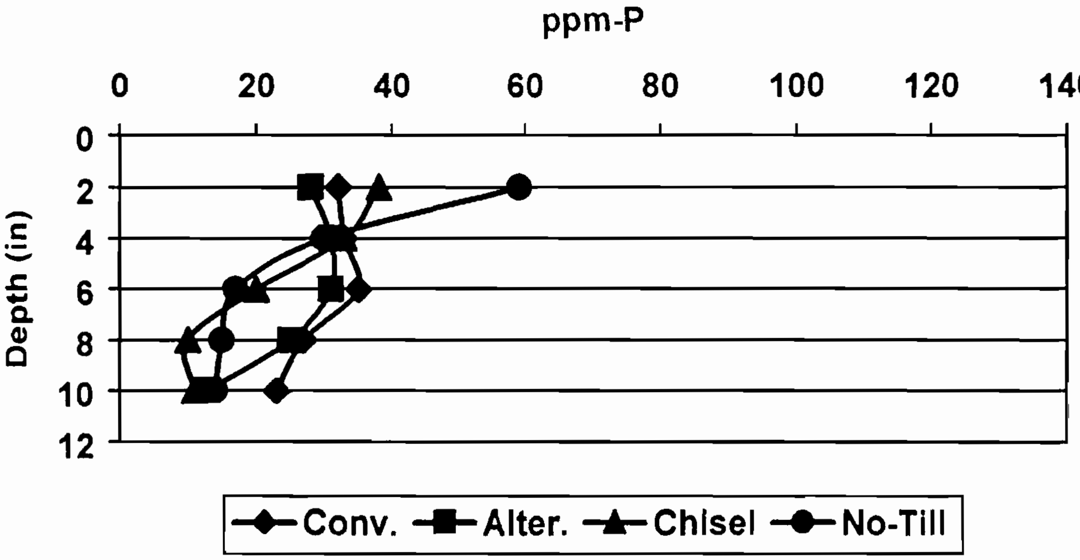


Figure 5. Incremental soil exchangeable K as influenced by tillage in the 1990 sampling of fertility treatment 04.

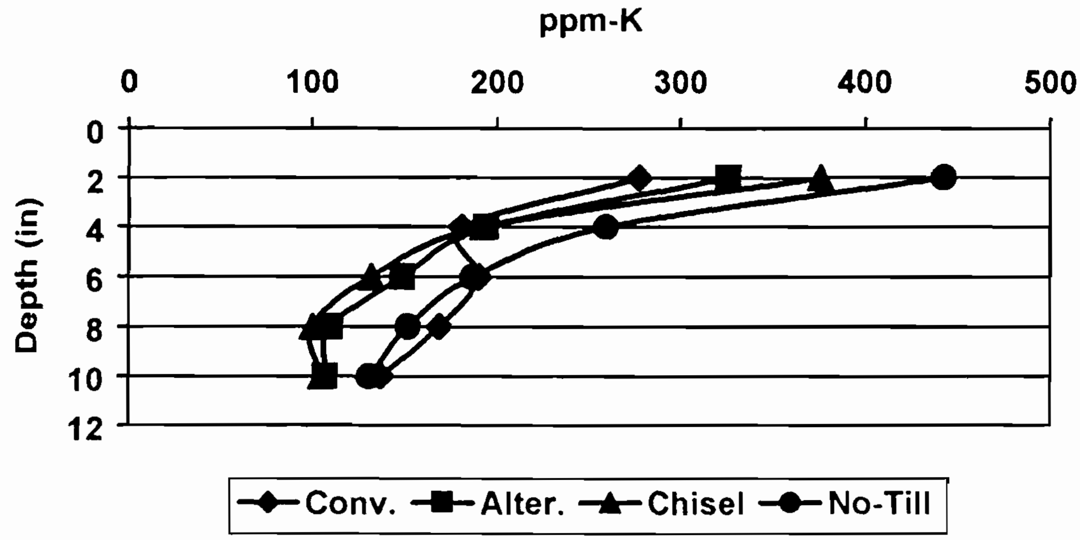


Figure 6. Incremental soil exchangeable K as influenced by tillage in the 1999 sampling of fertility treatment 04.

