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Selection of okra parents based on performance and genetic divergence

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A total of 200 okra accessions with wide variability and a potential for genetic improvement were stored in the Vegetables Germplasm Bank of the Federal University of Viçosa (UFV-BGH) in Viçosa, Minas Gerais State, Brazil. The objective of this work was to select parents by genetic divergence and behavior *per se* in 70 okra accessions from the BGH-UFV by quantitative and qualitative descriptors of economic interest. Analysis of individual and combined variance, by clustering of means by Scott-Knott test, of the accessions by Tocher's method and selection based on qualitative descriptors and behavior *per se* using the methodology of sum of inverted positions was made. The variability of the characteristics of the accessions as verified by the Scott-Knott test formed different groups and subgroups by Tocher's method. Fifteen accessions were selected with the qualitative descriptors, and based on the sum of inverted positions for quantitative descriptors the BGH-132, BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH- 7865, BGH-3196 and BGH-4890 okra accessions were selected as potential parents.

Key words: *Abelmoschus esculentus* (L.) Moench, germplasm bank, genetic resource, genetic improvement.

INTRODUCTION

India is the diversity center of cultivated okra [*Abelmoschus esculentus* (L.) Moench] (Haq et al., 2013). Also, this plant has great economic importance, especially in tropical and subtropical regions (Yuan et al., 2014), due to the fact that it does not need high technological input to be successfully grown (Aguiar et al., 2013). The climatic conditions of Brazil, especially in the northeastern, midwestern, and southeastern regions favor the intensive cultivation of okra, mainly by small producers (Aguiar et al., 2013). Okra fruit is a good dietary supplement which is free of fat and low in calories (Patil et al., 2013). Genetic improvement mainly depends on the amount of genetic variability present in the population (Koundinya et al., 2013). In any crop, the germplasm serves as a valuable source of base population and offer major source of variability (Ramya

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and Senthil Kumar, 2009). The Vegetable Germplasm Bank of the Federal University of Viçosa (UFV-BGH) has more than 200 okra accesses. The genetic characterization of these accessions provides useful information for understanding and harnessing genetic diversity (Cerqueira-Silva et al., 2014). Furthermore, these assessment works can be used to infer the variability of the collection and to identify its potential uses in genetic improvement programs (Gonçalves et al., 2009).

The genetic diversity assessed by biometric techniques or predictive processes, provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics (Govindaraj et al., 2015) and also provides information of potential parents for breeding programs (Costa et al., 2011). Moreover, multivariate methods based on predictive processes are being used for okra crop (Garg et al., 2011; Singh et al., 2012; Das et al., 2013). The choice of parents based on behavior *per se* is crucial for breeding programs and can generate superior populations (Santos et al., 2011). The objective of this study was to characterize and evaluate the genetic divergence of 70 okra accessions from the BGH-UFV to select potential parents based on the predictive processes and behaviors *per se*.

MATERIALS AND METHODS

Plant genetic resources and experiments

Seventy okra accessions from BGH-UFV were evaluated in two experiments in a randomized block design with three repetitions, in the Vegetable Crops Sector of the Department of Plant Science, Universidade Federal de Viçosa (20º45'14 "S, 42º52'53" W and 648,74 m) in Viçosa, Minas Gerais, Brazil. Two experiments were conducted with 37 and 33 okra accessions evaluated in the first and second experiments between September 2010 and February 2011 and September 2011 and February 2012, respectively. The following controls were used: Santa Cruz 47 (cultivar pure line), TPX903 and TPX4460 (hybrids) (Table 1).

