Selection index via REML/BLUP for identifying superior banana genotypes in the central region of Goiás state, Brazil[1]

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ABSTRACT

This study had the aim of evaluating 15 agronomic characters of 23 banana genotypes of the Cavendish, Prata, Prata-Anã, Pacovan, Mysore and Maçã groups, in three production cycles, in the climatic conditions of the central region of Goiás state, Brazil, identifying superior cultivars. The treatments were arranged in a completely randomized design, with replicates varying from 3 to 18 clones according to the availability of seedlings. Because of the unbalanced data, the components of variance were estimated using the mixed model methodology. In order to identify the superior genotypes, the predicted mean genotypic values were taken into account. The FHIA-02 (Cavendish group), PA42-44 (Prata Anã group) and FHIA-18 (Prata Anã group) genotypes presented the highest flowering precocity. The Bucanero, FHIA-17 (Cavendish group) and Grande Naine genotypes were the most productive. The Grande Naine, FHIA-17 and FHIA-02 genotypes presented the lowest sizes, and the FHIA-17, Bucanero and PV79-34 (Hybrid Pacovan) genotypes the largest pseudo stems circumferences. The genotypes with the lowest mortality rates were the Pacovan, Garantida (group Prata) and Calipso. Based on the multi-trait selection index, it was concluded that the FHIA-17, Grande Naine, Bucanero, and FHIA-02 genotypes were the most promising cultivars for production in the central region of Goiás due to their agronomic characters and high yield.

Keywords: *Musa* spp.; agronomical traits; clones, production; selection.

RESUMO

Índice de seleção via REML/BLUP para a escolha de genótipos superiores de bananeira na região central de Goiás

Este trabalho teve como objetivo avaliar 15 caracteres agronômicos de 23 genótipos de bananeira dos grupos Cavendish, Prata, Prata-Anã, Pacovan, Mysore e Maçã, em três ciclos de produção, nas condições climáticas da região central de Goiás, Brasil, a fim de identificar os melhores cultivares para essa região. Os tratamentos foram dispostos em delineamento inteiramente casualizado, com repetições variando de 3 a 18 clones de acordo com a disponibilidade de mudas. Por se tratar de dados desbalanceados os componentes de variância foram estimados utilizando a metodologia de modelos mistos. Com o intuito de identificar os genótipos superiores foi levado em consideração os valores genotípicos médios preditos. Os genótipos FHIA-02 (grupo Cavendish), PA42-44 (grupo Prata Anã) e FHIA-18 (grupo Prata Anã), apresentaram maior precocidade de floração. Os genótipos Bucanero, FHIA-17 (grupo Cavendish) e Grande Naine foram os mais produtivos. Os genótipos Grande Naine, FHIA-17 e FHIA-02 apresentam os menores portes e os genótipos FHIA-17, Bucanero e PV79-34 (híbrido de Pacovan) as maiores circunferências do pseudocaule.

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Os genótipos com as menores taxas de mortalidade foram Pacovan, Garantida (grupo Prata) e Calipso. Com base no índice de seleção, conclui-se que os genótipos FHIA-17, Grande Naine, Bucanero e FHIA-02 foram os mais promissores para serem produzidos na região central de Goiás, por apresentarem alta produtividade e caracteres agronômicos demandados pelos produtores.

Palavras-chave: *Musa* spp.; características agronômicas; clones; produção; seleção.

INTRODUCTION

Bananas are one of the most consumed fruits in the world. They are cultivated in more than 150 countries. Bananas are the sixth most important global food product (FAO, 2016). Brazil is a major banana producer. It holds the fifth place in world production (FAOSTAT, 2017), with an estimated production of 6,962,134 tons, which covers an estimated area of 516,980 hectares (IBGE, 2017).

