Table 1. Summary of soil factors and management practices at the Wisconsin tillage/manure management studies, 2002.

Location	Soil	Soil test pH	Soil test P	Soil test K	Soil test OM	Manure DM	Manure N	Manure P_2O_5	Manure K_2O	Planting date	N rate
			--- ppm ---		%	%	--- lb available/t ---				lb/acre
Arlington	Plano sil	5.7	68	96	4.1	16.9*	3.1	2.2	5.9	7 May	Var.**
Lancaster	Rozetta sil	6.8	31	102	2.3	22.0	3.7	3.8	7.6	10 May	160
Marshfield	Withee sil	6.5	83	208	3.6	24.5	2.4	2.2	5.7	22 May	120
Spooner	Pence ls	6.7	89	65	1.7	24.5	3.2	3.8	8.1	13 May	120

* N credit for unincorporated manure shown. ** N rate was a sub-subplot treatment at 0, 50, 100, 150 lb N/acre.

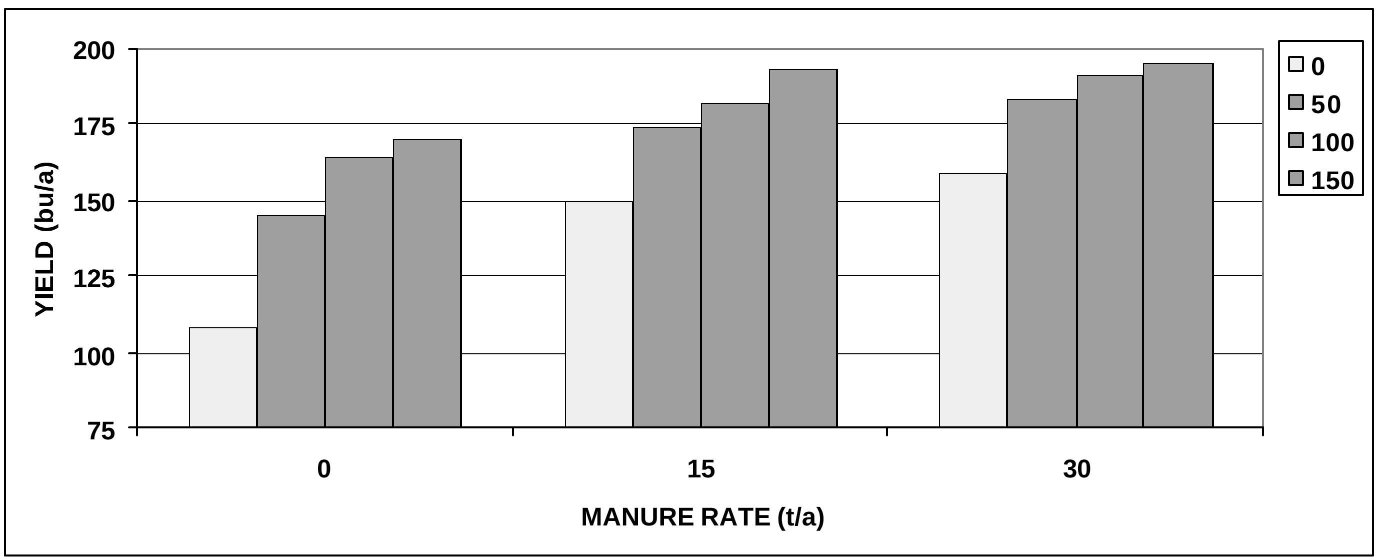

Figure 3. Interaction between N rate (lb/acre) and manure rate at Arlington, Wis., 2002.

