TECHNOLOGY EVALUATION AND DEVELOPMENT SUB-PROGRAM

THE DEVELOPMENT AND TESTING OF A DRY FERTILIZER PLACEMENT MACHINE

FINAL REPORT

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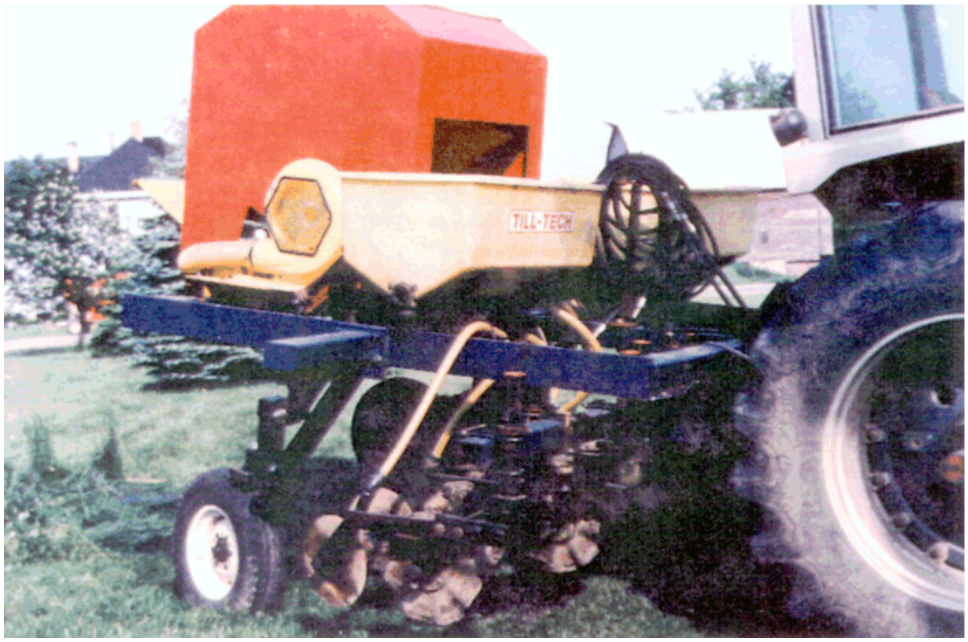
The Development & Testing
of a
Dry Fertilizer Placement Machine

<u>1989 -1990</u>



Fertilizer Zone-tiller

A
Technology Evaluation and Development Project

under

S.W.E.E.P

Doug Albin
Till-Tech Systems Limited

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EXECUTIVE SUMMARY

The objective of this project was to develop a machine which would provide farmers practising conservation tillage with the means to apply dry form nitrogen sources (ie. urea and/or ammonium nitrate). Before the project began, the standard nitrogen source used in reduced tillage systems was liquid 28% N which was applied by an applicator developed to inject the material into the soil.

From an environmental perspective, the benefits of the prototype machine (hereafter referred to as fertilizer zone-tiller) are seenas follows:

* the environmental risks associated with storage are lower with dry forms (urea and ammonium nitrate) than with liquid 28% N or anhydrous

* the fertilizer zone-tiller works effectively in no-till applications and in varied soil types (tested in sandy loam and clay loam soils). The coulter design cut previous-crop residue for accurate fertilizer placement while leaving trash between the rows for continued soilprotection from wind and water erosion.

* the fertilizer zone-tiller can be pulled in tandem with the planter thus reducing: 1) fuel consumption and, 2) field passes (risk of soil compaction is less)

The criteria for judging the success of this project were established as follows:

If corn fertilized using the fertilizer zone-tiller performed' at least as well as corn fertilized with the liquid 28% N applicator, then, the fertilizer zone-tiller is a feasible fertilizer placement machine.

If comparable or better results can be achieved using dry nitrogen fertilizers (vs. 28% N), then, conventional farmers who favour their use might be more inclined to convert to soil conservation cropping techniques.

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[1] Evaluation parameters - yield, biomass, height and nitrogen uptake

To establish whether the fertilizer zone-tiller has merit, it were tested over two years with two plots on a sandy loam site (1989, 1990) and one plot at a clay loam location (1990). While corn at the clay loam location did not show a response to nitrogen, good data were collected over two years at the sandy loam site. Results from the latter site are summarized below:

<u>Year 1</u> - **urea vs. liquid 28% N**

* liquid 28% N showed a slight advantage over urea though the yield difference was not statistically significant

<u>Year 2</u> - **dry fertilizer (20% ammonium nitrate** + **80% urea) vs. liquid 28% N**

* the dry fertilizer combination outperformed both liquid 28%N treatments (with and without coultering) by a significant 747 kg ha^{-1} and 1158 kg ha^{-1} respectively

In year 2, ammonium nitrate was applied to all dry fertilizer treatments at time of planting. The timing of urea application was varied according to the original testing procedure.

Starter fertilizer comprised of phosphorus and potassium was applied to plots based on soil test recommendations taken each year.

CONCLUSION

With the fertilizer zone-tiller performing at least as well as the liquid 28% N applicator, the data clearly suggests that it is a viable alternative in conservation tillage systems.

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OBJECTIVE

As previously stated, the objective of this project was to develop a dry fertilizer placement machine for use in no-till or reduced tillage cropping systems. Since the liquid 28% N applicator is viewed as the standard nitrogen fertilizer placement method in conservation tillage systems, it was used as the control to test our prototype. While the fertilizer zone-tiller is judged to be feasible if it at least matches results achieved by this standard, other factors should be considered when choosing between nitrogen fertilizer sources.

In addition to the environmental advantages of the proposed technology (highlighted above), other benefits of using dry fertilizer combinations vs. liquid 28% N and/or anhydrous ammonia are:

1. Dry fertilizer is easier to store and handle than nitrogen in the 28% or anhydrous form.

2. A lower volume of fertilizer is transported when N in dry forms are used vs. 28% N. This means less fuel to apply comparable amounts of actual nitrogen.

3. At times, there is a cost advantage to using urea vs. 28%.

4. More farmers have ready access to urea than to liquid 28% N.

5. Urea and ammonium nitrate fertilizers are safer products to handle than anhydrous ammonia.

The fertilizer zone-tiller itself will also provide utility in the following ways:

1. A spring pass by the machine prior to planting could result in faster drying and warming of the soil such that planting could be undertaken at an earlier date.

2. To reduce field passes, the machine could be pulled in tandemwith the planter.

3. The machine, with adjustments for fertilizer placement, can be used as a side-dressing unit.

4. Machine design accommodates split applications (ie. banding on both sides of the crop row) as opposed to placement in one large dose between the rows. This, we feel, will result inmore effective fertilizer use.

5. The machine is suitable to varied soil types and conditions.

6. The lift-assist wheels, in addition to supporting the weight of the machine and fertilizer, provide a safety benefit (ie. not as much weight on the tongue).

In summary, the action of the proposed machine is compatible with the objectives of a reduced tillage cropping system -- to reduce soil erosion and soil compaction with a view to maintaining the agricultural productivity of the soil in the long term.

METHOD - YEAR 1

1. TESTING PROCEDURE - 28% N vs. Urea applicator 1989 study

The method designed was to:

i) Compare the grain corn yield response to applied fertilizer N using a currently recommended method (28% N side-banded)and the new equipment.

ii) Compare the two fertilizer systems at two different times offertilizer application, seeding and 6-leaf stage.