Characterization and morphoagronomic selection

The quantitative and qualitative descriptors proposed by the International Plant Genetic Resources Institute (IPGRI) (1998) and others deemed necessary for their agronomic importance were used to characterize and evaluate the okra accessions (Table 2). The agronomic descriptors of economic interests were: (PI): precocity index (%) - the ratio between the sum of the mass of the fruits of the first six harvests and the total fruit multiplied by 100, (NFr): number of fruits per plant, (AFW): average fruit weight (g), and (TWF): total weight of fruits per plant (g). The accessions were selected as potential parents in three stages: (1) selection based on qualitative descriptors of economic interest (that is, green colour; predominant format of round fruit, angular pods, or smooth fruit surface), (2) *per se* behavior using the methodology of sum of inverted positions based on the weight posts index (Mulamba and Mock, 1978) for quantitative descriptors of economic interest, and (3) genetic divergence among accessions. Data from each experiment were submitted to the analysis of variance (*F test*) and the group means were compared by the Scott-Knott test at 5% probability. The best accessions were identified based on the sum of inverted positions methodology classifying the accessions for each of the characters of economic interest, aiming to improve favorable ones, and getting the sum of ranks. The means were compared by Scott-Knott test and used in the sum of the ranks with weights reversed based on access grouping. The accessions of groups of greatest interest received the highest score, and so on. The number of grades allocated was the same as that of accesses. For example, for the characteristic average fruit weight of the second experiment (Table 3), accessions were clustered into three groups: the first and more productive, received the grade three; the intermediate received grade two, and the lower production, received grade one.

The study of genotype × environmental interaction (Freeman, 1973) was made in the evaluation of genetic divergence among accessions to the characteristics of economic interest using the common control in the experiments as well as in the variance analysis and multivariate analysis, the Mahalanobis distance was used as dissimilarity measure (Mahalanobis, 1936) and the Tocher’s method to form groups (Rao, 1952). Analyses were performed using the computer application GENES (Cruz, 2013).

RESULTS

The 70 okra accessions showed variability when characterized by qualitative descriptors (IPGRI,1998). In the first stage based on the qualitative descriptors of economic interest (that is, green colour; predominant format of round fruit, angular pods, or smooth fruit surface), 15 of the 70 accessions were selected: BGH-132, BGH-311, BGH-7838, BGH-359 , BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH-7865, BGH-1248, BGH-3196, BGH-4162, BGH-4890, BGH-4913, 11 from the first experiment and 4 from the second, representing 22% of the accessions. The genotypes showed differences in both experiments ($p \leq 0.05$). For quantitative descriptors of economic interest, earliness index (%), number of fruits per plant, and average and total weight of fruits per plant (Table 3). Quantitative descriptors of economic interest allowed observing different groups of means by the Scott-Knott test at 5% probability. However, the average of the total fruit production in the first experiment and the number of fruits per plant in the second was similar to those of the control, while the average fruit weight in the second formed three groups (Table 3). The sum of inverted positions for quantitative descriptors of economic interest (Table 3) selected the BGH-132, BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH-7865, BGH-3196 and BGH-4890 accessions with the highest scores in the first stage and therefore as potential parents. The scores of these accessions were higher than the control, that is, Santa Cruz 47 and similar to the hybrid in different experiments, with higher scores for the BGH-4890. A total of 13% of genotypes was selected based on their *per se* to the economic performance descriptors.

The BGH-132 BGH-547, BGH-961 and BGH-7865 accessions were allocated to the group of the earliest production, highlighting the BGH-961, the most precocity index, superior to the hybrid controls (TPX903 and

Table 1. Code name, origin, and year of collection of 70 okra accessions from the Vegetable Germplasm Bank of the Federal University of Viçosa (UFV-BGH) and commercial controls, Viçosa, Minas Gerais State, Brazil.

