NITROGEN MANAGEMENT FOR NO-TILAGE CORN

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INTRODUCTION

Acceptance of no-tillage and reduced tillage crop production methods, often collectively referred to as conservation tillage, has expanded rapidly in many parts of the U.S. in recent years, particularly in the Mid-Atlantic and Southeastern regions. According to Peter C. Myers, chief of the Soil Conservation Service, "Conservation tillage is being adopted faster than any other practice in the history of farming. In 1972, (there were) 30 million acres. In 1982, (there were) more than 100 million acres. By the year 2010, as much as 95 percent of all U.S. cropland may be farmed with conservation tillage methods" (12). In Maryland, the extent of no-tillage and reduced tillage corn increased from less than 10,000 acres in 1970 to more than 350,000 acres by 1978 (1). A 1983 Maryland county-by-county survey showed that even in a year when the Federal Governnent's PIK (Payment-in-Kind) program encouraged an overall reduction in corn acreage, over 400,000 acres of corn were nevertheless reported in other Kid-Atlantic states where, on the average, conservation tillage corn acreage increased from less than 5% in 1970 to almost 30% in 1978 (1). No-tillage reduces costs for fuel, labor, and equipment. It can also reduce soil erosion losses on many soils by 50% to 90% percent and improve soil moisture retention (12,13,19).

Once it was recognized that no-tillage corn production was practical, it became apparent that many of the traditional lime and fertilizer practices long associated with conventional tillage might no longer be suitable or even possible. With the introduction of improved no-tillage planters, farmers foucd that they could establish excellent corn stands without prior soil tillage. It became obvious that traditional rates and methods of nitrogen application did not consistantly result in expected yields and acceptable nitrogen efficiency. A number of investigators have reported the need for increased fertilizer N for corn grown under no-tillage than under conventional tillage (3,10,11,16).

Some nitrogen management problems have resulted from the trend of the fertilizer industry away from ammonium nitrate and toward urea (9). Indications are that increased use of surface-applied urea or urea-based fertilizers in conservation ti1lage systems often present agronomical and subsequent economical problems for the farmer (2,17). It is well known that under favorable conditions, significant quantities of nitrogen can be lost to the atmosphere from surface-applied urea due to armmonia volatilization (5,9,18). The "bottom line" is that where urea or urea-based fertilizers are surface applied, particularly in the presence of organic residues, crop yields are often reduced (2,7,14,17). In some cases, ammonia losses from surface applied urea may be reduced by appropriate use of a nitrification inhibitor (6). Considerably improved N efficiency can be obtained by proper fertilizer placement (2,17), or if sufficient rainfall occurs at a fortuitous time. According to Fox and Hoffman (7), there is an apparent relationship between timeliness of rainfall after N application and possible N volatilization losses. They have suggested the following relationships: "(1) there was insignificant ammonia volatilization loss from unincorporated urea fertilizers if at least 10 mm (0.4 in.) of rain fell within *48* hours after fertilizer application; (2) if 10 mm or more fell 3 days after the urea was applied, volatilization losses are slight (<10%); (3) if 3 to 5 mm (0.1 to 0.2 in.) of rain fell within 5 days, or 7 to 9 mm (0.3 to 0.4) in.) within 9 days, volatilization losses could be moderate (10% to 30%); and (4) if no rain fell within 6 days, the loss could be substantial (>30%).

According to the 1984 FERTILIZER SUMMARY DATA published by the Tennessee Valley Authority (8), of the major direct applied nitrogen materials utilized on U.S. farms, 14.1% was attributed to urea and 27.8% to UAN solution. In Maryland, where no-tillage crop production has gained rapid popularity, 8.4% of the direct applied nitrogen came from urea, and 62.2% came from UAN solution. In Kentucky, another state with a high degree of farmer acceptance of no-tillage crop production practices, urea is reported to be the number one direct applied source of N. Urea accounts for 31.7% of the direct applied N, whereas UAN solution accounts for 12.6%. The relatively high popularity of UAN solutions in recent years is probably related to the fact that many herbicides and other pesticides can be tank-mixed with UAN, thus saving one or more extra trips across the field. The potential problems associated with surface applied urea and other urea-based fertilizers is already widespread, and will continue to grow as acreage of reduced tillage and no-tillage N management besides N source, include N rate, N placement and time of N application. These topics will be discussed in greater detail in the following sections.

