Effect of Nitrification Inhibitors on Nitrogen Utilization Efficiency in Sweet Corn

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Abstract

A field experiment using subsurface drip irrigation was conducted at the Maricopa Agricultural Center on a Casa Grande sandy loam soil to evaluate the effect of varying nitrogen (N) sources on the growth and yield of 'Sweetie' 82' sweet corn when applied with, and without four nitrification inhibitors (NI). The NI treatments included nitrapyrin (N-Serve®), dicyandiamide (DCD), ammonium thiosulfate, and N-Hib Calcium™. Nitrogen was supplied as urea-ammonium nitrate (UAN-32). In addition, an all nitrate source plus a control which received no added N were used. All N treated plots received a total of 111 lbs. N/acre in split applications at the V3, V6 and the V12 stages. All solutions were applied through buried, perforated PVC tubing to simulate application through the buried drip irrigation system. The inclusion of the nitrification inhibitors with UAN-32 had no significant effect on marketable ear yield, total N uptake or nitrogen use efficiency.

Introduction

The use of nitrification inhibitors has the potential to increase nitrogen (N) utilization by some crops and also reduce the likelihood of leaching losses of nitrate. This is accomplished by maintaining ammonium containing fertilizers in a nonleachable form (NH_4^+) prior to natural conversion to the leachable NO_3^- form. Currently very little information is available on the proven benefits of nitrification inhibitors in improving nitrogen utilization by crops under irrigated conditions. The objectives of this research were to compare the effectiveness of nitrification inhibitor treatments in conjunction with urea ammonium-nitrate solution at improving marketable ear yield and nitrogen uptake and recovery by sweet corn.

Materials and Methods

Using a commercial planter, "Sweetie '82" sweet corn was planted in 300 foot rows on 2 March, 1990 on three east-west oriented 40-inch beds. Drip tubing lines (Chapin Twin-wall IV®) were buried 8 in. below the center of each bed, using a tractor mounted, 2-row injecting apparatus. The beds were relisted and smoothed with a commercial bed shaper to provide a flat, firm seedbed for more uniform seed placement and seedling emergence. A single seed row was planted on the south side of each bed to take advantage of solar radiation during the early season. Water was applied daily to supply 100% of the consumptive use of sweet corn (Erie et al., 1982). A total of 21.2 inches of water was applied.

The center row within this uniform stand was used to investigate the effect of various nitrogen sources applied in conjunction with different nitrification inhibitors on yield and N uptake parameters in sweet corn. The specific treatments used are listed in Table 1.

Individual plots containing 5 plants each were 1 meter long and established at the V2 stage on 29 March. A system was needed that would permit multiple applications of fertilizer solutions that would simulate application through the buried drip tubing but would not unduly disrupt the root zone. A trench was carefully dug to just expose a 1 m section of the drip tubing at the V2 stage; then directly over the tubing, a U-shaped tube (constructed of 0.5 in. PVC pipe (I.D.) with a horizontal segment of 1 m length) was installed. The trench containing the U-tube was backfilled immediately after installation and required no further disturbance for the remainder of the growing season. The bottom of the horizontal segment of the U-tube was perforated every 8 in. with 1/16 in. diameter holes, permitting the uniform flow-through of 250 ml of the solution over a 5-minute period. The vertical portions of the U-tube were 18 in. long, and extended 10 in. above the soil surface.

The tube ends served as the point of access for pouring solutions into the U-tube. To minimize the entry of dust or other contaminants into the system, both ends of the U-tube were fitted with rubber stoppers whenever solutions were not being introduced. Applications of fertilizer solutions were individually dispensed into separate plastic bottles for each plot and applied in a total volume of 250 ml. The amount of water applied with each application of fertilizer solution represents 0.04% of the total irrigation water applied and therefore was a negligible contribution of moisture.

The total amount of N applied to treatments 1-8 was 111 lbs. N per acre. In the case of Treatments 5 and 6, applications of N from UAN-32 were reduced to compensate for N contained in dicyandiamide and ATS respectively. The rates and timing of fertilizer and inhibitor applications are listed in Table 2. All treatments were replicated four times in a randomized complete block design.

At the R1 or silking stage, earleaf samples were taken from the interior three plants in each plot. The leaf blade sampled was the one immediately below and opposite the primary ear.

At harvest maturity, the 5 plants within each plot were harvested and subdivided into five plant-part categories: leaves, stalk + tassel, cob + shank, husk + silk and grain. Plant parts were dried at 60°C, weighed and analyzed for total N content. In addition, the number and fresh weight of marketable and cull ears were determined.

The total nitrogen contained in the five plant parts was calculated as the product of the dry weight and the nitrogen concentration in the respective tissues. The total N contained in the aerial portion of the crop was calculated as the sum of the N contained in each plant part.

