Enhanced Growth of Drip Irrigated Sweet Corn Using a Nitrification Inhibitor

Thomas A. Doerge, Thomas C. Tucker and Ted W. McCreary

Abstract

A field experiment using subsurface drip irrigation was conducted at the Maricopa Agricultural Center on a Casa Grande sandy loam to evaluate the effect of varying nitrogen rates on the growth and yield of 'Jubilee' sweet corn when applied with, and without the nitrification inhibitor, nitrapyrin (N-Serve^R). N treatments of 89, 134 and 267 lbs. N/acre were applied as ammonium sulfate to one meter miniplots in three split applications between the V2 and the V10 growth stages. Individual N-Serve^R application rates were 0.5 lbs/acre. All solutions were applied through buried, perforated PVC tubing to simulate application through the buried drip irrigation system. The inclusion of N-Serve^R significantly increased dry matter accumulation, number of total ears and number of marketable ears/plant at all N levels. Plant tissue analysis suggested that enhanced uptake of ammonium-N as well as reduced leaching of nitrate-N contributed to this growth response to N-Serve^R.

INTRODUCTION

Nitrification inhibitors have long been used in agricultural systems to delay the conversion of ammonium forms of nitrogen into the more mobile nitrate form. It is believed that this reduces the potential for leaching losses of fertilizer-derived nitrates. A second potential benefit could occur if this delay in the nitrification process results in a greater root uptake of ammonium-N. Some plants have shown enhanced growth under mixed-N nutrition, when compared to the same plants supplied with only nitrate or only ammonium-N. In normal irrigated desert soils, the nitrification process takes place very rapidly, and most of the N absorbed by crop plants is in the nitrate form.

The objectives of this study were: 1) to demonstrate whether the inclusion of the nitrification inhibitor nitrapyrin (N-Serve^R) improves sweet corn yields in fields with a subsurface drip irrigation system that has a very low leaching potential; and 2) to evaluate whether any improvement in growth is the result of greater positional availability of nitrate-N, and/or whether it is due to the enhancement of direct ammonium uptake by sweet corn.

MATERIALS AND METHODS

Using a commercial planter, 'Jubilee' sweet corn was planted in 300 foot rows on 1 March, 1988 on six east-west oriented 40-inch beds. Drip tubing lines (Chapin Twin-wall IV^R) 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 three times weekly to supply 100% of the consumptive use of sweet corn (Erie et al., 1982).

This uniform stand of corn was used to investigate the effect of nitrification inhibitors and the total nitrogen (N) fertilizer rate on N uptake at various times during vegetable growth. Fertilizer N was supplied as pulse-labeled ^{15}N to permit a detailed evaluation of N use efficiency in response to the treatments imposed in this experiment. The factors and treatments listed below were arranged in a complete factorial design with three replications (Table 2).

Factor 1: Timing of ^{15}N application [22 lb. ^{15}N/acre, 6% ^{15}N-$(NH_4)_2SO_4$]

Levels:
1. V2 (too early)
2. V5 (optimum)
3. V10 (too late)

Factor 2: Total N fertilizer rate (labeled + unlabeled)

Levels:
1. 89 lb./acre
2. 134 lb./acre
3. 367 lb./acre

Factor 3. Nitrification inhibitor (Nitrapyrin or N-Serve^{R})

Levels:
1. 0 lb./acre
2. 0.5 lb./acre per application

Individual plots containing 5 plants each were 1 meter long, 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; directly over the tubing, a U-shaped tube (constructed of 0.5 in. PVC pipe (I.D.) with a horizontal segment of 1 m long) 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. All N applied (labeled and unlabeled) was ammonium sulfate [$(NH_4)_2SO_4$]. Table 1 shows the time and amounts of N applied. Nitrapyrin was applied to all + Nitrification Inhibitor plots with the V2, V5 and V10 applications, for a total of 1.5 lbs. nitrapyrin/acre during the season.

Table 1. Fertilizer schedule for the ^{15}N sweet corn study, Maricopa, 1988.

Growth Stage On Date of Application	Total N Fertilizer Applied (lb./acre)					
	89		134		267	
	Labeled	Unlabeled	Labeled	Unlabeled	Labeled	Unlabeled
	lbs. N/acre					
V1	0	22	0	22	0	22
V2	22	0	22	0	22	22
V4	0	0	0	0	0	45
V5	22	0	22	22	22	45
V8	0	0	0	22	0	45
V10	22	0	22	0	22	22
Subtotal N	67	22	67	67	67	200
Total N	89		134		267	

At harvest maturity, the 5 plants within each plot were harvested and sub-divided into five plant-part categories: leaves, stalk + tassel, cob + shank, husk + silk and grain. Plant parts were dried at 60°C and weighed. In addition, the number and fresh weight of edible ears were determined. The individual plant part samples will be analyzed for total N content by Kjeldahl digesting and steam distillation. Isotopic composition of plant N will then be determined by mass spectrometry. These results are not yet completed.