NITROGEN RATE FOR MAXIMUM YIELDS

As no-tillage corn gained in popularity during the 1970's, one difference observed between no-tillage and conventional tillage was the "apparent" need for higher nitrogen levels in no-tillage fields. Unfortunately, some individuals incorrectly interpreted this difference as an indication that no-tillage corn is a less efficient utilizer of fertilizer N than conventional tillage corn. But, when properly managed, no-tillage corn actually provides a MORE EFFICIENT vehicle for fertilizer N utilization than does conventional tillage.

Long-term N rate by tillage experiments conducted in Maryland since *1973* have provided data relative to the nitrogen requirements of the two tillage systems. These tests substantiated that at sub-optimal N rates, N deficiency symptoms were more pronounced in no-tillage than in conventional tillage corn. Some of this work illustrated the major differences in N requirements between the two tillage systems. In these tests, N was applied to both no-tillage and conventional tillage corn at rates of 0, 80, 120, 160 and 240 lb/A. Yield data from one typical location-year are presented in Table 1.

From the response curves in Table 1, it would appear that the 240 lb/A N rate resulted in highest yields for no-tillage and the 160 lb N/A rate resulted in highest yields for conventional tillage. However, neither of these curves actually "peaked" at these nitrogen levels. Using a statistical technique known as curvilinear regression, best fitting curved lines were selected for these data points. These lines showed that grain yields for both tillage systems continued to increase to some N rate(s) between 160 and 240 lb/A. Maximum yields should have occurred approximately 214 lb N/A for no-tillage and at approximately 183 lb N/A for conventional tillage corn -- approximately 31 lb/A more N for no-tillage than for conventional tillage corn in this case. These values illustrate typical differences in N requirements between the two tillage systems. Experience has shown that differences in maximum yield N requirements between typical no-tillage and conventional tillage corn systems average about 30 to 40 lb N/A more for no-tillage, but may vary from essentially 0 to more than 60 lb N/A. The magnitude of these differences depends upon many factors, such as soil type, past cropping history, seasonal rainfall and temperature, soil pH, etc. These are all factors which directly or indirectly influence the level of residual soil N available to the growing crop.

Despite no-tillage corn often requiring a higher fertilizer N rate than conventional tillage corn to obtain maximum yields, increased N levels on no-tillage corn are generally rewarded under Maryland conditions by higher yields than yields obtained on conventionally tilled corn at the same N level. For instance, in Table 1, no-tillage corn yields exceeded those from conventional tillage by approximately 20 to 36 bu/A at the more optimal N fertilization rates. When the amounts of fertilizer N required to produce a bushel of corn were calculated (Table 2), it was apparent that at N rates of less than 120 lb/A, no-tillage corn required about the same amount of N/bu as conventional tillage. But, at N rates of 120 lb/A or more, no-tillage corn required **LESS** N/bu than conventional tillage. For instance, at N rates of 120, 160 and 240 lb/A, each bushel of conventionally tilled corn required 1.0, 1.2 and 2.0 lb N/bu respectively compared to 0.9, 1.1. and 1.6 lb N/bu for no-tillage corn. At these higher N rates, conventional tillage corn required 1.1, 1.1 and 1.2 times more N respectively than similarly treated no-tillage corn. N efficiency relative to grain yields declined for both tillage systems as N rates increased. But N efficiency for no-tillage corn was always higher than that for conventional tillage corn at N rates of 120 lb/A or more.

Summarizing yield data collected over a 13-year period from as many as five Maryland locations (Table 3), showed that at sub-optimal N rates (below 80 lb N/A), conventional tillage corn out-yielded no-tillage corn 64% to 69% of the time. At the 80 lb N/A rate, the odds continued to be about evenly divided between the two tillage systems (46% for no-tillage and 54% for conventional tillage). But, at the more optimal N rates 120 lb N/A or more, the odds were reversed, and the probability for highest yields turned strongly in favor of no-tillage. No-tillage corn OUT-YIELDED conventional tillage corn 61% to 78% of the time at these higher, more optimal N rates.

Obviously, when managed properly and fertilized at the optimal N rate, no-tillage corn can be expected to deliver more efficient use of fertilizer N than conventionally tilled corn. No-tillage corn can be expected to normally return more profit per acre from properly applied N fertilizers than its conventionally tilled counterpart.

