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EVALUATION OF CULTIVARS AND PLANTING MATERIALS IN FALSE HORN PLANTAIN TYPE UNDER INTENSIVELY MANAGEMENT PLANTATION

Evaluación de cultivares y materiales de siembra en plátanos del tipo falso cuerno bajo un manejo intensivo de plantación

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ABSTRACT. Growth and production variables were measured in three experiments in the Costa Rican Caribbean zone, where two False Horn plantains phenotypes and their cultivars (experiments 1 and 2) also five planting materials (experiment 3) were compared during the plant crop. Cultivars of Harton phenotype had less bunch weight, number of hands and fruits ($p<0,0001$), but with thicker and larger ($p<0,0073$) fruits than those of Dominico Harton phenotype. Thus, Hartón phenotype cultivars should be oriented to the exportation market as fresh green fruit and Dominico Hartón phenotype cultivars to the industry. From the Hartón phenotype group, Hartón I and Tallo Verde I gave the best yield production while in Dominico Hartón phenotype, Dominico Hartón and Cobano were the best. Between planting materials the two treatments that included sword suckers (experiment 3) were more precocious ($p=0,0003$), and although no significant difference in yield ($p>0,0899$) was observed with the other treatments were, together with *in vitro* plants, which had the best overall performance. In addition, the use of water sucker could be also an alternative for planting, because are abundant in the mat, after harvest of the mother plant, and give uniform plantations as the sword suckers.

Key words: *Musa*, phenotypes, plantain, production, seeds

RESUMEN. Variables de crecimiento y producción fueron medidas en tres experimentos desarrollados en el Caribe de Costa Rica, donde se compararon, en plátanos del tipo Falso Cuerno (*Musa* AAB) y para un primer ciclo de cultivo, dos fenotipos con sus respectivos cultivares (experimentos 1 y 2) además de cinco tipos de materiales de siembra (experimento 3). Los cultivares del fenotipo Hartón presentaron racimos de menor peso, con menos manos y frutos ($p<0,0001$), pero estos últimos de mayores dimensiones ($p<0,0073$) que aquellos del fenotipo Dominico Hartón. Esto indica que la orientación de mercado de los cultivares del fenotipo Hartón debería ser para exportación de fruta verde y la de los cultivares del fenotipo Dominico Hartón para industria. El mejor comportamiento productivo del fenotipo Hartón fue mostrado por los cultivares Tallo Verde I y Hartón I y del fenotipo Dominico Hartón, por los cultivares Dominico Hartón y Cóbano. Entre los materiales de siembra, los dos tratamientos que incluyeron hijos espada fueron más precoces ($p=0,0003$) y aunque las diferencias productivas no alcanzaron a ser significativas ($p>0,0899$) con los demás tratamientos, fueron conjuntamente con las plantas *in vitro*, los que presentaron el mejor desempeño general. En adición, el hijo de agua también sería una alternativa de siembra, máxime que se expresa con abundancia en la cepa luego de la cosecha de la planta madre y puede originar plantaciones, al igual que el hijo espada, con alta homogeneidad.

Palabras clave: *Musa*, fenotipos, plátano, producción, semillas

INTRODUCTION

The cultivation of plantain (*Musa* AAB) in Costa Rica is based on the growing of high bearing the type False Horn known as Hartón or Curraré, which spreads in most cases by means of corms. To this type belong around a third of all bananas and cooking bananas (*Musa* AAB) planted in the humid tropics (1). It is estimated that in 2011 the country produced 90,000 metric tons of fruit corresponding to a planting area of 9500 hectares (2) for an annual yield of 9476 kg per hectare. In Costa Rica its use is directed either to industrial processing (45), local consumption (45) and export fresh fruit (10). Activity, which is located mainly in the Caribbean region, more than 5,000 families depend on small and medium farmers and generates more than 15,000 direct jobs (3).

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To this prospect, as part of strategies for crop improvement, a morphological characterization of local and introduced germplasm False Horn type, located in the Germplasm Bank CORBANA (4) was performed. Further multiplication and selection, basically high erection cultivars, and the grouping of these, according to the characteristics of the bunch and fruit, allowed the formation of two phenotypes. The first is defined by clusters of less weight, less hands and fruits but these ones with greater dimensions that was called Hartón and the second one with heavier bunches, more hands and fruits but with smaller dimensions that was called Dominico Hartón. The first phenotype included cultivars as Hartón Perez, Tallo Verde and Taylor and the second one, as Cóbano cultivars, Dominico Hartón and Tallo Rojo[A]. Bunch characteristics of these phenotypes and their relationship to the quality requirements based on the thickness and length of the fruit for export support, according to the above author, the orientation of cultivar production as fresh fruit phenotype Hartón and cultivars of Dominico Hartón phenotype, as raw material for industry.

