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GROWTH AND YIELD RESPONSE OF PUERTO RICAN SWEET PEPPER TO LEVELS OF DRIP IRRIGATION IN THE VIRGIN ISLANDS

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ABSTRACT: Puerto Rican sweet pepper also known as 'Ají dulce' (*Capsicum chinense* Jacquin) is a popular crop in the Virgin Islands. It is mainly used for culinary seasoning by most Puerto Rican residents. In spite of its popularity, no crop management studies have been done to improve yield and production. This study was conducted to determine the response of Puerto Rican sweet pepper to levels of drip irrigation. Peppers were planted on 1 May 2002 into rows 91 cm apart. Within-row spacing was 61 cm. Treatments consisted of three drip irrigation regimes (levels) based on soil moisture tension of -20 kPa, -40 kPa, and -60 kPa. The trial was laid out by using a randomized complete block design with three replications. Peppers were harvested on six dates from 23 July to 27 August 2002. Data collected included total number of fruits, number of marketable fruits, marketable fruit weight, and total irrigation water use. Results indicated no significant ($P>0.05$) differences in measured parameters; however, there was a trend for yield to increase with increasing irrigation rate. Plant height and marketable yield increased with increasing application of irrigation water from -60 kPa to -20 kPa. Regression analysis indicated a significant ($P<0.0274$) linear response to irrigation rates. Highest marketable yield was obtained from irrigation regime where soil moisture was maintained at -20 kPa. Although not statistically significant, decreasing soil moisture tension from -60 kPa to -20 kPa resulted in 30% increase in marketable fruit yield. Total water use was highest (1763 m^3 ha^{-1}) at irrigation regime of -20 kPa and lowest (547 m^3 ha^{-1}) at -60 kPa. Although yield was highest at the -20 kPa regime, water use and cost were not efficient, thus resulting in lower economic returns to irrigation water compared to returns with irrigation regimes of -40 kPa and -60 kPa.

INTRODUCTION

Among the Puerto Rican community in St. Croix, U.S. Virgin Islands, a particular sweet pepper cultivar known as 'Ají dulce' is popular and is mainly utilized for culinary seasoning. Ají dulce is not a hot pepper and its mild taste gives characteristic flavor to most Puerto Rican recipes. Ají dulce is also known as Puerto Rican chile pepper and described as a tiny, wrinkled, flying-saucer-shaped sweet chile that looks and smells like the incendiary Habanero or Scotch Bonnet hot pepper, but lacks the strong pungent flavor.

In the Virgin Islands, Puerto Rican sweet pepper along with West Indian hot peppers are a specialty cash crop. These specialty peppers are commonly grown by small-scale farmers for local markets, but there is also an opportunity for export market (Crossman et al., 1999; Marsh, 1988; 1991). Small-scale growers with limited farm resources can improve their income by growing Puerto Rican sweet pepper. Yield can be increased by growing improved cultivars combined with good management practices such as fertilization and drip irrigation. Little research information is available on Puerto Rican sweet pepper in the Caribbean. Most of the literature deals with hot peppers, where studies on cultivar evaluation, plant spacing and drip

irrigation have been reported (Adams et al., 2001; Anon, 1988; Cooper et al., 1993; Marsh and Rhoden, 1990; McGlashan, 1988; O'Keefe and Palada, 2002). No studies have been reported on the effect of drip irrigation on hot pepper in the Caribbean. But in Colombia, South America, Sanchez et al. (2003) reported no significant effect of irrigation levels on plant height, rooting depth and biomass of Ají dulce. However, they reported that yield increased with increasing irrigation rates.

Like other sweet pepper cultivars, Puerto Rican sweet pepper is sensitive to the effect of moisture stress. Cooper and Gordon (1992) reported reduced yields and decreased fruit size when hot peppers were subjected to severe moisture stress. Moisture stress resulted in severe fruit drop and decreased total yield (Ganpat, 1973). Studies in the Virgin Islands indicated that hot peppers did not respond to drip irrigation rates, but the interaction between irrigation and cultivar was significant (Palada et al., 2001). Drip irrigation is an efficient method of applying water and nutrients for the production of high value horticultural crops such as Puerto Rican sweet peppers. For example, Byer et al. (1992) reported that in Barbados, marketable yields in excess of 33,600 kg/ha can be achieved with the use of drip irrigation.

