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EFFECT OF CONTROLLED WATER REGIMES ON PUMPKIN GROWTH

Julio Rossy *Graduate Student, Department of Agronomy and Soils, College of Agricultural Sciences, University of Puerto Rico.*

Elvin Román-Paoli, Sonia Martínez-Garrastazú, Luis Ernesto Rivera, *Assistant and Associate Researchers, Agricultural Experiment Station, College of Agricultural Sciences, University of Puerto Rico.*

ABSTRACT.

Pumpkin, *Cucurbita moschata* (Duchesne) Poir, is one of the most important vegetables crops in the Caribbean Basin. Vegetables production in Puerto Rico tropical areas depends on drip irrigation for most of its irrigation requirements. However, information on basic drip irrigation management practices is still inadequate. Therefore, a research was conduced using Pan A evaporation readings, to establish drip irrigation management practices and quantify resulting crop response. The objectives of the study were: 1. To evaluate the effect of evapotranspiration replenishment on growth of pumpkins under tropical conditions, and 2. To determine water requirements for pumpkins under tropical conditions. Pumpkin plants (Soler and Isolate Summer selections) were submitted to four evapotranspiration replenishment treatments (ERT): 25, 50, 75, and 100% of Pan evaporation readings at two locations, Lajas and Juana Díaz. ERT did not affect leaf area at any of both locations. However, the dry matter accumulation was affected significantly by ERT, pumpkin selection and interaction of both main effect at Juana Díaz. The estimated evapotranspiration (100% ERT) at Juana Díaz (5.1 mm day^{-1}) was twice as great as that of Lajas (2.4 mm day^{-1}).

INTRODUCTION

There is much concern on the decrease of aquifers and water reservoirs, in Puerto Rico. Public policy favors the use of water in the metropolitan areas instead of the agricultural lands. Farmers, in attempts to increase yields, overirrigate. This situation tends to waterlog poorly permeable soils, favoring nitrogen losses in areas with higher permeability and incrementing the possibility of ground water contamination. Plant growth (vegetative and reproductive) can be extremely sensitive to water stress. Water stress during critical periods of crop development can have an adverse impact on plant growth and crop yield. Although soil water availability has a strong influence on crop development and yield performance, little information is available in the Caribbean on the water requirement of pumpkins. Pumpkin is the most important vegetable crop in Puerto Rico. During 1997-98, 17,750 MT were produced, reaching a farm a value of 6.3 millions (Departamento de Agricultura, 1998).

Although the Penman-Monteith method is the sole standard method to estimate potential evapotranspiration (ET_o), the Pan A evaporation method was used herein to estimate to estimate pumpkin ET. The Pan A evaporation method is simpler and provides a measurement of the integrated effect of radiation, wind, temperature, and humidity on the evaporation from an open surface (FAO, 1990). In addition, the Pan A method has been widely investigated in the Caribbean. The Pan A evaporation method was used in scheduling irrigation on tomato, using 0, 0.25, 0.50, 0.75 and 1.0 times Pan evaporation readings. The results showed higher fruit yields with irrigation quantities of 0.75 and 1.0 Pan. Total water use was higher with 0.75 Pan than with the soil maintained at a tension of 10 cb (Locasio and Smajstrla, 1993). Fractions of evapotranspiration replenishment treatments were also used on banana at Puerto Rico (Goenaga and Irizarry, 1995). The method has been recommended by the University of Florida to schedule irrigation on Florida (Smajstrla et al., 1998).

Further research is needed to determine the effect of irrigation on pumpkin growth and phenology to increase crop yield, improve quality and reduce production cost in Puerto Rico. The goal of this project is to generate the irrigation research demand for Puerto Rican farmers.

MATERIALS AND METHODS

A research was conducted at the Lajas and Juana Díaz Experiment Substations, of the University of Puerto Rico. The soils are classified as Vertisols (Typic Haplusterts) and Mollisols (Cumulic Haplustoll) at Lajas and Juana Díaz, respectively. At Juana Díaz , the mean rainfall deficit is 10.4 ± 5.2 cm, while at Lajas it is 5.85 ± 5.5 cm. Experimental plots at Lajas and Juana Díaz Experiment Substations have a drip-irrigation structure with a capability similar to irrigation systems used by farmers in the area.

Two pumpkins selections (*Cucurbita moschata*) were planted in a split plot arrangement (S_1- Soler and S_2-Isolate Summer). Whole plot consisted of a 4 x 2 factorial of four evapotranspiration replenishment treatments (25, 50, 75, and 100%). Whole plots consisting of one bed per plot were arranged in a randomized complete block design with four replications. Each plot was divided into five subplots. Subplots corresponded to sampling dates: 3, 5, 7, 9, and 15 weeks (close to harvest) after planting. Leaf area and dry matter accumulation were measured in two plants and pooled together to obtain an average response per subplot. To simplify leaf area and dry matter sampling, planting trials were planned one week apart to include the location effect in the ANOVA. However, due to several factors, the planting date at Lajas was delayed three weeks. Therefore, locations had to be analyzed separately. The experiments were established on February 19 at Juana Díaz and March 17, 1999 at Lajas. Plant samples were oven-dried at 60°C for dry matter determination. Leaf area was measured using a leaf area meter (LI-3100).

