AMMONIA AND BENEFITS OF DEEPER PLACEMENT [1]

J.T. HARAPIAK [2]

There are two forms of ammonia now available in western Canada. Aqua ammonia which is ammonia dissolved in water with an analysis of 20-0-0 has only been available in Saskatchewan in the last few years. Anhydrous or "water free" ammonia which has an anlysis of 82-0-0 has increased rapidly in use over the last ten years and is available at many locations throughout the three prairie provinces. The benefit of higher analysis for 82-0-0 is partially off-set by higher equipment costs, safety considerations and more stringent application conditions. The lower analysis of aqua and its related low vapour pressure simplify the handling and application of this product compared to anhydrous. As well, the potential for hazardous accidents is also accordingly reduced.

Compared to other nitrogen fertilizers, the placement of ammonia fertilizers is quite unique in that they are placed in bands quite deep within the soil whereas other fertilizers are surface broadcast and incorporated to a relatively shallow depth. The question arises as to whether this deeper placement has an effect on the utilization of the nitrogen by the crop.

This presentation will concern itself with the probable agronomic advantages of ammonia (aqua and anhydrous) that result from the method of application or placement. The potential benefit of the form of nitrogen (ie. ammonium) for fall application will also be considered.

LACK OF FIELD RESEARCH WITH AMMONIA

There has been very little field research conducted with ammonia in western Canada because of the hazardous properties of the product and secondly, because the nature of the ammonia application equipment does not lend itself to establishing replicated, randomized small plot experiments. In recognition of the increasing importance of ammonia as a fertilizer, in 1971, Western Co-operative Fertilizers Limited embarked on a program to insure that research would be initiated on this product under prairie conditions. Funds were provided to the University of Manitoba to proceed

---

1. Paper presented at the "Soils and Crops Workshop", University of Saskatchewan, Saskatoon, February 8, 1978

2. Chief Agronomist, Western Co-operative Fertilizers Limited, P.O. Box 2500, Calgary, Alberta T2P 2N1

with the purchase of an applicator to enable inclusion of ammonia in a nitrogen source study being funded at that institute. At about the same time, plans were initiated for the construction and calibration of a unit capable of applying anhydrous ammonia, aqua ammonia and solution fertilizers. It has been with this unit that the bulk of field research involving ammonia has been conducted in western Canada.

FARMER ACCEPTANCE OF AMMONIA

Initial fertilizer plants in western Canada were designed in such a manner that most ammonia produced was used in remanufacturing into other fertilizer products and consequently, only limited amounts of ammonia were available to farmers for direct application. However, once anhydrous ammonia had been established in an area, farmers developed a preference for the product because they felt that ammonia outperformed other forms of nitrogen. Various theories were advanced for this phenomenon including that ammonia was a superior source of nitrogen or that it dissolved extra phosphate from the soil. Some researchers suggested that higher rates of nitrogen application were the likely explanation. However, industry agronomists who had gained some experience with the product, advanced the theory that placement was a key factor.

The importance of deeper placement was illustrated in some field trials conducted by WCFL in 1969 where ammonium nitrate was compared to anhydrous ammonia applied by a commercial applicator at the rate recommended by the Alberta Soil and Feed Testing Laboratory. The data is presented in Table I. In these trials, the ammonium nitrate was applied at the time of, or shortly after, seeding and was not incorporated into the soil whereas ammonia was shanked 4-5" deep into the soil prior to seeding. Based

TABLE I - Effect of Ammonium Nitrate and Anhydrous Ammonia on Yield of Grain Grown on Stubble (WCFL, 1969)

Location	Crop	Nitrogen Rate (lbs/acre)	Average Yield Increase (cwt/acre) 34-0-0*	82-0-0
Drumheller	Barley	29	3.1	9.1
Evarts	Barley **	60	5.2	5.1
Eckville	Barley	60	3.8	8.0
Lacombe	Barley **	40	4.0	4.0
Coaldale	Barley	60	6.4	7.7
Drumheller	Durum	40	2.1	3.8
Barons	Durum	50	0.3	0.8
		AVERAGE	3.6	5.5

* Broadcast and not incorporated
** Excellent moisture conditions following seeding
Average check yield - 14.4 cwt/acre

on the average data for all of the trials, the advantage for anhydrous was 1.9 cwt/acre (5.5 vs 3.6 cwt/acre). For the barley trials, the advantage for anhydrous was 2.3 cwt/acre (6.8 vs 4.5 cwt/acre) Considering the two barley trials where moisture conditions was considered to be excellent following seeding, there was no advantage to anhydrous ammonia. However, at the three barley trials where seed-bed moisture was sparse and was not replenished immediately after seeding, the advantage for the deeper placed fertilizer was 3.8 cwt/acre (8.2 vs 4.4 cwt/acre). It was this kind of result that lead industry agronomists to believe that the benefits from anhydrous were due to superior positional availability and that these benefits would be greatest in drier regions and/or years of below normal soil moisture supplies in the early growing season..