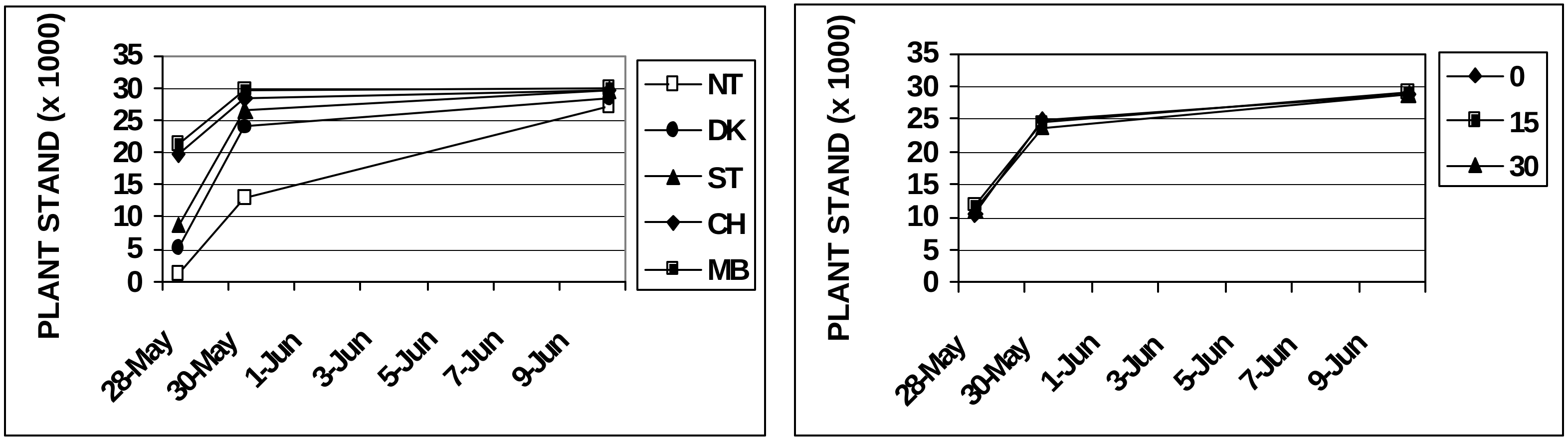

Figure 1. Main effect of tillage and manure rate (t/acre) on the emergence of corn at Arlington, Wis., 2002.

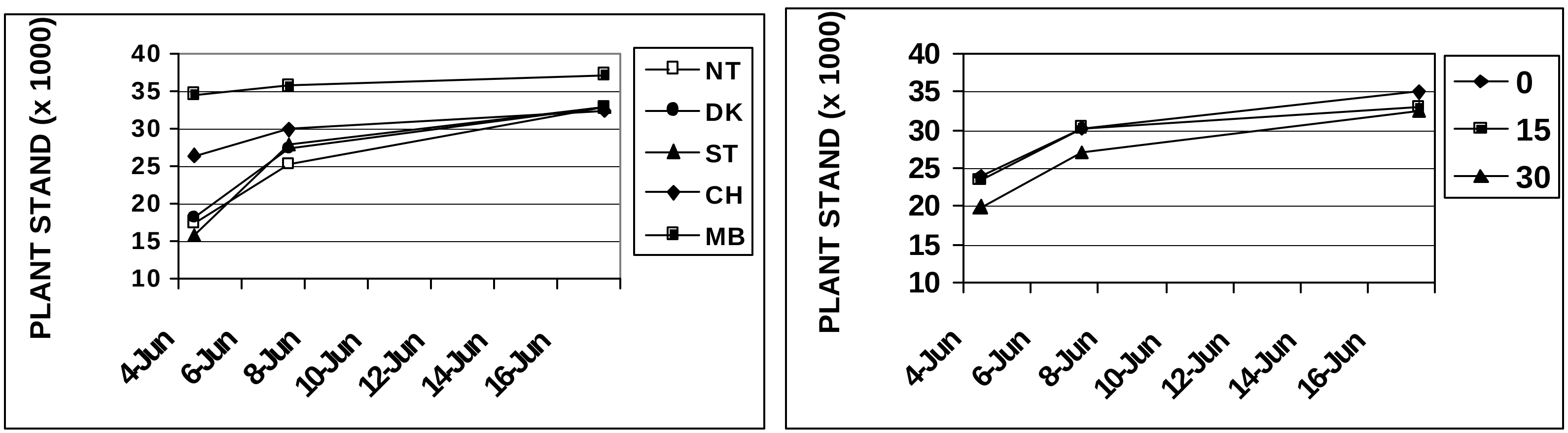

Figure 2. Main effect of tillage and manure rate (t/acre) on the emergence of corn at Marshfield, Wis., 2002.