Relatively few banana cultivars have been transferred from their Southeast Asia origin. This has resulted in a diversity decline of these plants, as they were taken from Asia to Africa and ultimately to the Americas. Thus, several banana trees genetic breeding programs have been created to expand their genetic base, mainly due to their susceptibility to diseases such as Black Sigatoka and Panama (Martin *et al.* 2016). Among them, we highlight the Brazilian Program for Banana Genetic Breeding, which is coordinated by Embrapa Mandioca and Fruticultura and was founded in 1976. This program aims the development of banana cultivars of the Prata, and Maçã types, which would be resistant to the main diseases of the crop (Weber *et al.,* 2017). As a result of this program, different cultivars were made available to farmers (Weber *et al.,* 2017), Castricini *et al.* 2017).

Genotypes of the breeding program need to be characterized and evaluated in different production soil, and climate conditions (Silva *et al.* 2016), which is relevant for evaluating agronomic characteristics, and for allowing the identification of promising cultivars for inclusion in breeding programs or technical indication to producers. Thus, several studies have been carried out on different soils and climates (Silva *et al.,* 2006 and 2016, Pimentel *et al.,* 2010, Marques *et al.* 2011, Borges *et al.,* 2011 and 2014, Ribeiro *et al.,* 2012, Mendonça *et al.,* 2013).

The aim of this study was to evaluate the performance of 23 banana genotypes from the Cavendish, Prata, Prata-Anã, Pacovan, Mysore and Maçã groups during three production cycles. In addition, it aimed to evaluate the agronomic and productive characters of resistant cultivars and the incidence of main diseases which are harmful to the banana trees, in the climatic conditions of the central region of Goiás, Brazil.

MATERIAL AND METHODS

The experiment was carried out at Embrapa Products and Markets Unit, located in Goiânia (Goiás state, Brazil). The period between flowering (2008) and the third production cycle (2010) was evaluated. Temperatures ranged from 16 °C to 31 °C in 2008, from 17 °C to 30 °C in 2009, and from 17 °C to 31 °C in 2010, with annual rainfall of 1726 mm and average relative humidity (ARH) of 74% in 2008, 1577 mm and 70% ARH in 2009, and 1240 mm, and 65% ARH in 2010 (Evaporimetric Station, 2015).

The micro propagated seedlings from Embrapa Cassava and Tropical Fruit (Table 1) were transplanted to the field, in a previously prepared area, with a spacing of 2.5 x 3.0 m. Organic fertilization was carried out with 10 liters of tanned bovine manure and phosphate fertilization (single superphosphate) with 40 g of P_2O_5 per pit in the planting. Thirty days after the initial plating, nitrogen and potassium fertilization (20-00-20) with 45 g of N and 45 g of K_2O per plant was carried out. The management practices carried out during the three production cycles were: complementary irrigation, weed control, pest control, removal of dry leaves, elimination of shoots (leaving only two) at the time of flowering, and elimination of the heart and pseudo stems cut after harvest.

The genotypes were arranged in a completely randomized design, with 23 treatments with replicates varying from 3 to 18 clones according to the availability of seedlings. Since the date are unbalanced, the components of variance were estimated using the mixed model methodology, which uses REML/BLUP (Restricted Maximum Likelihood/Best Linear Unbiased Prediction) method. Considering the model, y = Xm + Zg + Ti + y, where y is the data vector, m is the vector of measurements effects (assumed as fixed) added to the general mean, g is the genotypic effects vector (assumed as random), i is the interaction effects vector (genotypes x measurements), and e is the error vector (assumed as random), the uppercase letters represent the incidence matrices for these effects (Resende, 2002). For this analysis, Model 55 of Selegen software, which is a repeatability model, was used (Resende, 2016).

The following characters were evaluated: plant mortality (M); days from planting to flowering (DPF); number of living leaves in flowering (NLF); number of shoots (NS), which was counted at the moment of flowering; height of the plant in centimeter (HP), which was also measured at the moment of flowering with the aid of a flexible steel tape measure, positioned at ground level and measuring up to the leaf rosette (insertion point of the peduncle in the pseudo stems); circumference of the pseudo stems in centimeter (CPC), which was measured with a tape measure at 20 cm above ground level; mass of the bunch in kilos (MB); mass of the hands in kilos (MH); average weight of the fruits in grams (AWF), by weighing the second hand and the penultimate hand; number of hands (NH); number of fruits (NF); length (LF), and average diameter (DF) of the fruits in centimeters located at the center of the hands that were weighed, these measurements were made with the aid of an analog pachymeter; days from flowering to harvest (DFH); number of living leaves (NLH) at harvest time.

