Nutrient Uptake and Solute Movement in Drip Irrigated Summer Peppers[1, 2]

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ABSTRACT

A study on nutrient uptake (N, P, K, Ca and Mg) by peppers (var. Cubanelle) and fertilizer solute movement in relation to dripper location was conducted in the semiarid southern coast of Puerto Rico at the Fortuna Agricultural Research and Development Center. Soil samples were taken 9, 64, and 118 days after transplanting from each location, with three 15-cm depth increments and three 15-cm horizontal increments away from the dripper. These samples were analyzed for pH, EC, P, K, Ca, and Mg. All fertilizer was applied via drip irrigation. Factorial analysis indicated that solute movements at different positions were not statistically different. The relationships between nutrient uptake versus days after transplanting were of Mitscherlich's curve type. Greatest amount of nutrient uptake occurred during the last third part of the growing season, and followed an order of K > N > Ca > P > Mg.

INTRODUCTION

Fertigation[4] requires the knowledge of solute movement in the soil in relation to dripper location and nutrient uptake by plants during the crop season. It is difficult to modify the soil's physical properties and conditions which affect the moisture movement through the soil, yet operators can have an adequate control over the external factors such as dripper discharge and location, irrigation frequency and the nutrient source, all of which influence the growth characteristics of a plant.

Keng (6, 7) found limited movement of P and K in an Oxisol in Isabela. Goyal et al. (4) reported considerable movement of P in a Vertisol in Santa Isabel in a drip irrigated tomato field. Data on nutrient uptake and solute movement in trickle irrigated peppers is limited for southeast of Puerto Rico.

Drip irrigation calls for a complete fertigation schedule, thus providing adequate nutrients to the plant (3, 10 to 13). The application of soluble fertilizers in low concentrations satisfies the plant requirement at different stages of growth resulting in increased fertilizer-use efficiency (11,

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[2] This study was conducted under Southeast Regional Project S-143 (H-326), "Trickle Irrigation in Humid Regions-Puerto Rico". This contribution is partly based on a MS thesis submitted by the Senior author in the Graduate School of the University of Puerto Rico, Mayagüez Campus, in partial fulfillment of the requirements for the degree of Master in Science in the Faculty of Agronomy and Soils–1983.

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[4] Fertigation is the application of soluble fertilizers via irrigation systems.

12, 13). Fertilizer applied via drip irrigation must be soluble to avoid precipitation in drip lines and clogging of drip lines. Rolston and Broadbent (15) indicated that volatilization of ammonia was minimum when ammonium sulphate was broadcast on a Panoche clay loam. Goldberg et al. (3) found that nitrate applied via drip irrigation was within the wetting pattern around the root system of the plant. Bar-Yosef and Shiekhoslan (1) observed that the nitrate loss was not significant in a sandy soil when applied via drip irrigation. Kafkafi and Bar-Yosef (5) observed high nitrate concentrations (100 p/m) at 20 and 40 cm away from the dripper source in a highly calcareous soil. The P was within 20 cm of the source. Potassium was distributed more uniformly than phosphorus in the wetted zone. Goldberg et al. (3) indicated movement of P vertically and horizontally 20 cm away from the dripper in a sandy loam when inorganic P at the rate of 20 kg/ha was fertigated. Rauschkolb et al. (14) showed movement of orthophosphate away from the dripper location when applied via drip irrigation compared to that of banded applications in a Panoche clayey loam. They theorized that P movement was by mass flow in a saturated soil zone. Keng (6) found that P movement coincided with moisture movement in a sandy Bayamón soil, but it was limited in a clayey Coto soil. K movement was significant. Uriu et al. (16) observed considerable K movement away from the dripper location. Lorenz and Maynard (8) found that uptake of N, P and K by peppers was 157.2, 13.5 and 157.2 kg/ha, respectively. Biggest uptake occurred during the [illegible] part of crop development.

A preliminary field study on nutrient uptake (N, P, K, Ca [illegible]) by peppers and fertilizer solute movement was conducted at Fortuna Agricultural Research and Development Center located in the semiarid southern coast of Puerto Rico. The soil belongs to the San Antón series, with a pH of 7.9. The conductivity of the soil solution is 0.21 mmhos per cm. Chemical analysis of the soil (2) indicated 22 meq/100 g of cation exchange capacity, 1.71 p/m of P, 694.4 p/m of K, 494.4 p/m of Mg, and 5386 p/m of Ca.

