Title: Nitrogen and Phosphorus placement for wheat production in North Dakota.

Research Personnel

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Background and previous research

Considerable interest by farmers and fertilizer dealers has been generated in North Dakota concerning the simultaneous injection (dual placement) of liquid sources of phosphorus (P) and either anhydrous ammonia or liquid sources of N. Research done in Kansas has shown that liquid P fertilizer injected with anhydrous ammonia or urea-ammonium nitrate solution produced higher wheat yields and plant P contents than plots treated with a broadcast P application or with P banded with the seed (Leikam, et. al., 1979). Several explanations of these results are possible:

1. The greater P uptake from NP dual placement was due to a more advantageous placement of the P fertilizer. Deep placed P is in a better position for plant uptake than is shallowly placed P, due to the higher average soil moisture content around the deeper fertilizer band. This explanation was discounted by Leikam, et. al., (1979), although many of the Kansas experiments did not have adequate controls to fully judge the importance of this effect.

2. The greater P uptake could have been due, in part, to plant physiological factors. These factors have been recently reviewed by Miller

and Ohlrogge (1977). The placement of N in a P fertilizer band has long been known to increase P uptake. Nitrogen increases root proliferation in a P band and nitrogen also increases the physiologic capacity of plant roots to absorb P. Ammonium and nitrate forms of N are approximately equal in promoting the above physiological effects.

3. Another explanation for the results of Leikam, et al., (1979) is that there are effects of the added N on P solubility which improves the subsequent availability of P. Although some of these effects have been known for some time (Miller and Ohlrogge, 1977), there are some unique soil chemical aspects to the current interest in simultaneous N and P applications.

One new aspect is the effect of anhydrous ammonia on the solubility and plant availability of P. Whenever fertilizer P is applied to soil, a literal array of metastable P compounds precipitate. The compounds that precipitate in the bands surrounding many P fertilizers have been isolated and identified (Lindsay and Taylor, 1960; Lindsay et al., 1962). The fertilizer P-soil reaction products that form in the presence of anhydrous ammonia have not been studied. There are several reasons to believe that the fertilizer P-soil reaction products that form in the presence of anhydrous ammonia will be quite unlike the reaction products which form when the same P fertilizer is applied to soil without anhydrous ammonia. These reasons are:

a. The high pH of the initial reaction zone will plummet the activities of Al^{3+} and Fe^{3+} to infinitesimal levels. Also, as the pH drops with subsequent nitrification, the initial reaction products could be rendered unstable.

b. The presence of anhydrous ammonia will initially lower the soil water activity to very low levels. Most of the fertilizer P-soil reaction products studied to date have been found to have water as an integral part of their respective crystalline structures (Lindsay and Taylor, 1960). The presence of anhydrous ammonia in a fertilizer P-soil reaction band would certainly promote the precipitation of anhydrous reaction products which would prove to be unstable as moisture equilibrium is reestablished.

Urea-ammonium nitrate solution (UAN) is sometimes used in NP deep dual placement. A unique feature of this type of fertilizer application is that much higher N:P ratios are being used than have normally been researched in the usual NP fertilizer banding studies. Also, both phosphoric acid and pyrophosphate have been shown to reduce soil urease activity; thus leading to a slower release of ammonium from urea, thereby maintaining an elevated ammonium activity for a longer period and perhaps maintaining the presence of soluble ammonium phosphates.

The differences in fertilizer P efficiency between using a polyphosphate or an orthophosphate in NP dual placement have not been adequately researched. This question becomes significant in North Dakota because some growers are using ammonium pholyphosphate while others are experimenting with orthophosphoric acid in NP dual placement. One would expect differences in fertilizer efficiency between ortho- and polyphosphates, as they produce quite different fertilizer-soil reaction products (Lindsay and Taylor, 1960).

In summary, there are many questions, both at a basic and at an applied level which remain concerning NP dual placement. With these concepts in mind, the following research is proposed:

Objectives

1. To compare the relative P fertilizer efficiency from surface and deep applied P as a function of N source, N rate, and N placement. (5 field locations)

2. To evaluate the residual value of P from NP dual placement. (1 field location)

3. To compare the P fertilizer efficiency of ortho- vs. polyphosphate forms as affected by N source and placement. (2 field locations)

These experiments will mostly be planted on recrop (non-fallowed) sites. Yield potentials are highly weather-influenced, but a goal of 2400 kg/ha (35 bu/A) is suggested. Backup laboratory or greenhouse studies are not planned for this year, but may be included in subsequent proposals.

