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High-frequency Irrigation for Water Nutrient Management in Humid Regions

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ABSTRACT

A water-nutrient management method was designed to prevent plant-water and nutrient stresses while maximizing the available soil water storage to accommodate rainfall. This method minimized the need for the soil as a storage reservoir for water and nutrients by frequently irrigating a portion of the root zone with small amounts of water and nutrients. The optimal range of soil matric potential, based on soil oxygen diffusion rate, soil strength, water desorption characteristics, and unsaturated hydraulic conductivity was used to determine high-frequency irrigation criteria for sweet corn (*Zea mays* L.). Trickle-irrigated plots yielded 12 and 14% more corn than did the furrow- and sprinkler-irrigated plots. When fertilizers were broadcast and banded, soil NO_3-N profiles measured near the end of the growing season showed that, compared to furrow and sprinkler irrigation, trickle irrigation reduced NO_3-N losses from the root zone.

Optimal ear yield was produced with high-frequency trickle irrigation when the soil matric potential at the 15-cm soil depth was controlled at about -0.2 bar and plants were fertilized with 168 kg/ha each of N and K. Ear yield for this treatment was 66% higher than that for nonirrigated corn fertilized at the same rate. Soil NO_3-N did not accumulate in the profile with depth and time in plots fertilized at the 168-kg/ha rate, but did accumulate in plots fertilized with 336 kg/ha. Generally, plots trickle-irrigated with fertilizer solution had a higher soil NO_3-N content on the row than 50 cm from the row.

The results of this research indicate that water use efficiency, N-use efficiency, and N leaching can be controlled in sandy soils when N and K are applied with high-frequency trickle irrigation systems and N and K rates are adjusted to maintain an optimal N-level in corn plants.

Additional Index Words: **subsurface irrigation, trickle irrigation, soil-matric potential sensor, water use, irrigation requirements, NO_3–N leaching, N-use efficiency**

PROBLEMS of normal irrigation management in the semiarid West (11) are aggravated in the Southeast where rainfall is frequently erratic. If the soil water storage is exceeded, large rainfall leaches soluble nutrients stored in the root zone (6, 7) and may cause deficient aeration.

These problems can be solved by minimizing the use of the soil as a storage reservoir for water and nutrients. Frequent application of soluble nutrients in small quantities to the soil or possibly directly to the foliage, so that only a small quantity exists in the soil at any given time could reduce leaching by heavy rains. Frequent application of water in small quantities can provide adequate water for crop growth, leave considerable soil volume available for storage of rain, and substantially increase yields (10, 11, 13, 14). Furthermore, by irrigating frequently, water and nutrients are supplied to the soil where the roots are most active, when and where they are needed. Frequent irrigation of part of the root zone will compensate for insufficient stored water in the larger root zone.

This paper reports development and tests of water-nutrient management methods designed to prevent plant water and nutrient stresses and significant increases in soil strength while maximizing the available soil water storage for a typical sandy soil of Southeastern Coastal Plains.

THEORETICAL SYSTEM CONSIDERATIONS

In a typical nonirrigated, shallow-layered sandy loam soil of the Coastal Plains, roots of corn plants growing in rows 100 cm apart and spaced 15 cm on-row are observed in about 60% of the 25-cm-deep A1 horizon (Fig. 1). Generally, the A2 horizon is compact, restricts root penetration, and impedes water flow (1, 3, 4, 11) so much that essentially all the water available to the corn plant is stored in the A1 horizon. The water desorption curve, the corresponding calculated values of the unsaturated hydraulic conductivity, the growth-limiting oxygen diffusion rate (ODR) (8, 12, 16) and the strength-limiting soil matric potentials (1) of the A1 layer of a Varina sandy loam soil with a bulk density of 1.5 g/cm^3 have been determined (Fig. 2).

The soil matric potential at which root growth is limited is that at which the soil strength, measured with a soil resistance probe (penetrometer), is $\geq$ 20 kg/cm^2 (-0.4 bar) (1). The critical soil matric potential of -0.08 bar limits the ODR to 40 × 10^{-8} g^{-1}cm^2 min^{-1} (11, 12, 16) in the A1 horizon. A higher soil matric potential would result in oxygen deficiency sufficient to retard plant growth in this soil. As the soil bulk density increases, the optimal range of soil matric potential decreases. The bulk density of the A2 horizon is usually 1.7 g/cm^3 and the optimal soil matric potential range is < 0.2 bar. This partially explains the lack of root penetration into the A2 and B1 horizons.