MATERIALS AND METHODS

Four-week-old pepper transplants (var. Cubanelle) were planted March 17, 1982, 15 cm from the dual chamber drip line and on both sides of the drip line at 30 cm spacing within the row. The treatments included white plastic and black plastic covers replicated four times. Two plants randomly chosen from each plot were cut at the soil surface and were oven-dried for 48 hours at 70° C. Dry samples were chopped and ground, and analyzed for N, P, K, Ca, and Mg. Nitrogen was determined by the Kjeldahl macromethod; P by the L-ascorbic acid + NH_4Mo + H_2SO_4 + antimony potassium tartrate method; and K, Ca, and Mg by the dry ash method (2).

Nine soil samples were taken at 9, 64, and 118 days after transplanting from each location with a 3 × 3 grid pattern, three 15 cm depth increments, and three 15 cm horizontal increments directly below and horizontally perpendicular to an emitter, respectively. Each soil sample was air-dried and analyzed for pH, electrical conductivity of a 2:1 water-soil extract ratio (which was then multipled by 2 to estimate the conductivity of the saturation extract), bicarbonate-extractable P (Olsen method), and (1*N*, pH 7.00) ammonium acetate extractable Ca, Mg, and K. Samples were analyzed at the Commonwealth Department of Agriculture Laboratory, Dorado, Puerto Rico.

RESULTS AND DISCUSSION

Table 1 indicates N, P, K, Ca, Mg uptake versus days after transplanting relationships for drip irrigated summer peppers in white plastic and black plastic mulched plots. Figure 1 shows a typical nutrient uptake curve. The relationships were of Mitscherlich type and exhibited the five nutrient uptake phases, namely a lag phase (plants are being established), a log phase (nutrient uptake continues), a decreasing phase (nutrient

TABLE 1.—*Nutrient uptake by drip-irrigated summer pepper plants*

Treatment[1]	Parameter	Regression coefficients[2]			Coefficient of determination, R^2
		A	B	C	
		Pepper leaves and branches			
T2	Nitrogen	1.210	21.870	0.0430	0.95
	Potassium	2.065	26.350	0.0456	0.95
	Phosphorus	0.197	42.505	0.0511	0.98
	Calcium	1.150	32.140	0.0389	0.97
	Magnesium	0.185	32.093	0.0550	0.97
T3	Nitrogen	1.550	117.660	0.062	0.93
	Potassium	2.360	138.820	0.066	0.96
	Phosphorus	0.243	658.210	0.086	0.97
	Calcium	0.920	493.470	0.087	0.94
	Magnesium	0.228	171.630	0.073	0.93
		Pepper fruits			
T2	Nitrogen	1.360	22.960	0.0370	0.78
	Potassium	1.220	17.530	0.0390	0.76
	Phosphorus	0.410	32.240	0.0430	0.77
T3	Nitrogen	1.910	58.779	0.0380	0.96
	Potassium	3.210	54.349	0.0309	0.95
	Phosphorus	1.005	116.360	0.0299	0.97

[1] T2 = White plastic mulch, T3 = Black plastic mulch.

[2] Nutrient uptake relationship (Mitscherlich's curve type): $Y_{1,2} = A/(1 + Be^{-cx})$,
where Y_1 = Nutrient uptake for leaves and plants, g/plant;
Y_2 = Nutrient uptake by fruits, g/fruit;
Y = Total nutrient uptake, g/plant;
X = Days after transplanting;
A, B, C = Regression coefficients.