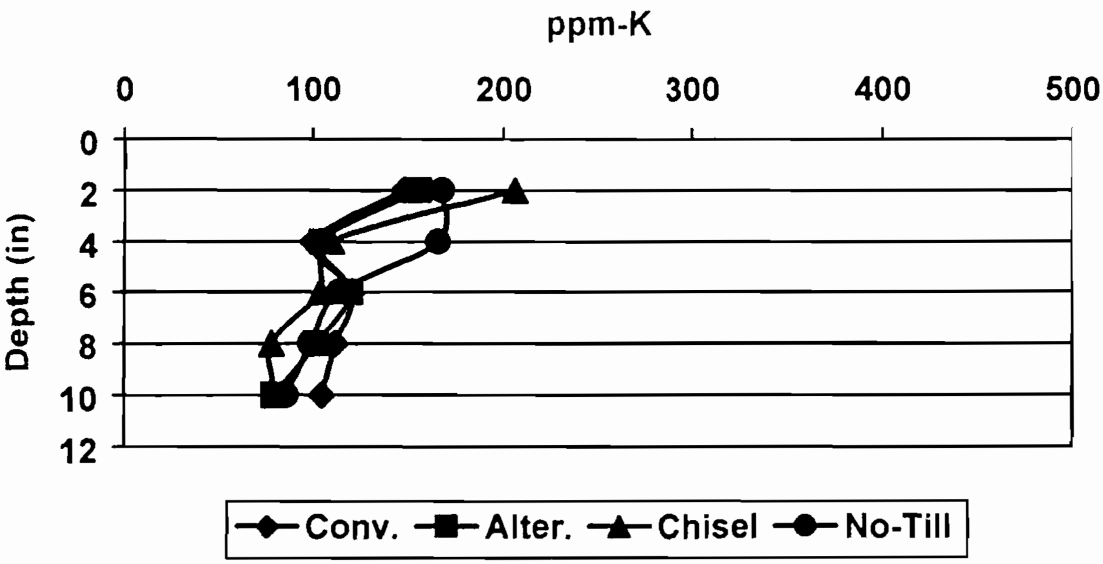


Figure 7. Incremental distribution of the soil organic matter as influenced by tillage in the 1990 sampling of fertility treatment 04.