In order to identify the superior genotypes for each evaluated character, it was considered: the predicted mean genotypic values (u + g + gem), which refers to the average genotype value over several years and capitalize an average interaction which comprises the three years of the evaluation; the heritability of genotype averages (broad sense); the genotypic values prediction accuracy (accuracy in genotype selection), based on the three years of measurements and the repeatability coefficient.

With the purpose of suggesting the best genotypes to be grown in the central region of Goiás state, considering all the characters, the multitrait selection index (model 101 of Selegen software) was used. Two alternative approaches were applied (Resende, 2002), the Active index, in which the character weights are given, and the Medium Rank index, adapted from Mulamba & Mock, in which the genotypic values are classified for each character and the average of the rankings of each genotype for all characters is presented as the final result. For the calculation of the indices, the NLL and NF characters were considered null because they did not present a significant genotypic variance, for M, DPF, HP and, DFH the lowest predicted genotypic values were considered, and the for the remaining characters, the highest predicted genotypic values were taken into account. The accuracy was used as weights in the Active index because it represents the reliability of the characters for selecting the best genotypes.

RESULTS AND DISCUSSION

A significant variance was observed among the evaluated genotypes for most of the characters, except for NLF and NS, therefore, they did not enter the multitrait

Table 1: Genotypes evaluated from Embrapa Mandioca and fruticulture Tropical

Genotypes	Treatment	Number of repetitions	Genome	Genealogy (Origin)
Caipira	12	18	AAA	Cultivar (Africa Ocidental)
Calipso	7	3	AAAA	Hybrid High Gate (Jamaica)
Bucanero	16	18	AAAA	Hybrid High Gate (Jamaica)
FHIA-02	23	18	AAAA	Cavendish Hybrid (FHIA)
FHIA-17	20	18	AAAA	Cavendish Hybrid
Thap Maeo	6	18	AAB	Cultivar type Mysore (Tailand)
FHIA-01 (Maravilha)	3	18	AAAB	Prata Anã Hybrid (FHIA)
FHIA-18	10	18	AAAB	Prata Anã Hybrid (FHIA)
PA42-44	13	18	AAAB	Prata Anã Hybrid (FHIA)
PA94-01	21	15	AAAB	Prata Anã Hybrid – Embrapa
ST42-08 (Garantida)	19	18	AAAB	Prata Hybrid (Embrapa)
PV42-53 (Pacovan Ken)	1	18	AAAB	Pacovan Hybrid (Embrapa)
PV42-142 (Japira)	9	18	AAAB	Pacovan Hybrid (Embrapa)
PV42-81(Vitória)	11	9	AAAB	Pacovan Hybrid (Embrapa)
PV79-34	14	9	AAAB	Pacovan Hybrid (Embrapa)
PV94-01	8	18	AAAB	Pacovan Hybrid (Embrapa)
YB42-21 (Tropical)	22	18	AAAB	Yangambi Hybrid - type Maçã (Embrapa)
YB42-03	5	18	AAAB	Yangambi Hybrid - type Maçã (Embrapa)
YB42-07	17	18	AAAB	Yangambi Hybrid - type Maçã (Embrapa)
Maçã	4	18	AAB	Cultivar (Brazil)
Grande Naine	15	18	AAA	Cultivar Cavendish
Pacovan	18	18	AAB	Cultivar (Northeast Brazil)
Prata Anã	2	18	AAB	Cultivar (Santa Catarina state, Brazil)

selection index because they were not able to differentiate the genotypes. For the interaction (years x genotype), no significant variance was detected for NS and DFH characters (Table 2), which demonstrates that, for these characters, a single measurement would be sufficient. Arantes *et al.* (2017), did a similar study and also found significant differences among treatments and cycles, with the exception of the flowering period.