The following treatments were performed on a 2 hectare sandy loam plot (Albin). While another plot on a clay loam site was planned, wet weather prevented planting in a timely manner.

2 Methods	-	28 % applicator vs. fertilizer zone-tiller
x		
2 Rates	-	application of 56 kg ha^{-1} of N
		vs.
x		application of recommended rate
2 Timings	-	N applied at planting vs.
		N applied at 4 - 6 leaf stage
x		
3 Replications	-	each replication was approximately 100 meters long x 60 meters wide (about 78, 30" corn rows)
= 24 plots	-	with headlands between the 3 replications, the total test area covered approximately 2 hectares

The experiment was set up as a randomized complete block with three replications. In addition to this design, the treatments were separated by an equal sized treatment with 0 kg ha^{-1} fertilizer N to use as a covariate in case of uneven site variability, which is common when using large plots. The large size of each treatment replication was to ensure adequate plot length for proper performance of the field equipment being tested. The liquid 28% N fertilizer was applied with the Department of Land Resource Science (University of Guelph) 28% applicator.

A diagram of the plot design is shown in Figure 1. The coding for Figure 1 is:

L	=	Liquid 28% N sidedress method
U	=	Urea zone till application system
50	=	target 50 kg ha^{-1} fertilizer N-rate (actual = 56)
150	=	target 150 kg ha^{-1} fertilizer N-rate (actual = 156)
1	=	application at time of seeding
2	=	application at 6-leaf stage

The urea application system has a set of twin coulters, which alongwith the fertilizer openers passively till an area approximately 25 cm wide around the seed row. In order to test the fertilizer placement system separately from the seed zone tillage effect, the plots which had the 28% N applied were first subjected to the zone-till fertilizer placement machine with the fertilizer supply shut off. Thus all treatments, including the check plots had intensivecoulter tillage in the seed row area. Thus, the experiment is testing the placement and type of fertilizer (dry urea versus 28% N).

The land chosen was known to be low in nitrogen reserves and the actual nitrogen response shown in test results confirmed this. Soil tests obtained by Mr. Albin prior to planting indicated that there were adequate soil reserves of both phosphorus and potassium.Accordingly, no starter fertilizer was applied.

Figure 1. **28% N vs. UREA**
Experiment - 1989

Block I	Block II	Block III
C 1	C 1	C 1
U 50-2	U 50-2	U 150-1
C 2	C 2	C 2
L 150-1	U 150-2	L 50-1
C 3	C 3	C 3
U 150-1	L 50-1	L 150-2
C 4	C 4	C 4
L 150-2	L 50-2	U 150-2
C 5	C 5	C 5
L 50-2	U 50-1	U 50-1
C 6	C 6	C 6
U 50-1	L 150-1	U 50-2
C 7	C 7	C 7
U 150-2	U 150-1	L 50-2
C 8	C 8	C 8
L 50-1	L 150-2	L 150-1
C 9	C 9	C 9

TYPE

U = Urea

L = Liq. 28% N

C = Check

DOSE

50 = 50 Kg/Ha

150 = 150 Kg/Ha

TIME

1 = Planting

2 = 6 Leaf

2. PLANTING

On May 18th, 1989 the test plot was planted at a target population of 66,720 plants per ha (27000 plants per acre) using the Pioneer 3902 corn variety. There were two machinery passes over the plot (three passes where the 28% fertilizer was applied):

1) the fertilizer zone-tiller was pulled through the entire plot and alternately applied fertilizer with nitrogen rates of zero, 56 and 156 kg ha^{-1} . The urea was placed in a split application, 11 cm from the seed, on both sides.

2) corn was then planted in the zone that had been prepared by the zone-till machine. The previous year's corn rows were used as markers for both passes. In the designated areas, fertilizer was applied by the 28% applicator some 13 cm from the seed, on one side of the row, and at the rates stated above.

Planting Checks

- the planter was inspected for mechanical problems prior to planting
- row spot checks were undertaken to ensure proper population and seed placement

Calibration

- during calibration of the prototype, checks were done to ensure that the fertilizer was split evenly on both sides of the row
- the liquid 28% N applicator was calibrated by a technician at the University of Guelph. Prior to usage, it was checked to ensure it was in good working order.

3. SIDE-DRESSING

Once the crop had emerged, yield and crop growth monitoring locations were selected within each of the treatment plots. Yield subplots consisted of two 6 m lengths of corn row from the inner two rows of the treatment. All data and harvested samples weretaken from these sub-plots to ensure reliable results.

On June 26th, 1989 fertilizer was side-dressed in the specified treatments and at the rates stated above. The urea was placed in a split application, 25 cm from the plant, on both sides, by the prototype. Liquid 28% N was placed between the rows at the mid-point (approximately 45 cm from the plant).

Fertilizer Flow

- during fertilization at both planting and side-dressing time,there were no problems with fertilizer flow

  Note: During later field testing however, humidity resulted inthe fertilizer gumming in the splitting device. As discussed later in the report, this problem was alleviated with the installation of an air delivery system.

A qualified field technician was present on both dates to ensure the plot was worked/planted according to the plot design preparedby Dr. Kachanoski, project Technical Advisor.

4. WEED CONTROL

- a visual inspection of the field indicated the weed control program to be adequate

Timing	Treatment
fall '88	Round-up @ 2.5 litre/ha + 2,4-D Ester @ 2.5 litre/ha + Surfactant
May 13/89	Dual @ 2.5 litre/ha + 2,4-D Amine @ 1 litre/ha + Surfactant
June 3/89	Banvil @ .62 litre/ha

Note: some mechanical weed control occurred when the fertilizer was side-dressed in late June.

5. HARVESTING

The corn was hand harvested and moisture content determined to express yield on a 15.5% (wt) moisture content basis. Plant samples were taken at the 6-leaf stage (June 18) for biomass andphosphorus measurement to determine if adequate levels were available[1]. Total plant samples were taken after maturity to determine total biomass production as well as %N and total N uptake. Plant populations and heights were examined in detail onJuly 15 (10-11 leaf stage) by selecting 10 sub-plots at random within each treatment and averaging the measurements. A summary of the observations is given in Appendix IV.

[1] The bicarbonate extractable (OMAF test) for phosphorusaveraged 29.0 ppm (ten samples). Based on OMAF Publication # 296, this represents an acceptable phosphorus level and thus it was not necessary to supplement with fertilizer.

5. **HARVESTING** (cont'd)

- these marked sub-plots were hand-harvested on or about Oct. 8th by qualified field technicians
- the remaining crop was combine harvested later that month and yielded the equivalent of 3700 kg/ha (58.9 bu./acre).

6. OTHER OBSERVATIONS

Aside from the test data summarized in tables and appendices, the following visual observations were made.

Some plant population skips were noted in all treatments (not all replications). This might be explained by planter malfunctions or germination problems; however, since skips were not observed on the rest of the field, where the same planter and corn hybrid had been used, we are unsure what the cause of the problem actually was.

Compared to the rest of the field, the plot was less vigorous. While the field was planted about 10 days earlier, it also benefitted from the application of a starter fertilizer comprised of 33.4 kg ha^{-1} of actual N in the form of ammonium nitrate (aeroprills).