Procedures and treatments

Procedures common to all field locations are: Initial soil samples to 120 cm, or to a restrictive layer, will be taken and analyzed for standard soil characterication parameters (NO_3-N, pH, EC, $NaHCO_3$-P, etc). Initial available water will be estimated. Plant tissue samples from measured areas will be taken at boot stage and analyzed for total P and total N. N and P uptake will be calculated. Grain yield, test weight, kernel weight, and protein will be measured, as well as grain total P and grain P uptake.

Specific treatment combinations are shown, and general locations given by type of experiment.

1. N rate x N placement x N Source x P Placement trials.

This experimental design is planned for five locations: Williston area: one winter wheat and two spring wheat locations; Minot area: one winter wheat and one spring wheat location. The specific treatments are given in Table 1.

2. NP dual placement residual trial.

Identical treatments as in Table 1. This trial was established at the Williston station in the spring of 1980. Due to the severe drought, very poor germination resulted. The crop was sprayed with Roundup and left untilled. Spring wheat will be planted in 1981 with either a shallow disking or with a no-till drill.

3. Ortho- vs. Poly-P x N source trials.

Two experimental locations are planned, one at the Williston station and one at the Minot station. Spring wheat will be the test crop. The specific treatments are shown in Table 2. Some juggling of N sources and rates was necessary to equalize N rates because of the N in the ammonium polyphosphate. The number of treatments in these experiments has been reduced to limit field variability. An increased number of replications (6-8) will be used if field space permits to improve precision.

Dates of initiation and completion

The project will begin 1 January 1981 and end 31 December 1931.

Funding requested

PPI Contribution

Travel expenses

Supplies and analyses

Wages

Total PPI contribution

University Contribution

Salaries (including benefits) of project participants

Secretarial and hourly labor

Institutional overhead

Total university contribution

Total Recogizable Tagible Budget

Approved:

NORTH DAKOTA STATE UNIVERSITY

_____ Date

_____ Agricultural Experiment Station

_____ Date

_____ Chairman, Department of Soils

_____ Date

_____ Principal investigator

PHOSPHATE-POTASH INSTITUTE

_____ Date

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Table 1. Treatment combinations for NP dual placement experiments.

Treatment Number	Nitrogen			Phosphorus[+]	
	Rate	Source[#]	Placement	Rate	Placement
	kg/ha			kg/ha	
1	0	—	—	15	Sfc
2	0	—	—	15	Deep
3	34	AA	Deep	15	Deep
4	68	AA	Deep	15	Deep
5	101	AA	Deep	15	Deep
6	34	AA	Deep	15	Sfc
7	68	AA	Deep	15	Sfc
8	101	AA	Deep	15	Sfc
9	34	UAN	Sfc	15	Sfc
10	68	UAN	Sfc	15	Sfc
11	101	UAN	Sfc	15	Sfc
12	34	UAN	Deep	15	Deep
13	68	UAN	Deep	15	Deep
14	101	UAN	Deep	15	Deep
15	34	AN	Sfc	15	Sfc
16	68	AN	Sfc	15	Sfc
17	101	AN	Sfc	15	Sfc
18	34	AN	Sfc	15	Deep
19	68	AN	Sfc	15	Deep
20	101	AN	Sfc	15	Deep

[#] AA - 83-0-0, UAN - 28-0-0, AN - 33-0-0

[+] P applied as H_3PO_4, 0-54-0

Table 2. Treatment combinations for Ortho- vs. poly-P dual placement trials.

Treatment Number	Nitrogen					Phosphorus		
	Total rate	AN[#] Sfc	N from APP	Injected N rate	Injected Source[+]	rate	source[+]	Placement
	kg/ha					kg/ha		
1	85	85	—	—	—	0	—	—
2	85	85	—	—	—	15	PA	Sfc
3	85	75	10	—	—	15	APP	Sfc
4	85	85	—	—	—	15	PA	Deep
5	85	75	10	—	—	15	APP	Deep
6	85	17	—	68	AA	15	PA	Deep
7	85	7	10	68	AA	15	APP	Deep
8	85	17	—	68	UAN	15	PA	Deep
9	85	7	10	68	UAN	15	APP	Deep

[#] Ammonium nitrate surface applied

[+] AA, 82-0-0; UAN, 28-0-0; PA, 0-54-0; APP, 11-37-0.

Literature cited

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