AN EVALUATION OF PRE-PLANT DEEP BANDING OF FERTILIZER[1]

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Abstract

Results of recent field research dealing with methods of fertilizer application are reported and discussed. Field work included the use of solution nitrogen (N), N and phosphate (P_2O_5) suspensions, and practical alternatives for the application of granular N and P_2O_5 fertilizers. The importance of placement of solution N is illustrated, compared to post-emergent broadcast application. The increasingly important dilemma with respect to fertilizer application under zero or minimum tillage management is discussed. Thirdly, some of the popular methods of application of N and P_2O_5 and the need for starter P_2O_5 are discussed in light of the growing number of alternatives presented to the farmer.

Introduction

The combined effects of inflation and soaring energy prices on the costs of chemical fertilizers continue to put increasing importance on the need to improve fertilizer use efficiency. Most farmers agree that rapidly rising costs of fertilizers as well as other farm inputs will generally be met by increasing prices for their products, but producers certainly do not expect this profit squeeze to be comfortable.

Recent developments in the farm implement and fertilizer industries have presented farmers a much longer list of alternatives for fertilizer application than was enjoyed only a few years ago. An emphasis therefore, must be placed on field research to provide farmers with recommendations on both how to minimize the costs of fertilizer application alternatives which are practically available, and how to achieve maximum yield responses and therefore profits from their total fertilizer investment.

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Results

1) Deep banding, pre-emergent, or post-emergent broadcasting of solution N

A total of 28 strip trials were established over a period of four years from 1977 to 1980, to compare three methods of application of solution N for the production of barley and rapeseed.

Nitrogen was applied at the rate of 56 kg N/ha in the form of 28-0-0 solution. Treatments consisted of pre-plant broadcasting and incorporation, deep banding, and post-emergent broadcasting. All treatments were spring-applied. Seeding was carried out by the farmer-co-operator. At almost all sites, starter fertilizer was applied with the seed at the rate he chose for the entire field. Post-emergent treatments were applied approximately two weeks after emmergence.

Table 1. Increase in yield of barley or rapeseed (100 kg/ha) due to method of application of solution N (WCFL 1977,'78,'79,'80)

Application method	Average yield increase (100 kg/ha) 1977	1978	1979	1980	Average	Relative rating (%)
Post-emergent b'cast	2.97	3.03	2.16	2.92	2.77	47%
B'cast, incorporated	5.30	3.84	4.65	5.03	4.71	80%
Deep banded	7.68	4.65	4.98	6.33	5.90	100%
Average check yield	16.77	13.74	11.31	20.40		
Number of sites	9	8	6	5		

Results in Table 1 indicate consistant responses by the yield of barley or rapeseed to the method of application of N. Particularly under drier early season conditions, post-emergent N resulted in a smaller increase in yield than pre-emergent broadcast and incorporated N. Deep banded N resulted in an average 25% larger yield increase than the increase in yield from broadcast and incorporated N.

Application of N by post-emergent spray offers convenience and the capability to apply herbicides in the same operation. It presents a contradiction however, in that the herbicides are effective at the plant surface, but the N is not effective unless it is leached into the root zone of the crop.

Post-emergent application of N with no soil incorporation results in complete dependance on rainfall soon after application in order for this method to be effective.

Pre-emergent application of solution N by broadcasting and incorporation resulted in an improvement in effectiveness over post-emergent application, but not as large as from deep banding. Normal tillage operations do not incorporate fertilizers effectively, leaving most of the fertilizer in the surface 2-4 cm. In regions where rainfall is limiting during periods of high demand by the crop, poor availability due to position results in greatly reduced effectiveness of the producer's fertilizer investment (Harapiak 1979).

2. Effect of banding vs broadcasting fertilizer on zero-till

Two trials were established near High River, Alberta, to compare deep banded N and P_2O_5 to the effect of surface application on the yield of barley. At these sites, N and P_2O_5 were applied as a 17-11-0 suspension at the rate of 72 kg N and 47 kg P_2O_5/ha, respectively. The test crop at these sites was a third consecutive crop of barley under zero-tillage management. The only previous soil penetration had occured at seeding, which was done with a heavy drill with disc openers.

Deep banding of fertilizer treatments was accomplished with narrow knives (1.6 cm), mounted on a 42 foot heavy-duty cultivator at 12 inch spacings. Banding depth was approximately 10 cm.

