

Yield performance of two French-type plantain clones subjected to bunch pruning^{1,2}

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ABSTRACT

Two introduced French-type plantain (*Musa*, AAB) clones, Maiden and Dominican Red, were evaluated to determine the effect of bunch pruning on fruit grade and marketable yield. Pruning treatments consisted in the removal of the male floral bud and lower hands from the immature bunch to maintain either four, five or six uppermost hands. The false-horn type clone Maricongo with the unpruned bunch was used as a control. A reduction in the number of hands from six to four in bunches of the French type clones significantly increased bunch mean fruit weight and individual fruit weight per hand. Regardless of the pruning treatment, the French type clones produced significantly more fruits per bunch than the false-horn type Maricongo with the unpruned bunch. There was no significant difference among the French-type clones for number of fruits per bunch when pruned to either four, five or six uppermost hands. These clones averaged 54, 66 and 77 fruits with their bunches pruned to four, five and six hands, respectively. The false-horn-type Maricongo with unpruned bunches produced 48 fruits. However, regardless of the pruning treatment, bunches from Maiden were always significantly heavier than those of Dominican Red and the unpruned Maricongo. Bunches of Maiden pruned to four, five and six hands weighed 23.3, 25.4, and 26.7 kg, respectively. Unpruned Maricongo bunches weighed 20.1 kg. The French-type Maiden plantain with bunches pruned to five uppermost hands yielded 177,271 marketable fruits/per hectare, equivalent to 68,326 kg/ha. This amount represented a significant yield difference of 47,344 marketable fruits per hectare (14,257 kg/ha) when compared to the unpruned Maricongo bunches. All fruits obtained from the Maiden plantain bunches pruned to five hands exceeded the local market fruit weight criterion of 270 g, including fruits in the distal hand, which compared favorably in size with fruits in the fifth hand of the unpruned bunch of Maricongo.

Key words: plantain clones, bunch management, yield, fruit quality

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RESUMEN

Potencial de rendimiento de dos clones de plátano tipo Congo sometidos a poda del racimo

Se evaluaron dos introducciones del plátano (*Musa*, AAB) tipo Congo, los clones Maiden y Dominicano Rojo, para determinar el efecto de la poda del racimo en el tamaño de las frutas y en el rendimiento. Los tratamientos de poda consistieron en la remoción del órgano floral masculino (pámpano) y de manos inferiores del racimo tierno manteniendo solamente las primeras cuatro, cinco o seis manos superiores. El clon local tipo cuerno, Maricongo, con racimos sin podar se utilizó como control. La reducción del tamaño de los racimos tipo Congo de seis a cuatro manos aumentó significativamente el peso medio de las frutas por racimo y el peso individual de las frutas por mano. Irrespectivamente de los tratamientos de poda, los clones del tipo Congo produjeron significativamente más frutas por racimo cuando se compararon con el tipo cuerno Maricongo sin poda del racimo. No se encontraron diferencias significativas entre los clones tipo Congo para número de frutas por racimo cuando éstos se podaron a cuatro, cinco o seis manos superiores. Los clones tipos Congo promediaron 54, 66 y 77 frutas por racimo cuando éstos se podaron a cuatro, cinco y seis manos, respectivamente. El clon Maricongo con racimos sin podar produjo 48 frutas. Sin embargo, irrespectivamente de los tratamientos de poda, los racimos obtenidos del clon tipo Maiden resultaron significativamente más pesados que los racimos podados de los clones Dominicano Rojo y Maricongo con los racimos sin podar. Los racimos de Maiden podados a cuatro, cinco y seis manos pesaron en promedio 23.3, 25.4 y 26.7 kg, respectivamente. Los racimos de Maricongo sin podar pesaron en promedio 20.1 kg. El clon Maiden con el racimo podado a cinco manos superiores tiene un potencial de rendimiento de 177,271 frutas mercadeables por hectárea, equivalentes a 68,326 kg/ha. Este rendimiento fue 47,344 frutas por hectárea (14,257 kg/ha) mayor cuando se comparó con la producción del clon Maricongo con racimos sin podar. Todas las frutas obtenidas del plátano Maiden con racimos podados a cinco manos sobrepasaron el peso medio de 270 g, criterio local utilizado para cualificar como mercadeable la fruta de plátano. Además, las frutas de la mano distal del plátano Maiden podado a cinco manos compararon favorablemente en tamaño con las frutas cosechadas de la quinta mano del racimo sin podar de Maricongo.