The A1 slab of soil for each plant is 25 cm deep, 100 cm wide, and 15 cm thick. The volumetric water content of this saturated

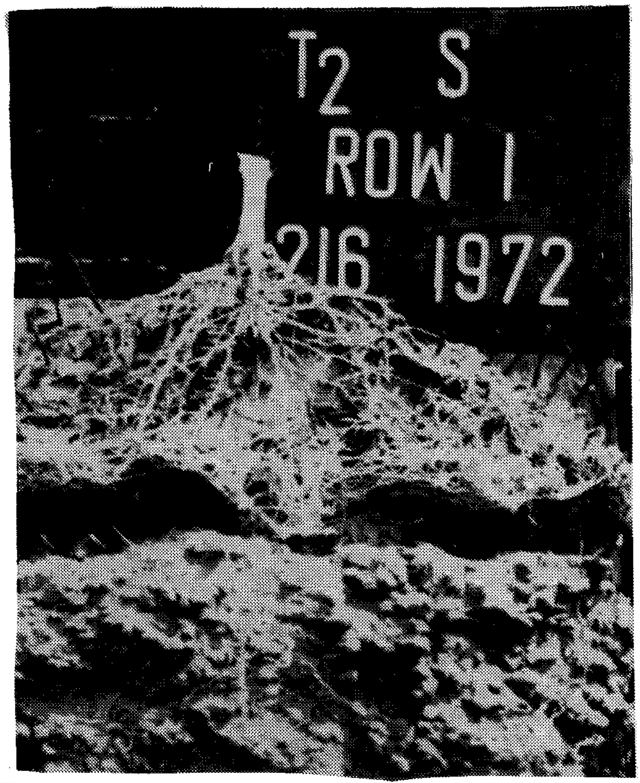

Fig. 1—Roots of nonirrigated corn plants growing in shallow, layered sandy loam soil with row spacing of 100 cm and plant spacing of 15 cm.

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[2] Soil Scientists.

soil is 39.5% (9.9 cm) at saturation, and 10% (2.5 cm) at -0.4 bar. The difference of 7.4 cm represents the maximal amount of water stored in the A1 horizon, water that is available to the corn plant before plant-water stress and strength impedance become detrimental to plant growth. This water will meet the plants' requirement for a maximum of 10 days, if the average evapotranspiration rate is 0.74 cm/day and the amount of water draining below the A2 horizon is negligible. Phene et al. (10, 11) have shown that without irrigation the soil matric potential at 15 cm from the soil surface will decrease from -0.08 bar to -0.40 bar in approximately 4 to 5 days at an average evapotranspiration rate of 0.8 cm/day. As the soil matric potential decreases, the unsaturated hydraulic conductivity of the surface soil decreases by a factor of 10^{-3}, and the effective soil matric potential at the root surface is further depressed (5). Since the unsaturated hydraulic conductivity of the soil has decreased markedly, the flux of water to the root zone does not equal the water demand, a water deficit develops within the plant, the stomates close, and transpiration decreases. The plant will remain under stress until water is added or until the evapotranspiration demand decreases.

Irrigation should be started before the soil matric potential decreases below -0.4 bar (the strength-limiting soil matric potential) and causes plant water stress. The soil water storage can be replenished by applying 5 cm of water with an irrigation system. However, after such an irrigation, intense rain may add excess water, causing oxygen stress and excessive leaching and runoff.

An accurately controlled high-frequency irrigation system can be used to maintain an optimal soil matric potential level in the middle of the range (Fig. 2) and effectively provide the amount of water required.

Soluble fertilizers applied through porous tubes with high-frequency irrigation will be distributed in low concentration within the active root zone and the nutrients will become rapidly available to the plant during and after each irrigation.

CONTROL SYSTEM DESIGN

Since the system is based on high-frequency irrigation rather than on the stored water concept, water application must be controlled sufficiently to adjust for the complex diurnal and seasonal changes in crop water requirements. The system should have sufficient water delivering capacity to meet plant requirements during periods of peak evapotranspiration. Irrigation must be controlled accurately and with minimal time lag to adjust for the extreme variability of the radiant energy, since rapidly changing weather conditions may prevent scheduling of irrigation (10, 11).[3]

How well the high-frequency irrigation system performs depends on the sensitivity of the soil-water-sensing device and the spatial location of the sensor with respect to the water source and the root system (11, 14).

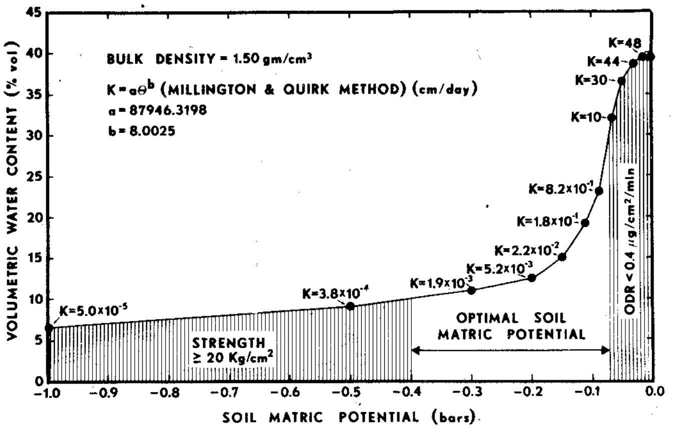

Fig. 2—Water desorption, ODR, and strength limiting soil matric potentials and calculated unsaturated hydraulic conductivity of A1 layer of Varina sandy loam soil.