In addition to this pulse-labeled ^{15}N experiment, a companion experiment was also established in the same location to permit periodic destructive sampling of plant tissue to monitor the N status occurring in each of the N level x Nitrification Inhibitor treatments. The companion experiment was identical to the ^{15}N experiment except that unlabeled N, also as ammonium sulfate, was substituted for the labeled N applications. This permitted the sampling of basal stalk tissue at the V5, V10 and R1 growth stages for nitrate analysis. At the R1 stage the earleaves opposite and immediately below the primary ear were also sampled for Kjeldahl N determination.

RESULTS

The application of nitrification inhibitor (NI) significantly increased the yield of marketable ears (+12% of -NI treated plots), total dry matter production (+10%) and number of marketable ears per plant (+10%) when averaged across all N rates (see Figure 1). Increases in plant growth were greatest in the plots receiving the lower rates of N fertilizer (89 and 134 lb. N/acre) although increases were also observed in the 267 lb. N/acre treated plots. This amount of N probably exceeded the N need for optimum production by 70 to 100 lb. N/acre. The measurement of growth increases even in these plots suggest that factors other than reduced leaching resulting from nitrification inhibition are causing improved plant performance. It is possible that enhanced ammonium uptake with the use of inhibitors may be involved. Total nitrogen and ^{15}N analyses, when completed, will be very useful in elucidating this question.