<u>RESULTS - YEAR 1</u>

<u>1989 Study</u>

Agronomic testing revealed two relationships of note:

a) tests comparing urea and 28% nitrogen sources showed a slight yield advantage to 28%, and,

b) in the timing comparison, higher yields were achieved when the fertilizer was applied at planting rather than at the 6 leaf stage of plant growth.

A summary of the data collected and the associated analysis of variance for the 1989 comparison of 28% N and the Urea zone-till applicator is given in Appendix IV. A summary of the average crop measurements for the Albin 1989 site as a function of applied N fertilizer is given in Table 1. As indicated there was a significant increase in the yield at the 56 and 156 kg N ha^{-1} application rates, over the check (0 kg N ha^{-1}) plots. However, the increase in yield from the 56 to 156 kg N ha^{-1} rates was not significant.

Similar trends were found with the other plant parameters (Table 1.), with significant increases measured in the 56 and 156 kg N ha^{-1} treatments over the check. Total N uptake increased by 90 kg ha^{-1} and 121 kg ha^{-1} for the low and high rate of fertilizer added respectively. Plant population was not significantly affected by the treatments.

Table 1. Average crop measurements for the 1989 Albin site as a function of applied N fertilizer.

Plant Measurement	Applied Fertilizer N (kg N ha^{-1})		
	0	6	156
Yield (bu/ac)	60.5[a]	88.7[b]	91.6[b]
Full Biomass (tonne/ha)	8.3	12.4	13.4
Biomass N (kg N /ha)	105	195	226
Tissue N (%)	1.25	1.54	1.68
Biomass (g/pl)	100	153	160
Population (pl/m)	7.6	7.4	7.6

Values in the same row with different letters are significantly different at the 0.05 probability level.

The analysis of variance[2] for treatment effects on yield is given in Appendix IV. The major effect is time of application (significant at only 0.11 level). A summary of the yield data is given in Table 2. The Duncan-Wallis multiple range test for difference in mean values indicated that the 28% N at time of planting was significantly greater (Prob $\leq$0.05) than Urea at time of sidedress (averaged across N rates). Also the overall average for application at planting time was significantly greater (Prob $\leq$0.05) than application at the 6 leaf stage (averaged across application times).

[2] Both Type I and Type II analyses were calculated in all Analyses of Variance as a means to check the integrity of each analysis. In Type I, the statistical hypothesis assumes all treatments will be different and those treatments that are comparable are highlighted. In Type II, the hypothesis assumes all treatment results will be similar and accordingly, those that are different are highlighted.

Table 2. Summary of yield measurements for Albin 1989. Corn Grain Yield (bu ac^{-1})

Fertilizer Application Method	56 kg N ha^{-1} applied			156 kg N ha^{-1} applied		
	Planting	6 leaf	Avg	Planting	6 leaf	Avg
28% sidedress	93.1	86.4	89.7	102.2	88.1	95.1
Urea zone-till	94.2	80.8	87.5	89.2	86.5	87.9
Average	93.6	83.6	88.6	95.7	87.2	91.5

A summary of the major crop characteristics for the different treatments at the planting and 6 leaf application times is given in Table 3 and Table 4 respectively. Analysis of variance for the different crop characteristics independently generally showed little significant effect of the fertilizer application system.

Table 3. Average crop measurements for application of fertilizer N at time of planting. Albin, 1989

Plant Measurement	Application at Planting.					
	56 kg N/ha			156 kg N/ha		
	28%	Urea	delt (%)*	28%	Urea	delt (%)*
Yield (bu/ac)	93.1	94.2	1.0	102.2	89.2	-12.7
Harvested cob(C/m)	6.6	6.4	-3.0	6.6	6.2	-6.1
Popul^{n} 10L (pl/m)	7.7	7.5	-2.6	7.7	7.4	-3.9
Height 10L (m)	1.0	0.9	-10.0	1.0	0.9	-10.0
Biomass 6L (g/pl)	3.5	2.8	-20.0	3.2	3.1	-3.0
Tissue N milk (%)	1.72	1.48	-14.0	1.78	1.63	-8.4
Biomass N (kg N/ha)	219	198	-9.5	264	207	-21.5

* (Urea - 28%)/28% * 100

However, over all measurements, the data clearly showed a consistently better crop response for the 28% N systems over the Urea zone-till system for the application at planting (Table 3). All parameters were higher in the 28% N system including height, biomass, total N uptake and harvestable cobs. The crop measurements for the 6 leaf application time (Table 4) are not very conclusive, with the Urea system favoured at the low rate (56 kg N ha^{-1}) and the 28% N system favoured at the higher rate (156 kg N ha^{-1}). The data suggest that the urea zone-till system did adversely affect crop growth compared to the 28% N system, but the yield was not affected enough to be statistically significant.

Table 4. Average crop measurements for application of fertilizer N at the 6-leaf stage. Albin, 1989

Plant Measurement	Application at Planting					
	56 kg N ha^{-1}			156 kg N ha^{-1}		
	28%	Urea	delt (%)*	28%	Urea	delt (%)*
Yield (bu/ac)	82.2	85.1	+3.4	94.4	88.5	-6.2
Harvested cob(C/m)	6.9	6.2	-10.0	6.6	6.1	-7.5
Popul^{n} 10 L (pl/m)	6.9	7.4	+7.2	7.8	7.7	-1.2
Height 10 L (m)	0.8	0.9	+12.5	0.9	0.8	-11.1
Biomass 6 L (g/pl)	3.1	3.3	+6.5	3.5	3.4	-2.9
Tissue N milk (%)	1.42	1.53	+7.8	1.7	1.62	-4.7
Tot. P1.N (kg N/ha)	152	210	+38.1	225	209	-7.1

* (Urea - 28%)/28% * 100

In summary, the Urea zone-till system was having a slight negative effect on corn grain yield and general crop growth characteristics. Secondly, applying the fertilizer at time of planting increased yields relative to application at the 6 leaf stage. It was decided that the 1990 Urea treatment would include 10% of its fertilizer N as a starter to try and offset the slight negative effects measured in 1989.

In consideration of these results testing in Year 2 was modified with a view to determining:

a) whether toxicity and/or volatilization could explain the lower yields in the urea treatments, and secondly,

   i) maybe the urea was too close to the root zone of the plant such that during the hydrolysis process, toxicity occurred

   ii) given that the urea was placed roughly 5 cm deep while the liquid 28% was injected about 13 cm below the soil surface, more volatilization may have occurred with the urea fertilizer

b) whether, a small amount of nitrogen, in the form of ammonium nitrate (aeroprills), applied at planting on all urea treatments, would result in yields similar to those achieved on the liquid 28% N treatments

In addition, another method was added to the original test to determine whether there is a yield response to coultering. This test was proposed in response to concerns by some reduced-tillage practitioners that planting is usually later than in conventionally-cropped fields because undisturbed soil takes longer to warm and dry. The fertilizer zone-tiller, while applying starter fertilizer, could be used to prepare a seed zone in fields that are too wet or cold to plant in. Particularly in a wet year, this zone tillage could be an important factor in getting the crop planted in a timely manner.

METHOD - YEAR 2

1. TESTING PROCEDURE - 28% N vs. Urea applicator 1990 study

The method described for Year 1 was modified to find out whether:

1) a dry fertilizer combination, including 20% ammonium nitrate would achieve results comparable to those from liquid 28%

   Perhaps urea does not provide nitrogen in a form usable by the plant until some time has elapsed after application. Conversely, ammonium nitrate may provide readily available nitrogen, soon after application. Therefore, in order to meet the nitrogen needs of the seedling, an early application of ammonium nitrate might enhance plant vigour and growth.