Richards (15) developed a manual water-management procedure in which tensiometers were used at two depths. The upper tensiometer initiated sprinkler or furrow irrigation, and the deeper tensiometer determined the duration of the irrigation cycle. Phene et al. (10) used a solid state soil matric potential sensor, located in the midroot zone, to initiate irrigations that maintained a relatively constant soil matric potential at a representative point in the root zone (11).

The basic logic for a control system was improved by basing the decision to irrigate on concurrent estimated evapotranspiration (2) and soil water measurement. If it is raining and soil water is deficient, irrigations are stopped to allow time for water to flow to the sensor.

METHODS AND MATERIALS

Experimental Design and Procedure

Experiments were conducted to determine water and N requirement of sweet corn. In the first experiment, yields of sweet corn irrigated with high-frequency porous tube, furrow, and sprinkler irrigation systems at three soil matric potentials, were compared under constant N, P, and K fertilizations. In a subsequent experiment, yields of sweet corn, fertilized with various rates of N and K, were compared under controlled soil matric potentials.

HIGH-FREQUENCY IRRIGATION AT THREE SOIL MATRIC POTENTIAL LEVELS.

In the first study (spring 1972), the experimental plan was a split-plot design of three replicates. The main treatments were high-frequency porous tube (T), furrow (F), and sprinkler (S) irrigation. The subplots were -0.1 bar (M_1), -0.2 bar (M_2), and -0.4 bar (M_3) matric potential levels at time of irrigation. Each subplot was 7.6 by 6.1 m in area with rows oriented in the longest dimension. These matric potentials represent the high, medium, and low levels of the optimal soil matric potential range.

The soil was adjusted to pH 6 by applying 5 metric tons/ha of lime, and treated with Diazinon AG 500[4] to control soil insects and worms. Total fertilization of N, P, and K was 184, 80, and 184 kg/ha, respectively, in five applications. The first, a preplant broadcast, was 120 kg!ha each of N and K and 80 kg/ha of P. The four subsequent applications of 18 kg/ha each of N and K were banded 15 cm from the plants at 15-day intervals during the growing season. Sweet corn (*Zea mays* L., Silver Queen var.) was planted with a 2-row planter, and thinned to a density of 65,500 plants/ha. The furrow ends were diked to impound runoff, and small dikes were constructed in the rows of the F- and S-irrigated plots to improve water distribution. Subplots were irrigated automatically for 15 min with 175 (T), 765 (F), and 296 (S) liters of water per treatment, when the soil matric potential at the 15-cm depth directly below the plant was -0.1 (M_1), -0.2 (M_2), and -0.4 bar (M_3), respectively. Number, weight, and length of marketable ears; plant height; and water applied were measured to assess the crop response. Sixty days after planting, the soil NO_3-N was measured in 15-cm depth increments at 0, 12.5, 25, 37.5, and 50 cm from the row. Nitrate-Nitrogen was determined with the NO_3 specific ion electrode.

HIGH-FREQUENCY POROUS TUBE IRRIGATION AT FIVE N AND K RATES.

The second experiment was conducted in the fall of 1972 and the spring and fall of 1973 to determine the yield response of porous tube-irrigated sweet corn fertilized with different quantities

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[3] J. H. Matthews, 1971. Comparative analysis of the effect of a closed-loop irrigation system on crop yield. M. S. Thesis, Georgia Tech. University.

[4] Trade names are used for identification purposes only and do not imply preference for this item by the USDA.

Table 1—Marketable ear weight, water applied, mean ear length, and mean soil matric potential when the soil was irrigated at -0.1 (M_1), -0.2 (M_2), and -0.4 (M_3) bars with high-frequency porous tube (T), furrow (F), and sprinkler (S) irrigation systems.

Soil matric potential	Irrigation			
	T	F	S	Mean
	Marketable ear weight†, metric ton/ha			
M_1	9.4	8.4	7.5	8.4
M_2	9.8	8.8	8.5	9.0
M_3	9.2	8.3	8.9	8.8
Mean	9.5 a‡	8.5 b	8.3 b	
	Water applied, cm			
M_1	11.8	25.3	24.1	20.4
M_2	10.5	15.3	18.9	14.9
M_3	7.2	10.3	17.0	11.5
Mean	9.8 a	17.0 b	20.0 b	
	Mean ear length, cm			
M_1	19.7	18.4	18.9	19.0
M_2	19.5	19.3	19.0	19.3
M_3	19.2	18.8	18.9	19.0
Mean	19.4 a	18.8 b	19.0 c	
	Mean soil matric potential at 15 cm, bar			
M_1	–0.054	–0.021	–0.044	–0.040 a
M_2	–0.121	–0.075	–0.081	–0.092 b
M_3	–0.241	–0.124	–0.185	–0.183 c
Mean	–0.139	–0.073	–0.103	