The drip irrigation system used was T-tape with orifices spaced 20 cm apart with beds with aluminum plastic mulch. Pumpkin fertilization and pest control was performed according to the recommendations of the Agricultural Experiment Station (Estación Experimental Agrícola, 1998).

The average Pan Coefficient (Kp) values used for pumpkin in the experiment were 0.63 and 0.66 for Juana Díaz and Lajas, respectively. The average Kc value of 0.78 was used for pumpkin. Kp and Kc values were estimated for the locations studied and for pumpkin. (Goyal et al., 1989). Those Kc and Kp estimates are based on mathematical models and long term climate data. Proposed fractions of evapotranspiration replenishment treatments (ERT) started after three uniform irrigations at 100% evapotranspiration replenishment to aid seedling establishment. Irrigation treatments were scheduled to be applied twice weekly at 72 hour intervals. Water applied was based on daily cumulative ET from the previous irrigation, and controlled accurately by volumetric valves and measured with flow meters. Rainfall recorded during the experiment was deducted from calculations. Water applied to each treatment

RESULTS AND DISCUSSION

A test for normality and equality of variance done to the data showed that the data did not meet analysis of variance (ANOVA) assumptions. Therefore, the data was transformed using the log function (Table 1). Coefficient of variation obtained for both variables was high at both locations. The analysis showed that ERT did not affect pumpkin leaf area in any of both locations (Table 1). Leaf area and dry matter sampling date was highly significant. The two-way interaction between pumpkin selection and sampling date was also highly significant at Lajas, meaning that the leaf area development was different for both pumpkin selections with time. At Juana Díaz, S_1 leaf area was significantly higher than S_2. The high variability observed at both locations for leaf area and dry matter, was attributed to the large genotypic variation observed on S_2 selection. Therefore, we recommend eliminating S_2 selection in future trials. Regardless the genotypic variation observed on S_2 selection, S_1 selection resulted better at Juana Díaz. Observed dry matter accumulation at Juana Díaz was affected significantly by ERT, selections, ERT*selection, and selection*sampling date interactions. From these results we may deduct that there is a predominant effect of location on pumpkin growth. Leaf area observed at Juana Díaz was greater than Lajas (Figure 1).

Observed dry matter accumulation was affected significantly by ERT, selections and selection* sampling date interaction at Juana Díaz (Table 1).

The estimated evapotranspiration (100% ERT) at Juana Díaz (5.1 mm day^{-1}) was twice as great as that of Lajas (2.4 mm day^{-1}). Therefore, the irrigation applied at Juana Díaz for each ERT was higher than Lajas. ET values were overestimated for Juana Díaz and underestimated for Lajas if compared with values calculated by Goyal et al., (1989). The results reported herein are supported by crop response data, contrasting with the values published by Goyal et al., (1989) which were based only on long term climate data and indirectly calculated using the Braney-Cridle method. The results obviously suggest that a singular irrigation recommendation cannot be done due to the large variation in climatic factors observed in the different geographic regions of Puerto Rico.

The response of leaf area seemed to be linear because response is not reaching a plateau (Figure 2). Apparently 75 and 100% evapotranspiration replenishment induced a better leaf area and growth. In the other hand, at Juana Díaz, the response induced by 75% ERT might be quadratic, in comparison with 100% ERT that seems to be increasing with an increase in water applied (Figure 2). At Lajas the average dry matter accumulation response seems to be higher at 75%, although no significant differences were found and for Juana Díaz at 25% (Figure 3).

Several factors such as: The lack of yield data (could not be taken due to factors beyond our control), poor plant stand at Lajas, high variability, and genotypic impurity observed on S_2 selection reduced the information that we expected from the trial. Based on the in formation gathered during this year, the research team decided to eliminate S_2 from future trials and increase plot size (for leaf area and dry matter sampling, yield). The same ERT will be tested in future trials because, a two-year data set is more realistic to make inferences. The research team is also planning to compare the pumpkin ET, obtained with Pan A evaporation method, with the result calculated with the Penman-Monteith method recommended by FAO.

