Estimation of Genetic Parameters for some Morphological Traits among Newly Selected Nigerian Roselle (*Hibiscus sabdariffa Linn.*) Genotypes

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Abstract

In order to assess some genetic parameters among newly selected Nigerian Roselle (*Hibiscussabdariffa* Linn.) genotypes; the roselle genotypes were evaluated for their morphological and yield attributes at the Department of Biological Sciences experimental garden, Federal University of Technology, Minna during 2012/2013 and 2013/2014 growing seasons, using a Complete Randomized Block Design (CRBD) with four replicates. The morphological parameters were investigated using standard procedures. The results on the morphometric parameters showed significant difference (P ≤ 0.05) for most of the parameters studied. The present study also revealed that some of the morphological parameters were influenced by environmental factors, such parameters are not suitable for selection. Moreover, higher estimates for genotypic variances than environmental variances for plant height at flowering, number of seeds per capsule, number of branches per plant and number of fruits per plant, indicate good characters for selection and improvement of the crop. The highest genetic advance as percentage of mean (129.80%) was obtained for number of branches per plant at 50% flowering; whereas, stem circumference at harvest had the lowest (6.36%). In addition, high values of broad sense heritability estimates (≥ 60%) was high for plant height at 6 week after thinning, plant height at 50% budding and flowering, number of branches at 50% flowering and number of seeds per capsule. Therefore, combination of high heritability estimates with genetic advance in the selection program is important for selection of the crop in the future. Emphasis should be made on those agro-morphological parameters that show greater genetic importance for selection and improvement of the crop in Nigeria.

Keywords: Genotypic variance, environmental variance, heritability, selection, improvement

Introduction

Vegetable Roselle (*Hibiscus sabdariffa* var. *sabdariffa* L.) belongs to the family Malvaceae. It is known by different synonyms and vernacular names, such as Roselle, Sorrel, Red sorrel and Mesta (Parkouda *et al.*, 2008). There are three common varieties of Roselle grown in Nigeria. Two of these varieties have red calyces ('Isapa Pupa': Yoruba; 'Zobo': Hausa), and the other one has green calyces ('Isapa': Yoruba; 'Yakuwa': Hausa) (Udom *et al.*, 2001; Falusi *et al.*, 2014). Roselle is a tetraploid (2n=4x=72) whose chromosomes are related to the diploid (2n=2x=36) *Hibiscus cannabinus* L. (Mclean, 1973). It is probably a native of Asia (India to Malaysia) to tropical Africa (Gomez-Leyva *et al.,* 2008). Being a tropical plant species, Roselle can be found in almost all tropical countries, such as Malaysia, South East Asia, Indonesia, Thailand and

Philippines (Rao, 1996).

The calyces are rich in acid and pectin; analysis of calyces has shown the presence of crude protein and minerals such as iron, phosphorus, calcium, manganese, aluminium, magnesium, calcium, sodium, and potassium (Gautam, 2004; Atta *et al.*, 2011). Amin *etal.* (2008), stated that the fruit of roselle contains more Ascorbic acid (Vitamin C) than *Ribesnigrum* L (Black currant) and nine times more than Citrus (*Citrussinensis* L.). Roselle is associated with traditional medicine and is reported to be used as treatment for several diseases such as hypertension and urinary tract infections (Diane *et al.*, 2010).

The success of any program geared towards improving any crop plant depends on the genetic variability, genetic advance and characters associated with the plant yield; these information are lacking on this particular crop in Nigeria.Genetic improvement of any crop plant is greatly dependent on the importance of several genetic parameters such as phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain; on which the breeding methods are formulated for further improvement (Rajib and Jagatpati, 2011) of any crop. Analysis of genetic variability reveals its presence and is of utmost importance as it provides the basis for effective selection (Rajib and Jagatpati, 2011). The different genotypic components of variance and heritability are important in determining selection efficiency (Omoigui *et al.*, 2006).The genetic variance of any quantitative trait is made up of additive (heritable) variance and non-additive (dominance and epistasis) variance (Mohamed *et al.*, 2012). It becomes very necessary therefore, to partition the observed phenotypic variability into its non-heritable and heritable components (Mohamed *et al.*, 2012). This is because selection of favourable genotypes for certain trait depends on the amount of variability existing in the material under study. It is on this background that this research is aimed at evaluating the nature of genetic variability, heritability and genetic advancement of some quantitative characters among some selected Nigerian Roselle genotypes.

Materials and Methods

The morphological parameters were investigated using standard procedures after the techniques of Akinyele and Osekita (2006); Hegazi and Hamideldin (2010). The number of leaves per plant (NL) at maturity were determined by counting the number of leaves attached to the plants. The height of the shoot of the plants at two weeks interval up to maturity was measured in centimetres (cm) using a metre rule. For each of the morphological parameters mentioned above, mean values per plant were determined for the Roselle accessions. The yields from the different accessions of Roselle were determined using the following indices: number of fruits per plant (NF), number of seeds per capsule (NSC), and weight of fruit (WF). For NSC and WF, ten fruits each were selected at random for all the accessions and the values were recorded for further statistical analysis.