All the characters presented low heritability, which indicates that they are quantitative and very influenced by the environment (Table 3). Considering a repeatability greater than 40% and accuracy greater than 60%, it is possible to identify, through the average genotypic value (Table 3), the superior genotypes for each character that presented significant variance among the treatments.

The Maçã (4), Bucanero (16), and FHIA-17 (20) genotypes demonstrated the highest mortality rate, while the Calypso (7), Pacovan (18), and Garantida (19) genotypes presented the lowest mortality rate. The avarage number of days from planting to flowering (DPF) ranged from 448.3 to 618.4, with the YB42-07 (17) genotype being the latest and the Maçã (4) genotype the earliest (Table 2). These characters presented a low repeatability, but with selective accuracy above 50% and 60% respectively. Based on predicted genetic values, the genotypes with the lowest mortality rates were Pacovan (18), Garantida (19), and Calipso, which shows that they were the least affected by the pests and diseases of the region. The FHIA-02, PA42- 44 (13), and FHIA-18 (10) genotypes presented higher precocity of flowering (Table 3). The precocity of flowering is an important characteristic because it reduces the exposure time to pathogens, and is able to increase the number of living leaves at the floral differentiation stage, and to favor a greater amount of female flowers during the inflorescence, which results in clusters with greater number of fruits (Robinson & Galán Saúco, 2010). Arantes *et al.* (2017) found the FHIA-18 and Pacovan cultivars were the earliest at the flowering stage and the FHIA-23 and FHIA-17 cultivars were the latest.

In the evaluation of plant height (Table 2), the Grande Naine (15) genotype demonstrated the lowest mean (HP = 262.2 cm), followed by FHIA-02 (23) and Calipso (7). The highest observed averages were of the Garantida (HP = 413.7 cm), Vitória (11), and Japira (9) genotypes. Similarly, Arantes *et al.* (2017) found that the highest cultivars in all cycles were the Japira, Pacovan-Ken, and JV42-135 genotypes, and the shortest ones were the Grande Naine and Caipira genotypes. On the other hand, Nomura *et al.* (2016) found, in the Ribeira Valley, high pseudo stems height values (> 4.5 m) in the Caipira cultivar, which is considered a substitute for Maçã cultivar. According to Santos *et al.* (2006), the ideal height range for commercial bananas, is between 2.0 and 3.5 m.

The height of the plant influences planting spacing and density, and consequently, the productivity Furthermore, it is an important feature in genotypes selection, since high cultivars are not desirable because they are of difficult harvest, the breaking of the pseudo stem, and the tipping over of plants (Santos *et al.,* 2006). These are recurrent problems in the Pacovan genotype and their descendants (Azevedo *et al.,* 2010). Thus, smaller sizes such as those found, based on the genotypic values (Table 3), for the Grande Naine (15), FHIA-17 (20), and FHIA-02 (23) genotypes, are the most desirable, especially in strong winds regions, since they benefit productivity avoiding damages to the bunches.

The FHIA-17 (20) genotype showed the highest pseudo stems circumference mean (CPC = 79.19 cm), while Caipira (12) genotype showed the lowest mean (CPC = 52.90 cm) (Table 2). Arantes *et al.* (2017) and Nomura *et al.* (2016) also found low pseudo stems circumference values for the Caipira cultivar. The pseudo stems circumference is related to the vigor of the plant. The more vigorous the plant, the greater its ability to support the bunches and the lower is the susceptibility to tipping (Silva *et al.,* 2011). In view of this, FHIA-17, Bucanero (16) and PV79-34 (14) are the most appropriate agronomically sized genotypes (Table 3).

At harvesting period, the highest number of living leaves (NLH) was observed in the PA42-44 (13) genotype and the lowest number in the Vitória (11) genotype. Differently from what was related by Arantes *et al.* (2017), who found the Prata-Anã cultivar to have the highest number of living leaves and the Garantida cultivar the lowest number of living leaves at the time of harvest. The size of the fruits is positively correlated with the number of living leaves present until harvesting time (Oliveira *et al.* 2013). In this study, it was possible to observe this because the genotype with the highest number of living leaves, PA42-44 (13), was one with the highest fruit weight mean, length, and diameter (Table 2).