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Table 1. Analysis of variance of transformed (log) leaf area (cm²) and dry matter (g) for two pumpkin selections (Soler and Isolate Summer) as affected by four evapotranspiration replenishment treatments (ERT) at Lajas and Juana Díaz.

sources of variation	df	PrF			
		leaf area		dry matter	
		Lajas	Juana Díaz	Lajas	Juana Díaz
block	3	NS	NS	NS	NS
ERT	3	NS	NS	NS	0.0586
selection	1	NS	0.0259	NS	0.0137
ERT* selection	3	NS	NS	NS	0.0207
Error (a)	21				
sampling date	4	0.0001	0.0001	0.0001	0.0001
ERT*sampling	12	NS	NS	NS	NS
selection*sampling	4	0.0007	NS	NS	0.0022
ERT*sampling*selection	12	NS	NS	NS	NS
Error (b)	90 (92)‡				

‡ Value in parenthesis represents degree of freedom for Juana Díaz

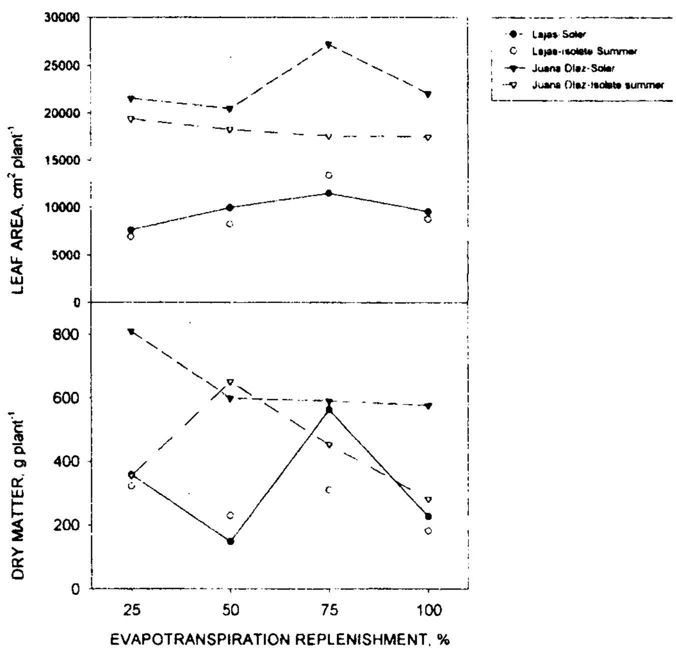

Figure 1: Response of two pumpkin selections to evapotranspiration replenisment treatments at Lajas and Juana Díaz.

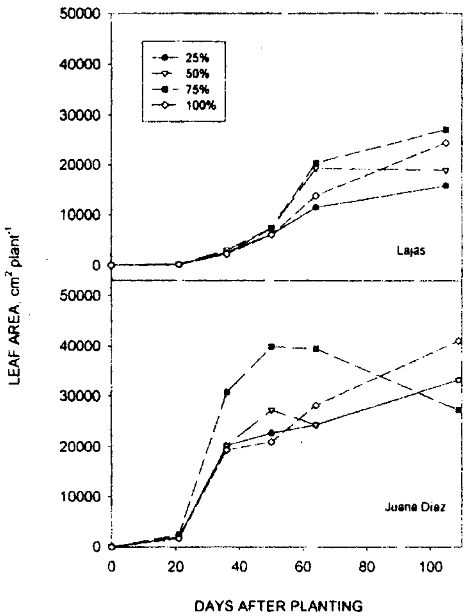

Figure 2 : Leaf area of Pumpkin (soler selection) as affected by evapotranspiration replenisment treatments at Lajas and Juana Diaz

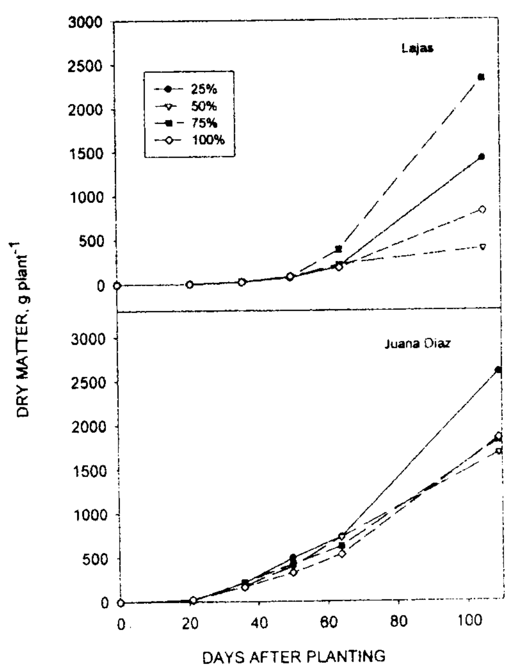

Figure 3 Dry matter acumulation of Pumpkin (soler selection) as affected by evapotranspiration replenisment treatments at Lajas and Juana Diaz