Code name	Origin	Year	Code name	Origin	Year
BGH - 36	Teófilo Otoni, MG	1966	BGH - 3143	Irã	1969
BGH -100	Feira de Santana, BA	1966	BGH - 3148	Irã	1969
BGH - 101	Feira de Santana, BA	1966	BGH - 3161	Paquistão	1969
BGH - 7799	Salvador, BA	1966	BGH - 3170	Turquia	1969
BGH - 132	Estância, SE	1966	BGH - 3182	Turquia	1969
BGH - 7800	Aracaju, SE	1966	BGH - 3183	Turquia	1969
BGH - 149	Aracaju, SE	1966	BGH - 3188	Turquia	1969
BGH - 182	Santo Antão, PE	1966	BGH - 3196	Turquia	1969
BGH - 190	Santo Antão, PE	1966	BGH - 3215	Turquia	1969
BGH - 7811	Recife, PE	1966	BGH - 3226	Turquia	1969
BGH - 295	Belo Horizonte, MG	1966	BGH - 3227	Turquia	1969
BGH - 311	Brasilia, DF	1966	BGH - 4162	Colatina, ES	1967
BGH - 315	Brasilia, DF	1966	BGH - 4364	Capinópolis, MG	1969
BGH - 339	Goiania, GO	1966	BGH - 7912	Viçosa, MG	1968
BGH - 345	Goiania, GO	1966	BGH - 4890	Ilha Careiro, AM	1975
BGH - 348	Jussara, GO	1966	BGH - 4891	Ilha Careiro, AM	1975
BGH - 358	Jussara, GO	1966	BGH - 4893	Manacaparu, AM	1975
BGH - 7838	Jussara, GO	1966	BGH - 4894	Lago Purpuro, AM	1975
BGH - 361	Jussara, GO	1966	BGH - 4897	Urucará, AM	1975
BGH - 395	Jussara, GO	1966	BGH - 4900	Santa Leopoldina, ES	1975
BGH - 435	Jussara, GO	1966	BGH - 4903	Perolândia, ES	1975
BGH - 541	Unaí, MG	1966	BGH - 4904	Perolândia, ES	1975
BGH - 547	Unaí, MG	1966	BGH - 4907	Mutum, MG	1975
BGH - 548	Unaí, MG	1966	BGH - 4908	Mutum, MG	1975
BGH - 577	Nova Friburgo, RJ	1966	BGH - 4910	Mutum, MG	1975
BGH - 643	S. J. Del Rei, MG	1966	BGH - 4913	Mutum, MG	1975
BGH - 667	Lavras, MG	1966	BGH - 4922	Aimorés, MG	1975
BGH - 693	Itiquira, MT	1966	BGH - 4945	Colatina, ES	1975
BGH - 740	Varzea Grande, MT	1967	BGH - 5408	Manaus, AM	1981
BGH - 960	Campinas, SP	1966	BGH - 5417	Senador Firmino, MG	1981
BGH - 961	Campinas, SP	1966	BGH - 5421	Viçosa, MG	1981
BGH - 7863	Porto Firme, MG	1967	BGH - 6988	Caxambu, MG	1999
BGH - 7864	Porto Firme, MG	1967	BGH - 7448	São Luis, MA	1999
BGH - 7865	Porto Firme, MG	1967	Santa Cruz 47	Agristar do Brasil	2010
BGH - 1248	Recife, PE	1969	TPX - 903	Agristar do Brasil	2010
BGH - 8013	Universidade Purdue	1966	TPX - 4460	Agristar do Brasil	2010
BGH - 3090	Armênia	1969			

*Local collection of reference or introduction of the accessions.

TPX4460) with high precocity. Moreover, productivity of these accessions was similar to that of the control group (Table 3). Interaction at the 1% probability level by *F* test for genotype × environment for characteristics of economic interest was not observed (Table 4). Cluster analysis by the Tocher's optimization method (Table 5) initially separated the genotypes into two groups; the first group having the largest number of genotypes (98.5%) and the second with BGH-6988 access. However, the total and average weight of fruits and especially the early precocity of the latter were not desired. Eleven subgroups were formed for group I due to its large number of genotypes (Table 5). Intra and inter groups D^2 values are presented in Table 5. Highest inter groups value (D^2) was noted (136.48). While groups I and II had 29.22 and zero intra groups values.

The BGH-132 and BGH-3196 accessions allocated in the first subgroup and the BGH-740 BGH-693, BGH-7865 and BGH-547 in the second subgroup with three controls were selected as parents, based on their behavior *per se*.

Table 2. Quantitative and qualitative descriptors to characterize and evaluate morphological and agronomic traits of 70 okra accessions in the vegetative (VS) and fruiting (FS) stages of the Vegetable Germplasm Bank of the Universidade Federal de Viçosa (BGH-UFV), Viçosa, Minas Gerais State, Brazil.