TILLAGE MANAGEMENT FOR MANURED CROPLAND [1/]

Richard P. Wolkowski [2/]

Nutrient management planning requirements will soon be implemented for most Wisconsin farms. This will result in greater accounting for nutrient credits and will likely prescribe manure application at more modest rates, especially if applied using a P basis. Planners will have to allocate manure to more acres, much of it sloping and managed with high residue tillage systems designed to meet "T" as required by the conservation plan. Manure will be directed to fields where corn was the previous crop because legume N credits will supply N needs for corn when rotating from alfalfa. Many producers will be concerned that leaving manure on the surface where high residue levels already exist may cause poorer planter performance and that the additional residue will exacerbate soil conditions that promote slow early growth. Surface crop residue is an important conservation practice for sloping fields. Numerous studies have shown that tillage that buries significant crop residue increases the potential for soil loss and the risk of P delivery to surface water. Thus a conflict in implementation may develop as producers decide whether they should follow their nutrient management plan or their conservation plan, or create a hybrid strategy that does not meet the specifications of either plan.

Future conservation and nutrient management planning efforts must be fully integrated. Proposals that would combine software for using RUSLE 2, the P index, and nutrient management programs are currently being explored. It is imperative that reasonable crop production systems for sloping manured land be developed. These should leave adequate levels of residue for soil erosion protection while not creating a growing environment that significantly reduces yield because of cool soil and unfavorable seedbed conditions.

This paper summarizes the first year of research that was conducted to examine corn growth and yield response to the various tillage practices on manured corn residue at several Wisconsin locations.

Methods and Materials

Small plot research studies were established at four locations on Wisconsin Agricultural Research Stations at Arlington, Lancaster, Marshfield, and Spooner in 2002. Straw- or stalk-bedded dairy manure was applied in the spring to fields having full, un-chopped corn residue remaining from the 2001 season. The manure was applied with calibrated box-type spreaders at all locations except Arlington, where a side-delivery model was used. The surface-applied manure was allowed to dry several days and was

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subsequently tilled by various methods. Corn was planted shortly after tillage. The tillage and planting equipment used was that which was available at each research station. It was not possible to standardize settings and operating characteristics and therefore performance variability between locations was expected. The Spooner site was irrigated. A summary of the soil types and general management practices is shown in Table 1.

Treatments were set out in a split-plot treatment arrangement with four replications at Lancaster, Marshfield, and Spooner. The Arlington study had similar manure and tillage treatments, but was further split into four N rate sub-subplots (0, 50, 100, and 150 lb N/acre). Main plot was manure that was applied with standard manure spreading equipment at rates of 0, 15, and 30 t/acre. Split plot treatment was tillage. Treatments were no-till using a planter equipped with standard disk openers for dry fertilizer and the seeding unit; strip-till in the row using a four row Remlinger strip-till unit; light (>3 in.) tandem disking; chisel plowing; and, moldboard plowing. The chisel and moldboard systems received secondary tillage to prepare a seedbed using the tandem disk. An application of a minimum of 10+20+20 lb N-P_2O_5-K_2O was applied with the planter on a 2 x 2 placement. Each site, other than Arlington, received a uniform application of N fertilizer at the UWEX recommended rate. Measurements taken included emergence, surface crop residue using the line-transect method, and grain yield and moisture.

Data were subjected to statistical analysis using methods for a split plot design. Where significant differences were found at the p=0.05 level a least significant difference (LSD) was calculated.