The banana yield was correlated with the characters of the bunches, and the FHIA-17 (20) genotype showed the highest mean (MB = 28.60 kg and MH = 10.87 kg), while Tropical (22) presented the lowest mean (MB = 26.33 kg and MH = 10.05 kg). The mass of the bunch is an important factor in banana productivity, but it cannot be solely considered for genotype selection, since other characters also influence this selection, such as the characters related directly to the fruit, such as size, weight, and shape. In this way, and based on the genotypic values (Table 3), we were able to highlight the following genotypes: Bucanero, FHIA-17, and Grande Naine, with the heavier bunches; Bucanero, FHIA-17, and Grande Naine, with the heavier hands; Thap Maeo (6), FHIA-17, and FHIA-02, with the highest number of

Table 2: Means and variance components of 23 banana genotypes estimated by the mixed model methodology

G	M	DPF	HP(cm)	CPC (cm)	NLF	NS	DFH	NLH	MB (kg)	MH(kg)	NH	NF	AWF (g)	LF (cm)	DF (mm)
1	0.278	541.7	359.8	65.06	10.42	4.316	172.0	4.586	16.00	14.68	6.033	74.60	201.7	20.72	34.50
2	0.204	563.3	294.1	70.23	11.31	1.643	133.0	4.791	13.92	12.66	6.860	87.86	144.4	17.55	28.23
3	0.259	553.7	320.6	76.40	10.71	1.605	113.4	3.300	21.24	19.83	6.825	88.00	227.8	20.95	33.20
4	0.519	448.3	337.5	66.94	15.42	3.346	109.2	3.885	10.98	10.00	6.577	82.81	127.5	15.48	33.42
5	0.148	562.3	371.8	65.36	8.95	1.909	120.3	3.196	10.25	9.49	5.326	79.13	109.0	13.70	30.80
6	0.259	553.7	351.7	60.91	9.43	2.025	103.5	3.825	12.86	12.04	9.475	140.25	86.5	12.60	25.48
7	0.000	526.8	285.5	62.88	8.25	2.375	104.6	3.444	17.66	16.51	6.222	99.78	154.3	20.17	26.22
8	0.222	526.8	347.0	62.51	9.33	1.476	122.5	4.167	13.40	12.41	5.238	65.86	173.7	17.25	31.47
9	0.148	538.6	407.1	67.44	8.74	1.814	119.6	2.043	10.84	10.04	5.196	61.59	144.9	17.36	27.57
10	0.130	496.2	286.5	61.12	10.04	1.933	137.0	4.872	17.22	16.16	8.128	109.62	158.0	17.63	32.45
11	0.222	552.1	409.4	69.24	9.76	1.476	135.3	1.476	12.44	11.53	5.000	64.00	166.4	17.69	25.64
12	0.148	500.4	289.4	52.90	9.19	2.279	140.2	4.000	11.32	10.54	6.978	124.07	82.8	13.39	27.50
13	0.167	486.0	308.3	65.19	11.98	1.822	147.2	6.889	15.21	14.10	6.356	76.91	177.9	19.40	33.61
14	0.148	525.3	352.7	74.23	8.82	2.136	148.5	3.522	15.29	14.28	6.522	81.13	166.4	16.98	30.87
15	0.222	587.2	262.2	67.09	10.23	2.225	112.8	4.167	23.75	22.34	7.619	114.74	192.1	21.11	28.38
16	0.407	564.5	303.7	73.84	10.61	3.161	130.4	4.844	27.44	25.81	7.656	120.59	235.3	23.94	34.88
17	0.259	618.4	356.3	63.44	9.51	2.282	136.4	4.250	10.51	9.69	6.525	86.65	105.8	13.68	26.18
18	0.056	519.1	406.7	63.80	8.86	2.592	156.2	3.451	10.80	9.83	6.039	72.76	128.9	16.56	28.06
19	0.074	540.3	413.7	65.22	9.23	1.958	129.9	3.140	10.31	9.49	5.340	59.16	138.5	16.18	27.72
20	0.389	576.1	299.3	79.19	9.56	2.250	102.0	4.636	25.13	23.14	8.788	134.36	178.8	19.76	29.58
21	0.156	539.5	329.6	75.52	9.30	1.788	123.9	3.579	18.09	16.67	8.053	114.21	141.3	17.59	28.22
22	0.148	580.3	355.4	70.68	9.17	1.333	107.4	3.891	10.87	10.05	5.065	72.98	125.0	15.08	28.11
23	0.167	481.7	272.4	58.74	10.21	1.814	108.9	4.089	16.05	15.05	7.333	98.56	152.2	15.99	29.51
$\hat{\sigma}_g^2$	0.008***	1503***	1853***	37.627***	2.061	0.126	221.6***	0.564***	25.07***	22.33***	1.588***	600.8***	1540***	8.037***	3.072*
$\hat{\sigma}_{ag}^2$	0.008**	663.9***	954.9***	11.349***	17.31***	0.325	19.265	0.365***	3.659***	3.402***	0.209***	85.17***	223.0***	0.522***	5.964***
$\hat{\sigma}_e^2$	0.113	5638.98	1138.80	36.299	8.453	2.115	2668.06	4.407	28.231	25.460	0.997	391.944	1785.68	5.580	28.864