Table 2. Effects of banding vs broadcasting on zero-till (WCFL, 1980)

Fertilizer treatment	Yield of Barley (100 kg/ha)	Yield Increase (100 kg/ha)	Relative rating (%)
Deep banded	44.4	13.0	100%
Broadcast	37.9	6.5	50%
No fertilizer	31.4	-	

- Data represents average of 2 trials.
- Drill-in fertilizer on all treatments: 3-17-33 kg/ha of N, P_2O_5, K_2O

The results presented in Table 2 indicate a response due to placement of N and P_2O_5 equal to the responses to broadcast application. In other words, return on the fertilizer investment was doubled due to deep banding rather than broadcasting.

The dilemma faced by farmers practising or considering zero-till management with respect to fertilizer application has been reviewed by Harapiak (1980).

Two concerns expressed by zero-till farmers are moisture loss and stimulation of weed germination caused by soil tillage. It is obvious that deep banding on zero-till is a contradiction of terms. The compromise reached however, by deep banding the suspension fertilizers with a minimum amount of tillage resulted in no yield reduction due to tillage, and no stimulating effect on weed growth at these sites.

3. Dual banding vs separate application of N and P_2O_5 fertilizers

Presently available machinery is resulting in a demand for an answer to the following question: How does dual banding of N and P_2O_5 compare to either broadcasting or deep banding N, and drilling in the P_2O_5 requirement? Since the greatest number of western Canadian farmers presently apply P_2O_5 fertilizers with the seed, field data of these comparisons are in high demand.

A series of replicated plots were established in spring, 1980 to compare methods of application of N and P_2O_5 fertilizers. The results presented in Table 3 are average data from three sites located at Stavely, Calgary and Olds, Alberta.

Table 3 Effects of dual banding of N and P_2O_5 vs broadcasting N and drilling-in P_2O_5 on yield of barley (WCFL, 1980)

Method of Application	Yield of barley (100 kg/ha)
Deep banded (N + P_2O_5)	36.8
Broadcast N, Drill-in P_2O_5	36.4
No fertilizer	27.1

- data represent average of 3 trials.
- N rate 56 kg N at Stavely, Calgary and 84 kg N/ha at Olds.
- P_2O_5 rate - 28 kg P_2O_5/ha.

Dual banded N + P_2O_5 at these three sites resulted in yield responses as high as those from a traditional method of broadcasting and incorporation of N and drilling in the P_2O_5 with the seed.

The average yields at these sites are an indication that these crops did not suffer severe moisture stress during the growing season. Responses to broadcast N were relatively greater than those observed in areas of more serious moisture limitations.

Another popular method of application of N fertilizers is banding. The use of anhydrous ammonia (gaseous or cold-flow), or aqueous ammonia implies banding. The farmers in this group want comparisons of N applied in these forms followed by drilling-in the P_2O_5 to dual-application of N and P_2O_5. This is the alternative provided by the recent availability of pneumatic applicators as well as dual application equipment for combinations of solutions, suspensions and anhydrous ammonia.

Results in Table 4 are average data from seven sites established in spring, 1980.

Table 4 Effects of dual-banding, N and P_2O_5 in spring vs seperate application on yield of barley or rapeseed (WCFL, 1980)

Method of Application	Yield of barley or rapeseed (100 kg/ha)
Dual-banded (N + P_2O_5)	26.7
Broadcast N, Drill-in P_2O_5	23.8
Deep banded N, Drill-in P_2O_5	25.8
No fertilizer	16.9

- data represent average of 7 trials:

Location	Crop	N rate as urea
Maidstone, Saskatchewan (2)	Rapeseed	85 kg N/ha
Champion, Alberta	Barley	60 kg
Vulcan, Alberta (2)	Barley	60 kg
High River, Alberta	Barley	60 kg
Lacombe, Alberta	Barley	60 kg

- P_2O_5 rate - 25 kg P_2O_5/ha at all sites.

Yield responses were increased by banding rather than broadcasting N and drilling-in P_2O_5. Dual banded N + P_2O_5 resulted in equal or slightly greater responses. The average difference was 90 kg/ha (1.6 bu/ acre) in favor of dual-banding N and P_2O_5, with no starter fertilizer.

At the sites located in southern Alberta (Table 4), the response due to placement of N was greater than at the sites presented in Table 3. As evidenced in part by lower average fertilized yields, positional availability was a larger consideration at the seven sites in Table 4 than at the three in Table 3.