Phases	Qualitative descriptors
VS	Growth habit; Leaf shape; Shape of the leaf; Leaf margin; Leaf tip; Leaf base; Variability of leaf shape; Leaf colour; Leaf brightness; rib Colour; Petiole colour; Petiole length; Stem hairiness; Flowering; Flower colour; Sepal colour, stigma colour; Inflorescence colour.
FS	Fruit type; Fruit colour; Fruit shape; Fruit surface.
VS	Leaf length; leaf width; internode diameter; internode length.
FS	Fruit length; Fruit width; fruit length/diameter; number of fruits per plant; total fruits per plant; average fruit weight; precocity index.

Table 3. Means[1] and grades[2] of the sum of inverted positions of four descriptors of economic interest for the accessions and control in the first and second experiments with okra genotypes of the BGH-UFV and three commercial cultivars.

Genotypes	PI[3]	NFr	AFW	TWF	Genotypes	PI	NFr	AFW	TWF
BGH - 36	7.02^{b11}	18.77^{a2}	39.11^{a2}	734.33^{a1}	BGH-541	2.24^{b1}	17.33^{a1}	36.81^{a}3	645.00^{a2}
BGH - 100	21.40^{a2}	21.22^{a2}	36.92^{b1}	783.89^{a1}	BGH-548	31.23^{a2}	10.44^{a1}	26.11^{b2}	279.89^{b1}
BGH - 101	11.25^{b1}	18.33^{b1}	41.21^{a2}	754.89^{a1}	BGH-8013	8.28^{b1}	20.22^{a1}	24.00^{b2}	482.78^{b1}
BGH - 7799	20.55^{a2}	19.66^{a2}	34.58^{b1}	679.77^{a1}	BGH-3090	27.62^{a2}	19.66^{a1}	25.97^{b2}	512.33^{b1}
BGH - 132	19.08^{a2}	21.77^{a2}	35.94^{b1}	780.77^{a1}	BGH-3143	14.24^{b1}	21.00^{a1}	25.79^{b2}	537.55^{b1}
BGH - 7800	6.790^{b1}	20.33^{a2}	38.59^{a2}	784.66^{a1}	BGH-3148	11.96^{b1}	22.11^{a1}	25.55^{b2}	566.88^{b1}
BGH - 149	1.89^{b1}	17.77^{b1}	46.27^{a2}	820.78^{a1}	BGH-3161	11.36^{b1}	22.77^{a1}	29.26^{a}3	669.88^{a2}
BGH - 182	13.52^{b1}	22.44^{a2}	39.46^{a2}	881.22^{a1}	BGH-3170	16.85^{a2}	18.66^{a1}	29.31^{a}3	546.55^{b1}
BGH - 190	16.22^{a2}	23.77^{a2}	37.30^{b1}	887.89^{a1}	BGH-3182	5.04^{b1}	20.00^{a1}	31.29^{a}3	624.33^{a2}
BGH - 7811	5.55^{b1}	19.33^{b1}	41.09^{a2}	793.33^{a1}	BGH-3188	4.30^{b1}	22.89^{a1}	22.92^{b2}	521.88^{b1}
BGH - 295	12.56^{b1}	19.66^{b1}	38.36^{a2}	755.78^{a1}	BGH-3196	10.62^{b1}	19.00^{a1}	30.30^{a}3	577.44^{b1}
BGH - 311	1.38^{b1}	11.88^{b1}	44.33^{a2}	525.44^{a1}	BGH-3215	16.81^{a2}	17.11^{a1}	34.26^{a}3	585.67^{b1}
BGH - 7838	5.34^{b1}	18.11^{b1}	45.76^{a2}	832.89^{a1}	BGH-3226	2.76^{b1}	17.44^{a1}	27.69^{b2}	483.33^{b1}
BGH - 339	16.96^{a2}	21.89^{a2}	36.82b2	817.11^{a1}	BGH-3227	1.72^{b1}	17.55^{a1}	24.33^{b2}	425.11^{b1}
