AES Keeping Up With Research 47

July 1980

How Nitrification Inhibitors Perform in Kansas*

L.D. Maddux, J.D. Ball, and D.E. Kissel

Nitrogen fertilizers are used extensively to increase crop yields. Crops often recover less than 50 percent of the applied nitrogen during the year of fertilizer application. The lower nitrogen recoveries can stem from the loss of nitrate nitrogen from the soil by leaching and denitrification.

Most nitrogen fertilizers contain ammonium or ammonium-forming types of nitrogen. In the soil, ammonium nitrogen generally is adsorbed onto clay and organic matter where it resists leaching and denitrification. However, at soil temperatures above 50° F, ammonium nitrogen is converted to nitrate nitrogen by a two-step process called nitrification. The ammonium nitrogen is first converted (oxidized) by Nitrosomonas bacteria to nitrite which is relatively unstable in soil and is rapidly converted by Nitrobacter bacteria to nitrate nitrogen.

Nitrate nitrogen is not adsorbed by the soil but remains dissolved in the soil solution where it moves freely with the flow of water and is taken up

*Contribution 80-312-s, Agronomy Department, AES, KSU, Manhattan, 66506

AGRICULTURAL EXPERIMENT STATION
Kansas State University, Manhattan
Floyd W. Smith, Director

Agricultural Experiment Station
Kansas State University
Manhattan 66506

KSU KANSAS STATE UNIVERSITY

Keeping Up With Research 47 July 1980

 7-80—3M

by plant roots. Too much moisture from rain or irrigation causes water to move below a crop's root zone and carry some nitrate with it. Nitrate moved below the root zone is considered to be lost by leaching. Nitrate also may be lost by denitrification, especially under extremely waterlogged conditions.

The percentage of the nitrogen fertilizer used by crops can be increased by reducing nitrogen losses. One method is to apply nitrogen when the crop needs it—by sidedressing or through irrigation (fertigation). Another method to reduce losses would be to apply an ammoniacal form of nitrogen and maintain it in this form as long as possible or until the plant uses it. This latter method could be accomplished by incorporating a nitrification inhibitor with the ammoniacal fertilizer to delay the nitrification process (slow conversion to nitrate).

Nitrification inhibitors prevent or retard the first step of nitrification of ammoniacal nitrogen by the Nitrosomonas bacteria. The only product now available for this use is nitrapyrin, 2-chloro-6-(trichloro-Methyl) pyridine (N-SERVE). Other products, such as etradiazole (DWELL), are currently being studied for labeling as nitrification inhibitors.

RESULTS OF KANSAS RESEARCH

Our research on Eudora sandy loam soil at the Kansas River Valley Experiment Field, Rossville, showed that N-SERVE inhibits nitrification, so that anhydrous ammonia remains in the ammoniacal form longer into the growing season (Table 1). A higher ammonium nitrogen level was maintained in the soil up to the tassel stage of growth (6-29-78 and 7-12-79) both years. Results in 1979 at the Sandyland Experiment Field, St. John, on a Pratt loamy fine sand and at the North Central Experiment Field, Scandia, on a Crete silty loam were similar.

Field evaluation on corn, wheat and grain sorghum have been conducted in Kansas with N-SERVE from 1975 through 1979 and with DWELL from 1977 through 1979. The five-year results (Table 2) show more sites with no response than sites with increases. Although we occasionally included N-SERVE and DWELL in the same study, they are listed as separate sites for each inhibitor.

CORN

Corn, which uses more nitrogen than wheat or sorghum, has been most responsive to nitrification inhibitors. All corn-yield increases attributable to

Table 1. Soil ammonium levels after application of anhydrous ammonia on a Eudora sandy loam, Rossville, 1978 and 1979.

150 lb N/a Applied	N-SERVE lbs ai/a	Ammonium Per Acre in Top Foot of Soil, ppm[1]					
		4/26/78	5/11/78	6/7/78	6/29/78	6/11/79	7/12/79
Fall	0	—	—	—	—	93	31
Spring	0	219	269	81	45	44	15
Fall	0.5	—	—	—	—	192	66
Spring	0.5	297	290	202	74	305	67

[1]Samples taken directly over the applicator knife and 1½ inches to each side were combined for analysis.

Table 2. Effects of N-SERVE and DWELL on yields of corn, wheat and grain sorghum on all soil types in Kansas, 1975-1979.

Crop	Inhibitor	Number of Responses		
		Increases	No Response	Decreases
Corn	N-SERVE	7	14	0
Corn	DWELL	1	5	1
Wheat	N-SERVE	4	25	2
Wheat	DWELL	0	6	0
Sorghum	N-SERVE	2	15	0
Sorghum	DWELL	1	1	0

N-SERVE or DWELL were on coarse textured (sandy) soils where leaching of nitrate nitrogen could be expected (Table 3). Even on coarse soils, yield responses (from 9-22 bu/a, Table 4) were obtained less than half the time—probably because weather conditions were not conducive to leaching some years. However, of the twelve sites listed as not responsive, three of nine N-SERVE sites and one of three DWELL sites on coarse textured soils showed a trend, though not statistically significant, of 7, 10, 16, and 9 bushels increase per acre, respectively. In most cases, increased yields correlated with higher nitrogen uptake by plants. Higher phosphorus uptakes also were observed at some sites. N-SERVE and DWELL usually performed similarly at sites where both were evaluated.

Table 3. Effect of N-SERVE and DWELL on corn yield in Kansas, 1975-1979.

