academicJournals

Vol. 10(21), pp. 2254-2258, 21 May, 2015
DOI: 10.5897/AJAR2014.9097
Article Number: 790CD1453146
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Physiological quality and genetic parameters of maize landraces seeds in southwestern Bahia

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Received 27 August, 2014; Accepted 26 April, 2015

The environmental adaptation of maize germpasm is mainly controlled by certain genes, such as ZmCCT. This factor is influenced by both the genotype and the environment itself, being the gene able to express itself in the germination and seedling vigor under the conditions that is offered. The objective of this study was to estimate genetic parameters for traits related to physiological quality in maize landraces seeds. Hundred seeds of six strains were used: Catingueiro, Colombianoroxo, Colombianopreto, Cabeça de negro, Colombiano Vermelho and Estrada de ferro, arranged in polystyrene trays, each tray with 25 seeds, maintained at a temperature of 19 to 23°C, moistened with 15 ml of deionized water daily. The experimental design was completely randomized, with four repetitions. We evaluated the percentage of seeds germinated in the presence of coleoptile (%); assessment of the total weight of adventitial and primary roots (g); assessment of the total weight of the coleoptile (g); assessment of the length of the longest coleoptile (mm) and the length of the largest adventitial root (mm); length ratio of shoots with roots using direct division between heritability and genetic gain variables. Data were submitted to ANOVA. Percentage data were transformed by the formula arcsin [(x +0.5) / 100] 1/2 before being submitted to ANOVA. For comparison of means, we adopted the Tukey test at 5% probability of error. The results indicated genetic variability for the different characteristics of the studied physiological quality, especially for Catingueiro variety with high heritability and possible genetic gain with the potential to be used in breeding programs.

Key words: Variety, genetic gain, heritability, vigor, *Zea mays* L.

INTRODUCTION

Maize (*Zea mays*. L) is one of the most important cerealsin Brazil, being produced in different regions of the country (Costa et al., 2013). Bahia is highlighted as a major producer of the Northeast region, with a production of 1.7 million tons (IBGE, 2013). More vigorous, with higher germination speed, good adaptation and

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productive seeds are characteristics desired by producers, and higher production can be attributed to the evolution of grain yield, which has a joint relationship with breeding techniques, adoption of supplies and different ways of managing and cultivation acquired by various cultures to which maize can be included (Mundstock and Silva, 2005).

Among the characteristics that offer good quality to seeds, genetic deserves close attention, because improvement in culture conferred an increase in yields of 78 kg ha^{-1}.year^{-1} between the 30 and 70 s, going to 4,316 Kg.ha^{-1} in 2010, giving improved corn plants a good gene expression (Martin et al., 2007; CONAB, 2011). Seeds of local varieties are considered components of agro biodiversity as they are of inestimable value for traditional populations (CATÃO et al., 2010). The environmental adaptation of maize germpasm is mainly controlled by certain genes, such as ZmCCT (Hung et al., 202). This factor is influenced by both the genotype and the environment itself (Gondim et al., 2006) and the genes may express on germination and seedling vigor under the offered conditions.

Gene expression is a result of the genetic dominance, additive and/or epistatic effect that may influence the hum of expression quantitative character in a population (Bespalhok filho et al., 2005). The genotype can be seen through evaluations on the phenotype of culture and its performance represents the genotypic value in occupied environment (Cargin et al., 2006). The phenotypic variance can be divided into: environmental produced variation, variation due to the different characteristics of heredity and variation acquired by the sum of the effects caused by environment and heredity. Vencovsky (1987) states that the variation can be calculated due to genetic differences between treatment and/or progeny, which is one of the favorable components to improvement, because it confers genetic gains. Genetic variability can be quantified by the coefficient of genetic variation, which expresses the genetic variation compared to the average evaluated character (Resende, 1991).

Heritability is the result on the quotient between phenotypic and genotypic variances, which assesses the efficiency of selection in the application of genetic variability (Carvalho et al., 2012). This heritability is divided into wide or narrow, and may vary according to the kind, character, environmental conditions, and phenological stages. The objective of this study was to estimate the genetic parameters of physiological related characters ofmaize landraces seeds, so as to provide practical directions for their application in breeding programs.