Palabras clave: clones de plátano, manejo del racimo, rendimiento, calidad de fruta

INTRODUCTION

About 90% of total plantain production in Puerto Rico originates from growing the false-horn type Maricongo clone; the local grade market criteria are based on fruit traits from this clone. A Maricongo fruit is considered marketable when it attains a weight of 270 g or more. Heavier and larger (25.4 cm or more in outer length) fruits fall into a superior grading and consequently a higher price (Soto-Santiago, 1994).

The Maricongo clone, however, is unstable for bunch phenotype, including bunch reversion from false-horn type to French-type, and is erratic in maintaining uniformity for number of hands and fruits per bunch (Irizarry et al., 1985; Krikorian et al., 1993; Irizarry et al., 2001).

These undesirable bunch traits affect yield and fruit quality. In spite of these constraints, this clone has demonstrated in multi-site experiments conducted under intensive management that it has a yield potential of about 45 marketable fruits per bunch (Irizarry et al., 1985).

During a nine-year period, 1986 to 1995, the cost of plantain production in Puerto Rico increased by about 27% (Irizarry and Montalvo-Zapata, 1986; Agric. Exp. Sta., 1995). However, during the same period, the farm-gate value of the crop increased by only 17% (Soto-Santiago et al., 1996). To keep this crop profitable, continued increases in production costs can be overcome only by passing on to the consumer the higher cost of production, having the Department of Agriculture of Puerto Rico subsidize the crop, or else increasing yields to compensate for increases in production costs.

In previous experiments, the authors have demonstrated that growing French-type plantain clones under intensive management and pruning of lower hands in the bunch will increase yield by about 20% without detriment to fruit quality (Irizarry and Goenaga, 1995, 1997; Irizarry et al., 1998). In bananas, Boncanto (1969) and Hasselback and Idoe (1973) reported that reducing the number of lower hands from the bunch significantly increased the size and weight of the fruits that remained in the bunch at the expense of reducing the total bunch weight. This practice was considered economically viable because it upgraded fruit quality (Calvo and Soto, 1985).

The use of French-type clones for commercial plantain production can result in not only a yield increase but also these clones may be an alternative in regions where black sigatoka is present. All active plantain genetic improvement programs, whose main objective is to develop black Sigatoka-resistant clones, use French-type female parents as the source of resistance (Vuylsteke et al., 1993; Rowe, 1994). So far, all disease-resistant clones that have been released from these programs are French-type plantains.

This study reports on the effect of bunch pruning lower hands in two introduced French-type plantain clones with the objective of increasing yield and improving fruit quality.

MATERIALS AND METHODS

An experiment was established 13 June 2001 at the Isabela Research Farm of the USDA-ARS, Tropical Agriculture Research Station (TARS). The farm is located in the northwestern region of Puerto Rico, 18.7°N, 67°W, at an elevation of about 126 m. The soil is a Coto clay, very fine, kaolinitic isohyperthermic Typic Hapludox with good drainage, a pH of 6.2, 28 mg/kg P (Bray 2), 187 mg/kg K, 1240 mg/kg Ca, and

73 mg/kg Mg in the top 20 cm of soil. During the experiment the mean monthly minimum and maximum temperatures were 21.1 and 30.0° C, respectively. Mean monthly rainfall was 141 mm. Plots were drip-irrigated when the soil water tension, measured with tensiometers at a depth of 30 cm, exceeded 20 Kpa.

Two French-type plantain clones, Maiden (TARS accession number 16511) and Dominican Red (TARS accession number 17816) and the locally grown false-horn type Maricongo (TARS accession number 16509) were chosen for this study. The Maiden and Dominican Red clones were selected because in addition to bearing stable French-type bunches, these clones possess little variability for number of hands and fruits per bunch. In addition, their bunch mean fruit weight and last hand individual fruit weight were among the highest in the French-type *Musa* AAB subgroup grown at the TARS germplasm plantain collection (Irizarry et al., 2001). The Maiden plantain was introduced from SI-ATSA, Honduras; and the Dominican Red, from the Dominican Republic. The false-horn type Maricongo is the most widely grown clone in Puerto Rico.

