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Yield and quality of 'Superplátano' (*Musa*, AAB) grown with drip irrigation in the semiarid region of Puerto Rico[1,2]

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ABSTRACT

The plantain clone Superplátano was evaluated with drip irrigation at the Fortuna Substation using three plant spacings of 3.05 by 1.22 m, 3.05 by 1.52 m and 3.05 by 1.83 m (2,628 to 1,790 plants/ha) and five bunch (raceme) pruning and bagging subtreatments. Two weeks after bunch emergence the immature racemes were pruned to either four, five or six uppermost hands. In addition, racemes with five and six hands were either bagged or unbagged. The Maricongo cultivar with unpruned bunches was used as a control. Plant spacing had no significant effect on number of fruits and weight per bunch, bunch mean fruit weight and individual fruit characteristics (diameter, length and weight) in the last hand of 'Superplátano' bunches. Hand pruning had a significant effect on bunch size and individual fruit characteristics in the fourth, fifth and sixth hands of 'Superplátano' racemes. Bunches pruned to either four, five or six hands averaged 59, 72 and 86 fruits and weighed 19.1, 21.6 and 23.3 kg, respectively. Regardless of the number of hands that remained in pruned 'Superplátano' bunches, these racemes contained significantly more fruits than the unpruned 'Maricongo'. Bunch mean fruit weight in the 'Superplátano' significantly increased from 273 to 324 g at the expense of reducing bunch size from six to four hands. Bunch mean fruit weight in the unpruned 'Maricongo' raceme was 325 g. The reduction in the number of hands from six to four significantly increased in-

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dividual fruit diameter, inner and outer lengths, and weight in the last hand of 'Superplátano' bunches. The pruning effect, however, was not sufficient to produce fruits in the 'Superplátano' comparable in mean diameter and weight to those corresponding to the same numerical hand of the unpruned 'Maricongo'. The combined pruning and bagging subtreatments had no additional effect on bunch size and individual fruit characteristics. The Superplátano clone with bunches pruned to five hands had a yield potential of 157,000 marketable fruits/ha; the unpruned Maricongo cultivar, whose racemes averaged nine hands, produced 124,130 fruits/ha.

Key words: plantain, bunch pruning, plant spacing, clone, evaluation

RESUMEN

Rendimiento y calidad del Superplátano (*Musa*, AAB) con riego por goteo en la región semiárida de Puerto Rico

Se evaluó el comportamiento del clon Superplátano con riego por goteo en la Subestación de Fortuna utilizando tres distancias de siembra: 3.05 por 1.22 m, 3.05 por 1.52 m y 3.05 por 1.83 m (2,628 a 1,790 plantas/ha) y cinco subtratamientos de remoción de manos inferiores y enfundado de racimos. A las dos semanas de brotar, los racimos se podaron dejando las cuatro, cinco o seis manos superiores. Los racimos podados a cuatro, cinco y seis manos se dejaron al descubierto o se enfundaron con bolsas de polietileno perforadas. Como control se usó el cultivar Maricongo con los racimos sin podar. La distancia de siembra no tuvo efecto significativo sobre el número de frutas ni el peso de los racimos, el peso medio de las frutas en el racimo o las características (diámetro, largo y peso) de las frutas individuales en la última mano del 'Superplátano'. Por otra parte, la remoción de manos tuvo un efecto significativo en el tamaño del racimo y las características individuales de las frutas en la última mano de los racimos del 'Superplátano'. Los racimos podados a cuatro, cinco o seis manos tuvieron en promedio 59, 72 y 86 frutas y pesaron 19.1, 21.6 y 23.3 kg, respectivamente. Independientemente del número de manos que se les dejaron a los racimos del 'Superplátano', éstos contenían sustancialmente más frutas que los racimos sin podar del 'Maricongo'. El peso medio de las frutas en el racimo del 'Superplátano' aumentó significativamente desde 273 a 324 g a expensas de la reducción en el tamaño de los racimos de seis a cuatro manos. El peso medio de las frutas en el racimo sin podar del 'Maricongo' fue de 325 g. La reducción en el número de manos de seis a cuatro aumentó significativamente el diámetro, los largos externo e interno y el peso de las frutas individuales en la última mano de los racimos del 'Superplátano'. Sin embargo, el efecto de la poda no fue suficiente para producir en el 'Superplátano' frutas comparables en diámetro y peso medio a las frutas correspondientes numéricamente a la misma mano del racimo sin podar del 'Maricongo'. Los subtratamientos combinados de remoción de manos y enfundado no tuvieron efectos adicionales sobre el tamaño del racimo y las características de las frutas en las manos evaluadas. El clon Superplátano con los racimos podados a cinco manos tuvo un potencial de rendimiento de 157,000 frutas mercadeables por hectárea; el cultivar Maricongo con los racimos sin podar y nueve manos en promedio produjo 124,130 frutas por hectárea.