2) there is a yield response to coultering

   The original experiment was designed to compare nitrogen sources and thus all treatments were coultered. However, from a practical point of view, the question to be answered is whether the dry fertilizer placement machine compares favourably with 28% N knifed into the soil when no-till planting (a popular method currently used by a majority of farmers practising soil conservation methods). In other words, there may, in fact, be a yield response to zone tillage at or prior to planting.

Year 2 testing (dry vs. liquid N sources) is summarized below:

3 Methods	-	dry fertilizer placed by prototype and planter (ie. combination urea and aeroprills)
		vs.
		liquid 28% injected into prepared zone
X		vs.
		liquid 28% and slot planting
2 Rates	**-**	application of 50 kg ha^{-1} N
		vs.
X		application of 150 kg ha^{-1} N
2 Timings	-	N (urea vs. 28%) applied at planting
		vs.
X		N (urea vs. 28%) applied at 4 - 6 leaf stage
3 Replications	-	each replication was approximately 100 meters long x 90 meters wide (about 118, 30" corn rows)
= 36 plots	-	with headlands between the 3 replications, the total test area covered approximately 3 hectares

Note: On all dry fertilizer treatments, the ammonium nitrate was applied with starter fertilizer at planting.

At each of the two sites (Albin's and Prong's) the experiments were set up as randomized complete blocks with a check treatment as an added covariate, with three replications (blocks). Each of the three blocks contained three fertilizer application systems (28% N side banded "L", 28% N side banded plus coultered row area "LC"or "C" in the statistical appendix, and Urea side banded plus coultered row "U"). Each of the application systems were used to apply N fertilizer at two rates (50 kg N ha^{-1}, and 150 kg N ha^{-1}), and each rate at two application times (seeding, and 4-6 leaf stage). This gave a total of 3 x 2 x 2 x 3 reps = 36 treatments. In addition to this design, each of the treatments were separated by an equal sized treatment with 0 kg N ha^{-1}(covariate check). This gave a total of 72 individual plots, each 3.6 m wide (4 corn rows at 0.9 m row spacing) by approximately 50 m long. The large size of each treatment replication was to ensure adequate plot length for proper performance of the field equipment being tested.

The check treatments (0 kg N ha^{-1}) were coultered once prior to a pass with the dry fertilizer placement machine.

A diagram of the field plot design is given in Figure 2.

Figure 2. **28% N vs. UREA**
Experiment - 1990

Block I	Block II	Block III
C 1	C 1	C 1
U 50-2	LC 150-2	U 150-1
C 2	C 2	C 2
L 150-1	LC 150-1	L 50-1
C 3	C 3	C 3
LC 50-2	U 50-2	L 150-2
C 4	C 4	C 4
U 150-1	U 150-2	LC 50-1
C 5	C 5	C 5
L 150-2	L 50-1	U 150-2
C 6	C 6	C 6
LC 50-1	L 50-2	LC 150-2
C 7	C 7	C 7
LC 150-2	U 50-1	U 50-1
C 8	C 8	C 8
L 50-2	LC 50-1	LC 50-2
C 9	C 9	C 9
U 50-1	L 150-1	LC 150-1
C 10	C 10	C 10
U 150-2	LC 50-2	U 50-2
C 11	C 11	C 11
L 50-1	U 150-1	L 50-2
C 12	C 12	C 12
LC 150-1	L 150-2	L 150-1

TYPE

U = Urea
LC = Coultered 28% N
L = Liq. 28% N
C = Check

DOSE

50 = 50 Kg/Ha
150 = 150 Kg/Ha

TIME

1 = Planting
2 = 6 Leaf

Urea Placement Experiment, 1990

Possible explanations for the inferior response to urea vs. liquid 28% N are:

i) The urea was too close to the root zone of the plant such that during the hydrolysis process, toxicity occurred.

ii) Given that the urea was placed roughly 5 cm deep while the liquid 28% was injected about 13 cm below the soil surface, there is the possibility that there was more volatilization with the urea fertilizer.

Accordingly, a separate experiment was conducted on the clay loam site (Prong) to test whether the placement of urea affected its performance. Treatments are outlined below.

Urea Placement Plot

2 Methods - urea placed 5 cm deep vs. 15 cm deep

X

4 Widths - urea banded on both sides of the seed at 10 cm, 15 cm and 25 cm at planting
vs.

X urea banded on both sides of the seed at 25 cm, at the 4-6 leaf stage

3 Replications - each replication was approximately 100 meters long x 60 meters wide (about 78, 30" corn rows)

= 24 plots - with headlands between the 3 replications, the total test area covered approximately 2 hectares

The urea placement experiment was set-up at one site (Prong farm) as a randomized complete block with three replications. A diagram of the field plot is given in Figure 3.

Figure 3. **UREA Placement Experiment - 1990**

Block I	Block II	Block III
C 1	C 1	C 1
2-6-P	2-10-P	2-4-P
C 2	C 2	C 2
6-10-P	6-4-P	2-10-S
C 3	C 3	C 3
6-4-P	6-10-S	6-10-P
C 4	C 4	C 4
6-10-S	2-10-S	6-6-P
C 5	C 5	C 5
6-6-P	2-4-P	2-6-P
C 6	C 6	C 6
2-4-P	2-6-P	2-10-P
C 7	C 7	C 7
2-10-S	6-6-P	6-10-S
C 8	C 8	C 8
2-10-P	6-10-P	6-4-P

Depth	Distance to row	Time of applic.
2 = 5 cm	4 = 10 cm	P = Planting
6 = 15 cm	6 = 15 cm	S = Sidedress
	10 = 25 cm	

2. PLANTING

Dry Fertilizer vs. 28% Experiment

- urea was placed in treatments at a depth of 7.5 cm and was a split application 13 cm on both sides of the seed
- the dry fertilizer treatments also had 20% of the total N applied (5 x 5 cm) as NH_4NO_3, at time of planting along with the starter fertilizer
- ammonium nitrate and starter fertilizer was applied via the fertilizer boxes on the planter
- 28% N was knifed in (14 cm depth) 13 cm on one side of the seed
- the corn was planted 4 cm deep
- the same planter was used on all plots
-

ALBIN (sandy loam)
- planting was concluded on May 11th at a target population of 67,900 plants ha^{-1}
- corn (Pioneer 3790) was sown
- a starter fertilizer comprised of 27 kg ha^{-1} phosphorus and potassium was applied to the plot as recommended by soil tests

PRONG (clay loam)
- in an effort to get the plot planted prior to June 1st, the seed was sown in wetter conditions than one would normally plant in; press wheels weren't closing the gap really well
- based on fertilizer tests, 30 kg ha^{-1} of actual phosphorus and potassium were applied as a starter fertilizer with the ammonium nitrate
- planted to corn (Pioneer 3790) on May 25 at a target population of 67,900 plants per hectare

Urea Placement Plot

(PRONG - clay loam)

- site was planted at the same time as the other experiment at the Prong site, and similar measurements were taken to monitor the site
- plot was coultered once with the fertilizer zone-tiller to promote soil drying
- close to 150 kg N ha^{-1} of N in urea form was applied according to the depths and widths stated above
- no aeroprills were applied with the planter

**** Note:** While we had hoped to band the fertilizer at a 15 cm depth, due to the blade size, placement was limited to the 10 cm level.
Furthermore, fertilizer aimed at 5 cm was not banded there, but rather was incorporated in the top 5 cm of soil.