G – genotypes; M – mortality; DPF – days from planting to flowering; HP – height of the plant; CPC – circumference of the pseudo stems ; NLF – number of suckers produced; DFH – days from flowering to harvest; NLH – number of living leaves at harvest; MB – mass of the bunch; MH – mass of the fruits.; MB – mass of the hands; NP – number of the hands; NF – number of fruits; AWF – average weight of the fruits; LF – length of the fruits; DF – diameter of the fruits. $\hat{\sigma}_g^2$ - estimative of genotypic variance; $\hat{\sigma}_{ag}^2$ - estimative of the variance of the interaction between years and genotypes; $\hat{\sigma}_e^2$ - estimative of residual variance. Statistical significance: '***' 0.001 '***' 0.01 '*' 0.05.

Table 3: Predicted genotypic values of 23 banana genotypes for each characteristic evaluated in the three production cycles and estimates of genetic parameters

Genótipo	M	DPF	HP	CPC	NLF	NS	DFH	NLH	MB	MH	NH	NF	AWF	LF	DF
1	0.246	599.836	367.707	67.501	9.562	2.557	151.244	4.528	16.618	15.403	6.807	89.649	184.551	19.886	32.005
2	0.207	598.480	320.185	69.550	10.472	2.218	142.300	4.765	16.002	14.728	7.544	101.014	160.539	19.079	30.235
3	0.236	604.982	331.704	71.815	9.875	2.206	132.986	3.961	19.581	18.254	7.436	98.290	204.066	20.659	32.726
4	0.373	575.540	350.353	68.020	20.280	2.521	130.715	4.624	14.258	13.168	7.222	95.221	150.057	17.550	32.178
5	0.178	596.666	354.613	65.792	8.749	2.307	138.058	4.153	14.064	13.050	6.780	96.117	144.236	17.296	32.940
6	0.236	598.962	349.229	64.059	8.868	2.455	128.376	4.534	14.956	13.944	8.905	128.579	127.129	16.300	28.205
7	0.150	571.743	312.728	65.536	8.516	2.433	135.947	4.549	17.946	16.719	7.179	106.254	168.572	20.764	30.764
8	0.217	578.580	348.147	65.075	9.067	2.237	140.811	4.641	15.948	14.805	6.862	90.526	180.648	19.394	33.164
9	0.178	583.504	375.324	66.903	8.442	2.301	142.223	3.672	14.446	13.402	6.661	86.938	165.734	19.386	30.720
10	0.168	556.428	315.249	63.892	9.500	2.351	142.184	4.975	17.326	16.196	8.035	108.881	166.403	18.843	33.011
11	0.216	594.708	388.673	68.820	9.192	2.219	144.916	3.851	15.234	14.128	6.623	87.821	176.347	19.559	29.936
12	0.178	559.497	316.512	60.157	9.075	2.548	142.581	4.774	14.179	13.180	7.387	117.275	125.151	16.474	29.370