INTRODUCTION

Plantain is the most economically important starchy crop in Puerto Rico. Since 1979-80, more than 315 million marketable fruits have

been produced annually with a farm-gate value that in 1990-91 exceeded $43 million (Ortiz-López, 1992).

A plantain is considered marketable when the mature-green fruit attains a mean weight of about 270 g, approximately 110 days after bunch-shooting. Because plantains are sold by units, uniformly heavier and larger fruits demand higher prices, particularly from December through May, when the local demand exceeds production. To conform with marketing standards and consumer preference, all plantains produced for the local market are of the false-horn type. In the false-horn type, the male flower bud attached to the raceme rachis dries and disintegrates during fruit filling. Within this type, Maricongo is the most popular locally grown cultivar, but because of a chimerism problem, bunch phenotype reversion is frequent and bunch size erratic (Irizarry et al., 1985; Krikorian et al., 1993). This problem requires continual clonal selection and roguing of "off type" plants to maintain the yield potential at about 45 marketable fruits per bunch (Irizarry et al., 1985). The availability of the stable Superplátano clone bearing French-type bunches, and containing seven to ten hands with numerous undersized fruits, offers the opportunity to increase yield if the bunch is properly managed. In the French-type clones the male flower bud remains attached to the raceme rachis from flowering to harvest. Under transient drought at Corozal, 'Superplátano' yielded 146,000 and 180,000 marketable fruits per hectare with racemes pruned to four and five uppermost hands, respectively (Irizarry et al., 1991).

This study reports the effect of three plant spacings and five bunch pruning subtreatments on raceme size and weight, individual fruit characteristics, and total yield of the 'Superplátano' grown with drip irrigation on the semiarid southern coast of Puerto Rico.

MATERIALS AND METHODS

An experiment was established 1 October 1991 at the Fortuna substation (AES-UPR), located on the semiarid southern coast of Puerto Rico at an elevation of about 21 m. Average annual rainfall is 917 mm with evaporation of 2,149 mm. Mean monthly minimum and maximum temperatures are 20.7 and 31.0° C, respectively.

The soil is a San Antón sandy clay (Cumulic Haplustolls, fine-loamy, mixed, isohyperthermic). In the top 20 cm soil layer the pH was 7.7, containing 18 mg/kg of P (Olsen method) and an exchangeable base capacity of 26.1 cmol(+)/kg. Before planting, the soil was subsoiled to a depth of about 90 cm.

Three plant spacings (main plot): 3.05 by 1.22 m (2,628 plants/ha), 3.05 by 1.52 m (2,150 plants/ha), and 3.05 by 1.83 m (1,790 plants/ha);

two cultivars (sub plot): Superplátano and Maricongo; and five bunch lower hand pruning and bagging; treatments (sub-sub plot) were arranged in a split-split-plot design with six replications. The bunch subtreatments consisted in the removal of the male flower bud and lower hands from the immature 'Superplátano' racemes to maintain either four, five or six uppermost hands. In addition, bunches pruned to five or six hands were covered with banana plastic polyethylene bags (Irizarry et al., 1992). Pruning and bagging were performed about two weeks after bunch emergence. Because the false horn type 'Maricongo' bunch neither retains the male flower bud nor responds to lower hands removal (Rodríguez et al., 1987), these racemes were not subjected to pruning and bagging but were used as a control. The main plot consisted of four rows 30.5 m long. Each row accommodated 15 'Superplátano' and three 'Maricongo' experimental plants. These plants represented the bunch sub-subtreatments and the control. Each main plot was surrounded by guard rows.

