Fall-Applied DAP, MAP, And Ammonium Sulfate: How Much N Is There In The Spring?

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Introduction

•Phosphorus (P) needs for corn (*Zea mays* L.) are typically met by the application of diammonium phosphate (DAP, 18-46-0) or monoammonium phosphate (MAP, 11-52-0) fertilizers.

•These fertilizers are widely used because they represent a low-cost N-source and the presence of ammonium can result in increased P uptake.

•In most of the Midwest, P is commonly applied in the fall when soil temperatures are above 50ºF. Under such conditions, high biological activity can result in rapid nitrification.

•Despite the potential for loss, all N from MAP and DAP is often assumed to be available for plant uptake (illustrated by the fact that N from these materials is typically taken into account when determining additional N fertilization for corn).

Objective

To evaluate the efficacy of N from fall-applied diammonium phosphate (DAP), monoammonium phosphate (MAP), and ammonium sulfate (AMS), relative to spring application of the same products.

Methods

•Laboratory

Cisne silt loam and Drummer silty clay loam soils were fertilized with MAP and DAP and incubated at room temperature for 16 weeks at 80 and 120% field capacity (FC).

•Field (Crop seasons 2004 to 2006)

•Field experiments were conducted at:

- University of Minnesota Southern Research and Outreach Center, Waseca, MN in a Webster clay loam glacial till soil.
- Crop Sciences Research and Education Center, University of Illinois, Urbana, IL in a Drummer silty clay loam soil.

•The study had a factorial design replicated four times with three N sources (DAP, MAP, and AMS), two application times [fall (late Oct. early Nov.) and spring (late Apr. early May)] and two N rates (40 and 80 lb N acre^{-1}) plus a zero N control.

•Corrective P rates (0-44-0) to offset the P content of MAP and DAP fertilizer were applied to appropriate plots to eliminate the possibility of a differential response to P among the treatments.

•Plot area was tilled by discing to a 3 inch depth in the fall and field cultivating in the spring.

•Plots were planted with corn in late April to early May.

•Soil samples were collected after treatment applications typically every two weeks to a 6 inch depth until soils froze in the winter. Sampling resumed in the spring with samples collected every two weeks at depths of 0-6 and 6-12 inches.

•Grain yield was collected at harvest.

•Percent N recovery for the top 12 inches of soil was calculated by subtracting soil N concentration in the check from the soil concentration in the treatment and dividing it by the N rate.

• 1lb (pound) = 0.454 kg

•1 inch = 2.54 cm

•Bushel corn acre^{-1} = 62.74 kg ha^{-1}

Results and Discussion

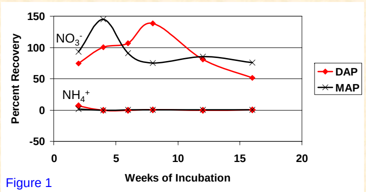

Figure 1

•After two weeks of incubation at room temperature and 80% FC nearly all N irrespective of source (MAP or DAP) was nitrified (Fig. 1).

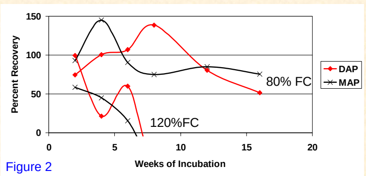

Figure 2

•Soil water content had an important impact in denitrification of N from MAP and DAP.

•At 120% FC all NO_3^- from both MAP and DAP was denitrified by week 8.

•At 80 % FC over 50% recovery was observed for MAP and DAP at week 16 (Fig. 2).

Table 1: Statistical analysis of main factors for ammonium, nitrate and total inorganic N (TIN) content in the 0-6 inch soil layer on May 25, 2004 at Urbana

Parameter	NH_4^+-N	NO_3^--N	TIN
Source:	----------------	mg kg^{-1}	----------------
DAP	3.0a	35a	32a
MAP	2.9a	29a	38a
AMS	2.9a	32a	35a
Time:			
Fall	2.6b	22b	25b
Spring	3.2a	42a	45a
Rate:			
40	2.8a	26b	29b
80	3.1a	38a	41a

•No differences (p>0.05) were observed among N sources for soil N concentrations at the end of May (Table 1).

•Spring- compared to fall-applications resulted in higher soil N contents at the time of rapid corn N-uptake.

•The 80 lb N acre^{-1} rate produced higher NO_3^- and TIN concentrations. By the end of May there was relatively little NH_4^+ present in the soil regardless of N rate.

•By in large, similar results were observed for all the main parameters being compared in all 6-site/years and for the different soil depth increments measured.

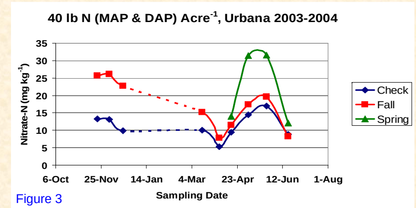

Figure 3

•Irrespective of rate or source of N, within 3-weeks of application nearly all the NH_4^+ in the top 6 inches of the soil had been nitrified in Urbana during 2003. Nitrate concentrations in the soil remained relatively constant throughout the late part of the fall (Fig. 3).

•A substantial decrease in NO_3^- concentrations between Mar 15 and Apr. 4 correlated with high temperature and water-saturated soil that led to rapid denitrification and immobilization.