NITROGEN SOURCE

As discussed briefly in the INTRODUCTION, N fertilizers containing urea frequently are not as efficiently utilized when surface applied as ammonium nitrate or other materials less sensitive to volatilization losses. In a series of Maryland tests conducted from 1976 to 1979 at three locations, ammonium nitrate resulted in the highest and urea the lowest average no-tillage corn yields (2). Yields from UAN solution were intermediate between ammonium nitrate and urea (Table 4). Calculated response curves fitted to a summation of this data covering 12 location-years estimated that at the 160 lb N/A rate, urea utilization by no-tillage corn was 61% as efficient as amrmnium nitrate and 80% as efficient as UAN. Broadcast UAN solution was 75% as efficient as ammonium nitrate and 125% as efficient as urea in these tests.

In spite of the frequently erratic behavior of urea under no-tillage conditions, the importance of urea to agriculture cannot be discounted. Urea has the highest N content of any solid N fertilizer on the market. And because of more favorable economics in manufacturing, as well as the lack of many government restrictions on transportation and storage that have been imposed upon ammonium nitrate, urea has the potential to become a very important dry nitrogen material. Therefore, it becomes extremely important that more efficient methods of utilizing urea and UAN solutions continue to be investigated and refined.

If the cost per unit of N were the same for all N sources, amrmnium nitrate would appear to be a better value than either UAN or urea for surface application on no-tillage fields. UAN would also appear to be more economical than urea under no-tillage conditions. However, any cost differential between these materials must be taken into account when determining application rates. If the cost per unit of N from urea or UAN is significantly lower than that of ammonium nitrate, then it may be economically sound to increase the rate of application for urea or UAN to compensate for the lower efficiency of these materials. But since any nitrogen fertilizer should be considered as a valuable resource to be conserved and also as a potential pollutant of lakes, streams, rivers and ground water, a more practical approach to improve N efficiency might be to modify the application method or time of application.

NITROGEN FERTILIZER PLACEMENT

One proven technique for increased efficiency of urea-based fertilizers is soil incorporation. Since this technique requires special equipment if utilized under no-tillage conditions, a research project was initiated in 1979 at the University of Maryland in cooperation with the Tennessee Valley Authority to develop and test the effectiveness of an experimental apparatus for soil injection of liquid fertilizers under no-tillage field conditions. Subsequently, a tractor-mounted three-point-hitch soil injector was developed for use on small plots. Solutions of ammonium nitrate, urea or UAN were placed between the rows about 15 inches from the plant, and about 4 to 6 inches deep. A plow coulter in front of the injection knife cut through plant residues. Results from some of this research are presented in Table 5 (4).

Over the four-year duration of this experiment, surface broadcast N resulted in the largest yield differences among N sources. Ammonium nitrate resulted in the highest yields, and broadcast urea resulted in the lowest. Broadcast UAN resulted in yields intermediate between those from ammonium nitrate and urea. Corn grain yields from broadcast urea averaged 26.8 bu/A less than those from ammonium nitrate. For individual years, this difference ranged from 13.4 to 36.5 bu/A. Grain yields from broadcast UAN averaged 11.2 bu/A less than those from broadcast ammonium nitrate. Over the four-year duration of the test, yields after UAN were 8.4 to 15.9 bu/A lower than yields from ammonium nitrate.

Soil injection improves N fertilizer efficiency under no-tillage conditions. In those cases where all three N fertilizers were soil injected, no statistically significant grain yield differences occurred between N sources. considering only the N, injection is obviously the most efficient method available. but, there are also some disadvantages with this technique. For instance, few farmers are currently equipped to inject prilled or granular but is not as rapidly accomplished as other methods of fertilizer application. Soil injection requires more energy than surface application. Most farmers already own, or have access to, a sprayer. But many do not have access to an injection apparatus. Thus, injection may not be as convenient as other techniques. Another potentially serious problem is that the traditional anhydrous ammonia-type knife often used for injection causes soil disturbance which may create an erosion problem on more rolling topography. High pressure injection, or use of solid stream nozzle behind a straight plow coulter may remove some of these disadvantages. Field testing of some of these innovative techniques in cooperation with the Tennessee Valley Authority, USDA and the Arcadian Corporation is being conducted. Some preliminary results obtained at five Maryland locations in 1984 and 1985 are presented in Tables 6 and 7. It is important to recognize that the timely spacing of rainfall events at most locations in 1984 probably was a major reason why larger differences did not occur more frequently between application methods or materials. Greater stress was placed upon the treatments in 1985. Unfortunately, 1985 was severely dry at some locations causing stand reductions and reduced yields. On the average, broadcast ammonium nitrate and UAN injected either by anhydrous knife or by low pressure solid stream nozzle into a plow coulter slot resulted in highest yields. But UAN broadcast or dribbled were a close second. Broadcast urea and UAM injected by the high pressure NUTRI-BLAST 2000 resulted in lowest yields in the 1985 tests.