Results and Discussion

The application of the various nitrification inhibitor treatments had no statistically significant effects on the growth, yield and N uptake parameters measured in this experiment (Table 3).

Several interesting trends were noted however. Plants grown with UAN-32 plus $CaCl_2$ (Treatment 2) were consistently larger, produced more ears and made more complete use of available N reserves. In addition, Treatments 7 and 8 (N-Hib Ca and NO_3 control respectively) produced the lowest level of marketable ears per plant but the highest levels of nonmarketable ears per plant. Other studies have found that predominately NO_3 uptake may increase vegetative but not reproductive growth. One could speculate that N uptake in these two treatments was mostly as NO_3, leading to the formation of a smaller percentage of marketable ears per plant. This hypothesis would require further testing.

The total N concentrations in the earleaves ranged from 1.9 to 2.3%. In comparison the adequate range for sweet corn is thought to be about 2.5 to 2.7% N. At this marginally suboptimal level of N fertility, the likelihood of measuring a response to a nitrification inhibitor should be maximized. And yet, no enhanced growth was measured when any of the inhibitors were supplied. This is in contrast to previous findings on this site when ammonium sulfate [$(NH_4)_2SO_4$] was the source of fertilizer N. The use of nitrapyrin in conjunction with $(NH_4)_2SO_4$ increased marketable ear yield (+12%), total dry matter production (+10%), number of marketable ears per plant (+10%) and ^{15}N uptake efficiency (15%). One possible explanation for this difference is that the use of nitrification inhibitors may be more beneficial when immobile forms of ammonium-only N sources are applied. These would include anhydrous ammonia, aqua ammonia, ammonium phosphate and ammonium sulfate. The presence of 25% of NO_3-N in the UAN-32 would also tend to lessen the likelihood of a growth response to inclusion of nitrification inhibitors.

Based on the results of this trial, nitrification inhibitors did not promote growth and marketable yield of sweet corn when used in conjunction with urea-ammonium nitrate solution, particularly when drip irrigation is used.

Table 1. Nitrogen sources and rates, and nitrification inhibitor treatments applied to 'Sweetie 82' sweet corn grown on a Casa Grande sandy loam.

Treatment No.	Fertilizer N Source*	Nitrification Inhibitor Name	Nitrification Inhibitor Rate	Ca Applied
		lbs./acre		
1	UAN-32	---	---	---
2	UAN-32 + $CaCl_2$	---	---	41.8
3	UAN-32	Nitrapyrin	1.5	---
4	UAN-32 + $CaCl_2$	Nitrapyrin	1.5	41.8
5	UAN-32	Dicyandiamide	26.7	---
6	UAN-32 + ATS	25% N as ATS	226	---
7	UAN-32	N-Hib Calcium*	639	41.8
8	$Ca(NO_3)_2$ + $NaNO_3$	---	---	41.8
9	none (Control)	---	---	---

*UAN-32 and ATS refer to solutions of urea-ammonium nitrate and ammonium thiosulfate respectively.

Table 2. Rates and timing of N fertilizer and nitrification inhibitors to 'Sweetie 82' sweet corn grown on a Casa Grande sandy loam.

Treatment No.	Nitrogen Fertilizer V3	V6	V12	Sources Inhibitor V3	V6	V12	Inhibitor Rate V3	V6	V12
	lbs. N per acre								
1	26	67	18	--	--	--	--	--	--
2	26	67	18	--	--	--	--	--	--
3	26	67	18	0	0	0	0.5	0.5	0.5
4	26	67	18	0	0	0	0.5	0.5	0.5
5	20	61	12	6	6	6	8.9	8.9	8.9
6	20	50	13	6	17	5	50	139	37
7	26	67	18	0	0	0	153	384	102
8	26	67	18	--	--	--	--	--	--
9	0	0	0	--	--	--	--	--	--

Table 3. Effects of various nitrification inhibitor treatments on the growth and N uptake of 'Sweetie 82' sweet corn grown on a Casa Grande sandy loam.

Treatment	Marketable Yield	Marketable Ears/plant	Nonmarketable Ears/plant	Ear leaf N	Total Dry Matter	Total N Uptake	Fertilizer N Uptake Efficiency
	tons/acre			%	tons/acre	lbs/acre	%
1	8.6	1.3	1.25	2.1	5.3	104	31
2	9.7	1.4	1.5	2.2	5.8	112	39
3	7.6	1.1	1.05	1.9	5.0	99	27
4	7.9	1.15	1.45	2.0	5.3	105	32
5	8.4	1.3	1.25	2.2	5.1	102	30
6	8.9	1.3	1.25	2.3	5.4	105	33
7	8.1	1.15	1.75	2.2	5.4	103	31
8	7.8	1.1	1.8	1.1	5.3	103	31
9	6.1	0.95	1.05	1.6	3.3	69	--