Corms obtained from sword suckers weighing about 2 kg were planted at a 1.2- by 3.1-m spacing (equivalent to 2,690 plants per hectare) in a split-plot design with four replications. Each replication contained plants of clones Maiden, Dominican Red and Maricongo (main plots). Each main plot was split to accommodate three bunch pruning treatments, which consisted in the removal of the male floral bud and the lower hands from the immature bunches of the Maiden and Dominican Red clones with the purpose of maintaining either four, five, or six uppermost hands per bunch. Bunch pruning was conducted during the first two weeks after bunch emergence. The bunch of the Maricongo clone was left unpruned and served as control. Each subplot contained four plants. Since Maricongo bunches were not pruned, these were not considered true subplots and hence data were analyzed as a RCB design. The experiment was surrounded by a row of guard plants.

At planting, each plant received 50 g of triple superphosphate. A 10-5-20-3 (N, P₂O₅, K₂O, MgO) fertilizer supplemented with 22.7 kg/t of a minor element mixture was applied at the rate of 610, 610, 915, and 610 kg/ha at one, five, eight, and ten months after planting, respectively. Yellow Sigatoka, nematodes, soil-borne insects and weeds were controlled by following recommended cultural practices (Agric. Exp. Sta., 1995).

The bunches were harvested when the fruits reached the mature-green stage, about 110 days after flowering. At harvest, the hands were separated from the bunch rachis, counted, and the number of fruits and weight per hand recorded. These data were used to determine the number of fruits and weight per bunch, the bunch mean fruit weight, and

the individual fruit weight in each hand. The outer length and diameter were measured in four fruits from the middle section of the distal hand of pruned bunches of Maiden and Dominican Red. Length was measured following the external curvature of the fruit from the peduncle to the apex, and diameter taken in the middle of the fruit. Fruits from the corresponding numerical hands of the unpruned false-horn Maricongo bunch were subjected to the same sampling methodology. The data were statistically analyzed by using the GLM procedure (SAS Institute, 1999) and means compared by using Fisher protected LSD at $P = 0.05$.

RESULTS AND DISCUSSION

Clones and bunch pruning treatments significantly affected the number of fruits, bunch weight, and bunch mean fruit weight (analysis of variance not shown). Regardless of the number of hands retained, the Maiden bunch always produced significantly more fruits and was significantly heavier than the unpruned Maricongo bunch (Table 1). The Maiden plantain bunch pruned to either four, five or six uppermost hands produced 54, 66 and 78 fruits, respectively. Bunch weight was 23.3 kg with four hands, 25.1 kg with five hands and 26.7 kg with six hands. The unpruned Maricongo produced bunches that had seven hands, 48 fruits, and weighed 20.1 kg. Within pruning subtreatments,

TABLE 1. *Yield components and estimated yield per hectare in two French-type plantain clones with the bunches pruned to a reduced number of hands and the false-horn type Maricongo clone with the unpruned bunch.*

Clone name and pruning treatment	Fruits per bunch	Bunch weight	Bunch mean fruit weight	Fruits per hectare	Bunch weight per hectare
	No.	kg	g	No.	kg
Maiden plantain, pruned to six hands	77.6	26.7	344.1	208,744	71,823
Dominican Red, pruned to six hands	77.0	24.3	315.6	207,399	65,367
Maiden plantain, pruned to five hands	65.9	25.4	385.4	177,271	68,326
Dominican Red, pruned to five hands	65.5	23.5	358.8	176,195	63,215
Maiden plantain, pruned to four hands	54.0	23.3	431.5	145,529	62,677
Dominican Red, pruned to four hands	53.5	21.1	394.4	143,646	56,759
Maricongo, unpruned with seven hands	48.3	20.1	416.1	129,927	54,069
LSD (0.05)	4.2	1.8	33.0	11,332	4,941

there was no significant difference between the French-type clones for number of fruits per bunch; however, the Maiden plantain bunch was always significantly heavier (Table 1).