This study was conducted with the following objectives: 1) determine growth and yield of Puerto Rican sweet pepper with drip irrigation regimes, and 2) measure water use and determine optimum drip irrigation requirement of Puerto Rican sweet pepper.

MATERIALS AND METHODS

The study was conducted at the Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI (lat. 17°42'N, long. 64°48'W). The soil is a Fredensborg loamy, fine carbonatic, isohyperthermic, shallow Typic Calciustolls. Mean annual precipitation is 1015 mm and rainfall distribution is not uniform through the year. The field experiment was conducted from May 1 to August 27, 2002. Thirty-day-old seedlings of local Puerto Rican sweet pepper cultivar were transplanted in three rows per plot with row spacing of 91 cm apart and in-row spacing of 61 cm. Treatments consisted of drip irrigation regimes (scheduling) based on soil moisture tensions of -20 kPa, -40 kPa, and -60 kPa as determined by soil tensiometer (Irrometer, Riverside, CA).

The drip irrigation system consisted of main and submain lines made of 15-mm black polyethylene hose. The laterals were made of 15-mm T-tape (Hardie irrigation, Sanford, FL) with laser-drilled orifices (emitters) 61 cm apart. Soil tensiometers were installed at 15-cm depth near the base of a plant to monitor soil moisture levels. The tensiometer was placed in the middle row for each treatment. Flow meters were installed for each irrigation regime to measure irrigation water use. The experimental design was a randomized block with three replications.

Prior to planting, basal application of composted (dehydrated) cow manure (2-1-2) was incorporated during the final field preparation (rototilling) at the rate of 10 tons/ha. Subsequent fertilizer was applied via fertigation with soluble fertilizer (20-20-20) at total rate of 100-100-100 NPK in kg/ha. This was applied in six equal fertigations on May 8, 23, June 7, 20, August 8 and 26. Insect pests were managed with organic sprays such as Bioneem, Botanicguard, Dipel, Mpede and Pyrellin.

The crop was harvested six times during the production season from July 23 to August 27, 2002. Yield samples were harvested from five plants of the middle rows. Plant height was measured during the first harvest. Data on number of fruits, fruit size, and fruit yield (total and marketable) were collected for each harvest. Irrigation water applied per treatment was recorded weekly and total water use was calculated at the end of the trial by subtracting the initial flow meter reading from the final reading taken at the last harvest.

Growth and yield data were analyzed for statistical significance by using the General Linear Model (GLM) by SAS. Differences in treatment means were compared by using the Duncan's Multiple Range Test at 5% significance level. To determine the response of Puerto Rican sweet pepper to irrigation level, a regression analysis was performed using irrigation regime as independent variable and plant height and yield as dependent variables.

RESULTS AND DISCUSSION

Plant Height

Data on Table 1 show that although plant height increased with increasing irrigation water application (-60 kPa to -20 kPa), the response was not significant. Differences in plant height between irrigation regimes were small (Table 1). No moisture stress was exhibited by plants under the -60 kPa, but plants were shorter than plants grown under -20 and -40 kPa irrigation regime. This result is consistent with those obtained by Palada et al. (2001) who reported that drip irrigation level did not influence plant height of hot pepper cultivars.

Number of Fruits, Fruit Size and Yield

The number of fruits was significantly influenced by irrigation regime (Table 1). A highly significant linear response ($P<0.01$) was observed with increasing irrigation water application. Number of fruits increased from 70.7/m^{-2} at -60 kPa to 98.2/m^{-2} at -20 kPa. This result is not consistent with those reported on hot peppers, where drip irrigation level had no significant effect on the total number of fruits (Palada et al., 2001). In this report, differences were influenced by cultivars rather than irrigation regimes.