•Nitrate levels in the 0-6 inch soil layer was substantially higher through May 25 for spring- compared to fall-applications.

•Significant decrease in NO_3^- concentration after May 25 was most likely the result of rapid N uptake by the crop.

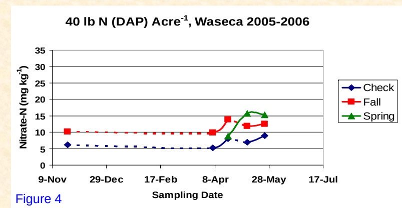

Figure 4

•Some nitrification had occurred three weeks after fall application in 2005, but little change in NO_3^- levels, compared to the fall, was observed in early spring in Waseca (Fig. 4).

•At the end of Apr. nitrification of fall treatments was nearly completed and spring treatments were starting to nitrify.

•Unlike Urbana in 2004 (Fig. 3), spring precipitation in 2006 was normal during the early spring in Waseca. By the end of May little N has been denitrified, immobilized, or leached out of the top 24 inch soil layer.

Table 2: Percent total inorganic N recovery at the end of May from the 0-12 inch soil depth increment for fall Vs. spring applications averaged across N rate and source.

	Recovered							Not plant available
	Waseca			Urbana				
	May 28 2004	May 23 2005	May 24 2006	May 25 2004	May 25 2005	May 25 2006	6-site/year Mean	6-site/year Mean
	% total inorganic N							
Fall	13	11	22	16	25	14	17	83
Spring	43	74	34	50	50	34	48	52
% Diff.	69	85	36	68	50	59	65	

•Recovery of N before rapid N uptake by corn (end of May) showed more recovery from spring- than fall-fertilizer applications (Table 2). Averaged across sites and years, 65% more N was recovered with spring- compared to fall-applications.

•The degree of water saturation of soils due to precipitation in the spring had an important impact on the efficiency of fall fertilizer application. Years with high spring precipitation caused greater denitrification and immobilization of inorganic N, while dryer springs favored more retention of plant-available N.

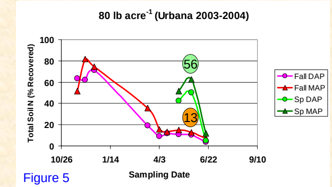

Figure 5

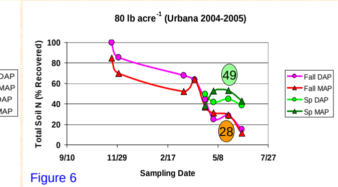

Figure 6

•Recovery of the fall applied materials declined rapidly to very low levels by early spring due to wet and warm conditions leading to denitrification (Fig. 5).

•Recovery of spring applied materials was higher than for fall treatments.

•No difference in recovery was observed between fertilizer sources.

•Recovery decline in late May reflects rapid N uptake by corn.

•Spring applied materials had higher recovery than fall applications (Fig. 6).

•In 2005, spring precipitation was lower than average, thus % N recovery of fall treatments was higher compared to 2004 (Fig. 5).

•No difference in recovery was observed between fertilizer sources.

Table 3: Statistical analysis of main factors for corn grain yield

Parameter	Waseca			Urbana		
	2004	2005	2006	2004	2005	2006
Source:	bushel acre^{-1}					
DAP	138a	135a	183a	185a	139a	144a
MAP	133a	137a	180a	190a	144a	147a
AMS	134a	138a	188a	193a	137a	148a
Time:						
Fall	130b	127b	188a*	185a	134b	140b
Spring	140a	146a	179b	193a	146a	153a
Rate:						
40	125b	130b	170b	175b	131b	136b
80	140a	143a	198a	203a	149a	157a
0-lb Control	97	89	125	141	109	107

•No differences (p>0.1) among N sources for corn yield (Table 3).

•Spring compared to fall applications generally produced higher yields. The exceptions were Waseca in 2006 and Urbana in 2004. In Waseca, yields were higher in 2006 (*p>F 0.029) for fall- compared to spring-applied fertilizer treatments confirming that there was no N losses from fall applications. In Urbana the lack of difference was not expected since there was substantial denitrification/immobilization in the spring of 2004. Likely much of the needed N was provided by mineralization in this exceptional year for corn production in Illinois.

•The 80 lb N acre^{-1} rate produced consistently higher corn grain yield.

•Average across all other variables the 40 and 80 lb N acre^{-1} rate produced 22 to 45 and 40 to 73 bushel acre^{-1} above the check, respectively.

Conclusions

•Incubation studies showed that ammonium in MAP and DAP nitrified quickly under warm temperatures, and high rates of denitrification occurred under water-saturated soil conditions.

•In the field, source of N (DAP, MAP, or AMS) had little influence on soil inorganic N concentrations and on grain yield.

•Rate and time of fertilizer application had significant impacts on soil inorganic N concentrations and on grain yield.

•Nitrification of fall-applied fertilizers was typically completed by the end of April. Thus, the efficiency of fall-applied ammoniated phosphate was diminished in wetter than normal springs due to greater N denitrification and immobilization.

•Mean recovery of total inorganic N for all sites-years at the end of May from the top 12 inches (30 cm) of the soil was 17% for fall- compared to 48% for spring-applied fertilizers.

•Averaged across all factors, corn yield averaged 9 bushel acre^{-1} (554 kg ha^{-1}) higher for spring applications compared to fall applications.

Acknowledgments

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