Results and Discussion

It is recognized that no-till leaves 90% of the initial residue on the soil surface and that moldboard tillage buries 90% of the residue. The amount of residue left by various chisel systems and other practices such as disking and strip-till is more variable and will be affected by tillage tool and operation. Where incorporation of manure is preferred, but relatively high amounts of residue are needed for conservation purposes, the “inter-mediate” intensity practices may be desirable. Manure, especially straw- or stalk-bedded manure, will provide a substantial amount of residue that can be counted for conservation planning purposes. The main effects of tillage and manure rate on the surface crop residue are shown in Table 2. Increasing manure rate from none to 30 t/acre resulted in increased surface residue from 7 and 20% at Arlington and Lancaster, respectively. The 30 t/acre manure rate added about 10% residue to the surface when averaged over tillage. Residue coverage ranged from 3% for moldboard system at Spooner to 98% for no-till at Arlington. The disk and strip-till systems were generally similar and left fields covered with 60 to 70% residue. The chisel systems typically left about 30 to 40% residue. The residue level at Spooner where chiseled was slightly higher, because the tool used at that location did not have any proceeding disks or coulters.

Table 2. Main effect of straw-bedded manure and tillage on the surface crop residue following planting and final stand at four study locations in Wisconsin, 2002.

Treatment	Arlington		Lancaster		Marshfield		Spooner	
	Res.	Stand	Res.	Stand	Res.	Stand	Res.	Stand
	%	x 1000	%	x 1000	%	x 1000	%	x 1000
Manure (t/acre)								
0	53	28.8	42	30.4	51	35.0	44	29.4
15	60	29.1	47	31.1	53	33.0	56	24.3
30	60	28.8	62	31.0	63	32.6	56	24.3
LSD $_{(0.05)}$	7	NS	13	0.5	8	1.6	6	1.9
Tillage								
No-till	98	27.1	72	30.8	86	32.8	82	17.0
Strip-till	68	29.7	66	30.4	72	32.8	72	27.9
Disk	73	28.3	66	31.5	77	32.8	60	25.0
Chisel	33	29.5	34	30.8	38	32.5	43	28.5
Moldboard	15	29.9	13	30.6	6	37.2	3	31.6
LSD $_{(0.05)}$	10	0.8	9	NS	9	NS	8	4.3
Significance (Pr>F)								
Manure	0.03	0.90	0.02	0.02	0.03	0.02	<0.01	<0.01
Tillage	<0.01	<0.01	<0.01	0.26	<0.01	0.07	<0.01	<0.01
M x T	0.66	0.03	0.71	0.31	0.84	0.78	0.58	0.93

It would be assumed that high levels of surface crop residue, especially where surface applied manure remains on the surface would slow emergence and possibly reduce stands. These effects would be in response to cooler soils and perhaps less effective planter performance in the wetter soil. Plant counts were taken as soon as the plants began to emerge at the Arlington and Marshfield locations only.

Emergence data for the manure rate and tillage main effects for the Arlington and Marshfield locations are shown in Figure 1 and 2, respectively. Plant counts were taken along a measured length of row on several dates in late spring, beginning when approximately 1/3 of the total seeds had emerged from the intensively tilled treatments. Manure rate did not affect emergence at Arlington, possibly because the lower dry matter content of the manure did not impose a significant restriction to planting. Emergence was delayed with the 30 t/acre rate at Marshfield. This site was very wet in the spring and was worked when conditions were relatively wet. Emergence was faster in the moldboard system for both locations. Chisel was intermediate to either the disk or strip-till treatment and no-till was the slowest, especially at Arlington.

The final stand values recorded approximately 45 days after planting are also shown in Table 2. These data show that increasing manure rate decreased stand several thousand plants per acre at Marshfield and Spooner, had no effect at Arlington, and increased stand several hundred plants per acre at Lancaster. The effect of tillage treatment on the final stand is also shown in Table 2. Tillage did not affect stand at Lancaster and Marshfield, although the difference at Marshfield was significant at the p=0.10 level. The moldboard system produced the highest stand at the Arlington and Spooner location, however the difference was only significant when compared to the disk and no-till systems. The strip-till system performed similarly to the chisel system with respect to final stand. The no-till system performed relatively poorly at Spooner because the planter at this station was light and not designed for un-tilled situations.