With proper equipment, soil injection of N solutions works very well, usually with a yield advantage. But, until significant improvements in machine availability occur, it is doubtful that many fanners will have injection available as a practical option. Since most growers either own or have access to a sprayer that could be used to apply fertilizer solutions, another application technique known as "dribbling", or surface banding, is being considered.

"Dribbling" of N solutions is a simple, low-cost procedure that can easily be accomplished by attaching a length of hose over the sprayer nozzle. This technique is effective for improving the efficiency of surface applied UAN under most normal growing conditions. Results from tests conducted at several

Maryland locations in 1982 are presented in Table 8.

In all four comparisons in Table 8, dribbled UAN was statistically superior to broadcast UAN. Increased yields from dribbling UAN compared to broadcast averaged 21.8 bu/A (17.8%) and ranged from 12.6 to 36.7 bu/A in favor of the dribble technique (9.2% to 30.6% increase). Even when corn is priced at only $2.00/bu, improved N efficiency from dribbling translated into an additional income of $25.20 to $73.40/A (average $43.60/A). Essentially, the only additional cost to this practice is for the purchase of a few lengths of hose, plus perhaps an extra trip over the field if the grower normally had been following the traditional practice of tank-mixing pesticides with UAN for simultaneous application. It would appear that surface banding (dribbling) UAN solutions on no-tillage corn is a reasonable alternative to the apparently large N losses otherwise experienced when broadcast application methods are employed.

TIMING NITROGEN APPLICATIONS

Proper timing of N applications on any crop is extremely important. But, it is doubtful that there has ever been a crop where proper N timing is more critical than it is for no-tillage corn. Proper N timing is particularly critical because of the many ways in which fertilizer N can be lost under no-tillage, many of which are not a serious concern under conventional tillage. A good “rule of thumb’’ is to ‘‘apply N fertilizer as near as possible to the time of plant need”. N leaching losses can be a problem on light-textured sandy soils regardless of the tillage system. But where no-tillage is practiced, a number of other factors nay also significantly influence N use efficiency if abused or ignored.

Under no-tillage management, N fertilizers may be lost from the soil by ammonia volatilization, denitrification and/or by biological immobilization. Or mechanisms include ammonia volatilization from surface applied urea or urea-based fertilizers, and denitrification, a process by which readily available nitrate N is chemically reduced (oxygen removed) until it is converted to a gas. Denitrification is believed to be a major source of fertilizer N losses from no-tillage soils and is most often a problem is wet soils where oxygen availability is limited. Denitrification can be serious during growing seasons in which wet soils are a problem, particularly when nitrogen was applied at times not coinciding closely with plant needs.

Another important mechanism that reduces fertilizer N availability is microbial immobilization, a process in which certain soil microbes decompose plant residues and convert them into soil organic matter (humus). Crop residues, such as old corn stalks, leaves, cobs, roots, etc. are relatively high in carbon and low in nitrogen. For soil microbes to convert such residues into protein relatively high in N, a readily available N source is necessary. Fertilizer N applied before needed by the crop could be consumed by microbes (immobilized), rendering it temporarily unavailable to plants. Most immobilized N remains unavailable to plants until the newly formed soil humus is broken down by oxidation (mineralized), releasing the immobilized nutrients. Cultivation, for instance, encourages mineralization by aerating the soil, allowing oxygen to react with the organic matter.

No-tillage corn production is an excellent example of a cropping environment in which N immobilization could be a serious problem. If N fertilizers are applied too early in the growing season, when N requirements of corn are minimal, then more biological N immobilization could occur than if N fertilizers were applied in a more timely manner. Corn requires very little N during its first 25 to 30 days. N applied during this period would not be in heavy demand by the crop. As plant dry matter increases, the crop's need for N also increases. N applied during this latter period could also be immobilized, but not likely to as great an extent as the early-applied N because there would be more intense competition for it by the rapidly growing plants. A good example of the possible combined effects of ammonia volatilization, denitrification and immobilization on corn grain yields, and the extent to which these effects can be minimized by N placement and timing of application is presented in Tables 9 and 10.