Reducing the bunch size from six hands to four hands in the French-type clones resulted in a significant increase in bunch mean fruit weight (Table 1). French-type clones with their bunch pruned to either five or six hands showed no significant difference for bunch mean fruit weight; however, bunches of Maiden pruned to four hands had the highest bunch mean fruit weight (431.5 g). This bunch mean fruit weight was significantly greater than that obtained in Dominican Red (394.4 g) with the bunch pruned to four hands but not significantly greater than the mean fruit weight obtained in the unpruned Maricongo (Table 1).

There was a highly significant difference between the French-type clones and the false-horn Maricongo clone for number of fruits per hand. Regardless of hand position, the bunch of the Maiden and Dominican Red clones always contained significantly more fruits per hand as compared to the same numerical hand of the unpruned Maricongo bunch (Table 2). There was no significant difference between the French-type clones for this bunch trait. These bunches averaged 14.5 fruits in the first hand, 13.7 fruits in the second hand, 13.0 fruits in the third hand, 12.6 fruits in the fourth hand, 12.0 fruits in the fifth hand and 11.6 fruits in the sixth hand. The unpruned bunch of the false-horn type Maricongo clone had 10.6, 9.5, 7.6, 6.3, 5.4 and 3.8 fruits in the first six uppermost hands, respectively, and 3.1 and 2.1 fruits in the seventh and eighth hands (Table 2).

There was a highly significant difference among plantain clones and bunch pruning treatments for hand mean fruit weight. Mean fruit weight of the first, second, third and fourth hands of the Maiden bunch pruned to four or five uppermost hands was not significantly different from that of the same hands in the unpruned Maricongo (Table 3).

TABLE 2. *Average number of fruits per hand in two French-type plantain clones and the false-horn-type Maricongo clone.*

Clone name	Hand position							
	First hand	Second hand	Third hand	Fourth hand	Fifth hand	Sixth hand	Seventh hand	Eighth hand
	----- Number of fruits -----							
Maiden plantain	14.7	13.6	13.0	12.7	12.0	11.7	—	—
Dominican Red	14.2	13.8	13.0	12.5	12.0	11.5	—	—
Maricongo	10.6	9.5	7.6	6.3	5.4	3.8	3.1	2.1
LSD (0.05)	2.3	0.6	0.7	0.6	0.5	0.6	—	—

When the Maiden bunch was pruned to six hands, mean fruit weight declined significantly when compared to that of Maricongo. However, since plantains are marketable by fruit units, which must weigh 270 g or more to be considered marketable, fruits obtained from the distal hands of the French-type Maiden plantain with the bunch pruned to either five or six hands met market standards (Table 3). Mean fruit weight in most hands of the Dominican Red bunch pruned to four, five or six hands was significantly less than that of unpruned Maricongo bunches (Table 3). It is noteworthy that fruits corresponding to the eighth hand of the unpruned Maricongo bunch did not attain the local market grade weight criterion of 270 g.

Plantain clones and bunch pruning treatments had a significant effect on fruit length. Fruits in the distal hand of the Dominican Red clone with the bunch pruned to either four, five or six uppermost hands were significantly shorter than those obtained from the unpruned bunch of the false-horn type Maricongo clone (Table 4). However, fruit length in the distal hand of the Maiden clone with the bunch pruned to four or five hands was similar to that obtained in the same numerical hand of the Maricongo bunch. These results are indicative that fruits from the distal hand of a Maiden bunch pruned to four or five hands conform to local grade market criteria and can compete with those of Maricongo for a superior market grade and higher price. Fruits in the distal hand of the Maiden and Dominican Red clones with bunches pruned to six hands were significantly shorter in outer length than those obtained from the same numerical hand of the unpruned false-horn type Maricongo clone (Table 4). There were no significant differences in fruit diameter among clones.

Clones and bunch pruning treatments had a significant effect on number of fruits and bunch weight per hectare (Table 1). The French-type Maiden and Dominican Red clones with bunches pruned to four, five or six hands produced a similar number of fruits per hectare (Table 1). Regardless of the bunch pruning treatment, both clones produced significantly more fruits per hectare than the false-horn type Maricongo with the unpruned bunch. The Maiden plantain always produced a significantly heavier bunch. When the bunch was pruned to either four or five uppermost hands, individual fruits in the first four hands of the bunch compared favorably for quality (hand mean fruit weight and outer length) with those obtained from the same numerical hands of the false-horn type Maricongo unpruned bunch (Tables 1, 3 and 4). This was not the case for the Dominican Red clone; therefore, we restrict our discussion on total yield (number of marketable fruits and bunch weight per hectare) to that obtained with the Maiden and Maricongo clones only.