This is consistent with production systems that include the use of high population densities and total renovation of the plantation after each crop cycle. This however also suitable cultivar should be complemented with planting materials that have the lowest cost but ensuring greater productive efficiency.

The conventional planting material may be formed by corm sections or corms whole from banana water or sword suckers without pruning roots and leaves caused by bagging plants in nursery bags of regrowth with pruning roots and pseudostem and for plants originated by rapid reproduction, range of materials is completed with the use of plants *in vitro* culture or conventional quick spread or thermal camera (5, 6, 7).

As an alternative to conventional plant material, the production technique based on *in vitro* culture has allowed the mass production of more early, consistent and productive, free from fungi, nematodes and bacteria healthy plants, and rapid multiplication of major genotypes the conservation of collections and international exchange of germplasm (8, 9). All these attributes have widespread use *in vitro* cultivated plants, particularly in planting and renovation of banana plantations for export as fresh fruit, whose plantations are renewed usually every 5 to 10 years, with population densities that do not usually they exceed 1800 plants ha^{-1} and wherein this seed material would be the most appropriate option. In this perspective, plants of Williams (*Musa* AAA) cultivar originated from water sucker, transplanted directly to planting site without pruning leaves or roots, seedlings were compared with in vitro culture for eight cycle's inheritance (8). As part of conclusions of the study indicates that for farms for domestic consumption or for plantations, whose fruit is destined for export, where there are health restrictions, cost or availability of in vitro plants, using seedlings from banana water sucker show a high potential for use in areas of high turnover, especially those grown in high density of population, whose demand for planting material is very high.

In this context intensive production that demands a high amount of planting material and given the frequent renovations that are required under this strategy, the use of these sources originated in the plantation would mean a significant reduction in the annual cost of operation, always as the health and vigor are similar compared to the material from *in vitro* plants.

The use of conventional planting materials in banana cultivation was studied in the Caribbean of Costa Rica (10) False Horn type plantains (*Musa* AAB, cv. Hartón). In this study, the bunch weight of plants from water children without pruning of roots and leaves and planted directly in the field, was similar to that obtained with plants originated from corms. In other cultivars False Horn type (*Musa* AAB, cv. Maricongo and Dwarf) the productivity of plants grown from corms of sword suckers was higher than those originated from corms of water suckers (11).

Meanwhile, other authors determined with another crop of False Horn type (*Musa* AAB, cv. Dominico Hartón) better production in plants grown from *in vitro* culture and sword suckers[B], that in turn they were between two equally productive, but higher than those arising from sprout nursery stock grown in the pseudostem and pruned roots.

The aim of this study is to evaluate different cultivars and planting materials False Horn type plantains (*Musa* AAB) under cultivation strategy of high population density and a crop cycle.

[A] Vargas, A. Cultivares de plátano del subgrupo Falso Cuerno (*Musa* AAB) en el Caribe de Costa Rica. I-Evaluación Agronómica. En: Memorias IV Congreso Nacional y III del Caribe de Ciencia y Tecnología de Alimentos, Centro Nacional de Ciencia y Tecnología de Alimentos, Universidad de Costa Rica (San José, 27-29 de octubre del 2009). p. 1. 1 disco compacto.

[B] Grisaales, F. y Lescot, T. Encuesta diagnóstico multifactorial sobre plátano en la zona cafetera de Colombia. Boletín Técnico no. 18. ICA, CIRAD. Armenia Colombia, 1999, 66 pp.

MATERIALS AND METHODS

Three experiments took place in 28 Miles Agricultural Research Center (10^0 5 '52' 'North latitude and 83^0 22' 33 '' west longitude) located in the province of Limon, Matina canton (Costa Rica Caribbean) in 2007 to 2010. In experiments 1 and 2 two phenotypes and their cultivars were evaluated and in Experiment 3, different types of planting materials were studied. In the study area and for each of the years, the maximum and minimum temperature was 31,8 and 20,7; 31,1 and 20,7 and 31,1 and 21,4 ^{0}C, the average relative humidity of 90,4; 91,0 and 91,4 % and accumulated precipitation (mm rainfall) of 2608, 2752 and 3718 mm. The soil, sedimentary and high natural fertility has average moderately acidic pH values (12), low percentages of organic matter, K and high contents of Ca and Mg.

Experiments 1 and 2 were planted with corms of 1-2 kg of weight to a population density of 2 500 plants ha^{-1} (2,0 x 2,0 m in picture) and in an area made up of domes. Hartón phenotype cultivars: 1- I Hartón selection, 2-Hartón selection II, 3- selection Tallo Verde I, 4-Tallo Verde selection II and 5-Victor Julio, while cultivars Dominico Hartón phenotype were: 6- Cóbano, 7-Dominico Hartón and 8-Maricongo.