3. SIDE-DRESSING

Urea vs. 28% Experiment

- urea was placed 7.5 cm deep and 25 cm from plant on both sides in a split application
- 28% was placed 14 cm deep and in one dose mid-row (about 45 cm from plant)

ALBIN - side-dressed on June 26 according to methods described

PRONG - side-dressed on June 28/July 7 according to the methods described above

2. WEED CONTROL

Timing	Treatment
ALBIN	
herbicides were	Dual @ 1.0 litre/acre
applied one week	Lorox @ 0.35 litre/acre
after planting	Atrazine @ 0.90 litre/acre

Note: some mechanical weed control occurred when fertilizer was side-dressed in late June

Timing	Treatment
PRONG	
early Apr.	2,4-D Ester 0.75 litre/acre
May 18	Roundup @ 1.0 litre/acre
June 15	Basogran @ 1.0 litre/acre
	spot spraying with Marxman at 1.8 L/acre rate
July 1	cultivated

(Observed that Basogran got smaller weeds but, where weed plants were more advanced, eradication did not occur. Therefore spot spraying was needed.)

3. HARVESTING

Once the corn had emerged, two 6m lengths of corn, with uniform plant populations, were selected from two adjacent rows within each replication. All data and hand-harvested samples were taken from these sub-plots by qualified field technicians.

The corn was hand harvested and moisture content determined to express yield on a 15.5% (wt) moisture content basis. Plant samples were taken at the 6 leaf stage. Total plant samples were taken after maturity to determine total biomass production as well as %N and total N uptake. Plant populations and heights were examined in detail in August by selecting 10 sub-plots at random within each treatment and averaging the measurements.

A summary of the observations is given in Appendices I, II and III.

6. OTHER OBSERVATIONS

ALBIN - plot development was comparable to surrounding corn
- obvious contrast between rates and methods
- dry fertilizer treatments at both 150 and 50 lb./acre rates appeared to be more vigorous than the 28% treatments

PRONG - in the fertilizer placement plot there was no visible evidence of fertilizer burn.

As in year 1 there were some skips in plant population for which an explanation is unclear. Since adjacent rows within the same planter pass did not show skips in the same areas, the problem cannot be attributed to inaccurate planting within the fertilized zone (ie. fertilizer burn if seed had been planted too close to fertilizer that was placed in a previous pass).

RESULTS - YEAR 2

1990 Studies

Fertilizer Zone-tiller vs. 28% Applicator- overview

Reliable results were obtained from the Albin plot (sandy loam) which showed a good response to nitrogen. Results showed that yields from the dry fertilizer treatments were 747 kg ha^{-1} and 1158 kg ha^{-1} higher than the 28% treatments, with and without coultering, respectively, (Table 6 - Avg. at 150 kg N ha^{-1}). Other crop growth parameters (full biomass, 6-leaf biomass, biomass N and Tissue N) also showed that the dry fertilizer system performed significantly (Prob $\leq$.10) better than the 28% methods (Table 7 - 150 kg N ha^{-1}). With respect to time of application, there was no significant difference in yields. Thus Year 1 results (which indicated better response when nitrogen was applied at planting) are inconclusive.

The Prong - clay loam plot did not show a significant response to nitrogen (Table 9); this indicates that pre-plot soil reserves of nitrogen were higher than expected. Nevertheless, results indicated that the fertilizer zone-tiller performed at least as well as the 28% method.

There was a positive response to coultering at the Albin - sandy loam plot (Table 6) but a negative response on the Prong - clay loam plot (Table 9). Therefore we cannot draw any conclusions about the effects of coultering.

A summary of the various measurements taken at the Albin (28% N vs. Urea), Prong (28% N vs. Urea), and Prong (Urea placement) experiments, along with the analysis of variance are given in Appendices I, II and III respectively. The experiments will be discussed individually, then an overall summary given. A summary of the yield and analysis of variance data for Albin 1989 (28% N vs. Urea) is given in Appendix IV.

Albin (28% N vs. Urea applicator) - 1990

The average crop response to applied fertilizer N over all application methods and times of application is given in Table 5. The data indicate a statistically significant (Prob ≤ 0.05) effect of applied fertilizer N for most crop characteristics except plant population (as expected). Corn grain yield (15.5% wt.) and total crop biomass (dry wt.) increased by approximately 52.2 bu ac^{-1} and 10 kg ha^{-1} respectively with the addition of 150 kg N ha^{-1}. This compares with an increase of 31.1 bu ac^{-1} grain yield and 6000 kg ha^{-1} biomass for the addition of 156 kg N ha^{-1} in 1989. The strong response to fertilizer N in both years at this site make it a valid site to test N fertilizer application systems.

Table 5. Average crop measurements as a function of applied N fertilizer, Albin 1990

	Applied N fertilizer (kg N ha^{-1})		
Measurement	0	50	150
Yield (bu ac^{-1})	53.3 ^{a}	71.6 ^{b}	105.5 ^{c}
6 leaf Biomass (kg ha^{-1})	138 ^{a*}	164 ^{ab*}	184 ^{b*}
Full Biomass (tonnes ha^{-1})	13.1 ^{a}	14.5 ^{a}	23.9 ^{b}
Biomass N (kg ha^{-1})	111 ^{a}	106 ^{a}	237 ^{b}
Tissue N (%)	0.84 ^{a}	0.73 ^{a}	0.99 ^{b}
12 leaf Plant # (pl^{-1})	5.8 ^{a}	5.7 ^{a}	5.8 ^{a}
# cobs (cobs $^{-1}$)	4.2 ^{a}	4.6 ^{a}	4.6 ^{a}

Values in the same row with different letters are significantly different at Prob ≤ 0.05.

* significantly different at 0.10 level.

A summary of the analysis of variance for treatment effects on corn grain yield (Albin 1990) is given in Appendix I, Table I.8. As indicated there was a very significant (Prob $\leq$ 0.001) effect of fertilizer application system (FERT) and fertilizer amount (DOSE), on grain yield (Appendix I, Table I.8.). The time of fertilizer application (TIME) was not significant. The yields at both times of application were averaged for each application type and fertilizer amount, before testing for specific differences among mean values using the Duncan-Wallis multiple range test. The data are summarized in Table 6.

As indicated in Table 6, there was a significant increase in yield in the Urea - coultering system (U) over both the 28% N method (coultering LC, and without coultering L). The difference was significant for both N rates, but at a slightly reduced probability (Prob $\leq$0.07) at the 150 kg N ha^{-1} rate. The average yield gain in the U system was 18.5 bu ac^{-1} and 25.3 bu ac^{-1} over the LC and L systems respectively (significant at the 0.05 level). The extra coultering with the LC system had higher average yields than the L system at both N rates, but the difference was not enough for it to be significant at the 0.10 probability level.

The other measured plant parameters are summarized in Table 7. Biomass and total plant N uptake were affected by treatment in a manner similar to yield. The urea application system (U) seems to give better crop response than either the LC or L treatment. The LC treatment was higher than the L treatment in biomass and N uptake at the low rate of applied N, but the opposite was true at high N applied. This supports the yield data suggesting a small but statistically insignificant effect of LC over L treatments. A summary of the analysis of variance for the plant measurements is given in Appendix I. As in the 1989 data, the treatment effects are not related to emergence or plant survival. The treatments had no significant effects on the number of plants at the 12 leaf stage or the number of cobs harvested per unit row length (Table 7).

