In-Crop Applications of N-P Fertilizers to Supply Corn N Needs

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Objective

Determine if surface applications of nitrogen-phosphorous-containing fertilizers at V4-V6 sidedress timing at a two-year crop removal P rate plus supplemented urea to meet corn N need can support corn yield and improve fertilizer application economics. Additionally, yield response in the following year's soybean crop was measured.

Background

The primary source of phosphorous fertilizer is the nitrogen-phosphorous (N-P) containing products of 11-52-0 Monoammonium Phosphate (MAP) and 18-46-0 Diammonium Phosphate (DAP). Based on the 2020-2021 state average corn and soybean yield, a crop removal rate of 109 pounds of P_2O_5 is needed, resulting in the application of 23 and 42 pounds of N when MAP and DAP, respectively, are used. When applied in the fall, the phosphorus from these products is solubilized and retained in the labile phosphorus soil pools. However, nitrogen is subject to nitrification (ammonium conversion to nitrate), resulting in nitrate forms, which can be lost to the environment through leaching or denitrification (nitrate conversion to gaseous forms). The net result from fall MAP or DAP application is the loss of most of this nitrogen before planting corn. An Illinois study found that only 31-35% of the nitrogen remained in the spring following a fall application of MAP and DAP (Fernandez, 2010). From a farm practices standpoint, most farmers will not provide any credit to the nitrogen supplied in a fall application. An in-crop application of MAP and DAP can allow the crop to use the applied N and P to meet corn N needs.

Method

After soybeans, corn was planted in 2020, 2021, and 2022 at the NW Agricultural Research Station in Custar, OH. The corn was no-till planted into soybean stubble in 2020 and 2022. For 2021, corn was planted into a stale seedbed prepared in the fall with a disk followed by a field cultivator. Corn in 2020 was planted on 5/4 and then destroyed and replanted on 6/3 due to low plant stand counts. In 2021 planting was on 4/27. For 2022, corn planting occurred on 5/23. Planting rates were 34,000 seeds per acre in all years. Starter N was applied at 40 pounds of N in a 2-inch by 2-inch band as 46-0-0. The hybrids used were Pioneer 0506AM, DK 55-54 RIB, and DKC 59-82 RIB in 2020, 2021, and 2022, respectively.

The desired total N rate for the corn crop was 180 pounds based on the Corn Nitrogen Rate Calculator (https://www.cornnratecalc.org) using a nitrogen to corn price ratio of 0.10. The target N rate at sidedress was 140 pounds, subtracting the 40 pounds of starter N from the 180 Maximum Return to Nitrogen (MRTN) rate. The two-year crop removal needs of corn at 180 bushels and soybean at 60 bushels using the *Tri-State Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa* (Culman, 2020) is 111 pounds of P_2O_5/Ac. The amount of 11-52-0 is 213 and 241 pounds 18-46-0 per acre to meet the two-year rotation P need. The nitrogen supplied from the MAP and DAP was 23 and 43 pounds per acre, respectively. The balance of nitrogen needed for the 140-pound sidedress rate was made using Super U, a urea fertilizer treated with a urease and nitrification inhibitor to reduce volatilization losses. The nitrogen form in MAP and DAP is Ammonium-N, thus not subject to volatilization losses. The dry fertilizer products were surface applied with a Gandy air spreader. The 28-0-0 was applied with a coulter injection unit. Table 1 summarizes all fertilizer products, application rates, and placement used. No P_2O_5 was applied to the 28-0-0 and Super U only treatment which served as a no P check to the MAP and DAP applications.

The target growth stage for sidedress application in all years was V5 (5 collared leaves). The 2020 sidedress application was made on 6/22 for the 28-0-0 and 6/25 for the other treatments. In 2021, all sidedress applications occurred on 6/15. The sidedress applications for 2022 occurred on 7/1.

Table 1. Summary of application timing, rate, and fertilizer source to supply 180 pounds per acre of Total N.

Treatment	Starter Source (lbs./Ac product)	Starter N supplied (lbs./Ac)	Sidedress N Source (lbs./Ac product)	N supplied (lbs./Ac)	Total N (180 lbs./A)	Sidedress placement
Check	46-0-0 (87 lbs.)	40	28-0-0 (47 gals)	140	180	Inject
In-crop P-DAP	46-0-0 (87 lbs.)	40	18-46-0 (241 lbs.)	43		
			46-0-0 Stab (210 lbs.)	97	180	Surface
In-crop P-MAP	46-0-0 (87 lbs.)	40	11-52-0 (213 lbs.)	23		
			46-0-0 Stab (253 lbs.)	117	180	Surface
Super U	46-0-0 (87 lbs.)	40	46-0-0 Stab (210 lbs.)	140	180	Surface

A partial nitrogen and phosphorus nutrient cost budget was determined to compare a two-year N and P fertilizer program cost for a corn-soybean rotation.