Experiment 3 (planting materials) consisted of five types of seed (Figure 1) from the phenotype Hartón (cv Hartón high note.) that consisted of: 1- corms (1,4±0,1 kg) from sword suckers of 1,1±0,1 m high, 2-water suckers (0,45±0,05 m) without root pruning and leave partial pruning, 3-seedlings *in vitro* culture (0,14 m±0,02) of apex, 4- sword suckers (1,01±0,05 m) with a maximum of two true leaves 5- sword suckers (0,52±0,06 m) with single filiform leaves. Treatment 2 (water suckers) was seeded with 3,96±0,68 sprouts true leaves, treatment 3 *(in vitro)* to 2,44±0,74 seedling true leaves, treatment 4 (large sword suckers) with sprouts of true leaves 1,19±1,0 and 12,4±0, threadlike leaves and treatment 5 (small sword suckers) with sprouts of 10.7±0,9 threadlike leaves. Materials of this experiment were planted in a conventional terrain of flat topography.

In all three experiments performed fertilization when plants emitted an average of 5 to 10 leaves of 35 g $plant^{-1}$ of ammonium sulfate ($N\text{-}SO_4$) and when plants emitted on average 15, 20 and 25 leaves with 45 g $plant^{-1}$ 3/31/15 ($N\text{-}P_2O_5\text{-}K_2O$). Black Sigatoka (*Mycosphaerella fijiensis*) was fought with systemic fungicides and protectors in rotation and mixture with mineral oil to a total volume by application of 15 L ha^{-1} by a terrestrial nebulizer motor pump (Stihl®, model SR- 400) used to sprinkle. The chemical control was complemented by work of removing leaves and leaf sections affected by the disease.

Figure 1. Materials of seeding in banana (from right to left) corms, water sucker sprouts, plants *in vitro*, sword suckers with two true leaves and sword suckers with only filiform leaves

The weed control was performed by means of veneering with machete or scythe. Combating nematodes by applying to soil granular nematicides, it was performed only in Experiment 2 with the ethoprophos addition (10 g plant^{-1} commercial product). It was not necessary chemical control of insects. In all experiments, all plants were secured (propped up) with two rods wild cane (*Saccharum robustum*). No dehanding or deschire and clusters were covered 15 days after flowering with polyethylene covers impregnated with bifenthrin insecticide. The harvest in all cases was performed at 11 weeks of flowering, considering a market orientation towards exports as green fruit.

The three experiments included only the first harvest cycle. The first two were harvested among climatological times, favorable weather at the beginning and adverse one and the end for the development of the plant and bunch already defined for the Caribbean of Costa Rica (13) and covered the period from March to June 2009 in experiment 1 and from September to December 2010 in the experiment 2. Experiment 3 was harvested in a favorable climatic period from June to August 2008.

Variables measured in all experiments in bloom were: number of leaves, height (m) and thickness (cm) of pseudostem, number of days from planting to harvest: number of leaves, bunch weight (kg), number of hands and fruits. In experiments 1 and 2, the thickness (mm) and length (cm pulp to pulp) of the central fruit of the outer row were measure in the second, fourth and sixth hand while in experiment 3 was performed the first to the sixth hand. In addition to harvesting experiments 1 and 2 the appearance of the bunch and his rachis was determined visually.

In experiments 1 and 2, the experimental design was Randomized Complete Blocks with five replications, where each of blocks consisted on a row of nine useful plants of each cultivar. In Experiment 3, the design was also used Randomized Complete Block with five replications where each block consisted of 12 useful plants of each treatment.

Statistical analysis consisted on Analysis of Variance and average separation by LSD test for all further experiments and contrasts for experiments 1 and 2 using the SAS statistical software (SAS Institute Inc. Cary, NC, USA, Version 9.1).

RESULTS AND DISCUSSION

I- Cultivars (experiments 1 and 2)

The number of leaves at flowering (Table I), with the exception of the larger value (0,4 leaves; p=0,0023) which occurred in Hartón phenotype cultivars: Tallo Verde I, Tallo Verde II and Victor Julio in experiment 2, showed no differences among Hartón phenotype cultivars in experiment 1(p=0,1367) and in both experiments among Dominico Hartón phenotype cultivars (p>0,1455) and between phenotypes (p>0,2971).

Pseudostem height (Table I) differed only (p=0,0216) in experiment 1 among Hartón phenotype cultivars, where Tallo Verde I, Tallo Verde II and Hartón I were the highest (0,22 cm). There were no differences among Hartón phenotype cultivars of experiment 2 (p=0,1530) and in both experiments among Dominico Hartón phenotype cultivars (p>0,4430) and among phenotypes (p>0,1081).