BGH - 345	18.25^{a2}	21.55^{a2}	37.19b2	802.11^{a1}	BGH-4162	6.93^{b1}	27.89^{a1}	23.96^{b2}	566.55^{b1}
BGH - 348	10.14^{b1}	22.11^{a2}	39.49^{a2}	892.66^{a1}	BGH-4364	10.97^{b1}	16.77^{a1}	28.11^{b2}	473.77^{b1}
BGH - 358	24.06^{a2}	11.77^{b1}	44.37^{a2}	512.77^{a1}	BGH-4890	6.22^{b1}	22.44^{a1}	30.47^{a}3	680.55^{a2}
BGH - 359	12.28^{b1}	18.11^{b1}	36.23^{b1}	658.33^{a1}	BGH-4893	11.10^{b1}	20.33^{a1}	21.24^{b2}	430.55^{b1}
BGH - 361	16.84^{a2}	22.33^{a2}	31.23^{b1}	697.44^{a1}	BGH-4894	15.32^{b1}	16.66^{a1}	26.96^{b2}	448.89^{b1}
BGH - 395	17.03^{a2}	21.44^{a2}	34.04^{b1}	730.22^{a1}	BGH-4897	5.21^{b1}	16.89^{a1}	24.65^{b2}	418.00^{b1}
BGH - 435	17.90^{a2}	24.11^{a2}	38.88^{a2}	916.66^{a1}	BGH-4903	9.39^{b1}	18.77^{a1}	27.91^{b2}	527.44^{b1}
BGH - 547	17.28^{a2}	22.44^{a2}	34.92^{b1}	695.66^{a1}	BGH-4904	10.90^{b1}	18.77^{a1}	35.71^{a}3	670.55^{a2}
BGH - 577	10.98^{b1}	20.11^{a2}	47.97^{a2}	966.00^{a1}	BGH-4907	10.37^{b1}	21.50^{a1}	23.69^{b2}	507.16^{b1}
BGH - 643	6.95^{b1}	22.55^{a2}	36.41^{b1}	829.88^{a1}	BGH-4908	0.52^{b1}	25.44^{a1}	30.40^{a}3	771.33^{a2}
BGH - 667	22.33^{a2}	17.89^{b1}	40.08^{a2}	721.33^{a1}	BGH-4910	8.29^{b1}	20.11^{a1}	25.37^{b2}	510.22^{b1}
BGH - 693	10.21^{b1}	23.22^{a2}	38.55^{a2}	892.55^{a1}	BGH-4913	10.84^{b1}	23.44^{a1}	22.63^{b2}	527.66^{b1}
BGH - 740	12.22^{b1}	19.99^{a2}	39.43^{a2}	783.33^{a1}	BGH-4922	00.00^{b1}	17.89^{a1}	26.90^{b2}	479.66^{b1}
BGH - 960	19.37^{a2}	19.72^{a2}	35.40^{b1}	698.88^{a1}	BGH-4945	08.23^{b1}	18.89^{a1}	26.31^{b2}	495.22^{b1}
BGH - 961	28.55^{a2}	17.77^{b1}	40.69^{a2}	721.33^{a1}	BGH-5408	10.85^{b1}	16.33^{a1}	29.88^{a}3	490.11^{b1}
BGH - 7863	09.61^{b1}	23.22^{a2}	44.93^{a2}	1049.3^{a1}	BGH-5417	28.25^{a2}	22.83^{a1}	26.78^{b2}	611.72^{a2}
BGH - 7864	17.57^{a2}	21.11^{a2}	39.85^{a2}	837.22^{a1}	BGH-5421	11.65^{b1}	19.78^{a1}	26.98^{b2}	537.44^{b1}
BGH - 7865	15.46^{a2}	22.11^{a2}	33.58^{b1}	740.55^{a1}	BGH-6988	00.00^{b1}	22.55^{a1}	8.660c1	194.11^{b1}
BGH - 1248	13.68^{b1}	22.55^{a2}	38.01^{b1}	646.83^{a1}	BGH-7448	00.00^{b1}	23.66^{a1}	36.86^{a}3	863.33^{a2}
BGH - 3183	21.38^{a2}	22.66^{a2}	34.55^{b1}	784.11^{a1}	SantaCruz	09.66^{b1}	23.66^{a1}	26.73^{b2}	503.22^{b1}
BGH - 7912	00.96^{b1}	16.66^{b1}	38.99^{a2}	646.33^{a1}	TPX-903	24.97^{a2}	24.55^{a1}	21.49^{b2}	513.44^{b1}
BGH - 4891	05.55^{b1}	16.66^{b1}	41.06^{a2}	685.66^{a1}	TPX-4460	22.31^{a2}	27.07^{a1}	25.87^{b2}	517.28^{b1}
BGH - 4900	06.46^{b1}	16.72^{b1}	34.64^{b1}	578.83^{a1}					

Table 3. Contd.