Fertilizer costs are shown in Table 2 as average fertilizer costs for mid-June 2020, 2021, and 2022 reported by DTN (https://www.dtnpf.com). Fertilizer prices increased during the study

years to historic highs. For example, MAP in 2020
was $406 per ton but had risen to $1046 per ton in 2022. The price of 28-0-0 increased from $235 per ton (2020) to $630 per ton (2022).

For the partial budget, the value of nitrogen in N-P fertilizers was assigned the value of N in anhydrous ammonia. This N value was subtracted from the total per ton fertilizer cost, and the remaining value was divided by the P_2O_5 content to determine the P value per pound. To determine the two-year fertilizer program cost charges for the fall, P_2O_5 application machinery and fertilizer, plus the opportunity cost of N not recovered in a cash crop were included in the budget. A charge of $7 per acre was used for the fall N-P product application (Ward, 2022). No charge was added for the sidedress or in-crop P application since all plots had an application pass. Depending on the equipment needed, there may be an application cost difference for the dry fertilizer application compared to the liquid 28-0-0 application, which is not included in the analysis. We excluded yield from the partial budget since there was no statistically significant difference in our primary comparison of N-P fertilizers versus UAN alone.

Table 2. Average fertilizer prices for mid-June of 2020, 2021, and 2022 as reported by DTN.

Fertilizer	Product Name	Cost ($ per ton)	Cost ($ Unit N)	Cost ($ Unit P)
18-46-0	DAP	703	0.88	0.42
11-52-0	MAP	740	0.88	0.53
28-0-0	UAN	409	0.73	-
46-0-0	Urea	618	0.67	-
46-0-0 Stab	Super U	738*	0.80	-
86-0-0	Anhydrous Ammonia	902	0.88	-
* Price is urea cost per ton plus $120.				

Results

Corn yields from the nitrogen treatments were not statistically different for 2020 and 2022, while the Super U yielded significantly lower than other treatments in 2021 (Table 3). Corn yield was not affected by the in-crop application of phosphorus. Soil test P (STP) was between 20 and 40 PPM Mehlich-3, the maintenance range of the *Tri-State Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa (2020)*. Measured soybean yields in 2021 and 2022 following the previous year corn also showed no yield differences (Data not shown). The finding of no corn and soybean yield response is expected when STP is in the maintenance range. The nutrient management strategy used in the Tri-State Fertilizer Recommendations when STP is in the maintenance range (20-40 PPM Mehlich-3) is to apply P nutrient to maintain the STP, not to increase yield. Differences in yield did occur between years, primarily due to lower seasonal precipitation in 2020 (Figure 1).

Table 3. Yield Results for corn in 2020, 2021, 2022 seasons using different N-P sources.

	Treatment	Sidedress N Source	2020 Yield (bu/Ac)	2021 Yield (bu/Ac)	2022 Yield (bu/Ac)
1	Check	28-0-0	148a	206a	209a
2	In-crop P (DAP)	18-46-0			
	Super U	46-0-0 Stab	151a	202a	206a
3	In-crop P (MAP)	11-52-0			
	Super U	46-0-0 Stab	146a	200a	213a
4	Super U	46-0-0 Stab	145a	189b	236a
		LSD (0.1)	6	8	45
		CV %	3	3	16

Table 4 shows only the corn nitrogen program cost. Total nitrogen program cost includes N applied at all application timings and N unit cost based on fertilizer source (Table 2) to meet the 180 pounds per acre MRTN rate. The lowest cost nitrogen program was urea starter plus UAN sidedress at $129 per acre. The in-crop DAP, in-crop MAP, and urea increased cost by $14, $12, and $10 per acre, respectively, over UAN. Focusing only on the total N program cost does not provide a full picture of a fertilizer program that often extends over multiple crops or years. To fully understand fertilizer N and P cost over the crop rotation, we need to look at application cost, the opportunity cost of lost N from the fall application, plus the cost of P.

Table 4. Nitrogen program costs for a 180-pound N/Ac MRTN rate using all sources.

	Treatment	Starter Source	Cost per acre of starter N supplied	Sidedress N Source	Cost per acre of sidedress N supplied	Total Cost N to meet 180 lb./Ac MRTN rate
1	Check	46-0-0	$27	28-0-0	$102	$129
2	In-crop DAP	46-0-0	$27	18-46-0	$38	
				46-0-0 Stab	$77	$143
3	In-crop MAP	46-0-0	$27	11-52-0	$21	
				46-0-0 Stab	$93	$141
4	Super U	46-0-0	$27	46-0-0 Stab	$112	$139

A customary practice is to make P (and K) applications for two crops, often corn and soybean, applying P in the corn year. Does considering the broader fertility program cost and unrecovered nutrient change the economic cost of in-crop P applications? For example, using a blended dry N-P and N-only fertilizer at sidedress can reduce the number of trips across the