The thickness of the pseudostem (Table I) differed (p=0,0082) among Hartón phenotype cultivars only in experiment 1, wherein this difference was given by the smaller thickness (1,0 cm) of Hartón II regarding others. There were differences (p<0,0020) in both experiments among phenotype Dominico Hartón cultivars where Cóbano and Dominico Hartón had on average the highest value (1,6 and 1,4 cm, respectively) compared to Maricongo. There were only differences (p=0, 0003) among phenotypes in experiment 2 where plants of Dominico Hartón phenotype were thicker (1,0 cm) than the Hartón phenotype.

The number of days from planting to flowering (Table I) differed only in experiment 2 for both phenotypes (phenotype Hartón; p=0,0143 and Dominico Hartón phenotype; p=0,0434) with an average reduction in the first of them of 16 days in cultivars Hartón I and II , and in the second of 13 days in the Dominico Hartón cultivar. Differences between phenotypes (p=0,0396) were in experiment 1 where that period was on average lower (eight days) in Hartón phenotype cultivars.

In general both phenotypes there was a similar behavior between themselves and among cultivars that conformed to the growth variables, since in those where statistical differences were expressed, the magnitude of the corresponding value was of little importance.

Table I. Variables of growth in banana phenotype (*Musa* AAB) of False Horn type. Experiments 1 (2008) and 2 (2009)

Phenotype	Cultivar/Selection	Number of leaves	Pseudostem		Flowering days
			Height (m)	Thickness (cm)	
			Experiment 1		
Hartón (H)	Hartón I	10,9	3,9ab	23,0a	264
	Hartón II	10,6	3,7b	22,1b	274
	Tallo Verde I	11,3	4,0a	23,5a	266
	Tallo Verde II	10,8	4,0a	23,2a	278
	Víctor Julio	10,9	3,8b	22,8a	260
Dominico Hartón (DH)	Cóbano	11,0	3,9	23,6a	267
	Dominico Hartón	10,8	4,0	23,5a	280
	Maricongo	10,6	3,9	22,4b	282
			Contrastes (probabilidades)		
Between phenotype H		0,1367	0,0216	0,0082	0,0743
Between phenotype DH		0,2061	0,4430	0,0020	0,0891
Between phenotypes H y DH		0,2971	0,8819	0,2004	0,0396
			Experiment 2		
Hartón (H)	Hartón I	12,0b	3,4	22,2	277b
	Hartón II	12,0b	3,4	22,4	282b
	Tallo Verde I	12,4a	3,5	22,5	292ab
	Tallo Verde II	12,3a	3,5	22,4	298a
	Víctor Julio	12,5a	3,6	23,5	297a
Dominico Hartón (DH)	Cóbano	12,4	3,6	24,4a	304a
	Dominico Hartón	12,3	3,5	24,0a	286b
	Maricongo	12,1	3,5	22,4b	293ab
			Contrasts (probabilities)		
Between phenotype H		0,0023	0,1530	0,0676	0,0143
Between phenotype DH		0,1455	0,5691	0,0003	0,0434
Between phenotypes H y DH		0,8210	0,1081	0,0003	0,1285

This condition does not allow any of the tested materials can be considered more appropriate than another by virtue of their ability to retain or lose leaf area, from its differential response climatic factors based on the carrying of the plant or its precocity given for days from planting to flowering.

The number of leaves at harvest (Table II) was similar among Hartón phenotype cultivars (p>0,6329) and among materials of Hartón Dominican phenotype (p>0,3872) in both experiments. There were only differences (p=0,0246) among phenotypes in experiment 2 wherein the Hartón phenotype showed a higher average of them (0,2 leaves).

Bunch weight (Table II) did not change (p>0,3035) in both experiments among Hartón phenotype materials but this condition did occur (p<0,0459) among Dominico Harton phenotype materials, where the Dominican Hartón cultivar was superior to Cóbano (1.3 kg) and Maricongo ones (1,9 kg). Bunches of Dominico Harton phenotype had a higher weight than the Hartón phenotype (2,0 kg and 2,6 kg Experiment 1, Experiment 2) but only in the second experiment differences reach significance p<0,0001) .

The number of hands per bunch (Table II) differed (p>0, 0185) in both experiments among Hartón phenotype materials where Tallo Verde I in experiment 1 and Hartón I, Tallo Verde I and Victor Julio in experiment 2 presented on average more hands (hands 0,6 and 0,4, respectively). There was no difference in this variable among Dominico Harton phenotype materials in the first experiment (p=0,2953) over itself in the second (p=0, 0505) where Cóbano and Dominico Harton had the highest number (0,4 hands). Hartón phenotype clusters had fewer hands (p=0,0001; 0,5 hands) that clusters of Dominico Hartón phenotype.