Santa Cruz	09.33^{b1}	16.89^{b1}	42.25^{a2}	680.89^{a1}					
TPX - 903	22.94^{a2}	24.33^{a2}	29.00^{b1}	704.00^{a1}					
TPX - 4460	20.69^{a2}	26.00^{a2}	32.31^{b1}	837.77^{a1}					
Mean	13.69	20.16	38.49	768.86	Mean	10.73	21.11	26.84	533.06
MS trat[4]	138.14*	27.87*	52.2*	36094.1*	MStrat	194.15*	31.1*	78.03*	42788.51*

[1]Means followed by the same letter, for column belongs to the same group, according to the grouping of Scott-Knott test, at 5% probability. [2]Notas received for the group allocated according sum of inverted positions. [3]PI Precocity index (%); (NFr): number of fruits per plant; AFW: average fruit weight (g); TWF: total weight of fruits per plant (g). [4]Treatment mean square, significant at the 5% probability.

Table 4. Summary of variance analysis of the environments (Env.) in relation to the commercial control for the descriptors of economic interest (Desc.) of okra genotypes of the BGH-UFV and three control cultivars.

Desc.	Mean Square					Mean	CV(%)
	Bl/Env. (2)[1]	Env. (1)	Genotypes (2)	GxE (2)	Residue (10)		
PI[2]	07.23	5.02	345.90	0.650^{ns}	36.17	18.18	33.06
Nfr	02.63	0.026	21.37	63.93^{ns}	18.57	22.37	19.26
TWF	10.20	241741.9	10969.6	10629.4^{ns}	6930.1	625.00	13.31
AFW	11.42	593.97	68.69	92.18^{ns}	15.35	28.77	13.61

[ns]Non significant at 1% probability by *F* test. [1]Degree of freedom. [2]PI precocity index (%) per block/environment (Bl/Env); NFr: number of fruits per plant; TWF: total weight of fruits per plant (g). AFW: average fruit weight (g).

Table 5. Groups (Gr.) and Subgroup (subgr.) formed with 70 okra accessions from the BGH-UFV and three cultivars and distance intra and inter groups by Tocher's method based on Mahalanobis' generalized distance (D^2).

Gr.	Subgr.	Genotypes	
	1	BGH-182 BGH-348 BGH-7800 BGH-345 BGH-643 BGH-7799 BGH-4900 BGH-4891 BGH-132 BGH-3227 BGH-311 BGH-7838 BGH-5408 BGH-4913 BGH-295 BGH-359 BGH-4162 BGH-4922 BGH-435 BGH-3196 BGH-4393 BGH-960 BGH-100 BGH-339 BGH-3143	
	2	BGH-740 BGH-5421 BGH-693 Santa Cruz 47 BGH-4894 BGH-7865 BGH-7864 BGH-4945 TPX 4460 BGH-190 BGH-8013 BGH-3090 BGH-395 BGH-3148 BGH-547 BGH-361 BGH-3188 BGH-4897 BGH-101 BGH-7912 BGH-5417 BGH-3183 BGH-4910 TPX 903 BGH-4903 BGH-36 BGH-3182	
	3	BGH-577 BGH-7863 BGH-1248 BGH-149 BGH-7448 BGH-4908	
I	4	BGH-3161BGH-4890 BGH-3170 BGH-3215	
	5	BGH-961 BGH-548	
	6	BGH-541 BGH-3226 BGH-7811	
	7	BGH-667	
	8	BGH-4904	
	9	BGH-358	
	10	BGH-4364	
	11	BGH-4907	
II		BGH-6988	
		Distance intra and inter groups	
		I	II
I		29.22	136.48
II			0.00

The BGH-1141, BGH-4890 and BGH-961 were allocated in the third, fourth, and fifth subgroups, respectively.