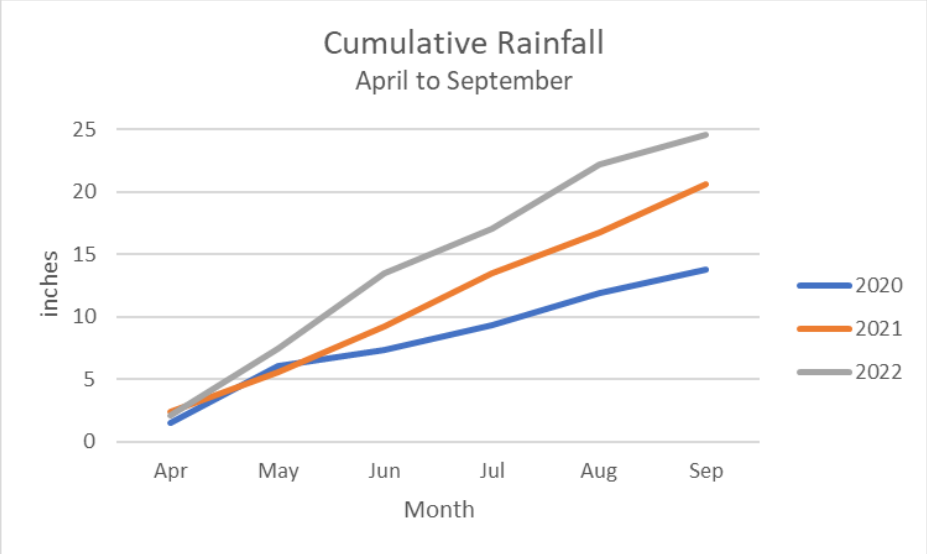
field by eliminating the fall pass. A second advantage is utilizing the N applied with the N-P fertilizer as part of the N sidedress needed.

Table 5 is a partial budget for the two-year fertilizer program costs based on nutrient cost in Table 2. The most economical program is the in-crop DAP, followed by the in-crop MAP at $190 and $199 per acre, respectively.

Table 5. Cost of fertilizer program with application cost over a two-year crop rotation.

Fertilizer Program Used	Cost of Corn N Program ($/A)	Fall Applied P Product	Application Cost of Fall Applied P ($/A)	Cost N not available to cash crop ($/A)	Cost of P ($/A)	Two Year fertilizer program cost ($/A)
28-0-0	$129	18-46-0	$ 7	$ 38	$ 47	$ 221
28-0-0	$129	11-52-0	$ 7	$ 21	$ 58	$ 215
In-crop DAP	$143	NA	$ 0	$ 0	$ 47	$ 190
In-crop MAP	$141	NA	$ 0	$ 0	$ 58	$ 199
46-0-0 w/ Stab	$139	18-46-0	$ 7	$ 38	$ 47	$ 231
46-0-0 w/ Stab	$139	11-52-0	$ 7	$ 21	$ 58	$ 225

Figure 1. Growing season precipitation accumulation for three growing seasons of this study. Data source: https://www.oardc.ohio-state.edu/weather1/



Summary

Using the nitrogen from phosphorus-containing fertilizers to meet part of the sidedress nitrogen needs for a corn crop can improve fertilization economics. Surface-applied MAP and DAP applied at sidedress had fertilizer costs of $16-31 per acre lower compared to the standard UAN coulter injected application with fall-applied P. There was no yield penalty from

the surface-applied dry nitrogen products compared to the coulter injected UAN. Relative product prices, application equipment available, and application speed will influence actual fertilizer program costs.

A wide range of application equipment could be used for an in-crop N-P application. Spinner spreaders to applicators with individual row units could be used for the in-crop application of dry fertilizer. A few farms have adapted row units to in-crop incorporation of dry fertilizer. For smaller farms, the ability to use application equipment for fall K and in-crop N-P application may be an economic incentive to invest in their own fertilizer application equipment. Variable rate applications would also be possible with dry fertilizer with at least two separate bins, which is becoming more common.

Environmental impacts of nutrient application were not directly measured in the study. Using 4R stewardship principles, the application of nutrients near the time of highest crop uptake will increase nutrient use efficiency and decrease environmental loss. The in-crop application may have a reduced risk of environmental loss since the application was made to an actively growing crop where evapotranspiration reduces water movement through the surface and tile drainage.

A reduction of 23-43 pounds per acre of nitrogen applied was achieved with the in-crop N-P fertilizer application. One potential negative impact of the in-crop P program is the surface application of nitrogen. Using stabilized N products can reduce losses that can impact yield and water quality. While water quality impacts were not measured, surface-applied nutrients are more susceptible to losses from surface water, especially where a runoff-producing rain occurs shortly after application, or if the field is subject to significant surface water movement.

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