The number of fruits per cluster (Table II) differed (p=0, 0012) among Hartón phenotype cultivars in experiment 2, where Victor Julio, Hartón I had on average the most quantity (four fruits). In the Dominico Harton phenotype this variable showed differences in both experiments (p<0,0347) where Dominico Harton showed the greatest amount (2,5 and 8,1 fruits; respectively). Dominico Harton phenotype showed the highest number (p<0, 0001) of them in both experiments (16, 9 fruits and 17,0, respectively).

Table II. Production variables in banana phenotypes (Musa AAB) of False Horn type. Experiment 1 (2008) and 2 (2009)

Phenotype	Cultivar/Selection	Number of leaves	Bunch weight (kg)	Number of banana hands	Number of fruits
			Experiment 1		
Hartón (H)	Hartón I	4,4	12,3	6,6b	29,6
	Hartón II	4,3	11,2	6,6b	26,7
	Tallo Verde I	4,3	12,4	7,1a	30,0
	Tallo Verde II	4,5	11,7	6,6b	26,9
	Víctor Julio	4,2	12,0	6,4b	29,9
Dominico Hartón (DH)	Cóbano	4,3	3,8ab	7,1	46,0a
	Dominico Hartón	4,1	14,7a	6,9	47,2a
	Maricongo	4,3	13,1b	7,2	43,4b
			Contrasts (probabilities)		
Between phenotype H		0,6329	0,3687	0,0071	0,1937
Between phenotype DH		0,7840	0,0459	0,2953	0,0347
Between phenotypes H and DH		0,2893	0,0001	0,0001	0,0001
			Experiment 2		
Hartón (H)	Hartón I	4,8	12,7	6,9a	33,7a
	Hartón II	4,8	11,9	6,2c	28,4b
	Tallo Verde I	4,9	12,0	6,6ab	29,0bc
	Tallo Verde II	4,7	11,7	6,5b	27,0c
	Víctor Julio	4,8	12,3	6,7ab	30,8ab
Dominico Hartón (DH)	Cóbano	4,5	14,4b	7,1ab	46,2b
	Dominico Hartón	4,6	16,0a	7,4a	52,2a
	Maricongo	4,7	13,8b	6,9b	42,0c
			Contrasts (probabilities)		
Between phenotype H		0,6602	0,3035	0,0185	0,0012
Between phenotype DH		0,3872	0,0004	0,0505	0,0001
Between phenotypes H and DH		0,0246	0,0001	0,0001	0,0001

The thickness of the central fruit (Table III) of the outer row of selected hands (second, fourth and sixth hand), except the highest value of Tallo Verde I (2, 0 mm; p=0. 0025) in the fourth hand of experiment 2 did not change in the remaining hands among cultivars Hartón phenotype (p>0,1891) or between the Dominico Hartón phenotype (p> 0,1193) but if the two phenotypes (p<0, 0073) where the first one presented in all of them thicker fruits.

The length of the central fruit (Table IV) of the outer row of selected hands (second, fourth and sixth hand), except to the higher value of Tallo Verde I and II in the fourth and sixth hand of experiment 1 (1, 4 and 1,3 cm; p=0, 0153 and p=0, 0340, respectively) and Maricongo and Dominico Harton (1,1cm; p=0, 0102) in the sixth hand of Experiment 2, was unchanged in the remaining hands among Hartón phenotype cultivars (p>0,1873), or among the Dominico Hartón phenotype (p>0, 0769) but if the two phenotypes (p<0,0001), where the first one showed in all of them, longer fruits.

The same amount of leaves both flowering and at harvest among cultivars of both phenotypes is an aspect already mentioned by other authors in plantations located at 1,050 meters (14) who indicate that the development rate over time and symptom evolution among phenotypes Dominico Hartón cultivars (cv. Dominico Hartón) and Hartón (cv. Africa 1) do not differ among themselves and that for both materials the progress of Sigatoka (black and yellow) was quick with high values in the rate short periods of development and evolution of symptoms, appearance also indicated under greenhouse conditions for both cultivars (15).

In contrast to growth variables, productive behavior allowed to differentiate clearly both phenotypes, since Hartón phenotype plants showed clusters of lower weight and fewer hands and fruits than those of Dominico Hartón phenotype, but were thicker and longer in the first of the two phenotypes. This particularity in relation to the fruit size also has been mentioned by other authors (16, 17). This consideration is of great importance since in both export banana fresh fruit to industrial use are governed, especially for the first activity, the size of the fruit. Quality standards[C] required for transport to the United States, fruits with a minimum thickness of 39,7 mm and a maximum of 49,2 while for Europe, more distant market, this ranges go from a low of 38,1 to a maximum of 47,6 mm with a length Minimal fruit pulp to end in all cases (25,4 cm to 22,9 cm of pulp to pulp).