† Weight does not include husk.
‡ Means followed by the same letter are not significantly different (95% confidence level).

of N and K. The soil matric potential of irrigated plots was maintained near -0.2 bar at the 15-cm depth in the row. The randomized block design of three replications consisted of high-frequency porous tube-irrigated plots fertilized with 0, 28, 56, 168, and 336 kg/ha each of N and K, and nonirrigated plots fertilized with 168 kg/ha each of N and K. Superphosphate at 112 kg/ha was broadcast uniformly before planting. Equal amounts of N and K were applied daily in nutrient solutions combined with the irrigation water through the porous tubes, according to predetermined N and K crop requirements. The growing season of the corn crop was divided into four equal 15-day periods to reflect the various crop growth stages. During each successive 15-day growth period, 14, 42, 33, and 11% of the total N and K were applied daily in increments, respectively, equal to 1/15 of these percentages. The irrigation system was controlled automatically by a calculator-based data acquisition system using closed loop electronic sensor feedback control (10).[3] Nonirrigated plots were fertilized with four applications of N and K, totaling 168 kg/ha of N and K each, in the same proportional percentages as those of the irrigated plots and applied at the beginning of each crop growth stage.

The crop response was based on marketable ear yield, number of ears per stalk, mean ear weight and length, percentage of pericarp, total dry matter production, plant N, soil nitrate profile, plant heights, N in the leaf base, and cob and kernel dry matter. The early plant samples were the entire aerial portion of the plant and later samples were the first mature leaf next to the whorl. Plant nitrogen was determined by the Kjeldahl method.

The net seasonal NO_3-N increase was calculated by subtracting the NO_3-N contents of the soil in nonfertilized plots from that of fertilized plots (to account for residual and mineralized N), before planting in the spring and in the fall after two crops had been grown. The resulting spring values were subtracted from fall values (to account for the net gain in NO_3-N) and these values were plotted as a function of time and depth.

The Irrigation Systems

Phene (11) described the water treatment, nutrient and chemical distribution system, and the soil matric potential measurement and control system.

Trickle irrigation water was applied through a polyolefin plastic porous tube (Viaflo, E. I. DuPont de Nemours & Co., Inc.), which was installed in the upper root zone in the row, 5 cm from the plants and at 3- to 5-cm depth.

Furrow irrigation water was applied with gated pipes. Pressure was controlled to maintain the essential flow and volume for water distribution to the end of the furrow during the 15-min irrigation cycle.

Rotating sprinklers were used on the sprinkler irrigated plots (model 4089, LR Nelson Mfg. Co., Inc.). The sprinklers were mounted on 2.5-m-long telescopic rods, which were manually adjusted to keep the sprinklers about 35 cm above the top of the crop canopy. The sprinkler wetting pattern was square and approximately equal to the plot size. Water distribution uniformity was dependent on wind speed.

The Irrigation Control and Soil Matric Potential Measurement System

The irrigation system for each treatment was controlled by the electronic soil matric potential sensor (10) (McCune-Neal, probe 1002). Soil matric potential sensors were installed in each plot, midway in one of the yield rows, at 15-, 30-, and 45-cm depths directly below the plant. Plots were irrigated when the soil matric potentials at 15-cm depth varied from the preset control level. Electrical wiring schematic used in coupling the soil matric potential sensors to the calculator-based data acquisition system are available from the authors.

The data from each plot, including Julian date and time, soil matric potentials at three depths, and irrigation commands or instructions were printed on a teletypewriter and recorded on punched paper tape at three hours intervals. Pan evaporation over grass was also measured and recorded with the data acquisition system.

RESULTS

Effects of Matric Potential and Irrigation Methods

The marketable ear yields of sweet corn (ears longer than 15 cm) for the T, F, and S plots at the M_1, M_2 and M_3 soil matric potential levels are shown in Table 1. The T treatment outyielded the F and S treatments by 12 and 14%, respectively. Yields did not differ among the corn irrigated at the M_1, M_2, and M_3 soil matric potential levels. These data show that the soil matric potentials chosen to schedule irrigation within the optimal range (Fig. 2) did not affect the yield of sweet corn, possibly because high-frequency irrigation tends to apply water often to wet a small portion of the root zone, at rates less than evapotranspiration.

Table 1 also shows the water applied at the M_1, M_2 and M_3 soil matric potentials with the T, F, and S systems. Significantly less water was applied to the T plots at the three soil matric potentials than to the F and S plots. The mean water applied to the plots did not differ significantly among the three soil matric potentials, although the mean water applied by the three systems at the M_1 level was almost twice that applied at the M_3 level.