13	0.187	552.514	324.752	66.112	11.324	2.229	146.671	5.869	16.334	15.174	7.079	91.583	178.064	19.882	33.214
14	0.182	578.976	356.271	71.860	8.898	2.570	147.182	4.436	16.633	15.508	7.292	95.640	173.545	18.729	32.092
15	0.217	603.854	293.711	66.750	9.787	2.715	135.326	4.740	21.470	20.114	8.052	115.774	189.423	21.341	31.061
16	0.314	611.961	331.046	72.178	10.049	3.048	137.558	4.689	22.299	20.895	7.723	114.432	201.054	21.607	33.070
17	0.236	621.085	354.233	65.482	9.283	2.821	145.757	4.668	14.187	13.138	7.470	101.031	141.090	17.169	29.783
18	0.129	560.178	376.741	65.339	8.810	2.916	153.383	4.390	14.150	13.029	7.041	90.858	152.859	18.624	30.811
19	0.138	572.802	377.928	65.747	9.157	2.601	143.340	4.368	14.041	12.988	6.711	84.631	160.990	18.669	31.351
20	0.304	629.870	301.120	74.976	8.979	2.341	131.118	4.812	22.135	20.471	8.786	128.513	179.494	20.441	30.702
21	0.182	597.033	341.642	71.707	9.038	2.115	139.633	4.362	17.791	16.471	7.990	111.472	158.557	18.956	30.279
22	0.178	602.013	350.778	69.062	8.872	2.132	132.725	4.546	14.333	13.292	6.532	91.684	151.941	17.914	30.898
23	0.187	549.493	311.116	63.678	9.734	2.273	137.185	4.872	17.786	16.615	8.077	109.754	172.379	18.936	33.249
h^2_a	0.0295	0.0963	0.2348	0.2206	0.0370	0.0246	0.0381	0.0528	0.2201	0.2181	0.2842	0.2787	0.2170	0.2842	0.0405
r	0.0590	0.1925	0.4695	0.4412	0.0741	0.0492	0.0762	0.1056	0.4401	0.4362	0.5683	0.5574	0.4339	0.5684	0.0810
Ac	0.5294	0.6124	0.6320	0.6481	0.3470	0.3616	0.5761	0.5576	0.6622	0.6614	0.6691	0.6678	0.6620	0.6758	0.4890

M – mortality; DPF – days from planting to flowering; HP – height of the plant; CPC – circumference of the pseudo stems ; NLF – number of living leaves in flowering; NS – number of suckers produced; DFH – days from flowering to harvest; NLH – number of living leaves at harvest time.; MB – mass of the bunch; NP – number of the hands; NP – mass of the hands; NFr – number of fruits; AWF – average weight of the fruits; LF – length of the fruits; DF – diameter of the fruits; h^2_a – heritability of averages; r – repeatability; Ac – accuracy in genotype selection).

Table 4: Medium Rank selection index (left) and Active selection index (right) of 23 banana genotypes evaluated