[C] Banana Development Company. Especificaciones de empaque para plátano. PL-1. Del Monte, departamento de Control de Calidad, Guápiles, Costa Rica, 2006.

Table III. The central fruit thickness from external row of selected hands (second, fourth and fifth) to the harvest in banana phenotype (Musa AAB) of False Horn Type. Experiments 1 (2008) and 2 (2009)

Phenotype	Cultivar/Selection	Thickness (mm)of the central fruit. Hand 2	Hand 4	Hand 6
			Experiment 1	
Hartón (H)	Hartón I	46,8	43,5	43,9
	Hartón II	46,3	44,8	45,0
	Tallo Verde I	48,8	45,7	44,7
	Tallo Verde II	47,2	45,3	45,7
	Víctor Julio	45,9	43,6	44,4
Dominico Hartón (DH)	Cóbano	44,0	42,3	38,9
	Dominico Hartón	44,6	42,6	39,6
	Maricongo	43,3	42,3	39,3
			Contrasts (probabilities)	
Between phenotype H		0,1891	0,3186	0,4928
Between phenotype DH		0,4485	0,5054	0,7854
Between phenotypes H and DH		0,0001	0,0073	0,0001
			Experiment 2	
Hartón (H)	Hartón I	43,9	43,0c	42,3
	Hartón II	44,6	43,9bc	43,4
	Tallo Verde I	45,0	44,1b	44,0
	Tallo Verde II	44,8	45,8a	43,8
	Víctor Julio	44,1	44,3b	43,2
Dominico Hartón (DH)	Cóbano	42,3	41,7	40,1
	Dominico Hartón	41,1	41,0	40,2
	Maricongo	41,8	41,8	40,8
			Contrasts (probabilities)	
Between phenotype H		0,2137	0,0025	0,2160
Between phenotype DH		0,1193	0,3605	0,5359
Between phenotypes H and DH		0,0001	0,0001	0,0001

Table IV. The central fruit length of the external row in selected hands (second, fourth and fifth) to the harvest in banana phenotypes (Musa AAB) of False Horn type. Experiments 1 (2008) and 2 (2009)

Phenotype	Cultivar/Selection	Length (cm from pulp to pulp) of central fruit Mano 2	Mano 4	Mano 6
			Experiment 1	
Hartón (H)	Hartón I	28,8	27,0ab	24,4b
	Hartón II	27,8	25,6c	23,7b
	Tallo Verde I	29,4	27,6ab	25,2a
	Tallo Verde II	29,0	28,0a	25,9a
	Víctor Julio	27,7	26,5b	24,7ab
Dominico Hartón (DH)	Cóbano	24,7	22,2	21,4
	Dominico Hartón	24,6	22,3	21,9
	Maricongo	24,3	23,1	22,0
			Contrasts (probabilities)	
Between phenotype H		0,2613	0,0153	0,0340
Between phenotype DH		0,8834	0,3066	0,5927
Between phenotypes H and DH		0,0001	0,0001	0,0001
			Experiment 2	
Hartón (H)	Hartón I	25,5	24,9	23,6
	Hartón II	26,5	25,2	23,5
	Tallo Verde I	26,2	25,2	23,2
	Tallo Verde II	26,6	25,3	23,6
	Víctor Julio	26,3	25,5	23,8
Dominico Hartón (DH)	Cóbano	24,3	22,7	20,9b
	Dominico Hartón	24,3	22,9	21,6ab
	Maricongo	24,9	23,6	22,3a
			Contrasts (probabilities)	
Between phenotype H		0,1873	0,6060	0,7498
Between phenotype DH		0,4284	0,0769	0,0102
Between phenotypes H and DH		0,0001	0,0001	0,0001

According to these parameters, fruits of Hartón phenotype reached that value in all measured hands of both experiments, whereas this did not happen for the Dominico Hartón phenotype. However, it was in the length of the fruit where differences became more evident as the minimum value was fulfilled in most of fruits of measured hands of Hartón phenotype, but this did not happen in all of the same Dominico Hartón phenotype. In contrast, the industry standard for minimum 40 mm thick and 15, 2 to 17,8 cm long (pulp to pulp) widely included all measured hands of cultivars of this latter phenotype.

The genetic material of False Horn banana type should be based on market orientation, where clusters of thick and long fruit represented by the Hartón phenotype, are intended for export as fresh fruit, and those with higher weight and quantity raw materials such as Dominico Hartón phenotype, they are for industrial use. It can highlight the best growth performance in the Hartón phenotype of Tallo Verde I and Hartón I and Dominico Hartón phenotype in Dominico Hartón and Cóbano. This differentiation of phenotypes based on market orientation, allows proper cultivar selection depending on the requirements and specifications of fruit quality. Regardless of the fruit size, both phenotypes cultivars (cv. Harton and Dominico Harton) had highest percentages of dry matter, especially the second one that was above average (17). This is essential in processes of manufacture in as much as processed products industry looking for materials with higher dry matter content in order to decrease the oil amount in the final product.