After planting and until corm germination, the experiment was overhead irrigated at the weekly rate of about 25 mm. Thereafter, the experiment was drip irrigated on alternate days, Monday through Friday, with a pan factor value of one, in which the water lost through evapotranspiration the previous week was replenished the following week after subtracting any recorded rainfall (Goenaga et al., 1993). No irrigation was applied when the total rainfall of the preceding week exceeded 20 mm. Table 1 presents monthly evaporation and rainfall and water applied during the planting-to-harvest cycle.

The planting material was medium size corms weighing about 2.5 kg. At planting, 11 g of P as triple superphosphate was placed beneath the propagating corms. Six weeks later the plants received a single application of a 10-5-20 (N, P_2O_5, K_2O) fertilizer at the rate of 460 kg/ha. Twelve weeks after planting, the plants began receiving weekly fertigations of N and K at the rate of 6 and 14 kg/ha, respectively, from urea and potassium nitrate as source of nutrients. Fertigations were supplemented with Fe, Zn and Mn EDTA chelates at the rate of 0.25, 0.6 and 0.8 kg/ha, respectively. When irrigation was not necessary, the weekly fertigation was postponed and applied at a double rate the following week.

Weeds, nematodes and soil-borne insects were controlled in accordance with published recommendations (Irizarry and Montalvo, 1995). Throughout the experiment, the yellow sigatoka was not a problem.

At bunch-shooting, plant height and pseudostem diameter were measured, and the number of functional leaves was recorded. These measurements were taken from the base of the plants to about 1 m

TABLE 1.—*Monthly evaporation and rainfall recorded, and water applied to the 'Superplátano' and 'Maricongo' plants during 1 October 1991 through 31 December 1992 at the Fortuna Substation.*

Month	Evaporation	Rainfall	Irrigation applied
	mm	mm	plant
October, 1991	182.6	45.5	—
November	153.2	82.6	—
December[1]	134.1	5.1	41
January, 1992	134.6	228.3	110
February	156.0	20.3	355
March	196.9	18.5	564
April	184.7	78.0	212
May	169.2	44.0	278
June	202.4	33.5	302
July	232.2	3.3	695
August	207.5	85.1	384
September	177.5	99.1	153
October	160.3	171.2	69
November	126.5	171.2	97
December	130.0	31.2	265

[1]Initiation of drip irrigation: 23 December 1991.

above ground level for pseudostem diameter and at the point of bunch emergence for plant height. About 110 days after bunch-shooting the racemes were harvested, weighed and number of hands and fruits counted. The bunches were dehanded from the fourth to the sixth uppermost hands, and each hand was weighed and fruits were counted. Mean fruit weight of the whole bunch and of each dissected hand was determined. Subsequently, fruits from the two rows in the middle section of each sampled hand were measured to determine diameter and inner and outer lengths.

The recorded data were subjected to an analysis of variance and means compared by using Duncan's multiple range test.

RESULTS AND DISCUSSION

Plant spacing had a significant effect on height of the Maricongo cultivar, number of days required by the 'Superplátano' for fruit filling, and on yield of both cultivars. 'Maricongo' plants grown at the closest spacing developed a significantly taller pseudostem (3.8 m) than plants grown at wider spacings (Table 2). Plant spacing had no significant effect on plant height of the 'Superplátano', which averaged 3.5 m. Between the two cultivars, Maricongo developed the taller pseudostem,

TABLE 2.—*Effect of three plant spacings on plant height and time required by fruits to attain the mature-green stage in two plantain cultivars.*

Plant spacing and density/ha	Plant height		Time from bunch emergence to harvest	
	'Maricongo'	'Superplátano'	'Maricongo'	'Superplátano'
	m		days	
3.05 by 1.22 m (2,628)	3.8a[1]	3.6a	109.6a	114.9a
3.05 by 1.52 m (2,155)	3.6b	3.5a	108.2a	112.4b
3.05 by 1.83 m (1,792)	3.6b	3.5a	107.7a	110.5b

[1]Means within a column followed by the same letter do not differ significantly at the 0.05 probability level.

but differences from that of Superplátano were significant only at the closest spacing (data not shown).