Although the effect of irrigation was significant on the number of fruits, fruit size was not influenced by irrigation regime (Table 1). However, data showed that smaller fruits (3.55 g) were produced from irrigation regime of -60 kPa than those from -40 and -20 kPa treatments, with average fruit size of 3.82 g and 3.75 g, respectively. Palada et al. (2001) reported that fruit weight (size) was not influenced by drip irrigation, but differed significantly among cultivars of hot pepper.

There was a significant linear response ($P<0.05$) for marketable fruit yield to irrigation regime (Table 1). Marketable fruit yield increased with increasing irrigation water application. Yield increased from 2527 kg ha^{-1} at soil moisture tension maintained at -60 kPa to 3706 kg ha^{-1} at -20 kPa (Table 1). Increasing irrigation regime from -60 kPa to -20 kPa resulted in 32% yield increase for Puerto Rican sweet pepper. The significant yield increase due to increased level of drip irrigation obtained in this study is not consistent with that reported on hot peppers (Palada et al., 2001). However, their results indicated an interaction between cultivar and irrigation regime.

Table 1. Response of Puerto Rican sweet pepper to irrigation regimes, UVI-AES, 2002.

Irrigation Regime (kPa)	Plant height (cm)	Fruit No. (m^{-2})	Fruit size (g)	Marketable Yield (kg ha^{-1})
-20	71.6	98.2	3.75	3706
-40	70.3	86.8	3.82	3296
-60	67.6	70.7	3.55	2527
Linear	NS	**	NS	*
Quadratic	NS	NS	NS	NS

*Significant at P<0.05, **Significant at P<0.01, NS=not significant

Irrigation Water Use, Efficiency and Economic Returns to Irrigation Water

Data on the estimated irrigation water use and efficiency are shown in Table 2. The highest total irrigation water use was recorded in plots under -20 kPa irrigation regime, and the lowest irrigation water use was obtained from plots under -60 kPa. The higher irrigation water use at -20 kPa regime resulted in higher water cost ($7457/ha) compared to $2314/ha for the -60 kPa regime (Table 2). This finding resulted in lower water use and cost efficiency for irrigation regime with higher water application (-20 kPa and -40 kPa) than that of -60 kPa. Consequently, this was reflected in lower economic returns to irrigation water for the irrigation regimes of -20 kPa and -40 kPa. Although ratio of returns to irrigation water was lower in higher irrigation regimes, other economic parameters should be considered in determining economic returns and profitability. The 32% increase in yield under the -20 kPa regime may result in higher overall returns if all other costs are considered in the budget analysis. However, the data presented here would indicate that Puerto Rican sweet pepper can be produced under limited or reduced irrigation water application. Minimum drip irrigation level resulted in higher returns to irrigation water.

Table 2. Estimated gross returns, water use, cost efficiencies and returns to irrigation water of Puerto Rican sweet pepper grown under three drip irrigation regimes, UVI-AES, 2002.

Irrigation Regime (kPa)	Gross returns[1] ($/ha)	Water use (m^{-3}/ha)	Water cost[2] ($/ha)	WUE[3] (l/kg)	WCE[4] ($/kg)	Returns to irrig. water[5] ($/$)
-20	24,459	1763	7457	475	2.01	3.28
-40	21,754	867	3667	263	1.11	5.93
-60	16,678	547	2314	216	0.92	7.21

[1]Puerto Rican sweet pepper local market price at US$6.60/kg.
[2]Irrigation water cost at US$4.23/$m^{-3}$
[3]WUE=water use efficiency expressed in kg sweet pepper produced per cubic meter of water used.
[4]WCE=water cost efficiency expressed as cost of water to produce a kilogram of sweet pepper ($/kg).
[5]Returns to irrigation water= dollar return per dollar cost of irrigation water ($/$).

SUMMARY AND CONCLUSIONS

This study has shown that irrigation regime influenced the yield of Puerto Rican sweet pepper in terms of number of fruits produced and marketable yield. Marketable yield increased with increasing application of irrigation water. Irrigation regime did not influence growth in terms of plant height. Neither was fruit size affected by irrigation regime, but smaller fruits were produced under reduced irrigation application. This study also indicates that Puerto Rican sweet pepper can be produced with minimum irrigation water; however, maximum yield response is possible at maximum irrigation water application.

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