MATERIALS AND METHODS

The experiment was conducted in the Bio factory of *Universidade Estadual do Sudoeste da Bahia* (UESB). Seeds of sSeeds six maize landraces varietiesvarieties, harvested ined in 2012, were selected: Catingueiro, Colombiano roxo, Colombiano preto, Cabeça de negro, Colombiano vermelho and Estrada de ferro. All varieties come from plantations made by Diretoria de Campo da UESB (DICAP). These varieties are widely cultivated in the Southwestern region of Bahia - Brazil. The experimental design was completely randomized with six treatments and four repetitions for each treament. Each repetition was represented by a tray containing 25 seeds.

The seeds were selected and arranged in polystyrene trays, covered with moistened cotton in 60 ml of deionized water. Each repetition was daily rehydrated with 15 ml of deionized water. The average temperature during the experiment ranged from 19°C to 23°C. The occurrence of seed germination was daily observed by coleoptile emission; they were counted and identified for variables analysis:

(i) Germination speed, in days, was determined by Edmond and Drapala equation (Oliveira et al., 2009).

$$TM = \frac{G1T1 + G2T2 + ... + GiTi}{G1 + G2 + ... + Gi} \quad (1)$$

Where: TM - number of days to coleoptile emission; G1 to Gi - number of germinated seedlings occurring every day; T1 to Ti - number of days of growth.

(ii) Percentage of germination in 1st and final count, calculated by the percentage of germinated seeds every day;

(iii) Count of the number of roots;

(iv) Percentage of seeds germinated with the presence of coleoptile;

(v) Evaluation of total weight of adventitious and primary roots (g), by weighing with a precision balance using three decimals;

(vi) Evaluation of the total weight of coleoptile (g), by weighing with a precision balance using three decimals;

(vii) Evaluation of the length of the longest coleoptile (mm), using a precision graduated ruler;

(viii) Evaluation of the length of the longest adventitial roots (mm), using a precision graduated ruler;

(ix) Relation of the shoot length with the roots, using direct division between the variables.

Data were subjected to analysis of variance and Tukey test at 5% probability using SAEG program.

Genetic parameters estimates were determined using the methodology presented by Oyiga and Uguru (2010) and Sunday et al. (2007):

(1) Genotypic, phenotypic and environmental variability were calculated *via* the following formulas:

$$Vg = \frac{MSg - MSe}{r} \quad (2)$$

$$Vp = \frac{MSg}{r} \quad (3)$$

$$Ve = MSe \quad (4)$$

Where Vg, Vp and Ve are genotypic, phenotypic and environmental variances, respectively, and MSg, MSe and r are the mean square of genotypes, mean square error, and the number of repetitions, respectively.

(2) Coefficient of genotypic, phenotypic and environmental variation were calculated *via* the following equations:

Table 1. Medios values for different variables evaluated in maize varieties, UESB, Vitória da Conquista - BA, 2013.

Varieties	TG (%)	VG (%)	SC (%)	CMC (mm)	PTC (g)	NMR	CMR (mm)	PR (g)
Catingueiro	97± 3.83 a*	2.735 ± 0.27 b	95± 5.03 a	41.733± 22.50 a	1.450± 1.08 a	108± 16.05 a	50.675± 24.28 a	2.141± 1.47 a
Colombiano roxo	90 ± 9.52 ab	2. 995± 0.18 b	69± 22.24 ab	23.380± 5.94 a	0.725± 0.38 ab	101± 36.74 a	58.105± 14.48 a	1.339± 0.76 ab
Colombiano preto	76 ± 9.80 ab	3.153± 0.15 ab	34± 9.52 c	20.390± 7.61 a	0.254± 0.09 b	39± 6.18 b	36.220± 8.16 a	0.503± 0.24 b
Cabeça de negro	79 ± 11.49 ab	3.625± 0.32 a	44± 25.09 bc	17.280± 7.80 a	0.320± 0.24 b	46± 20.43 b	32.893± 12.63 a	0.461± 0.28 b
Colombiano vermelho	92 ± 3.27 ab	3.133± 0.13 ab	64± 0.00 abc	35.745± 3.02 a	0.915± 0.20 ab	95± 9.98 a	64.228± 20.02 a	1.518± 0.24 ab
Estrada de ferro	72 ± 9.80 b	2.848± 0.39 b	57± 8.25 bc	28.798± 6.74 a	0.589± 0.19 ab	79± 4.43 ab	57.755± 4.71 a	1.028± 0.27 ab