Table 6. Yield measurements at Albin site (1990) (28% N vs Urea applicator)

Fertilizer Application Method	Corn Grain Yield (bu ac^{-1})					
	50 kg N ha^{-1} applied			150 kg N ha^{-1} applied		
	Planting[1]	6 leaf[1]	Avg	Planting[1]	6 leaf[1]	Avg
28% sidedress	65.5	51.6	58.5[a]	88.2	93.4	90.8[A]
28% sidedress + Coultering	71.0	60.2	65.6[a]	102.8	91.9	97.4[AB]
Urea sidedress + Coultering	78.3	102.8	90.6[b]	111.5	107.1	109.3[B]

1 Time of application

Values in the same column with different small letters are significantly different at Prob ≤0.05.

Values in the same column with different capital letters are significantly at Prob ≤0.07.

Table 7. Measured crop growth parameters for Albin site (1990)

	Measured Plant Parameters					
	50 kg N ha^{-1} applied			150 kg N ha^{-1} applied		
	L	LC	U	L	LC	U
Full Biomass (tonne ha^{-1})	11.3 [a]	16.2 [a]	16.0 [a]	21.1 [b]	18.3 [ab]	32.2 [c]
Biomass 6 L (kg ha^{-1})	158 [ab]	181 [ab]	210 [b]	130 [a]	140 [ab]	208 [ab]
Biomass N (kg N ha^{-1})	84 [a]	114 [ab]	121 [ab]	200 [b]	175 [ab]	337 [c*]
Tissue N (%)	0.74 [a]	0.70 [a]	0.70 [a]	0.95 [a]	0.90 [a]	1.05 [b]
12 1 f # plants (pl/m)	5.7 [a]	5.7 [a]	5.9 [a]	5.6 [a]	5.6 [a]	6. 2 [a]
# cobs (Cobs/m)	4.3 [a]	4.7 [a]	4.7 [a]	4.6 [a]	4.6 [a]	4.7 [a]

L = 28% N sidedress, LC = 28% N sidedress + coultered, U = Urea + coultered

Values in the same row with different letters are significantly different at the 0.10 probability level.

* Values are significantly different at the 0.05 probability level.

The 1989 data for the Albin site suggested that the urea zone-till system had a slight negative effect on corn yield response compared to the 28% N. However, the yield loss was slight and not significant. The addition of the starter fertilizer N with the urea zone-till system in 1990, and the increased placement distance appears to have eliminated any small negative effects the urea system had on grain yield, and in fact significantly increased the yield. While we suspect both were factors, further study would be necessary to reliably identify the reason(s) for the improvement. The coultering effect (zone-till) did not appear to increase the yield response using 28% N.

The 1989 data also showed a significant increase (Prob $\leq$ 0.11) in yield for the N applied at planting. The analysis of variance did not indicate time of application was significant in 1990 (Appendix I, Table I.8.). However, the 1990 data show a possible TIME interaction with dose and fertilizer application type (Prob $\leq$ 0.08). The data in Table 6 indicate that except for the urea 50 kg N ha^{-1} treatment, all treatments had higher yields for the planting application compared to the 6 leaf application. The high yield of the 6 leaf urea 50 kg N ha^{-1} treatment is possibly masking the time effect and creating a time interaction with Dose and Fertilizer application. However, the time effect is certainly not as strong as in the 1989 experiment.

<u>Prong site (28% N vs. Urea applicator)</u>

A summary of the effects of N fertilizer application rate on measured plant parameters is given in Table 8. The response to applied N at this site is smaller than the Albin site. There is a significant yield gain for both the 50 kg N ha^{-1} and the 150 kg N ha^{-1} treatments over the check (0 kg N ha^{-1}) treatment, but no significant difference between the 50 and 150 kg N ha^{-1} treatments. Similar trends were observed for the other measured plant parameters. The increase in yield for the 50 kg N ha^{-1} treatment (over the check) is an economic increase[3], but the yield gain from 50 to 150 kg N ha^{-1} is not. The yield response is similar to that observed in Albin 1989.

[3] An economic increase is defined as the situation where the marginal return is greater than the marginal cost assuming a price ratio equal to 5 (ie. the cost of a kg. of fertilizer is five times the value of a kg. of grain)

Table 8. Average crop measurements as a function of applied N fertilizer, Prong site (1990).

Measurement	Applied N fertilizer (kg N ha-1) 0	50	150
Yield (bu ac^{-1})	100.2 [a]	113.0 [b]	114.7 [b]
6 leaf Biomass (kg ha^{-1})	73 [a]*	89 [b]*	91[b]*
Full Biomass (tonne ha^{-1})	38.8 [a]	43.7 [ab]	45.9 [b]
Biomass N (kg N ha^{-1})	394 [a]	337 [a]	429 [b]
Tissue N (%)	1.02 [a]	0.77 [a]	0.93 [a]
12 leaf Plant # (pl^{-1})	5.8 [a]	5.8 [a]	5.9 [a]
# cobs (cobs $^{-1}$)	4.7 [a]	5.1 [b]	5.2 [b]

Values in the same row with different letters are significantly different at the 0.05 probability level.

* significantly different at the 0.10 probability level.

Since check yield is being used as a covariate, the analysis of variance (Appendix II, Table II.10.) for yield against the treatments indicated only a 0.18 probability level for yield response to applied N rate. No other factor were significant in the overall analysis of variance. A summary of yield data collected is given in Table 9.

Table 9. Corn grain response to treatments at Prong site 1990. (28%N vs Urea applicator)

Fertilizer Application Method	Corn Grain Yield (bu ac^{-1})					
	50 kg N ha^{-1} applied			150 kg N ha^{-1} applied		
	Planting[1]	6 leaf[1]	Avg	Planting[1]	6 leaf[1]	Avg
28% sidedress	111.1	116.9	114.0	115.9	118.6	117.2
28% sidedress + Coultering	103.9	109.4	106.6	107.9	105.2	106.5
Urea sidedress + Coultering	130.1	106.9	117.0	121.1	119.5	120.3

[1] Time of application

A summary of the yield data averaged across N rates and application time is given in Table 10 and indicates the U and L treatments are significantly higher (prob ≤ 0.10) than the LC treatment. The 6 leaf biomass values indicated a similar effect with U and L significantly different than LC (Appendix II). None of the other plant measurements were significantly different. The effects were not picked up as significant in the overall analysis of variance. The lower yields in the LC treatment may be due to the very wet spring and poor conditions at the site during the coultering.

In summary, the data suggest that at the 0.10 probability level there was a slight advantage of the L and U treatments over the LC treatment, but there was no significant difference between the L and U treatment. The decrease in yield in the LC treatment is attributed to the coultering effect, which in this case decreased the yield. Since the coultering is also used in the Urea treatment, the decreased yield from the coultering may be offsetting the increased yield in the U over the L treatment which was measured in the Albin site. The negative effect of coultering on this site and the low N response make conclusions difficult. However, the new Urea zone-tilled applicator (U) was at least as good as the L method, and slightly better (0.10 probability level) than the LC method (Table 10).