Results obtained from four trial sites in north-eastern Alberta are presented in Table 5 (Penney, 1980).

Table 5 Deep banding vs traditional methods of fertilizer placement on phosphate deficient soils of north-eastern Alberta (Penney, 1980).

Fertilizer Treatment*	Yield of barley (100 kg/ha)
Deep banded ($N + P_2O_5$)	36.2
Side banded N, drill-in P_2O_5	34.9
Deep banded ($N + 2/3\ P_2O_5$), drill-in 1/3 P_2O_5**	37.4
No fertilizer	21.2

* fertilized at 84 kg N/ha and 50 kg P_2O_5/ha
** 33 kg P_2O_5 deep banded with N, 17 kg P_2O_5 drilled in.

On the moist, low phosphate soils at these sites, the highest yields were obtained when some (one-third) of the P_2O_5 was applied with the seed. Interestingly, when all of the N and P_2O_5 was deep banded (approximately 10 cm), yields were higher than when N was side banded, and the phosphate drilled in.

Discussion of Results

The relative explosion in the growth of availability of fertilizer application alternatives has generally caught agronomists by surprise. Benefits of dual application of N and P_2O_5 have been clearly illustrated by Rennie and Soper (1958). In controlled studies, uptake of P_2O_5 by plants significantly enhanced by the intimate presence of ammoniacal N. Phosphate uptake from both $NH_4H_2PO_4$ and $Ca(H_2PO_4)_2$ was increased only when mixed with ammonium N, and this effect continued to increase at rates up to 40 lb N per acre in addition to that contained in the $NH_4H_2PO_4$.

This benefit would obviously not occur when P_2O_5 is drilled in with the seed and N is applied separately. Because practical methods for dual banding have not been available until recent years, research on the merits of dual application has been very limited, and has resulted in a lack of consensus of opinion among agronomists.

Results presented in this paper indicate that dual banding of N and P_2O_5 resulted in yield responses equal to or greater than those from separate application where P_2O_5 was drilled in with the seed. Generally, early season soil moisture during 1980 was lower, and temperature was higher than normal. The relationships between soil moisture and temperature, and early season root growth/phosphate uptake are generally acknowledged as reviewed by Webb (1977).

On phosphate-deficient soils of north-eastern Alberta, maximum yields were obtained when some of the P_2O_5 was retained, and drilled in with the seed (Penney, 1980). Preliminary results observed by the authors indicate that at some sites, drilling in 28 kg P_2O_5/ha did not produce larger responses when the same amount of P_2O_5 was deep banded with urea below the depth of seed (unpublished results).

Although research results are limited, benefits from starter phosphate generally range from zero to five bushels per acre. It would appear that responses will be in the upper portion of this range on soils severely deficient in P_2O_5, and/or soils that are cold and wet in spring. We feel that maximum yields will not be obtained unless a large percentage of the P_2O_5 is banded with NH_4-N below the depth of seed. On warm soils which are not very phosphate deficient, a farmer may be well- advised to apply all of his phosphate by dual banding below the seed. It should be kept in mind that for pre-plant banding to be a practical and economical alternative, yields would not have to exceed those obtained in the traditional approach of seeding and fertilizing because of operational considerations.

References

Harapiak, J. T. 1979. A case for sub-surface banding of fertilizer. Alberta Soil Science Workshop, Lethbridge, Alberta, February 26 - 27, 1979.

Harapiak, J. T. 1980a. Approaches to applying phosphate fertilizers. In Western Canada Phosphate Symposium. Proceedings of the Alberta Soil Science Workshop, Calgary, Alberta, March 11 - 12, 1980.

Harapiak, J. T. 1980b. Fertilization under zero and minimum tillage conditions. Paper presented at Managing Agricultural Technology for Profit Seminar, Banff, Alberta, March 21 - 24, 1980.

Penney, D. C. 1980. Personal communcation. Soils Branch, Alberta Agriculture, Edmonton, Alberta.

Rennie, D. A. and R. J. Soper 1958. The effect of nitrogen additions on fertilizer-phosphorus availability. J. Soil Sci. 9:155-167.

Webb, J. R. 1977. Soil factors. In Band Applications of Phosphatic Fertilizers. Edited by G. E. Richards. Published by Agric. Products Division, Olin Corporation, Little Rock, Arkansas.