Relatively long term tests have been conducted at three locations across Maryland to test the effectiveness of nitrogen solution placement and time of application on nitrogen efficiency by no-tillage corn. Tests were established in 1980 on silt loam soils at two Coastal Plain locations (Poplar Hill Research Farm and Wye Research Center), and at one Piedmont location (Forage Research Farm) to compare the effects of broadcast versus injection of UAN solution on no-tillage corn yields. UAN solution was applied either within a few days of planting (early treatment) or about one month after planting (late treatment). These tests have been continued following the same treatment format through 1985.

After 18 location-years, a summary of the yield results as influenced by time of application and broadcast versus dribble (surface band) are given in the first half of Table 9. many corn growers have traditionally used the "early" broadcast technique as a standard method of application. Many like this method since it allows them to "tank mix" many of their pesticides with UAN, and apply everything with just one pass over the field. But is the time saved worth the risk of lower nitrogen efficiency and subsequent nitrogen losses? These tests were designed to help answer this question. With that objective in mind, we will consider the "early" broadcast application technique as the standard against which to compare the other treatments.

These data would indicate that although the efficiency of UAN (compared to broadcast) can be greatly improved by either injection or by delayed (late) rather than early (near planting) application, highest yields and highest nitrogen efficiency were obtained following a combination of correct placement and application timing. UAN injected near planting increased yields 7.4% over those obtained following broadcast UAM near planting (Table **10).** UAN broadcast about one month after planting resulted in about a 10.3% yield increase compared to the earlier broadcast application. However, by both delaying the application and by injecting instead of broadcasting, yields were increased 14.2%. Although the effects of time of application on grain yields following injection were relatively small (3.5%), the effects of the combined placement and time of application treatments obviously are additive.

The dribble technique was not initially included in these tests. The experimental design was modified slightly in 1983 to accommodate this surface banding method which many farmers prefer because it is easy to use, requires only a simple modification to equipment many farmers already own, and has been proven to be generally a more efficient method to apply UAN than broadcasting near planting. The nine location-years of data are presented in the second half of Table 9. These data show trends very similar to those for the 18 location-years of data in the first half of Table 9. In these tests, dribbling UAN near planting tended to he more efficient than broadcasting, and increased yields 4.7%. Injection near planting increased yields 19.8% compared to the early broadcast (Table 10). It is believed that more timely rainfall events in the spring soon after UAN was applied resulted in improved efficiency of broadcast UAN. Had more time elapsed between UAN application and the first significant rainfall, more of the broadcast UAN would probably have been lost. By broadcasting the UAN about one month after planting, grain yields were increased 12.5%. The delayed dribble application improved grain yields 7.7% over the early dribble and 12.8% over the early broadcast. The delayed UAN injection was about the same as early UAN injection with a yield increase of only 1.1%. Rut when grain yields from the delayed injection were compared to yields from the early broadcast, yields improved 21.1%. Some very important and useful observations from this work were that (1), for those growers who can inject UAN, there is more flexibility regarding time of application. And (2), for those growers who can delay their UAN application, there are more options available in method of application.

SUMMARY

An attempt has been made to demonstrate the importance of more careful nitrogen management on no-tillage corn. Factors that were of minimal importance under conventional tillage require more intensive management under no-tillage conditions. Special consideration must be given to N source, time of N application and N placement. Based upon current research and experience, a suggested fertilization program for no-tillage corn might be as follows:

***Use a starter fertilizer in a band near the row to supply 20 to 40 lb/A of N. Ideally, this fertilizer should also include P_2O_5 and K_2O in a 1:2:1, 1:3:1, or one of many other widely recommended ratios for starter fertilizers.

***Broadcast according to soil test any remaining P_2O_5 and K_2O requirements. Timing is not as critical for this operation as long as leaching and erosion are not problems. It is preferable that application be made sometime before planting.

***Apply the remaining N requirement about 4 to 6 weeks after planting, or when the corn has attained a height of 12 to 18 inches. If UAN solution is utilized, dribble (surface band) or inject between the rows.