EVALUATING POSITIONAL AVAILABILITY

In the spring of 1976, a series of 17 cereal grain trials were completed across the prairies comparing aqua, anhydrous and solutions (28-0-0) fertilizers as sources of nitrogen. The solutions were compared shanked into the soil, as well as broadcast and incorporated. The results are summarized in Table II. In this data there was a trend suggesting superior performance of the deeper placed nitrogen.

TABLE II - Influence of Fluid Nitrogen Source and Placement on Yield of Cereal Grain Grown on Stubble (WCFL, 1976)

Nitrogen Source and Placement	Average Yield Increase (cwt/acre)
20-0-0 (S)	5.3
82-0-0 (S)	5.4
28-0-0 (S)	4.8
28-0-0 (B)	4.3

Average check yield - 13.9 cwt/acre
Nitrogen rate - 50 lbs/acre in spring of year
S - Shanked into soil at depth of 4-5"
B - Broadcast (ie. sprayed) and incorporated

However, in these trials, the differences due to source of nitrogen and positional availability could not be isolated. Ideally, to obtain a true evaluation, ammonia would have to be compared sub-surface banded and surface applied. Of course, the physical nature of anhydrous would prevent this type of comparison being accomplished. A cultivator was therefore modified to enable comparisons between surface and sub-surface placement of dry nitrogenous fertilizers. The average results from the five trials where comparisons were conducted in 1976 are summarized in Table III. In these trials there was a 2.1 to 2.5 cwt/acre advantage for the deeper placed dry nitrogen fertilizer. In 1976, the early growing season was drier than normal and the results proved the benefit of having the nitrogen in the moist soil where the crop is actively rooting.

TABLE III - Influence of Dry Nitrogen Source and Placement on Yield of Cereal Grain Grown on Stubble (WCFL, 1976)

Nitrogen Source and Placement	Average Yield Increase (cwt/acre)
34-0-0 (B)	6.1
34-0-0 (S)	8.6
46-0-0 (B)	5.7
46-0-0 (S)	7.8

Average check yield - 12.3 cwt/acre
Nitrogen rate - 50 lbs/acre in spring of year
B - Broadcast and incorporated
S - Shanked into soil at depth of 4-5"

In 1977, similar comparisons were conducted at 11 locations. The results are summarized in Table IV. It is evident that the benefits of deeper placement of nitrogen were less than in the previous year. In retrospect, based on the climatic conditions encountered, this could have been expected. For although the early spring of 1977 was extremely dry, at about the mid-point of seeding season, most of the prairie region received heavy, general rains. Under these circumstances, surface soil conditions would be excellent, and as illustrated in Figure 1, broadcast

TABLE IV - Influence of Dry Nitrogen Source and Placement on Yield of Grain Grown on Stubble (WCFL, 1977)

Nitrogen Source and Placement	Average Yield Increase (cwt/acre)
34-0-0 (B)	5.8
34-0-0 (S)	6.9
46-0-0 (B)	5.7
46-0-0 (S)	5.5

Average check yield - 16.8 cwt/acre
Nitrogen rate - 50 lbs/acre in spring of year
B - Broadcast and incorporated
S - Shanked into soil at depth of 4-5"

nitrogen and sub-surface banded nitrogen would both be readily accessible to the expanding root system of an actively growing crop. In a drier year such as experienced in 1976, surface applied and incorporated nitrogen might not be available to a crop since roots do not grow into dry soil.