Order	Genotype	Medium Rank	Gain	Gain %	Order	Genotype	Active Index	Gain	Gain %
1	20	6.9231	6.9231	73.3333	1	20	46.0088	46.0088	20.5209
2	15	7.0769	7	71.4286	2	15	44.9056	45.4572	19.0759
3	16	7.0769	7.0256	70.8029	3	16	44.8592	45.2579	18.5537
4	23	7.3846	7.1154	68.6486	4	23	42.6237	44.5993	16.8287
5	10	8.3077	7.3538	63.1799	5	3	42.1767	44.1148	15.5594
6	7	8.4615	7.5385	59.1837	6	10	41.6153	43.6982	14.4682
7	3	9.1538	7.7692	54.4554	7	7	41.2172	43.3438	13.5397
8	13	9.6154	8	50	8	13	41.0424	43.0561	12.7862
9	21	10.8462	8.3162	44.296	9	21	39.7752	42.6916	11.8312
10	2	11.6154	8.6462	38.79	10	14	38.3192	42.2543	10.6859
11	14	11.8462	8.9371	34.2723	11	2	38.1086	41.8774	9.6986
12	8	11.9231	9.1859	30.635	12	8	37.6082	41.5217	8.7667
13	4	13.6923	9.5325	25.8845	13	6	36.2772	41.1182	7.7099
14	12	13.8462	9.8407	21.943	14	1	35.8677	40.7432	6.7275
15	1	13.9231	10.1128	18.6613	15	4	35.1888	40.3729	5.7575
16	6	14	10.3558	15.8774	16	22	35.1178	40.0445	4.8971
17	22	14.3846	10.5928	13.2849	17	12	34.9191	39.743	4.1074
18	9	15.3077	10.8547	10.5512	18	19	34.3126	39.4413	3.3171
19	5	15.3846	11.0931	8.1752	19	5	34.1001	39.1602	2.5807
20	11	15.6923	11.3231	5.9783	20	18	34.074	38.9059	1.9146
21	18	16.1538	11.5531	3.8681	21	9	33.6961	38.6578	1.2647
22	19	16.2308	11.7657	1.9911	22	11	33.6236	38.429	0.6653
23	17	17.1538	12	0	23	17	32.5877	38.175	0

hands; Thap Maeo, FHIA-17, and Caipira (12), with the highest number of fruits; FHIA-01 (3), Bucanero, and Grande Naine, with the highest average fruit weight; Bucanero, Grande Naine, and Calipso (7), with the largest length of the fruits.

The two methodologies for calculating the multitrait selection index (Table 4) presented the same four first genotypes, however they presented different gain values due to the difference between the methodologies. Since in the Active index it is necessary for assigning weight (precision between 0 and 1) for each character, which reduces the percentage of the gain; in the index of Medium Rank selection it is not necessary to attribute weight to the characters, which increases gains percentage. Regardless of the gain presented by the two methodologies, the FHIA-17, Grande Naine, Bucanero, and FHIA-02 genotypes, in this order, proved to be the most productive and with the most desired agronomic characters. The Bucanero cultivar was also recommended by Lédo *et al.* (2018) based on physical-chemical characters of the fruits of thirteen banana genotypes, to be cultivated in coastal flat regions. The Grande Naine cultivar has shown great performance according to Patel *et al.* (2018), who reports a constant increase in banana production and productivity in India, due to the adoption of this variety and other Cavendish clones. According to Nomura *et al.* (2017), the FHIA-17 cultivar has great

potential for introduction into the Brazilian production system for showing characteristics similar to the Grand Naine cultivar. According to Weber *et al.* (2017) the FHIA 02 cultivar shows an adequate profile and high yield potential, which can be an alternative to the traditional Prata subgroup.

CONCLUSION

The FHIA-02 (23) from the Cavendish group, PA42-44 (13) and FHIA-18 (10) from the Prata Anã group are the most precocious genotypes. The genotypes with lowest mortality rates are: Pacovan (18), Garantida (19) from the Prata group, and Calipso (7). The FHIA-17 (20) genotype is the most productive, along with Bucanero (16) and Grande Naine (15). The Grande Naine and FHIA-02 (23) genotypes have the smaller in size. The Bucanero and PV79-34 genotypes possess the highest pseudo stems circumference.

The FHIA-17, Grande Naine, Bucanero, and FHIA-02 genotypes are the most promising for the central region of Goiás and they can adapt well to other regions of similar climate.

The indexes used (Medium Rank and Active) are concordant with the selection of the first four genotypes. However, they are discordant with the magnitude of the expected gain.

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