Water deficit, the difference between the rainfall and 80% of pan evaporation, was 12.6 cm, and only four of the nine treatments received less than this—all of the T treatments and the F plot at the M_3 level. Table 1 data show that, although an automated and electronically controlled high-frequency irrigation system is used, F and S system designs required that more water be applied by furrow and

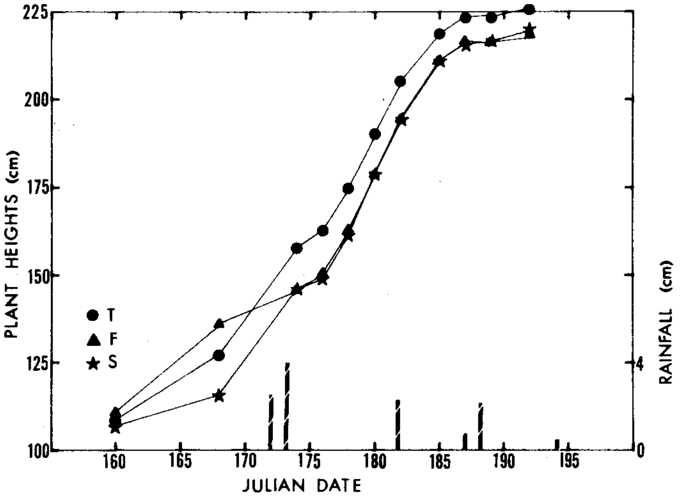

Fig. 3—Mean plant heights for the T, F, and S irrigation methods. (Averages of the M_1, M_2 and M_3 soil matric potential levels.)

sprinklers than by porous tubes, and a greater portion of the soil surface is wetted. If large, unpredictable rainfall follow any T or S irrigation excessive soil wetness will probably occur. Because T-irrigation requires less water per irrigation, it is best suited for high-frequency irrigation and it can be scheduled to replace only water loss by evapotranspiration.

The mean ear length of 19.4 cm from T plots was significantly longer than the mean of those harvested from the F and S plots (Table 1). Inasmuch as soil matric potential was presumably adequate for all irrigation treatments, yield differences must have resulted from either low oxygen in the root zone (16) or increased NO_3-N leaching from the root zone in the F and S plots.

Figure 3 shows the mean time course of plant heights for the T, F, and S methods. Rainfall is indicated by the vertical bars. After the second height measurements, corn irrigated by the T system was significantly taller than that irrigated by the F and S systems. The effect of excess water on sweet corn growth is clearly demonstrated by the plant height measurements between days 168 and 176, when 6.5 cm of rain fell and water was ponded for several hours on the M_1 treatments of the F and S plots which had been irrigated prior to the rainfall. Mean plant heights for the M_1, M_2, and M_3 soil matric potentials were not significantly different because plant heights for the T and F treatments at the M_2 soil matric potentials and for the S treatment at the M_3 soil matric potential were greatest and the soil matric potential range of control chosen was optimal. These data are consistent with those presented in Table 1.

Table 1 shows the mean soil matric potential at 15 cm from the surface when the soil was irrigated at the M_1, M_2, and M_3 levels with the T, F, and S systems during the period from Julian day 160 to 195. Although there were no significant differences between the mean soil matric potentials of the T, F, and S plots, the trend indicates that the T plots were drier than those irrigated with the F and S systems. However, the average soil matric potentials were significantly different for the M_1, M_2, and M_3 control levels. Since about 13 cm of rain fell during the period, the mean soil matric potentials were expected to be higher than the control points.

Soil NO_3-N content profiles for the M_1 level of the T, F and S treatments, shown on Fig. 4, were measured 60 days after planting. The NO_3-N profiles reflect different quantities of water and methods of irrigation. The NO_3-N profiles of the F and S plots have similar patterns. Inasmuch as water was applied uniformly to the soil surface by the sprinkler system, it was expected that the downward flux of NO_3-N would be uniform; however, as the corn plants grew, the leaf canopy diverted more of the overhead-applied water towards the furrows. The zone of lowest NO_3-