Clusters of Hartón phenotype (Figure 2A) had pendulous fruits and a rachis with neutral or hermaphrodite flowers, short, while those from the Dominican Hartón phenotype (Figure 2B) had perpendicular fruits and a rachis with neutral or hermaphrodite flowers, long.

This feature, regardless of the productive condition of both phenotypes, is of a vital importance and usefulness since it allows mainly in function of different length and shape of the rachis, an accurate identification of cultivars between Harton and Dominico Harton phenotypes.

Figure 2. False Horn banana representative bunch of phenotypes: A-Hartón and B-Dominico Hartón, showing for each of them the disposition of rachis and fruits (indicated inside the ellipse) with neutral or hermaphrodite flowers

II- M**aterials of seeding (experiment 3)**

The number of leaves at flowering and the height and thickness of the pseudostem did not change (p>0, 7895) among different planting materials evaluated. However, there were differences (p=0, 0003) in the number of days from planting to flowering, where the sword sucker with two true leaves reduced that period to 51, 24, 36 and 19 days on the corm , whole regrowth, plant in vitro culture and sword sucker with only threadlike leaves, respectively (Table V).

The number of leaves at harvest differed (p=0, 0444) among planting materials. The whole regrowth showed the highest quantity and the corm and the plant *in vitro* the lower one. It was not possible to determine statistical differences (p>0, 2979) in bunch weight, number of hands and fruits (Table VI). However, the clusters from in vitro culture and sword suckers were on average 1,4 kg heavier than those from corms or whole plant regrowth (Table VI).

Table V. Growth variables in different seeding materials of False Horn type banana (Musa AAB, cv. Hartón). Experiment 3 (2007)

Type of material	Number of leaves	Pseudostem		Flowering days
		Height (m)	Thickness (cm)	
Corm[1]	11,7	3,3	21,7	296 a
Complete regrowth[2]	11,8	3,6	22,1	269 bc
In vitro[3]	11,7	3,7	22,7	281 ab
Sword sucker with two true leaves	11,6	3,5	22,0	245 d
Sword sucker with filiform leaves	11,7	3,6	21,8	264 c
Standard error	0,1	0,2	0,8	5
Probability	0,7895	0,9739	0,9158	0,0003

1/ 1 to 2 kg of weight. / 2regrowth of water suckers transplanted directly to the field without root pruning and partial pruning of leaves. /3 from *in vitro* culture of buds. 4/ and 5 Regrowth of sword suckers transplanted directly to the field without root and leaves pruning

The thickness and length of the central fruit of the outer row did not differ among planting materials (Table VII; P>0, 0899 and Table VIII, p>0, 2574, respectively).

Given production strategies based on a great number of plants per hectare and the renewal of the plantation after each growing season it is necessary to have a lot of uniform seed. Under this concept, the material vegetative planting production originated in the plantation would be the most attractive option, since seedlings *in vitro* culture are rarely used in this crop, mainly due to its availability and cost and expression of the banana streak virus (BSV). This virus is naturally integrated into the genome of many musaceae without expressing symptoms (18, 19), but the micropropagation technique influences in its transcription of the integrated form to episomal (infectious particle) causing expression of symptoms and producing diseased plants (20).

At such a prospect, the use of corms as seed material would not be the best alternative in rainy seasons, since it deteriorates quickly and replanting with the same source material causes unevenness in the plantation, along with a lower precocity, which together with the *in vitro* plants, presented the material in this study. However, its use, basically for being the most known material and worked by farmers, would be restricted to dry season but with soil moisture.

Table VI. Production variables in different seeding materials of False Horn Type Banana (*Musa* AAB, cv. Hartón). Experiment 3 (2007)

Type of material	Number of leaves	Bunch weight (kg)	Number of hands	Number of fruits
Corm[1]	4,3b	13,0	6,5	26,6
Complete regrowth[2]	5,0a	12,6	6,3	25,8
In vitro[3]	4,3b	14,5	6,6	26,7
Sword sucker with two trueleaves[4]	4,7ab	13,9	6,3	29,5
Sword sucker with filiform leaves[5]	4,8ab	14,2	6,5	28,6
Standard Error	0,2	0,8	0,2	1,3
Probability	0,0444	0,3745	0,8130	0,2979

1/ 1 to 2 kg of weight. / 2regrowth of water suckers transplanted directly to the field without root pruning and partial pruning of leaves. /3 from *in vitro* culture of buds. 4/ and 5 Regrowth of sword suckers transplanted directly to the field without root and leaves pruning