***On the average, approximately 30 to 40 lb/A more N may be required for no-tillage than for conventional tillage corn. But, the amount may vary considerably from soil to soil, possibly from 0 to 60 lb/A or more. The difference in N requirement between the two tillage systems will depend upon soil conditions and past cropping history. But, experience in Maryland suggests that any extra N required is normally justified by the higher yield potential of no-tillage corn.

***For those growers who can inject UAN, there is considerable flexibility regarding time of application.

***For those growers who can split their UAN application and delay application of most of the N until three or four weeks after planting, more options are available in method of application.

DATA

Table 1. Grain Yields for Conventional tillage and No-Tillage Corn Following Variable Nitrogen Rates. Poplar Hill Research Farm. 1985.

	N (lb/A)**					
Tillage	0	80	120	160	240	Mean
	bu/A					
No-Tillage	23.3	97.3	128.8	153.0	155.9	111.7*
Conv. Tillage	37.7	102.3	108.0	126.2	119.9	98.8"
Mean	30.5	99.8	118.4	139.6	137.9	105.2

NOTE: LSD/.05:N Rate = 20.7 bu/A; LSD.lO: Tillage x N Rate - 24.3 bu/A.
* Tillage means are significantly different at the 5% level.
**40 lb N/A applied 4-29-85, remainder applied 6-7-85.

Table 2. Ratios of Fertilizer N to Grain Yield for Conventional Tillage and No-Tillage Corn Following Variable Nitrogen Rates. Popular Hill Research Farm. 1985.

	N (lb/A)					
Tillage	0	80	120	160	240	Mean
	bu/A					
No-Tillage	0.0	0.8	0.9	1.1	1.6	0.9
Conv. Tillage	0.0	0.8	1.0	1.2	2.0	1.0
Mean	0.0	0.8	1.0	1.2	1.8	-.-
Ratio: Conv. Till/ No-Tilalge	-.-	1.0	1.1	1.1	1.2	-.-

NOTE: Ratios calculated from points on best-fitting curvilinear regressions.

Table 3. Influence of Tillage on Probability of Obtaining Maximum Corn Yields from Variable Nitrogen Rates at Five Maryland Locations. 1973-1985.

Nitrogen	No-Tillage1/		Plow Tillage/2		
Rate lb/A	No. Tests	%	No. Tests	%	Total Tests
0	16	31	36	69	52
40	9	36	16	64	25
80	24	46	28	54	52
120	33	67	19	33	52
160	37	73	15	27	52
240	21	78	6	22	27

1/ Number of tests and percent of time in which no-tillage corn out-yielded conventional tillage corn.
2/ Number of tests and percent of time in which conventional tillage corn out-yielded no-tillage corn.

Table 4. Influence of Nitrogen Rate and Source on No-Tillage Corn Grain Yields at 3 Locations. 1976 to 1979.

N Source	N (lb/A) 0	40	80	120	160	Mean
	bu/A					
Ammonium Nitrate	85.6	107.0	130.5	141.4	147.7	122.4
Urea	85.6	100.6	119.6	126.9	135.8	113.7
UAN	85.6	97.3	120.7	134.3	141.9	115.9
Mean	85.6	101.4	122.6	132.4	140.3	117.4

NOTE: LSD/.05: N Source = 3.2 bu/A, N Rate =3.2 bu/A,
N Source x N Rate = 6.4 bu/A

Table 5. Four-Year Summary of the Influence of N Source and N Placement on No-Tillage Corn Yields. Poplar Hill Research Farm. 1979 to 1982.

Nitrogen Placement	N Source 1/ Ammonium Nitrate	Urea	UAN	Mean
	bu/A			
Broadcast	153.9	127.0	142.7	141.2
Injection	155.1	152.8	158.1	155.4
Mean	154.5	139.9	150.4	148.3

NOTE: N placement means significant at 5% level. 1/ N applied at 120 lb/A.
LDS/.05: N source = 4.2 bu/A, N source by N placement = 6.0 bu/A.

Table 6. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Several Locations. 1984.