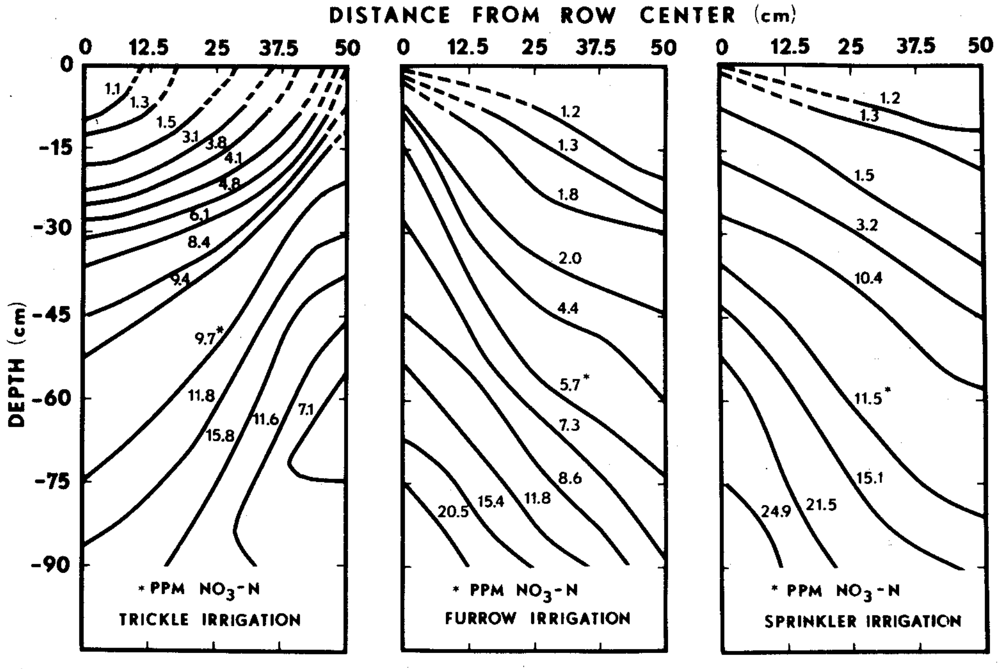

Fig. 4—Soil NO_3-N content measured in the M_1 plots irrigated by high-frequency T, F, and S irrigation methods.

Table 2—Marketable ear weight, quality, and dry matter production for high-frequency porous tube trickle-irrigated and nonirrigated sweet corn for various N and K fertilization rates.

N and K fertilization rate	Marketable ear weight‡	Number of marketable ears/stalk	Mean ear wt.‡	Mean ear length	Pericarp	Total dry matter
kg/ha	metric tons/ha	ears/stalk	g	cm	%	metric tons/ha
0	1.0 e	0.33 e	135 d	12.3 c	0.99 b	3.6 d
28	3.3 d	0.55 d	180 c	13.5 b	1.07 b	6.9 c
56	4.4 d	0.68 c	170 c	13.3 b	0.99 b	7.8 c
168	14.8 b	0.90 ab	261 a	16.7 a	1.01 b	11.4 a
168†	8.9 c	0.86 b	225 b	14.6 b	0.97 b	9.2 b
336	17.2 a	0.98 a	262 a	17.5 a	0.91 a	11.9 a

† Nonirrigated sweet corn fertilized with 168 kg/ha of N and K.
‡ Weight includes husk.
* Column means followed by the same letter are not significantly different (95% confidence level).

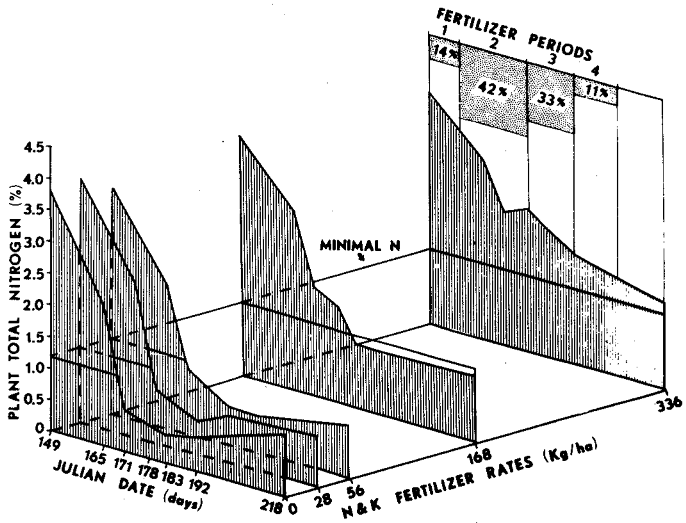

Fig. 5—Nitrogen in corn plant tissue on porous tube trickle-irrigated plots as a function of time and fertilizer rates.

N content for the T treatment lies on the row, next to the plants; however, the NO_3-N content of the upper 25 cm of soil is greater in the T treatment profile than in either of the F or S treatments.

Results of this experiment indicate that in humid regions, where unpredictable rainfall may follow an irrigation, water management systems that minimize soil as a reservoir for water and nutrient storage, can effectively supply water to the root zone of crops, decrease losses of NO_3-N by leaching, and increase plant growth.