Table VII. Central fruit thickness of the external row (hands1 to 6) in different seeding materials of False Horn type banana (Musa AAB, cv Hartón).Experiment 3 (2007)

Type of material	Central fruit thickness (mm)			Position of the hand in the bunch		
Corm[1]	1ª	2da	3ª	4ta	5ta	6ª
Complete regrowth[2]	48,2	47,8	49,1	47,9	47,6	47,3
In vitro[3]	47,4	47,3	47,7	46,3	47,0	46,0
Sword sucker with two trueleaves[4]	48,7	47,8	49,0	48,8	47,6	47,4
Sword sucker with filiform leaves[5]	48,3	47,3	48,0	46,2	45,8	46,5
Standard Error	48,9	48,9	48,5	47,6	47,2	47,4
Probability	0,4	0,7	0,7	0,7	0,9	0,9
Probability	0,8171	0,5129	0,5587	0,0899	0,5815	0,7320

1/ 1 to 2 kg of weight. / 2regrowth of water suckers transplanted directly to the field without root pruning and partial pruning of leaves. /3 from *in vitro* culture of buds. 4/ and 5 Regrowth of sword suckers transplanted directly to the field without root and leaves pruning

Tabla VIII. LLength of the central fruit ofd the external line (hands 1 ro 6) in sowing different materials of False Horn banana (*Musa* AAB, cv. Hartón). Experiment 3 (2007)

	Length of the central fruit (cm from pulp to pulp)			Hand position in the bunch		
	1ª	2da	3ª	4ta	5ta	6ª
Corm[1]	27,6	27,9	28,2	26,2	25,7	24,1
Complete regrowth[2]	27,8	27,2	28,1	26,5	26,1	24,5
In vitro[3]	28,1	27,8	28,5	27,2	26,5	24,6
Sword sucker with two trueleaves[4]	27,0	26,4	26,9	25,6	25,1	24,3
Sword sucker with filiform leaves[5]	27,8	28,0	27,8	26,5	26,4	24,4
Standard Error	0,4	0,7	0,5	0,5	0,6	0,6
Probability	0,4512	0,4795	0,2574	0,3858	0,4982	0,9781

1/ 1 to 2 kg of weight. / 2regrowth of water suckers transplanted directly to the field without root pruning and partial pruning of leaves. /3 from *in vitro* culture of buds. 4/ and 5 Regrowth of sword suckers transplanted directly to the field without root and leaves pruning

On the contrary and according to obtained results in this study, both the sword sucker with two true leaves as the sword sucker with only threadlike leaves had an excellent productive performance with more precocious and with the *in vitro* plants, improved productivity

Under conditions of high population density, shadow generated by the plantation reduces the expression and development of suckers in the production unit, find it difficult behavior at the renewal plantation time of the first material planting cycle with these characteristics, situation, besides in the case of sword suckers with single filiform suckers, whose presence occurs in greater quantity .

That way both suckers, especially that of threadlike leaves, planted directly in the field without pruning leaves or roots, would be a productive alternative, not only during the rainy season, but in the intensive production strategies banana, where renewal would be with more uniform and readily available materials. In addition, its manipulation would be minimal, as well as its cost, since it would suffice to transfer from the row of plants, or harvested crop, at the inter-row under renovation. Although both suckers of sword production had a better performance than the whole regrowth, this material also represents an alternative planting, especially occurs in a high amount in the strain so may result in plantations, like the sword suckers, a high homogeneity. In these materials the protective use base on clays as kaolinite (not used in this work) would provide better protection of material against solar radiation effects and allow a faster recovery of the same to post-transplant stress, particularity it would also make possible sword and water suckers transplantation in drier seasons

CONCLUSIONS

The use of cultivars, in the case of False Horn type bananas, must be based on market orientation, either with the use of those with clusters of lower weight, but less fruit larger, ideal for local market or fresh fruit exportation, or clusters of greater weight but with smaller fruits, more opportunity for industrial use. Hartón phenotype cultivars included in the first group (Hartón I and II, Tallo Verde I and II and Victor Julio) and Dominico Hartón phenotype the second (Cóbano, 7- Dominico Hartón and 8-Maricongo)

The use of sword suckers in direct seeding without pruning leaves or roots represents a practical and inexpensive option with which efficiently renew after each cycle of crop plantations with high demand for seed. This has a special significance particularly when such renewal must be made during high precipitation periods. This consideration is also binding on the water sucker, material although did not reach the productive performance of sword suckers; it is also a viable alternative management systems with high population density and the plantation renovation after each crop cycle. These three planting materials for their lower cost, greater hardiness and precocity represent an alternative to the use of *in vitro* plants and corms.

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