Regardless of bunch pruning subtreatments, the 'Superplátano' grown at the closest spacing of 3.05 by 1.22 m required significantly more time (114.9 days) from bunch-shooting to fruit filling than plants grown at wider spacings (Table 2). Plant spacing had no significant effect on the time needed by the 'Maricongo' for fruit filling, which averaged 108.5 days. 'Superplátano' consistently took more time for fruit filling, but significant differences from 'Maricongo' were detected only at the closest spacing (data not shown).

Plant spacing had no significant effect on pseudostem diameter, number of functional leaves at flowering, number of fruits and weight per bunch, bunch mean fruit weight, and individual fruit characteristics (diameter, length and weight) in the last hand of 'Superplátano' bunches pruned to either four, five or six uppermost hands.

Both cultivars significantly increased the number of fruits and weight per hectare with a reduction in plant spacing. The 'Superplátano' grown at the closest spacing of 3.05 by 1.22 m produced 190,900 marketable fruits/ha or 58.2 t/ha (Table 3). The 'Maricongo' grown at the same spacing yielded 149,000 marketable fruits/ha or 49.9 t/ha. Regardless of plant spacing, 'Superplátano' significantly outyielded 'Maricongo' for number of fruits and weight per hectare (data not shown).

Cultivar and hand pruning subtreatments had a significant effect on number of fruits and weight per bunch, and bunch mean fruit weight. Regardless of the number of hands that remained on the 'Superplátano' bunches after pruning, these racemes contained significantly more fruits than the unpruned 'Maricongo' bunches, which averaged nine hands (Table 4). However, bunch mean weight dif-

TABLE 3.—*Effect of three plant spacings on the yield of the 'Superplátano' with bunches pruned to a reduced number of hands and the 'Maricongo' with unpruned racemes containing an average of nine hands.*

Plant spacing and density/ha	'Superplátano'	'Maricongo'	'Superplátano'	'Maricongo'
	------ fruits/ha ------		-------- kg/ha--------	
3.05 by 1.22 m (2,628)	190,924a[1]	149,095a	58,150a	49,946a
3.05 by 1.52 m (2,155)	155,112b	123,086b	46,839b	38,834b
3.05 by 1.83 m (1,792)	128,934c	100,209c	39,670c	33,303c

[1]Means within a column followed by the same letter do not differ significantly at the 0.05 probability level.

ferences from 'Maricongo' were significant only in 'Superplátano' racemes pruned to five and six hands. Bunch mean fruit weight in the 'Superplátano' significantly increased at the expense of reducing bunch size from six to four hands (Table 4). On the basis of the bunch mean fruit weight criterion of about 270 g, fruits from 'Superplátano' bunches pruned to six hands qualified as marketable. However, the 'Superplátano' bunches pruned to four hands and the unpruned 'Maricongo' racemes produced superior grade fruits.

Hand pruning subtreatments significantly affected individual fruit characteristics in the fourth, fifth and sixth uppermost hands of the 'Superplátano' bunches. The reduction in number of hands from six to four significantly increased fruit thickness, inner and outer lengths, and mean fruit weight in the last hand, but the pruning effect was not sufficient to produce'Superplátano' fruits comparable in size to those of 'Maricongo' (Table 5). Fruits in the fourth, fifth and sixth hands of unpruned 'Maricongo' bunches were thicker and heavier than fruits corresponding to the same numerical hands of pruned 'Superplátano'

TABLE 4.—*Yield attributes in the 'Superplátano' with bunches pruned to a reduced number of hands and 'Maricongo' with unpruned racemes.*

Cultivar and bunch pruning subtreatment	Production per punch		Mean fruit weight
	Fruits	Weight	
	no.	kg	g
'Superplátano' - six hands	85.8a[1]	23.3a	273.4c
'Superplátano' - five hands	71.7b	21.6b	301.1b
'Superplátano' - four hands	59.1c	19.1c	323.8a
'Maricongo' - unpruned with nine hands	56.6d	18.4c	325.2a

[1]Means within a column followed by the same letter do not differ significantly at the 0.05 probability level.