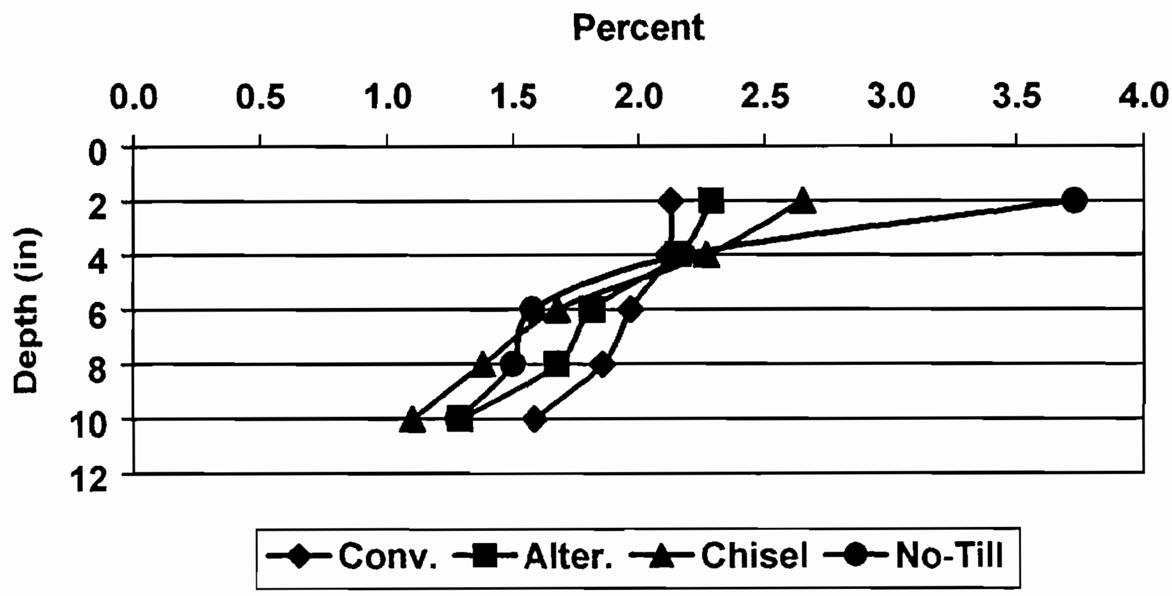
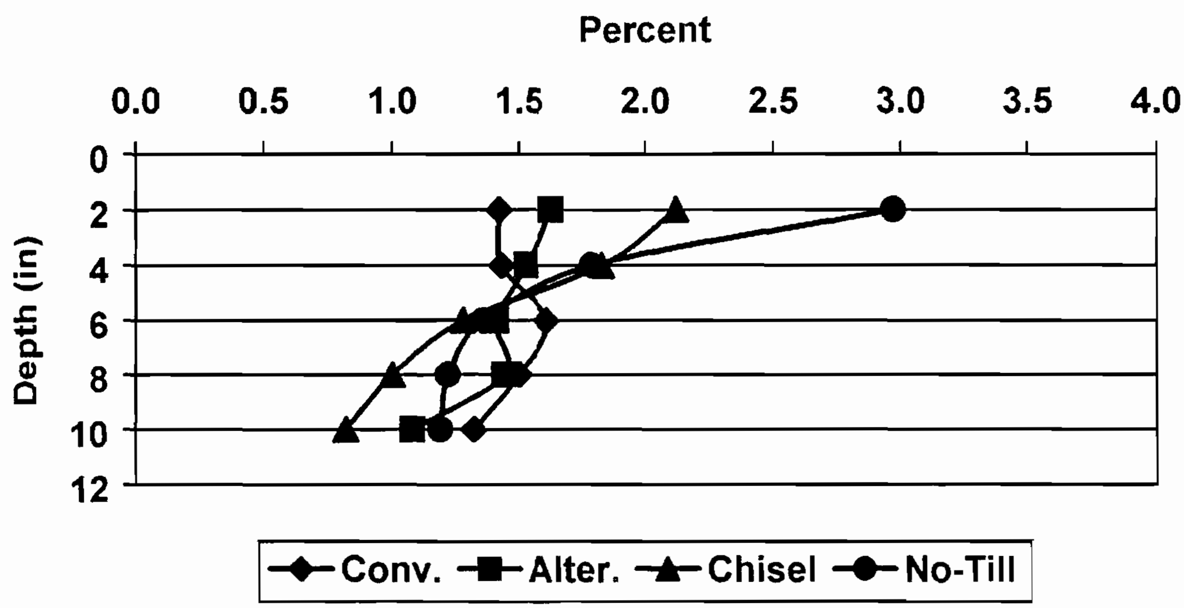


Figure 8. Incremental distribution of the soil organic matter as influenced by tillage in the 1999 sampling of fertility treatment 04.



PROCEEDINGS OF THE

THIRTY-FIRST
NORTH CENTRAL
EXTENSION-INDUSTRY
SOIL FERTILITY CONFERENCE

Volume 17

November 14-15, 2001
Holiday Inn University Park
Des Moines, IA

Program Chair:
Keith Reid
Ontario Ministry of Ag, Food & Rural Affairs
581 Huron Street
Stratford, Ontario N5A 5T8
519/271-9269

Published by:
Potash & Phosphate Institute
772 – 22nd Avenue South
Brookings, SD 57006
605/692-6280