Response of Sweet Corn to High-frequency Porous Tube Trickle Irrigation with Nutrient Solution

Marketable ear weight of spring-grown sweet corn increased as N and K rates of fertilization increased (Table 2). Marketable ear weight of irrigated sweet corn fertilized with 168 kg/ha of N and K was 66% greater than that of nonirrigated sweet corn fertilized with the same amounts of N and K. Of the yield parameters measured, only marketable ear weight increased significantly when N and K rates were increased from 168 to 336 kg/ha. Mean ear weight, mean ear length, and total dry matter of the trickle irrigated corn fertilized with 168 kg/ha of N and K were significantly greater than those of nonirrigated corn fertilized at the same rate. The percentage of pericarp of trickle irrigated corn fertilized with 336 kg/ha each of N and K, was significantly lower than that of corn for all other treatments, indicating that corn kernel quality was better for this treatment. Results from the second crop in the fall of 1973 followed similar trends.

The percentage of N in trickle-irrigated sweet corn plants

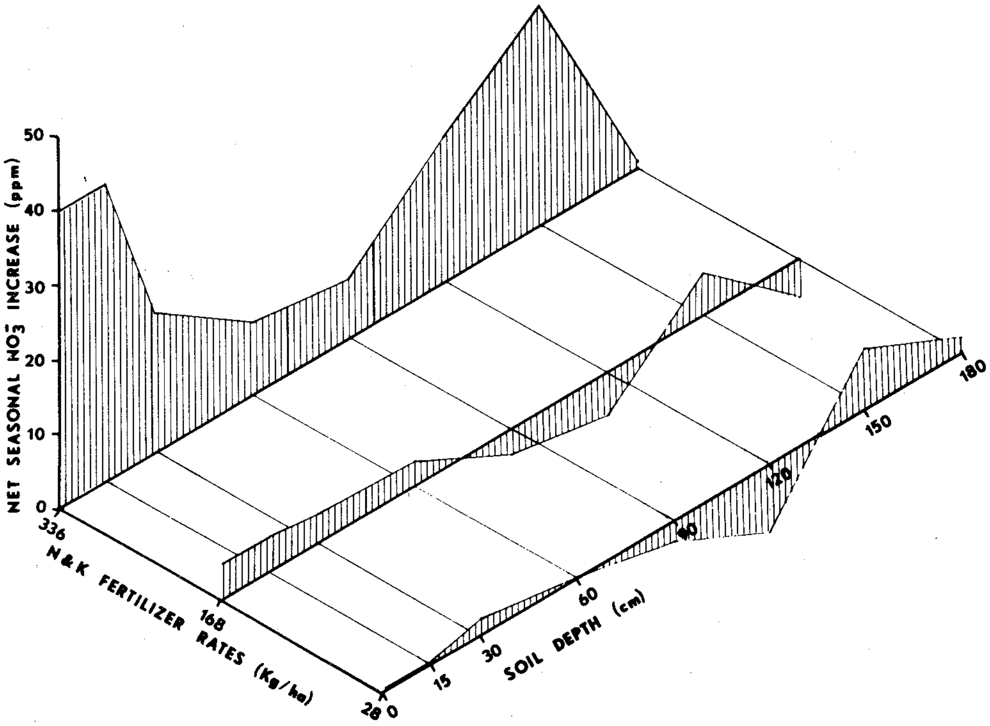

Fig. 6—Mean net seasonal soil NO_3-N content variations with N and K fertilizer rates and soil depth measured 5 cm from the porous tube.

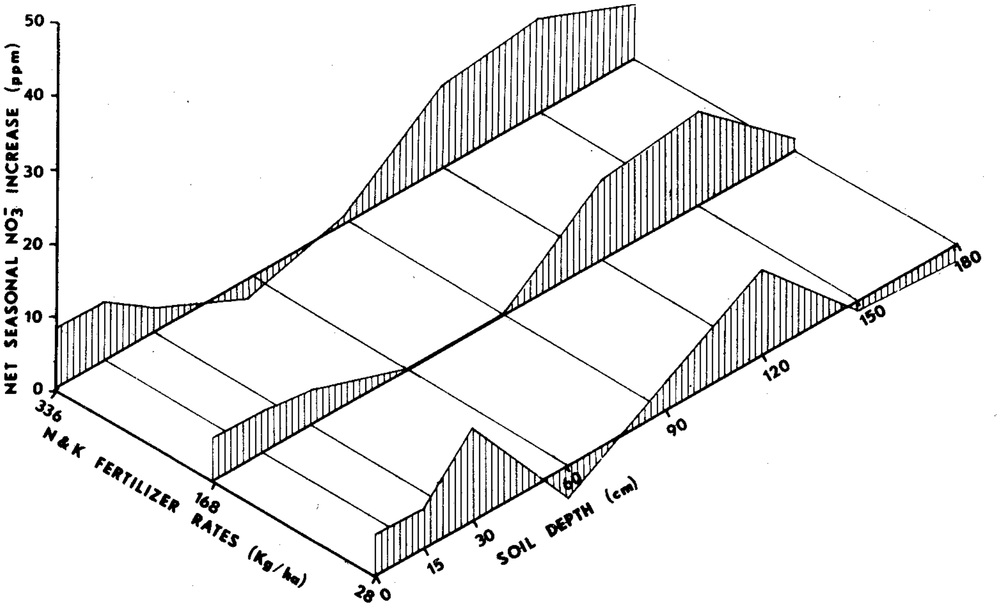

Fig. 7—Mean seasonal soil NO_3-N content variations with N and K fertilizer rates and soil depth measured at midway between rows.