TABLE 3. Mean fruit weight in hands of two French-type plantain clones with their bunches pruned to a reduced number of hands and mean fruit weight in all hands of the unpruned bunch of the false-horn-type Maricongo clone.

Clone name and pruning treatment	Mean fruit weight							
	First hand	Second hand	Third hand	Fourth hand	Fifth hand	Sixth hand	Seventh hand	Eighth hand
	----- g -----							
Maricongo, unpruned	460.0	421.0	413.7	373.0	—	—	—	—
Maiden plantain, pruned to four hands	424.8	419.5	396.3	363.0	—	—	—	—
Dominican Red, pruned to four hands	405.0	387.5	373.5	341.3	—	—	—	—
LSD (0.05)	49.0	NS	34.8	28.8	—	—	—	—
Maricongo, unpruned	460.0	421.0	413.7	373.0	363.0	—	—	—
Maiden plantain, pruned to five hands	433.0	384.8	378.9	344.5	302.0	—	—	—
Dominican Red, pruned to five hands	424.3	370.0	355.3	321.0	299.0	—	—	—
LSD (0.05)	NS	36.4	34.8	28.8	27.5	—	—	—
Maricongo, unpruned	460.0	421.0	413.7	373.0	362.7	352.0	345.0	232.0
Maiden plantain, pruned to six hands	394.3	373.8	340.3	304.5	271.5	271.3	—	—
Dominican Red, pruned to six hands	371.5	332.3	311.0	287.0	268.8	242.0	—	—
LSD (0.05)	49.0	36.4	34.8	28.8	27.5	12.3	—	—

TABLE 4. *Fruit size in the distal hand of two French-type plantain clones with their bunches pruned to a reduced number of hands and size of fruits corresponding to the same numerical hand of the unpruned bunch of the false-horn-type Maricongo clone.*

Clone name and pruning treatment	Fruit size	
	Outer length	Diameter
	cm	mm
Maricongo, unpruned	27.07	48.70
Maiden plantain, pruned to four hands	26.52	50.30
Dominican Red, pruned to four hands	26.00	48.18
LSD (0.05)	0.96	NS
Maricongo, unpruned	26.31	47.50
Maiden plantain, pruned to five hands	25.83	47.50
Dominican Red, pruned to five hands	25.00	46.45
LSD (0.05)	0.50	NS
Maricongo, unpruned	23.88	44.10
Maiden plantain, pruned to six hands	23.00	44.50
Dominican Red, pruned to six hands	23.14	44.00
LSD (0.05)	0.41	NS

The French-type Maiden plantain with the bunch pruned to five hands yielded 177,271 marketable fruits per hectare, equivalent to a marketable weight of 68,326 kg/ha (Table 1). The false-horn type Maricongo with the unpruned bunch yielded 129,927 marketable fruits per hectare, weighing 54,069 kg/ha. The 47,344 marketable fruits per hectare or 14,257 kg/ha difference was significant. All fruits obtained from the French-type Maiden plantain with the bunch pruned to five hands surpassed the local market fruit weight criterion of 270 g. Although all fruits obtained in the Maiden plantain with the bunch pruned to six hands also fulfilled the 270-g local market criterion, those in the distal hand were somewhat “marginal” in reaching this weight (Table 3).

The French-type Maiden plantain and the locally selected Superplantain (Irizarry and Goenaga, 1995; 1997) possess some common bunch traits. Both plantains contain a similar number of fruits per hand and about the same number of fruits when the bunch is pruned to a reduced number of hands. However, the Maiden plantain is unique in that it produces heavier bunches with a higher mean and individual fruit weight. This clone is being mass propagated for planting in a commercial orchard for further testing.

The authors recommend that in order for bunch pruning to have a measurable effect on the weight and size of the fruits that remain in the bunch, pruning must be conducted within two weeks after bunch

emergence or as soon as the separation of the hands in the bunch is visible. A delay in applying the treatment will result in a diminishing effect on fruit size and weight. Bunch pruning can easily be done from the ground by using a 3- to 4-m-long aluminum rod with a curved knife attached to one end of the rod (Irizarry et al., 1991).

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