Table 10. Average grain response to treatments at Prong 1990

	Corn Grain Yield (bu ac[1])		
Fertilizer Method	Planting[1]	6 leaf	Avg
28% sidedress	113.5 [ab]	117.7 [a]	115.6 [b]
28% sidedress + Coultering	105.9 [a]	107.3 [a]	106.6 [a]
Urea sidedress + Coultering	125.6 [b]	113.2 [a]	119.4 [b]

Values in the same column with different small letters are significantly different at the 0.10 probability level.

Prong site Urea placement,

When the urea was applied at planting, there were no conclusive effects of varying widths and depths. However, yields were significantly lower when urea was placed 25 cm from the plant at the 6 leaf stage with treatments at the 15 cm depth yielding the least. This result could be explained either by toxicity or possibly by root damage that may have occurred while sidedressing. We assume the urea was available to the plant (6 leaf stage) at the 25 cm width, since the yields at planting indicate higher yields at the 25 cm width than at closer distances (Table 11).

A review of results (Table 11) suggests that volatilization was not a factor in the lower response to urea vs. 28% seen in Year 1.

A summary of the analysis of variance on yield response to the urea placement treatment is given in Appendix III, Table III.8.. As indicated there were significant effects for both width, depth, and time of placement. A summary of the yield data is given in Table 11. The most significant (prob $\leq$0.001) effect is the decrease in yield in the 6 leaf application treatment for both depths at the 25 cm width placement. This is a very significant effect which was also measured, but not picked up as significant in the previous Albin (1989) experiment. The increased replication of only Urea at different times and placement in this experiment allowed the difference to be measured as significant. An analysis of the Depth x Time (DxT) interaction (Appendix III) indicated that the 6 leaf - 15 cm depth treatment was also significantly lower (prob $\leq$0.05) than the 6 leaf - 5 cm treatment.

In order to analyze the effect of Depth and Width without the confounding effects of the 6 leaf time placement, a second analysis of variance was completed for only the treatments applied at time of planting. This is summarized in Appendix III, Table III.9., and indicates that once the effects of time of application are excluded, no other significant effects are measured. Analysis of variance was completed on all other plant parameters and the same effects were obtained.

Table 11. Grain yield response to placement of urea
Urea zone-till system, Prong 1990

	Corn Grain Yield (bu ac^{-1}) Width (cm)				
	Planting application				6 leaf appl.
Depth (cm)	10	15	25	Avg	25
5 cm	119.9	108.0	121.1	116.5	93.1 [A]
15 cm	105.8	116.2	120.8	114.3 [a]	69.3 [A]
Average	112.9 [a]	112.3 [a]	121.0 [a]	115.4	81.2

[A] Sites are significantly different than other measured yields at the 0.0001 probability level and significantly different from each other at the 0.05 probability level.

Values in the same row with different lower case letters are significantly different at the 0.05 probability level.

ECONOMIC IMPLICATIONS

Timing of Application

During this study, there were no yield advantages to the application of urea at the 6 leaf stage. Consequently, there would be an economic advantage to the fertilizer zone-tiller if this machine was pulled in tandem with the planter thus eliminating one field pass.

Fuel Consumption

There were no significant differences in fuel consumption or time required to apply fertilizer with the fertilizer zone-tiller vs. the 28% applicator.

Fertilizer Costs

With transportation costs, liquid 28% N is usually more expensive per kg. N applied than is urea.

While relative costs may vary from time to time, based on fertilizer prices obtained in the spring of 1991, the dry fertilizer combination (20% ammonium nitrate + 80% urea) was 6.6% cheaper (per kg. of N) than liquid 28% N.

Therefore, with dry fertilizer yields equal or better than 28% yields, there is an economic advantage to the dry fertilizer system described.

EOUIPMENT DEVELOPMENT AND MODIFICATIONS

1. OPERATIONAL PERFORMANCE - YEAR 1

In year 1, the four-row prototype was a pull-type machine. Two John Deere fertilizer boxes distributed the urea to 4 main hoses. A splitter device, designed by Till-Tech, directed the fertilizer to the two fertilizer attachments servicing each row.

Performance during plot use was generally good. The coulters (two per row) tilled a seed zone approximately 25 cm wide. Two types of fertilizer attachments were used. Three rows were equipped with disc openers and one outside row with back-swept knives (two attachments per row). No visual difference in the operational performance of these attachments was detectable. It should be noted that since test data were taken from sub-plots located in the middle two rows, the fertilizer attachment type is not a variable in the data.

In addition to plot use, the machine was field tested by Mr. Albin who used it to side-dress about 135 acres of corn. During this larger scale operation, some problems were encountered and these are described below.

2. PROBLEMS AND SOLUTIONS

During Planting

- visual inspection of fertilizer boxes during operation indicated that the fertilizer was flowing freely
- it was found that the fertilizer attachment adjusting mechanism for depth was not maintaining adequate depth control.

Solution: The adjusting mechanism was removed. Depth control now achieved by adjusting the coulter unit.

During Side-dressing

- it was necessary, due to a drier (harder) soil (vs. at planting), to add temporary weights in order to maintain an even coulter depth. This adjustment was made prior to entering the plot. The problem wasn't observed when the plot was planted.

Solution: Installation of weight brackets.

During Side-dressing (cont'd)

- it was observed that the machine tramped some corn when turning. This was due, in large part, to the fact that it was originally constructed as a pull-type machine rather than as a 3-point hitch with caster wheels. The machine was converted to a 3-point hitch draw method, with lift-assist wheels, prior to planting in 1990.

During Field-testing

During early July, 1989, Mr. Albin field tested the machine by using it to side-dress some 135 acres of corn. The larger scale use of the machine unveiled the following problems:

1) With greater vibration, the fertilizer tubes worked themselves loose at the point where they joined the fertilizer attachments.

Solution: A more secure attachment method.

1) Due to air humidity, the urea fertilizer was gumming in the splitting device (which directed the fertilizer to both sides of the row for a split application).

Solution: Modification to install an air delivery system.

Benefits:

- only one large fertilizer box would be required
- a more consistent fertilizer application rate

3. OPERATIONAL PERFORMANCE - YEAR 2

In the winter of 1990, the machine was converted to a three-point hitch type with lift-assist wheels. A Beline air delivery fertilizer box was mounted on the frame. The splitters were removed such that fertilizer was metered into 8 hoses (2 per row).

Calibration occurred at the Albin farm on May 7th. Plot work was delayed on May 8th since air humidity was causing the urea to stick and the fertilizer was not flowing properly. By mid afternoon however, the weather conditions had changed such that the dry fertilizer flowed smoothly. Similar problems were not experiencedat the Prong - clay loam site.