Soil Texture	Inhibitor	Number of sites with yield:		
		Increases	No Response	Decreases
Coarse	N-SERVE	7	9[a]	0
Coarse	DWELL	1	3[a]	0
Silt Loam	N-SERVE	0	5[b]	0
Silt Loam	DWELL	0	1[b]	1
Silty Clay Loam	N-SERVE	0	2	0
Silty Clay Loam	DWELL	0	1	0

[a] Three of nine N-SERVE sites and one of three DWELL sites with no statistically significant yield response had increases of 7, 10, 16, and 9 bushels per acre, respectively.

[b] Three of five N-SERVE sites and the DWELL site with no statistically significant yield response had decreases of 5, 4, 7, and 15 bushels per acre, respectively.

DWELL decreased yields on silt loam at the Tribune Branch Experiment Station by 16 bushels per acre in 1978. The same trend, although not significant, was also observed with DWELL in 1979 (15 bushels decrease per acre) and with N-SERVE in 1979, 1978 and 1976 (5, 4, and 7 bushels decrease per acre, respectively). We have no logical explanation for these yield decreases due to nitrification inhibitors on this silt loam soil.

WHEAT

Nitrification inhibitors have had relatively little effect on wheat yields in Kansas (Table 5). One significant yield increase was observed with DWELL on a sandy soil in 1979, but only at one nitrogen rate and one inhibitor rate. Excessively wet conditions favoring nitrogen losses were considered responsible for the 5.6 bushel increase per acre with N-SERVE at the Osage County silty clay loam site in 1978 (Table 6). Two yield decreases of 7.3 and 2.2 bushels per acre were observed at the Sandyland Experiment Field in 1976 and 1978, respectively. Recent research indicates that applying N-SERVE before planting winter wheat lets much of it degrade before spring, so it would be less effective in reducing spring nitrogen losses.

Yield increases from placing nitrogen in the same band as phosphorus fertilizer is thought to be a result of N-SERVE maintaining the nitrogen in the ammoniacal form for a longer period of time, thus having a greater effect on phosphorus uptake than without N-SERVE. However, an additional yield advantage with N-SERVE has not been observed at every location where dual placement has resulted in increased yields.

GRAIN SORGHUM

As shown in Table 2, only three of the nineteen sites showed an increase in sorghum yield with N-SERVE or DWELL. N-SERVE gave a four bushel per acre increase at the Colby Branch Station in 1976 and 24 bushels per acre at the Sandyland Experiment Field (coarse soil) in 1977. An 11 bushel per acre increase was obtained with DWELL at the Sandyland Experiment Field in 1977. Most of the sorghum studies have been on medium to fine textured soils.

SUGGESTIONS FOR USE

Research has shown that, under excessive rainfall, maintaining applied nitrogen in the ammoniacal form could benefit crops on sandy soils subject to leaching losses of nitrate nitrogen and possibly on fine textured or claypan soils subject to denitrification.

Corn grown on coarse textured soil is more responsive to nitrification inhibitors than corn on fine textured soil. Present recommendations for corn on coarse textured soil include sidedressing ni-

Table 4. Yields of corn at sites responsive to N-SERVE and DWELL in Kansas, 1975-1979.

Year	County	Inhibitor	Corn yield, bu/a @15.5% Without Inhibitor	With Inhibitor	Change
1976	Sedgwick	N-SERVE	133	148	+15
1976	Stafford	N-SERVE	97	114	+17
1977	Stafford	N-SERVE	91	106	+15
1977	Gray	N-SERVE	95	109	+14
1978	Greeley	DWELL	121	105	−16
1978	Shawnee	N-SERVE	94	103	+ 9
1978	Stafford[1]	N-SERVE	99	113	+14
1978	Stafford[1]	DWELL	99	114	+15
1979	Shawnee[2]	N-SERVE	142	164	+22

[1]One study area with N-SERVE and DWELL as separate treatments.
[2]At 75 lb N/a only.

Table 5. Effect of N-SERVE and DWELL on wheat yields in Kansas, 1975-1979.

Soil Texture	Inhibitor	Number of sites with yield: Increases	No Response	Decreases
Coarse	N-SERVE	0	3	2
Coarse	DWELL	1	1	0
Silt Loam	N-SERVE	0	13	0
Silt Loam	DWELL	0	1	0
Silty Clay Loam	N-SERVE	1	2	0
Dual placement of nitrogen and phosphorus				
Silt Loam	N-SERVE	2	6	0
Silt Loam	DWELL	0	1	0
Silty Clay Loam	N-SERVE	1	1	0
Silty Clay Loam	DWELL	0	1	0

Table 6. Yields of wheat obtained at sites responsive to N-SERVE in Kansas, 1975-1979.[1]

Year	County	Wheat yield, bu/a Without Inhibitor	With Inhibitor	Change
1976	Stafford	34.3	29.0	− 7.3
1978	Osage	59.6	65.2	+ 5.6
1978	Stafford	31.0	28.8	− 2.2
Dual placement of nitrogen and phosphorus				
1977	Reno	35.2	46.7	+11.5
1977	Labette	42.3	48.6	+ 7.3
1978	Osage	48.9	57.5	+ 8.6

[1]No responses were obtained in 1975 or 1979.

trogen or applying it with irrigation. A nitrification inhibitor might be an alternative, but there is little research in Kansas to indicate whether corn yields obtained by sidedressing or fertigating can be equaled by the application of preplant nitrogen plus a nitrification inhibitor.

Wheat and grain sorghum have shown little response to nitrification inhibitors. However, many of the sorghum studies were on silt loam soils not usually susceptible to nitrogen losses, so a nitrification inhibitor might be warranted in some cases. If the past history of a field indicates losses of applied nitrogen in years of excessive moisture, a nitrification inhibitor might be a good investment.