* Different letters in the same column differ significantly by Tukey test at 5% probability.

$$GCV = \frac{\sqrt{Vg}}{\overline{X}} X100 \quad (5)$$

$$PCV = \frac{\sqrt{Vp}}{\overline{X}} X100 \quad (6)$$

$$ECV = \frac{\sqrt{Ve}}{\overline{X}} X100 \quad (7)$$

Where GVC, PCV and ECV correspondingly refer to phenotypic, genotypic and environmental variation coefficients, respectively, and $\overline{X}$ to the overall mean ofeach treatment.

(1) Heritability

$$h^2 = \frac{Vg}{Vp} \quad (8)$$

Where Vg and and V presents thepresent genotypic and phenotypic variability, respectively.

(2) Genetic gain

$$\Delta G = i\Delta ph^2 \quad (9)$$

Where i referrefers to a constant (equivalent to 2.06 when the intensity selection is 5%), Δp to the standard deviation of the phenotypic variance and h^2 to heritability.

Data in percentages were transformed to ArcSin square root ((x +0.5)/ 100), by SISVAR program, version 5.3 before being submitted to ANOVA, and those in other forms were submittedto ANOVA directly (FERREIRA, 2010). For means comparison, we adopted the Tukey test at 5% probability of error using SISVAR program, version 5.3 (Ferreira, 2010).

RESULTS AND DISCUSSION

Germination for the different maize landraces strains presented significant difference between Catingueiro and Estrada de ferro varieties (Table 1). Germination rate percentage parameter (TG), germination speed (VG), seeds with coleoptiles (SC), length of the longest coleoptile (CMC), total weight of coleoptile (PTC), average number of roots (NMR), longest root length (CMR), weight of roots (PR).

Costa et al. (2013) reported that reportedgermination index in maize landraces ranged from 47 to 75%. For germination speed, Cabeça de negro Black Head showed greater speed, without, however, differ from Colombiano preto and Colombiano vermelho which did not differ from the others (Table 1). Lower germination was observed in cultivars of Catingueiro and Cabeça de negro (Costa et al., 2013). The highest percentage of seeds with presence of normal seedlings (95%) was shown in Catingueiro strain; relative to the length of coleoptiles and roots, the strains showed no significant differences. For the weight of the seedlings and roots, Catingueiro showed the highest values, without differ from Colombiano preto, Colombiano vermelho, Estrada de ferro variet, for both evaluated characteristics. The Catingueiro, Colombiano preto and Colombiano vermelho strains showed higher number of roots, however, the Estrada de ferro did not differ from those and another's (Table 1). Results corroborate Cato et al. (2010) for Catingueiro strain in germination rate and germination speed variables. In general, the Catingueiro strain showed the best characteristics for almost all studied variables, except for the speed of germination, but not harming the development of seed for other variables evaluated.

Statistically the Catingueiro variety obtained higher performance than the other varieties not relevant mathematically evaluate the data.

As can be seen in Table 2, there was high heritability (h^2) and low genetic gain (GA) for the variables: root weight, shoot weight, presence of

Table 2. Estimation of the mean square; average; phenotypic variance (Vp); genotypic variance (Vg) and environmental variance (Ve); phenotypic variation coefficients (PCV); genotypic variation coefficients (GCV) and environmental variation coefficients (ECV); heritability (h^2) and genetic gain (GA) for the variables of six cultivars of maize landraces seeds, UESB, Vitória da Conquista - BA, 2013.