N Treatment	Poplar Hill	Wye Res. Center	Belts-ville	Forage Farm	Sharps-burg	Mean
	bu/A					
Check	49.4	51.2	82.0	144.9	109.6	87.4
Ammonium Nitrate	170.4	173.3	150.7	195.9	146.3	167.3
UAN Broadcast	140.6	135.1	143.5	197.3	146.0	152.5
UAN Dribbled	143.8	158.5	141.2	184.2	142.2	154.0
UAN Injected 1/	182.0	156.4	162.6	198.7	141.7	168.3
UAN Injected 2/	165.0	155.0	154.4	200.3	144.6	163.9
UAN Injected 3/	161.9	155.4	145.6	177.1	146.8	157.4
Urea Broadcast	----	115.8	123.1	163.1	148.6	137.6
LSD.05	12.1	26.0	21.1	25.4	16.7	

NOTE: 120 lb N/A applied near planting time. UAN injected by 1/ anhydrous ammonia knife, 2/ low pressure solid stream nozzle into plow coulter slot, or 3/ high pressure NUTRI-BLAST 2000.

Table 7. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Several Locations. 1985.

N Treatment	Poplar Hill	Wye Res. Center	Belts-ville	Forage Farm	Sharps-burg	Mean
	- - - - - - - - - - - - - - -	- - -	bu/A	- - -	- - - - - - - - - - - - - - -	
Check	68.3	33.9	57.4	41.4	107.3	61.7
Ammonium Nitrate	127.6	138.0	108.0	179.1	166.2	143.7
UAN Broadcast	139.6	113.1	101.2	162.5	161.4	135.6
UAN Dribbled	134.3	109.7	83.7	162.1	167.5	131.5
UAN Injected 1/	143.8	144.2	99.6	178.3	163.4	145.9
UAN Injected 2/	142.6	118.0	98.2	185.2	160.8	140.9
UAN Injected 3/	137.6	96.6	84.6	116.2	----	108.8
Urea Broadcast	----	119.3	90.8	107.2	161.3	119.7
LSD .05	19.3	15.8	22.1	34.8	15.7	

NOTE: 120 lb N/A applied near planting time. UAN injected by 1/ anhydrous ammonia knive, 2/ low pressure solid stream nozzle into plow coulter slot, or 3/ high pressure NUTRI-BLAST 2000.

Table 8. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Wye Research and Education Center and Poplar Hill. 1982.

N Treatment	Wye/1	Poplar Hill/1	Poplar Hill/1	Poplar Hill/2	Mean
	- - - - - - - - - - - - - - -	- - -	bu/A	- - - - - - - - - - - - - - -	
Check	33.3	31.1	42.3	42.3	37.2
Ammonium Nitrate	112.4	155.1	141.9	163.6	143.2
UAN Broadcast	99.0	119.9	136.3	159.0	128.6
UAN Dribbled	119.9	156.6	148.9	176.0	150.4
UAN Injected	124.2	167.2	156.2	178.4	156.5

NOTE: 1/ N rate = 120 lb/A, 2/ N rate = 160 lb/A.

Table 9. Influence of Nitrogen Placement and Time of Application on Average No-Tillage Corn Grain Yields at Three Locations. 1980-1985.

N Placement & Time	- - 1980 to 1985 - - May/1	June/2	********	- - 1983 to 1985 - - May/1	June/2
	- - - - - -	- - - - - -	bu/A	- - - - - -	- - - - - -
Broadcast	135.6	149.6	********	124.4	140.0
Dribble	---.-	---.-	********	130.3	140.3
Inject	145.6	154.8	********	149.1	150.7
LSD.05	4.5			6.5	

NOTE: UAN applied at a rate of 120 lb N/A.
1/ UAN applied in May within 2-3 days of planting.
2/ UAN applied in Juen approximately 4 weeks after planting.

Table 10. Relative Influence of Nitrogen Placement and Time of Application on Average No-Tillage Corn Grain Yields. 1980 to 1985. May Broadcast = 100%.

N Placement &	- - 1980 to 1985 - - May/1	June/2	********	- - 1983 to 1985 - - May/1	June/2
	- - - - - -	- - - - - -	% /3	- - - - - -	- - - - - -
Broadcast	100.0	110.3	********	110.0/3	112.5
Dribble	---.-	---.-	********	104.7	112.8
Inject	107.4	114.2	********	119.8	121.1

NOTE: UAN applied at a rate of 120 lb N/A.
1/ UAN applied in May within 2-3 days of planting.
2/ UAN applied in June approximately 4 weeks after planting.
3/ Relative to May Broadcast = 100.0.

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