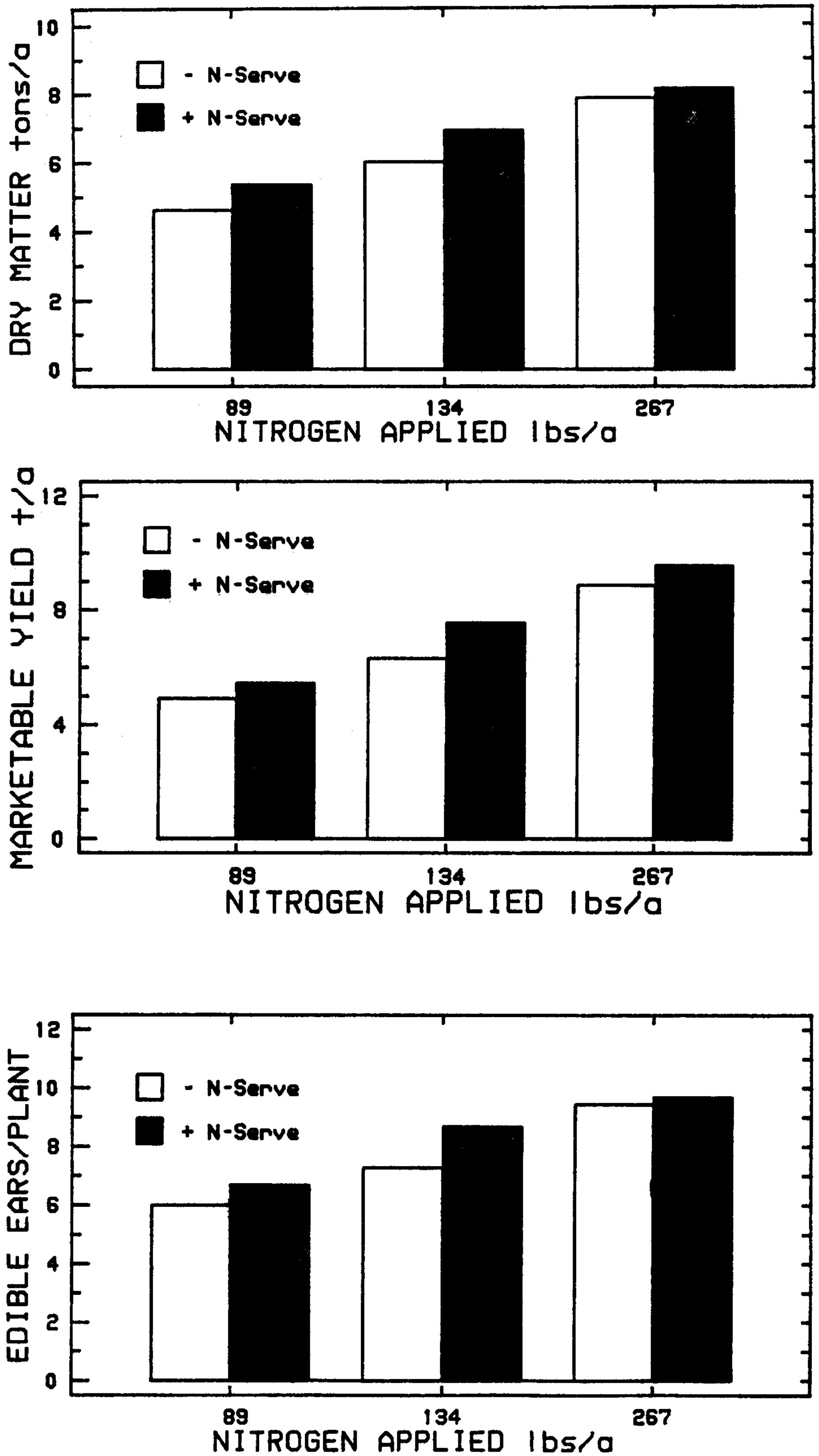

Figure 1. The effect of nitrogen fertilizer rates and the application of nitrapyrin on dry matter production (top), marketable yield (middle) and number of marketable ears/plant (bottom) for drip irrigated 'Jubilee' sweet corn.

The application of nitrapyrin significantly changed the concentration of NO_3-N in basal stalk tissue at the V10 and R1 growth stages (Figure 2). The reduction in the NO_3-N levels in response to nitrapyrin application became more pronounced as the total amount of N applied increased. This suggests that the application of nitrapyrin delays nitrification enough to promote the direct uptake of applied N in the NH_4 form.

The trend toward increasing earleaf total N concentrations (Figure 3) with the inclusion of nitrapyrin also suggests that plant N uptake is greater when a nitrification inhibitor is applied. Whether this greater N uptake is the result of greater positional availability of N (due to retention of the NH_4^+ cation) and less leaching of subsequently formed NO_3 and /or due to an overall enhancement of total N uptake with mixed (NH_4^+ and NO_3) N nutrition cannot be determined solely from the data presented in this report. Future research in 1989 will specifically quantify the leaching of ^{15}N labeled ammonium sulfate applied with various rates and types of nitrification inhibitor compounds.