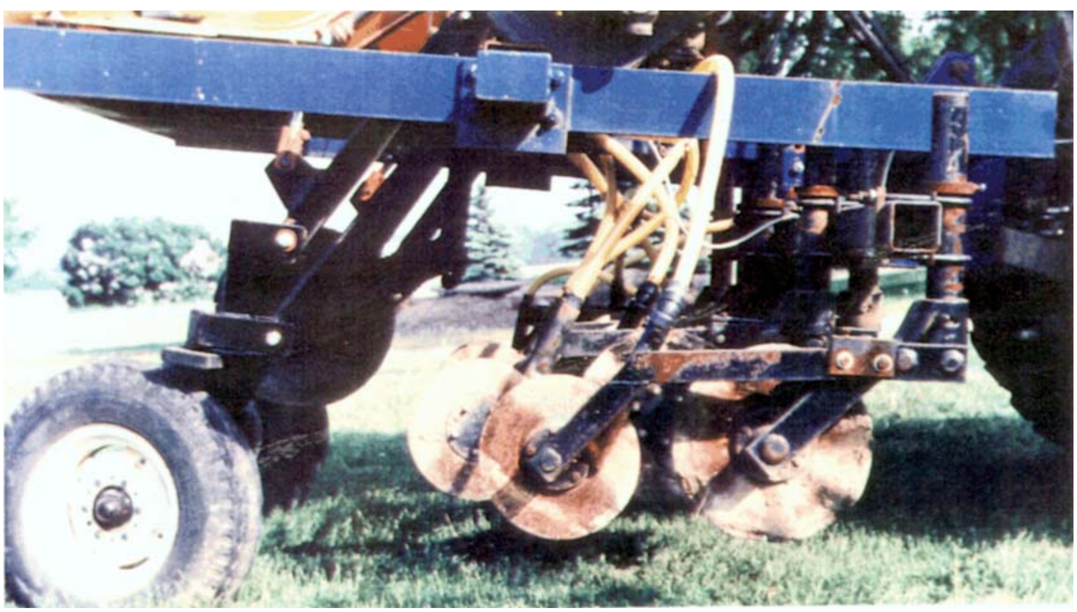
4. EQUIPMENT DESIGN AND SPECIFICATIONS

The machine was designed and constructed by Till-Tech Systems Limited (Till-Tech). The following specifications describe the prototype machine as is and DO NOT necessarily describe fertilizer zone-tillers produced for sale after March 31, 1991.

• Hitch mounted	
• Working width	12 feet
• No. of toolbars	1
• Toolbar gage/dimensions	4" x 4" x .250"
• Spring-loaded, swivel coulters	2 per row
• Coulter type	2 inch wavy blades
• Method of depth control	Hydraulic
• Transport width	12 feet
• Transport length	10 feet
• No. of wheels	2
• No. of rows	4
• Hopper capacity	22 cu. ft.
• Hopper material	steel painted with epoxy paint
• Hopper equipped with agitator?	No
• Application rate - Min. (lbs./acre)	3
• Application rate - Max. (lbs./acre	180
• Distributor fan diameter - inches	13
• Distributor fan speed	3000 RPM
• Dist. fan - # of blades	44
• Fan driven by	Hydraulic motor
• Metering Drive System	Electronically driven; in-cab control regulates the speed of the metering system in conjunction with a ground speed compensation system

Front view of coulter and disc opener for left side of Row 1

Lateral view of Fertilizer Zone-tiller showing 3-bar construction



5. ENHANCEMENTS NEEDED FOR COMMERCIAL USE

1) Metering system. The roller-type metering device in the air delivery unit on the machine did not satisfactorily accommodate sticky product which resulted from humid conditions.

Solution: We feel a chain delivery system would ensure more accurate distribution of the product to all fertilizer attachments.
Secondly, an agitator in the fertilizer box would break up any product that was sticking prior to itreaching the chain metering device.

2) Marking system. A marking system was not required for the purposes of this study as "natural" markers were available (ie. previous crop rows) in both proposed plots. However, when corn is planted into the residue of soybeans or small grains, natural markers may not always be distinguishable. Since the normal, or recommended, practice in no-till situations is a crop rotation that includes only 1 year of corn, a marking system would be necessary to make this machine suitable for commercial use.

Funding for a marking system was approved for year 2 of this project however, the markers were back-ordered until after planting. Consequently, markers were neither installed nor charged as a project expense.

SUMMARY

Table 12 gives an overall summary of corn grain yield for the different site/treatment/years. For the 12 comparisons (rate/year/placement of 28% (L) versus dry form N, the dry fertilizer (U) treatment was only lower for 3 comparisons. In fact, the U treatment is almost statistically significantly higher than the L treatment, overall. This and the fact that the U treatment was statistically higher than the L treatment at the Albin farm (1990) indicates that the dry fertilizer system as tested is at least as good as the 28% liquid treatment [1].

The comparable performance of the Urea system is attributed to some combination of split placement (both sides of row), starter N in ammonium nitrate form (20% of total nitrogen)[2], and possibly the coultering system.

Table 12. Overall yield summary for different site/treatment/years

Site/Treatment	Corn Grain Yield (bu ac⁻¹)			
	Planting		6 leaf	
	28% N	Urea	28% N	Urea
ALBIN 50 kg, 1989	93.1	94.2	86.4	80.8
ALBIN 150 kg, 1989	102.2	89.2	88.1	86.5
ALBIN 50 kg, 1990	65.5	78.3	51.6	102.8
ALBIN 150 kg, 1990	88.2	111.5	93.4	107.1
PRONG 50 kg, 1990	111.1	130.1	116.9	106.9
PRONG 150 kg, 1990	115.9	121.1	18.6	119.5
Average	96.0	104.1	92.5	100.6
UD1/1990	--	121.1	--	93.1
UD2/1990	--	120.8	--	69.3
Average		108.3		95.8

1 The experiment cannot conclude that Urea fertilizer is better than 28% N fertilizer, since this was not tested.

2 More work needs to be done on the specific effects of the starter N, and time of application.

The fertilizer zone-tiller/dry fertilizer system yields an economic advantage when the fertilizer costs are compared; urea is usually a cheaper source of nitrogen, since less product is transported when it is used (compared to liquid 28% N).

Other advantages of the fertilizer zone-tiller, as it facilitates dry fertilizer placement, are seen as follows:

Environmental risks are lower when using dry fertilizer vs. liquid 28% N since liquid more readily percolates through the soil if spilled.

It is a readily adaptable fertilizer system for the many farmers who are already equipped to handle dry fertilizer. In contrast, storage tanks and injection pumping equipment are required when liquid 28% is used. Furthermore, environmental legislation in Ontario requires that special containment facilities be constructed if liquid 28% is stored on farm.

Dry fertilizer is available to a wider cross-section of farmers (ie. in some parts of Ontario, liquid 28% is not an option due to availability/cost).

In conclusion, given the economic and environmental advantages of the dry fertilizer system tested, the fertilizer zone-tiller is clearly a viable, if not preferable, option for fertilizer placement in conservation-tillage programmes.

PROJECT PUBLICITY

* Innovative Farmers of Ontario - a group of 75-100 producers toured the plot on June 26th, 1990; they expressed interest in knowing the effects of varied fertilizer placement.

* Brant Cty. plot was included in a self-guided tour organized by the Grand River Conservation Authority. The plot is appropriately posted with signs.

* Information about the plot was available at the International Plowing Match, hosted by Brant Cty. in 1990.

* Plot sites posted with SWEEP - TED signs.

* Paris Star - project mentioned in an article featuring Mr. Albin. He was interviewed in connection with his receiving a Certificate of Appreciation from the Grand River Conservation Authority for his efforts in promoting soil conservation to county farmers.

* Country Guide - article entitled "Machinery made for residue" (December 1990) described the fertilizer zone-tiller ("urea placer") and its benefits.

* Brant Conservation Competition annual meeting - Feb. 1991 Dr. Kachanoski mentioned the project as part of his presentation. Considerable interest was shown by those in attendance.

* 1990, 1991 TED Conferences