as a function of time, fertilizer rates, and fertilization periods (Fig. 5) shows that during the seedling stage (days 149–165), differential application of N and K did not cause significant differences in N content of sweet corn. This finding implies that large N application during the first few days of growth may not be necessary, since the percentage of N in all plant tissues was considerably above the minimal level of plant dry matter N. As tassels emerged (day 183), the large demand for N was reflected by a rapid decrease in the percentage of N for all treatments, except that fertilized with 336 kg/ha each of N and K. The nonfertilized plots and those receiving 28 and 56 kg/ha each of N and K were deficient in N from ear formation until harvest, although the dry matter N content increased slightly.

Corn plants fertilized with 168 kg/ha each of N and K were slightly N deficient from the tasseling stage (day 183) to harvest (day 218). The N content of corn fertilized with 336 kg/ha each of N and K was above the minimal dry matter N content of sweet corn during the entire growing period.

Figure 6 shows the mean net seasonal soil NO_3-N increase with various fertilizer rates and soil depth measured near the porous tube for spring and fall sweet corn fertilizations, each with the N and K fertilization rates shown on the abscissa, for a total of applied N and K equal to twice the values shown on the abscissa. Since the residual and mineralized N was accounted for by subtracting N measured in the nonfertilized plots from that measured in the fertilized plots, the net increase in soil NO_3-N with depth and fertilizer rates probably resulted from N fertilization. The NO_3-N for the trickle-irrigated plots fertilized with N and K rates of 28 and 168 kg/ha are not significantly different from each other, but are highly different from the plots fertilized with 336 kg/ha each of N and K.

The mean net seasonal soil NO_3-N increase with fertilizer rates and soil depth measured midway between the rows for trickle-irrigated plots (Fig. 7) were not significantly different for the various depths or treatments. Figures 5, 6, and 7 substantiate the need for the soil water-nutrient management method proposed for the humid regions and emphasize the effectiveness of the high-frequency water-nutrient/trickle irrigation method for application and distribution of water and nutrients.

Plant height (relative to the tallest plant) (Fig. 8) was not affected by fertilizer rates during the seedling stage (days 142–165). As the corn matured, however, plant heights of nonfertilized corn became significantly shorter than all the other. Plant heights in plot fertilized with 28 and 56 kg/ha each of N and K were significantly different from those fertilized with 168 and 336 kg/ha each of N and K. Plants fertilized with 168 and 336 kg/ha each of N and K showed no difference in plant height.

CONCLUSIONS

Distribution of water and nutrient solutions with the porous-tube is adaptable for high-frequency irrigation in

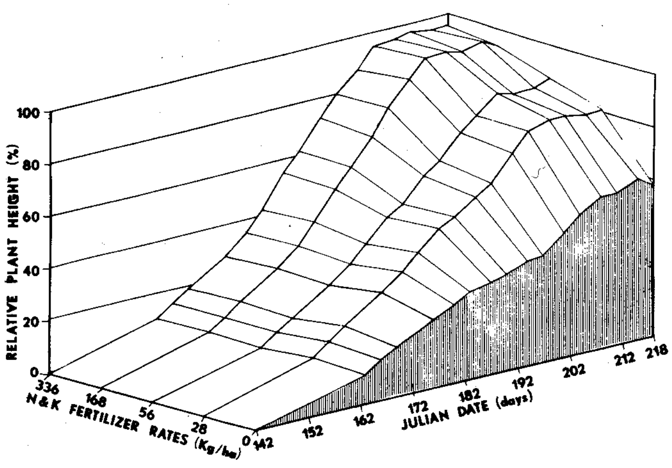

Fig. 8—Relative corn plant height as a function of N and K rates and time.

sandy soils of Southeastern Coastal Plains. Nutrient solution can supply water and nutrients as required by the crop, thereby decreasing the need for water and nutrient storage in the root zone. Conversely, furrow and sprinkler irrigation systems may supply too much water per irrigation and cannot be easily adapted to sensor-controlled, high-frequency irrigation in this region. Increasing soil water storage capacity may reduce root damage from excess rainfall and poor aeration. Daily low-rate application of nitrogen and potassium with a high-frequency trickle irrigation system improved nutrient uptake efficiency of corn and reduced leaching loss of nutrients. High-frequency irrigation is not based on the stored water concept. Except after rainfall, any major malfunction of the high-frequency irrigation system leaves only a small amount of soil water available which would be inadequate without immediate resupply.

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