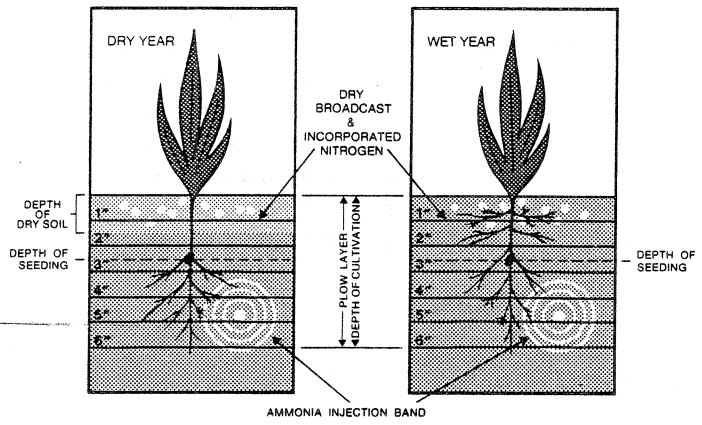

Figure 1. Influence of Fertilizer Placement and Moisture Distribution on Availability of Fertilizer Nitrogen

COST OF DELAYING NITROGEN APPLICATION

In the spring of 1977, 13 trials were established across the prairie region comparing aqua and anhydrous to nitrogen solution fertilizer applied in various methods. This data is presented in Table V. Despite the heavy rainfall conditions experienced during the 1977 seeding

TABLE V - Influence of Fluid Nitrogen Source and Placement on Yield of Grain Grown on Stubble (WCFL, 1977)

Nitrogen Source and Placement	Average Yield Increase (cwt/acre)	
	13 trials	9 trials
20-0-0 (S)	4.9	5.8
82-0-0 (S)	5.7	6.4
28-0-0 (S)	5.5	6.8
28-0-0 (B)	3.7	4.7
28-0-0 (P)		2.6

Average check yield - 17.1 (13 trials)
14.9 (9 trials)

S - Shanked into soil at depth of 4-5"
B - Broadcast (sprayed) and incorporated
P - Post emergent application

period, the benefits of deeper placement of nitrogen from solutions fertilizer were quite evident and approximately double the differences obtained with the dry products as reported in Table IV.

In years when the task of applying nitrogen fertilizer is not completed in the fall or prior to seeding, an alternative that is often suggested is to apply the nitrogen after the crop is growing. Although this may be a satisfactory approach for supplying nitrogen in some years, the data presented in Table V quite clearly illustrates that in 1977, there was a high cost associated with delaying the application of nitrogen. Based on yield increases obtained, if sub-surface applied 28-0-0 is assigned a rating of 100%, the relative values for the broadcast and post-emergent applications of nitrogen were 69% and 38% respectively.

FALL APPLICATION OF AMMONIA

As previously indicated, ammonia fertilizers are unique in that they are placed in concentrated bands relatively deep within the soil to avoid atmospheric losses because of the vapour pressure of these products. As well, the strong attraction of the ammonium ion for soil particles results in the nitrogen being readily immobilized and held in the soil in a relatively restricted zone or band. Under these conditions and in combination with lower soil temperatures, the rate of conversion to nitrate is slowed considerably. This is desirable when nitrogen is applied in the fall of the year since nitrogen in the nitrate form is susceptible to denitrification losses in the spring of the year if the soil becomes flooded for a significant period of time.

It has been speculated that banding of an ammonium type fertilizer late in the fall might be one method of reducing over-winter losses. In the fall of 1976, ten trials were established across the prairies to evaluate the performance of fall applied ammonia fertilizers.

TABLE VI - Influence of Fluid Nitrogen Source, Timing and Placement on Yield of Grain Grown on Stubble (WCFL, 1976/77)

Treatment	Average Yield Increase (cwt/acre)
82-0-0 (F)	6.3
82-0-0 (S)	6.4
20-0-0 (F)	7.5
20-0-0 (F) + ATC	6.8
20-0-0 (S)	7.5

Average check yield - 21.4 cwt/acre
Nitrogen rate - 50 lbs/acre
F - Fall Applied
S - Spring Applied
ATC - Nitrification inhibitor

This data is presented in Table VI and similar data for eight dry nitrogen fertilizer trials is presented in Table VII. It is obvious

TABLE VII - Influence of Dry Nitrogen Source, Timing and Placement on Yield of Grain Grown on Stubble (WCFL, 1976/77)

Treatment	Average Yield Increase (cwt/acre) Broadcast	Shanked
34-0-0 (F)	6.0	6.5
34-0-0 (S)		6.1
46-0-0 (F)	6.7	5.0
46-0-0 (S)		8.2

Average check yield - 22.7 cwt/acre
Nitrogen rate - 50 lbs/acre
F - Fall applied
S - Spring applied

that the conditions encountered during the over-winter period (ie. dry fall, below normal snowfall and dry early spring) did not result in any significant losses of nitrogen applied in the fall of 1976. These trials are being repeated starting in the fall of 1977 and hopefully conditions favoring denitrification losses will be encountered at some of the plot locations in the spring of 1978.