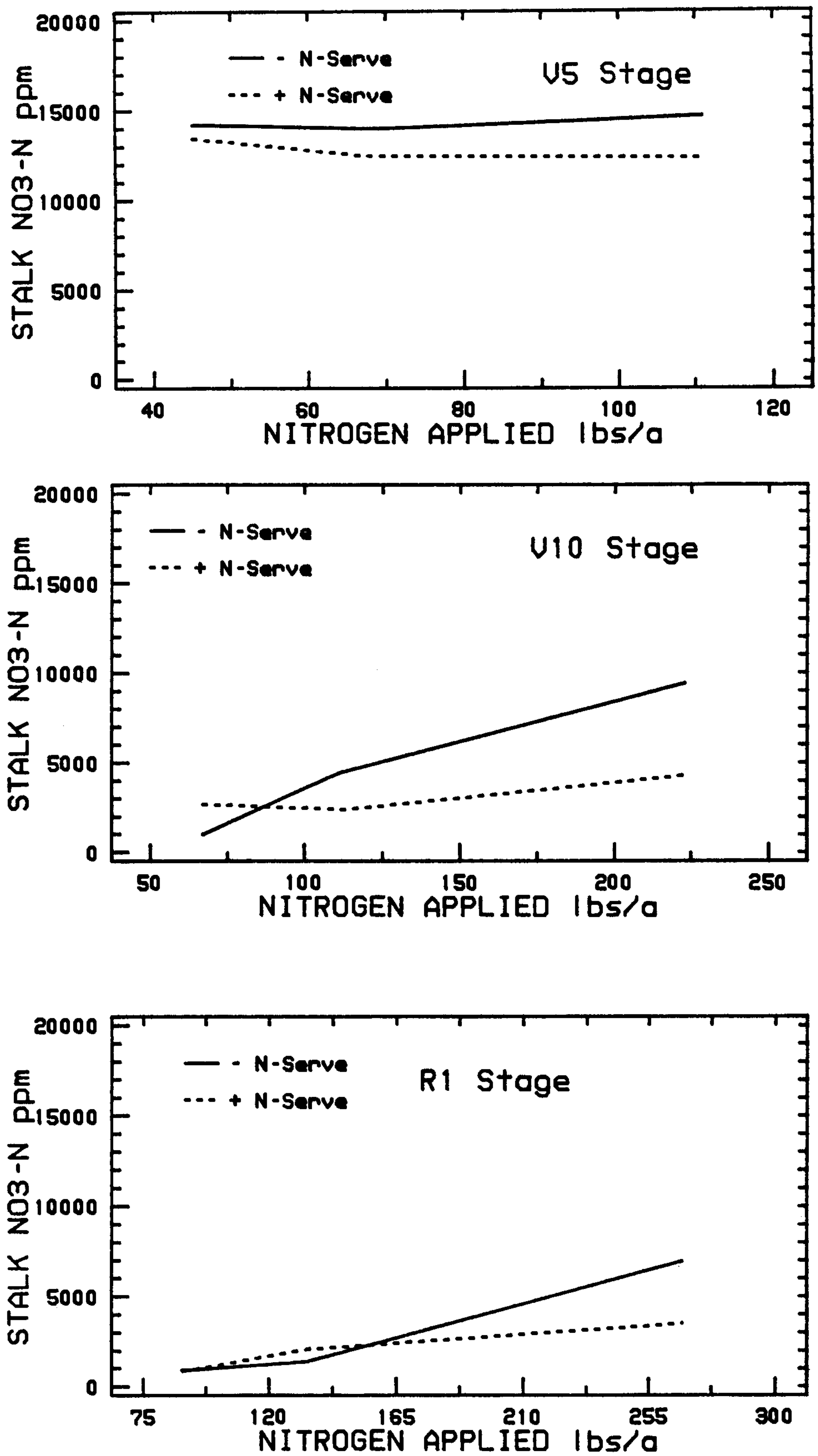

Figure 2. The effect of nitrogen fertilizer rates and the application of nitrapyrin on basal stalk nitrate levels in 'Jubilee' sweet corn at the V5 (top), V10 (middle) and R1 (bottom) growth stages.

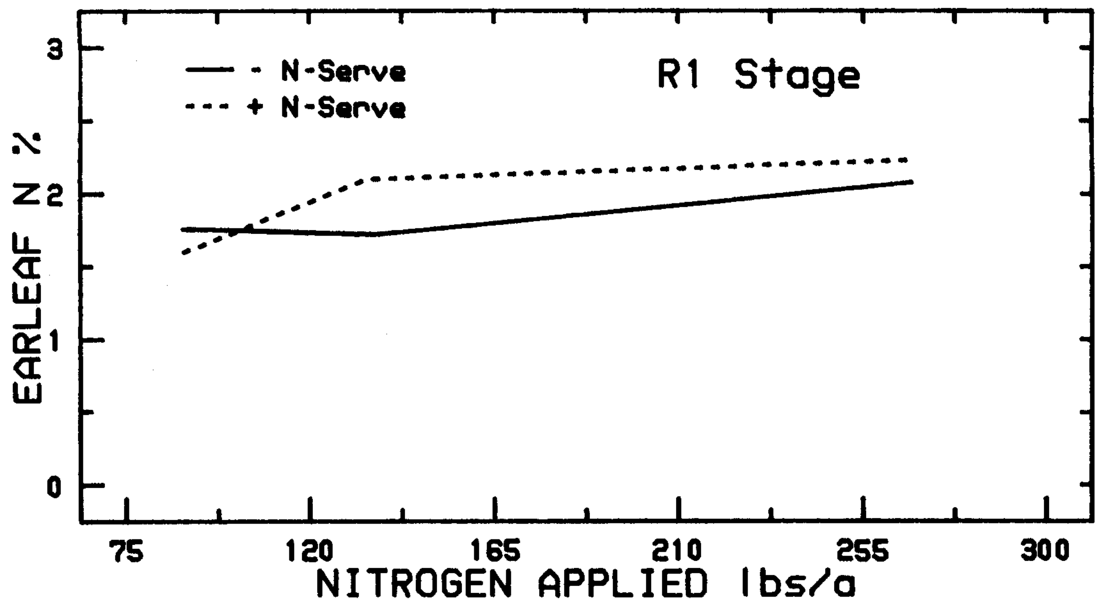

Figure 3. The effect of nitrogen fertilizer rates and the application of nitrapyrin on total Kjeldahl N levels in the earleaves of 'Jubilee' sweet corn at silking.

These preliminary results clearly indicate a potentially significant role for nitrification inhibitors in improving marketable yields of sweet corn, even under a well-managed drip irrigation system. We hypothesize that this improvement in sweet corn growth is due to both reduced leaching of fertilizer-derived nitrates and to enhanced total N uptake with mixed NH_4^+ + NO_3^- nutrition. Previous research suggests that individual applications of nitrapyrin should be between 0.25 and 0.5 lbs./acre. Thus, a total application of 1 to 2 lbs. of nitrapyrin per acre per season may well be justified for subsurface drip irrigated sweet corn if yields can be increased by about 10%.

The use of nitrification inhibitors for sweet corn growers using other forms of irrigation, such as furrow or overhead sprinklers, may be much less effective in stimulating plant growth, due to the inability of these systems to place ammonium-containing fertilizers directly into the root zone. Similar responses of other crops to the inclusion of nitrification inhibitors with ammonium- containing fertilizers may not always be realized. Previous work with upland cotton showed no increase in plant biomass, lint yield or ^{15}N uptake when nitrification inhibitors were applied through a buried drip system (Doerge and Tucker, 1987).

REFERENCES

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