The main effect of manure rate and tillage on the corn grain response is shown in Table 3. There were no significant interactions at any location for the relationship between manure rate and tillage. Increasing manure rate increased yield at both Arlington and Lancaster. There was a very weak trend for an increase at Spooner. This response may be attributed to improved soil physical characteristics or the addition of nutrients even though the response occurred where the recommended N rate was applied and the corn had received substantial P and K in the form of starter fertilizer. It is possible the S or other nutrients from the manure may have enhanced yield. Yield significantly decreased at Marshfield where 30 t/acre manure was applied. As mentioned previously conditions at planting were very wet at this site and even though stand was minimally affected by manure it was apparent that the heavy rate of manure affect the yield potential of the crop.

Table 3 also shows the effect of the various tillage systems on yield. Moldboard plowing produced the highest yield at Arlington with the other systems showing similar results. Differences were not significant at Lancaster, however it is interesting to note that moldboard plowing had the lowest yield at that site. Moldboard plowing produced the highest yield at Marshfield and presumably reduced the yield limiting effects of the wet spring soil conditions. Disking and no-till were the least desirable systems at this site. Yield at Spooner was the highest in the moldboard, however there was much more variability at this site because of the performance of the planter. This was especially obvious for no-till.

A N rate variable was installed at the Arlington location. This resulted in a total of 240 plots making a similar design impractical at the other locations. There was a significant interaction between N rate and manure application. This interaction is shown in Figure 3 and shows an expected response where the response to N is lower where manure is applied. The manure treatments supply an estimated 45 and 90 lb N/acre respectively. These data show that a combination of manure and N fertilizer was needed to optimize yield in this field.

Table 3. Main effects of straw-bedded manure and tillage on the corn grain yield at four study locations in Wisconsin, 2002.

Treatment	Arlington	Lancaster	Marshfield	Spooner
	bu/acre			
Manure (t/acre)				
0	147	224	181	167
15	175	232	172	173
30	182	236	146	178
LSD $_{(0.05)}$	25	7	19	NS
Tillage				
No-till	164	234	156	126
Strip-till	166	229	172	173
Disk	162	236	153	179
Chisel	170	229	165	189
Moldboard	178	225	183	198
LSD $_{(0.05)}$	11	NS	14	25
N Rate (lb/acre)				
0	139	--	--	--
50	167	--	--	--
100	179	--	--	--
150	186	--	--	--
LSD $_{(0.05)}$	6	--	--	--
Significance (Pr>F)				
Manure (M)	0.03	0.03	0.01	0.36
Tillage (T)	0.04	0.11	<0.01	<0.01
M*T	0.99	0.17	0.47	0.91
N Rate (N)	<0.01	--	--	--
M*N	<0.01	--	--	--
T*N	0.21	--	--	--
M*T*N	0.98	--	--	--

N rate treatments at Arlington only.

Summary

Future nutrient management efforts will likely direct more manure to sloping fields having corn stubble. This will create a management issue in that tillage may be needed to create a reasonable seedbed, but may result in the incorporation of too much residue, potentially increasing the risk of soil erosion from the field. Small plot field studies were established at four locations to examine the effectiveness of different tillage systems for providing adequate cover for conservation purposes with minimal yield reduction. Tillage treatments were applied to full corn stubble that had received no manure, 15, or 30 t/acre of straw-bedded dairy manure. First year results show variability in response to both tillage and manure rate. Responses were site-specific and are likely a result of differences in climate, equipment, and operation parameters. These data show that uniform application of manure, even at relatively high rates can be managed in high residue systems on well-drained soils. The selection of the high residue system that works best under manured conditions will depend on the grower's preference and the availability of equipment. Regardless of the conservation tillage system selected, planters designed to operate in heavy residue are important for successful crop production. As always, operations under wet conditions should be avoided.