Variables	Mean squares	Mean	Vp	Vg	Ve	PCV	GCV	ECV	(%)	GA
PR (g)	1,647	1,165	0,412	0,305	0,425	55,084	47,442	55,983	74,177	0,981
NR	3351,967	77,667	837,992	751,011	347,922	37,272	35,285	24,016	89,620	53,443
CR (mm)	649,009	49,979	162,252	106,296	223,823	25,486	20,629	29,934	65,513	17,191
PPA (g)	0,772	0,709	0,193	0,138	0,221	61,997	52,370	66,364	71,355	0,646
CPA (mm)	354,641	27,888	88,660	57,359	125,206	33,764	27,158	40,124	64,695	12,549
Shoot presence	113,075	15,125	28,269	24,922	13,386	35,153	33,006	24,190	88,162	9,656
Root +shoot weight (g)	4,644	1,874	1,161	0,850	1,243	57,509	49,218	59,494	73,244	1,626
Ratio CPA/root(mm)	0,066	0,566	0,016	0,008	0,034	22,686	15,808	32,541	48,558	0,128
VG (%)	0,388	3,081	0,097	0,080	0,067	10,112	9,194	8,419	82,668	0,531
TG (%)	25,067	21,083	6,267	4,906	5,444	11,874	10,505	11,067	78,280	4,037

PR - root weight; NR - Numbers of root; CR - root length; PPA - shoot weight; CPA - shoot lenght; VG - germination speed; TG - germination rate.

shoot, root plus shoots weight, germination speed and germination rate, on the other hand, there was high heritability and moderate genetic gain for root length and shoot length; high heritability and high genetic gain for number of roots and moderate heritability and low genetic gain for the ratio of shoot length with root, considering the intervals determined by Johnson et al. (1955). Similar results were found by Sunday et al. (2007) in work with rice seeds.

The highest estimates of genotypic variability coefficients (GCV) were observed among the parameters including PPA(weight of shoots), root + shoot weight, CR (root weight), NR (number of roots), presence of shoots, CPA (shoot length), and CR (root length), showing high genetic variability for traits evaluated, with the possibility of obtaining greater genetic gain for the desired characters, as they showed a percentage above 20%, according to the methods of Oyiga and Uguru (2010) and Sunday et al. (2007).

The lower environmental variation coefficient (ECV) was 8.419% for VG (germination speed) and the greatest was 66.364% for PPA (shoot weight). For the other parameters a high ECV was observed, which implies greater difficulty in selection of these traits. In this case say that there is environmental influences in the formation of character, however, it is worth noting that the genetic influence is considerable, which is given by the heritability as can be seen in Table 2 for all variables (Oyiga and Uguru, 2010).

Differences of PCV and GCV for germination rate, root number, presence of shoots, germination speed, indicated that such characteristics are ruled primarily by genetic factors and minimal environmental influence on phenotypic expression of the characters, so the selection of these characteristics based on phenotypic seems to be effective.

On the other hand, major differences were found in root weight, root length, shoot weight, shoot length, root plus shoot weight, ratio of shoot/root characteristics, indicating a greater environmental influence, reducing response to possible phenotypic selection. The high heritability (h^2h^2) presented in most variables suggests that the phenotype reflects the genotype showing ease in the selection of studied varieties. The high heritability also points the presence of sufficient genetic variation to obtain additional gains by selecting on these varieties. According to Rodrigues et al. (2011), the GCV for maize, in Brazilian conditions, over 7%, indicates a good germplasm genetic potential to be used in breeding.

According to results, it was found that both the genetic variance (Vg) and genetic gain (GA) had different values within the same population for a given characteristic, showing that even having presented a high heritability; the environment may have influenced the variables in low to moderate genetic gains.

Conclusion

The Catingueiro variety, in general, presents better physiological quality among the others, which indicates that there is genetic variability with high heritability and possible genetic gain, and therefore is important their conservation, collection and subsequent evaluation in plant breeding programs in the Southwest Region of Bahia.

Conflict of Interest

The author(s) have not declared any conflict of Interest.

ACKNOWLEDGEMENT

To FAPESB and CAPES and by the granting of the scholarship.

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