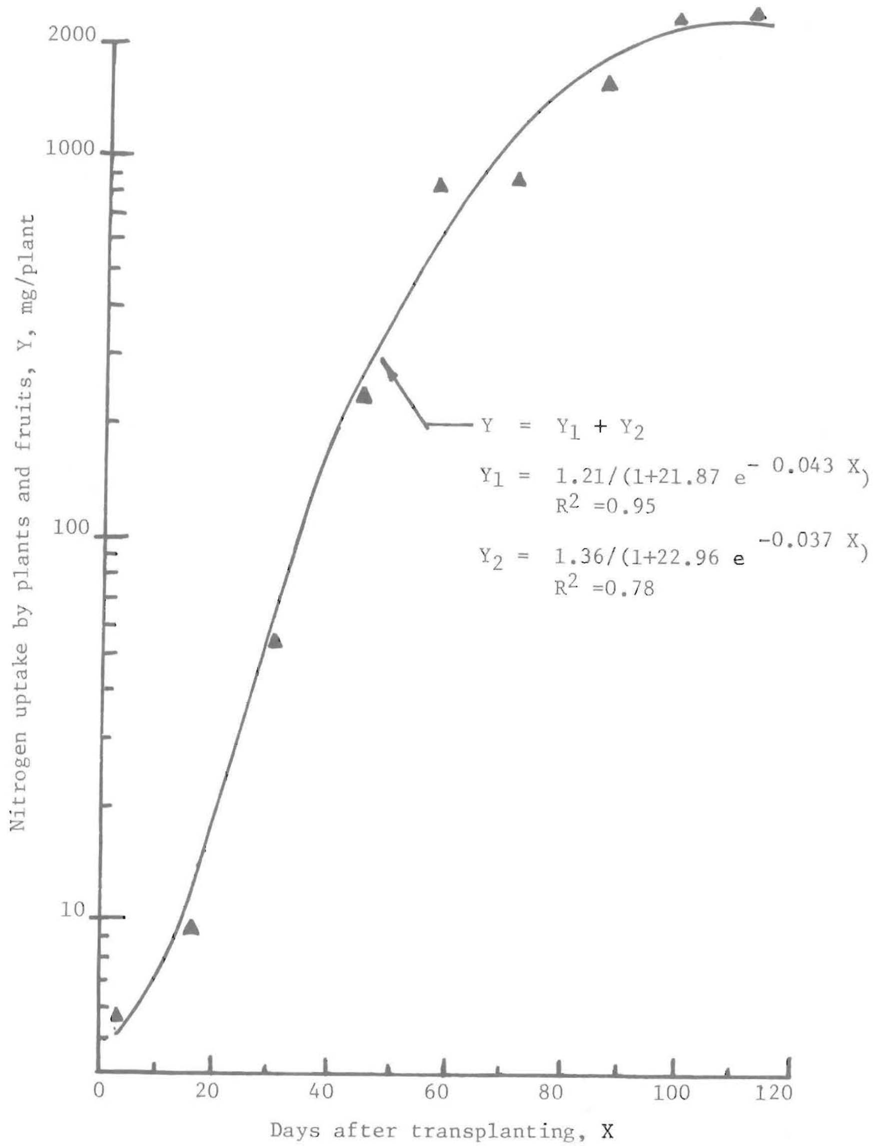

FIG. 1.—Nitrogen uptake by drip-irrigated pepper plants in white plastic mulched plots. Each data point is a mean of four observations.

uptake rate is decreasing, but plant still continues to extract the nutrient), a point at which nutrient uptake is maximum, and a senescence phase. Table 1 shows the values of regression coefficients (A, B, C) and coefficient of determination (R^2). The regression coefficients were significant at the 5% level. The nutrient uptake values on days of observation were not statistically different at 5% in the white plastic and black plastic mulched plots.

The greatest amount of nutrient uptake occurred during the last third of the growing season, and followed the order of K > N > Ca > P > Mg. These results agree with those of Lorenz and Maynard (8).

Factorial analysis indicated that P, K, Ca and Mg concentrations in the soil samples, and pH and EC at different positions with respect to dripper location, were not statistically different at the 5% level. P concentrations were higher directly under the dripper. K concentrations decreased with depth because peppers were able to extract K at 15–45 cm depth because 60% of the roots were in this zone. Ca concentrations at planting and at last harvest were not significantly different, possibly because of low uptake of Ca by the plants. Mg concentrations at locations away from the drippers increased with crop season though the differences were not significant. The pH varied from 7.5–7.7 at different locations and during the crop season. The electrical conductivity values decreased with depth at all locations away from the dripper and were in the range of 0.1–0.3 mmhos per cm. These results are in agreement with those of Goyal et al. (4).

RESUMEN

Se estableció en el Centro de Investigación y Desarrollo Agrícola de Fortuna, Juana Díaz, localizado en la costa semiárida del sur de Puerto Rico, un experimento para estudiar la extracción de nutrimentos (N, P, K, Ca y Mg) por el pimiento (cv. Cubanelle) y el movimiento de solutos en relación a la posición del gotero. Se tomaron muestras del suelo a los 9, 64 y 118 días después del trasplante en varias posiciones con respecto a los goteros y se analizaron para pH, CE, P, K, Ca y Mg. Todos los fertilizantes se aplicaron a través del sistema de riego por goteo. Los analisis factoriales no indicaron diferencias estadísticas en el movimiento de solutos a diferentes posiciones. Se usaron curvas de Mitscherlich para describir la relación entre nutrimentos contra días después del trasplante. La mayor extracción de nutrimentos ocurrió durante la última (tercera) parte del ciclo de vida del cultivo y siguió el orden de K, N, Ca, P, Mg.

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