DISCUSSION

The variability of the qualitative descriptors between the accessions provides information of potential parents for hybridization and development of new cultivars (Sanwal et al., 2012). These characteristics are linked to the economic value of the okra fruits, as the green colour of the fruit is preferred by consumers (Solankey et al., 2013). The selection of BGH-132, BGH-311, BGH-7838, BGH-359, BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH-7865, BGH-1248, BGH- 3196, BGH-4162, BGH-4890 and BGH-4913 accessions was based on qualitative descriptors, namely, colour of fruit; and predominant format of round fruit, angular pods, or smooth surface. However, some accessions with angular pods format were selected because Santa Cruz cultivar, one of the most planted in Brazil, has fruits with round shape, which does not meet the preference of the foreign market. This shows there is a necessity in the production system, including cultivars with angular pods format adapted to Brazilian climate and to increase export of preferred okra in the foreign market (Purqueiro et al., 2010). Differences between genotypes for quantitative descriptors of economic interest in precocity index, number of fruits per plant, and average and total weight of fruits per plant confirmed the high variability of okra accessions in the germplasm bank, which is important for the genetic improvement of population of this plant (Koundinya et al., 2013). Moreover, these features contribute to increased crop yield, which is the main objective of okra breeding programs (Dhankhar and Mishra, 2005).

The BGH-132, BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH-7865, BGH-3196 and BGH-4890 accessions were selected by the sum of inverted positions for quantitative descriptors of economic interest. This index is an efficient technique to select genotypes, as for other crops (Vivas et al., 2012; Almeida et al., 2014). The highlight of the BGH-132, BGH-547, BGH-961, and BGH-7865 accessions by early precocity and productivity is important because genotypes that bloom first provide earliest crops with longer fruiting period and higher number of fruits per plant (Medagam et al., 2012). The selection and introduction of these accessions enable breeding programs to explore heterosis obtaining cultivars or hybrids with higher productivity and income (Jindal et al., 2010). The non-significance of genotype × environment interaction for traits of economic interest demonstrated no differences in responses compared to the control to environmental variations, which may complicate studying morphological and agronomic traits of economic interest (Kyriakopoulou et al., 2014). To determine the divergence, the genetic distances between the genotypes were initially estimated by the Generalized Distances of Mahalanobis. Group with single genotype (II) indicates their independent identity and importance due to unique characters possessed by them. The intra group values were less than inter-groups values indicating the homogenous and heterogeneous nature of the genotypes within and between the groups (Singh et al., 2013). Both groups initially formed by Tocher's method showed genetic distance between accessions, which is important to qualify the degree of divergence among populations and to evaluate the relative contribution of different components of the total divergence (Bhutia et al., 2015). The BGH-6988 access, the only one in the second group, presented inadequate mass and total fruit production and precocity index. In addition, this access has purplish fruits, a standard not acceptable to the national and international market that prefers green fruit (Solankey et al., 2013). The estimated distances with high magnitude between pairs of individuals within group I justify the establishment of a subgroup, and crosses between accessions of different subgroups could enable restoration of transgressive segregant in advanced generations (Bhutia et al., 2015).

The BGH-740, BGH-693, BGH-7865 and BGH-547 accessions selected as parents made up the same subgroup as the three controls, based on their behavior *per se*. Accessions similar to the cultivars can be interesting because they could be used as parents in breeding programs, because is faster for the recovery of the agronomic characteristics (Adalid et al., 2012).

Conclusion

The okra accessions of the BGH-UFV have wide variability for quantitative and qualitative morphological and agronomic descriptors. The BGH-132 BGH-547, BGH-693, BGH-740, BGH-961, BGH-7863, BGH-7865, BGH-3196 and BGH-4890 can be used as potential progenitors in okra breeding programs.

Conflict of interests

The author(s) did not declare any conflict of interest.

Abbreviations

NFr, Number of fruits per plant; **AFW,** average fruit weight; **TWF,** total weight of fruits per plant.

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