TABLE 5.—*Comparison of fruit characteristics in the last hand of 'Superplátano' bunches pruned to either four, five, or six hands, and fruits corresponding to the same numerical hand of unpruned 'Maricongo' racemes.*

Hands in the bunch	Fruit diameter		Fruit inner length		Fruit outer length		Fruit mean weight		Fruits per hand	
	'Superplátano'	'Maricongo'	'Superplátano'	'Maricongo'	'Superplátano'	'Maricongo'	'Superplátano'	'Maricongo'	'Superplátano'	'Maricongo'
no.	mm		cm		cm		g		no.	
Fourth	40.6a[1]	43.6a	21.7a	20.9a	23.5a	24.6a	271.2a	299.2a	14.3a	7.0a
Fifth	39.0b	43.0a	20.5b	20.0b	23.6a	24.7a	245.6b	299.8a	14.2a	5.3b
Sixth	35.9c	43.0a	19.5c	19.5b	21.7b	23.8b	213.2c	269.0b	14.1a	4.2c

[1]Means within a column followed by the same letter do not differ significantly at the 0.05 probability level.

FIGURE 1. Number and size of fruits in the last hand of 'Superplátano' bunches pruned to either four, five or six uppermost hands as compared to fruits corresponding to the same numerical hand of the unpruned 'Maricongo' racemes.

racemes. However, fruits in the sixth hand of the unpruned 'Maricongo' racemes were significantly shorter and lighter than fruits in the fifth and fourth hands (Table 5). On the basis of the individual fruit weight, not all fruits in the fifth and lower hands of the pruned 'Superplátano' bunches and in the sixth and lower hands of the unpruned 'Maricongo' racemes conformed with the 270 g market grading criterion. Regardless of the number of hands that remained in the 'Superplátano' bunches after pruning, there was no significant difference between cultivars for inner fruit length (data not shown). The 'Superplátano' racemes contained a similar number of fruits in the fourth, fifth and sixth hands. However, number of fruits per hand in the 'Maricongo' bunches was significantly affected by the numerical position of the hand (Table 5; Figure 1). Regardless of the numerical position of the hand in the bunch, the number of fruits per hand in the 'Superplátano' was significantly greater than for 'Maricongo' (data not shown).

TABLE 6.—*Total yield of the 'Superplátano' with bunches pruned to a reduced number of hands and the 'Maricongo' with unpruned racemes.*

Cultivar and bunch pruning subtreatment	Yield per ha	
	Fruits	Weight
	no.	kg
'Superplátano' - six hands	188,198a[1]	51,663a
'Superplátano' - five hands	157,014b	47,455b
'Superplátano' - four hands	129,759c	42,060c
'Maricongo' - unpruned with nine hands	124,130d	41,129c

[1]Means within a column followed by the same letter do not differ significantly at the 0.05 probability level.

The combined pruning and bagging subtreatments had no additional effect on bunch size and individual fruit characteristics in the last hand of 'Superplátano' racemes pruned to either five or six uppermost hands (data not shown).

Total yield per hectare was significantly affected by cultivar and hand pruning subtreatments. The 'Superplátano' with bunches pruned to either four, five or six hands produced 129,759; 157,014 and 188,198 fruits/ha, respectively (Table 6). The unpruned 'Maricongo' racemes with nine hands produced 124,130 fruits/ha. Likewise, fruit weight per hectare was always higher in the 'Superplátano' but differences over 'Maricongo' were substantially greater only with bunches pruned to five and six hands. Increments in the number of hands of the pruned 'Superplátano' bunches from four to six consistently increased the total yield at the expense of a reduction in size and weight of individual fruits (Table 5).

We concluded that the 'Superplátano' can be successfully grown with drip irrigation on the southern semiarid coast of Puerto Rico with the close spacing of 3.05 by 1.22 m (about 2,628 plants/ha) without detriment to the bunch and individual fruit characteristics. Under these growing conditions an optimum yield of 157,000 marketable fruits/ha can be expected with bunches pruned to the five uppermost hands.

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