NF were determined by counting the total number of fruits or pods a plant produced at the completion of the life cycle. NSC were determined by opening up the capsules and counting the number of viable seeds which were determined by their relative large size and firmness. WF were determined by measuring the pods on a weighing balance, mean values of yield parameters per fruit or plant were determined for the Roselle plants.

Genetic Parameters Estimates

Broad Sense Heritability (h^2) was estimated according to Falconer (1989) using:

$$h^2 = \frac{\sigma 2g}{\sigma 2ph} \qquad \text{(equation 1)}$$

Where $\sigma^2 g$ is the genotypic variance; $\sigma^2 ph$ is the phenotypic variance. Phenotypic and Genotypic variances were obtained from the analysis of variance table using equations 2 and 3 as follows:

$$\sigma^2 g = \frac{MS1 - MS2}{rXs} \qquad 2$$

$$\sigma^2 ph = \frac{MS1}{rXs} \qquad\qquad 3$$

(Where r: replication, s: season, MS1: Mean square for cultivar, MS2: Mean square for cultivar X season).

The mean values were used for genetic analyses to determine Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), using equation 4 and 5 as follows:

$$GCV\,(\%) = \frac{\sqrt{Genotypic\ Variance}}{Grand\ Mean} \qquad 4$$

$$PCV\,(\%) = \frac{\sqrt{Phenotypic\ Variance}}{Grand\ Mean} \qquad 5$$

Genetic advance (GA) was calculated with the method suggested by Singh and Chaundry (1985) using equation 6 as follows:

$$GA = k.\,\sigma ph.\,h^2 \qquad\qquad 6$$

Where K: constant = 2.06 at 5% selection intensity, σph: square root of phenotypic variance, h^2: Heritability
GA as percentage of mean (GAM) =
(GA/Grand Mean) X 100   7

Results

Genotypic Variance, Phenotypic Variance, Environmental Variance, Broad Sense Heritability, Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV) and Genetic advance for seven characters are presented in Table 1. The results revealed considerable phenotypic and genotypic variances among the various accessions for the characters under consideration. The results revealed inconsistency in the environmental and genotypic variances. In some of the characters studied, the genotypic variance was quite higher than the environmental variances (Plant height at 6 weeks after thinning, Plant height at 50 % flower bud formation and Plant height at flowering).

In addition, Genotypic Variance (GV) was higher than Environmental Variance (EV) for number of seeds per capsules (Table 1). However, the influence of the environmental factors on the expression of other characters as indicated by the magnitude of the EV was quite evident. This indicates that a large proportion of the Phenotypic Variance (PV) was caused by environmental influences for those characters. Consequently, such characters do not possess promising genetic variability; so, selection for them might not be efficient and successes might be very low. But for where the GV is higher than EV, such character is suitable for selection and successes are expected to be high.

The highest GV (905.51) was for number of leaves per plant at maturity, this is followed by plant height at harvest (433.33), then number of branches at flowering. The least GV (0.44) was recorded for stem circumference at harvest. Phenotypic variance (PV) was also highest in number of leaves per plant at maturity (2300.44), followed by plant height at maturity (1579.67), then plant height at flowering (251.75), and followed by number of fruits per plant (229.37); then the lowest PV (3.30) was found in stem circumference at harvest (Table 1). Genotypic Coefficient of Variation (GCV) was highest for number of branches at flowering (65.17 %) followed by number of fruit per plant (43.43 %), then followed by plant height at six weeks after thinning (27.47 %). This was followed by plant height at flowering (27.22 %), then number of branches per at four weeks after thinning (25.70 %), then weight of fruit (23.20 %); the least GCV (8.61 %) was found in stem circumference at harvest.

The highest PCV (74.30 %) was for number of fruit per plant, followed by number of fruit per plant, then followed by number of branches per plant at flowering (67.74 %). Generally, moderately high PCV were recorded for all the other traits studied (Table 1). Genotypic coefficient of variation, which is the real indicator of the extent of genetic variability in a population, was high for all the characters, except stem circumference at

harvest. For all the tested character, higher PCV than GCV values were obtained. The highest Broad sense heritability (h^2) (93.00 %) was recorded number of branches at flowering with an expected genetic advance over percentage of mean (GAM) of 129.80 %. This was followed by number of seeds per capsule (71.00 %) with an expected GAM of 36.24%; followed by plant height at six weeks after thinning and plant height at flowering (66 % each) with expected respective GAM values of 46.05 % and 45.52 %. Weight of fruit also showed moderately high heritability (47 %) with GAM value of 31.90 %. Stem circumference at harvest produced the lowest heritability value (13.00 %) and a corresponding lowest GAM value (6.36 %) (Table 1).

Discussion

In an attempt to determine the extent to which variation in yield components are responsible for variations in yield among various Roselle accessions, it should be noted that total variability depends on heritable and non-heritable components. In this study, the twenty Roselle accessions exhibited significant differences for most of the traits investigated. The observed variations among these genotypes can be attributed to both environmental and genetic factors; Similar results had been reported by Elsadig *et al.* (2013); Jalal and Ahmad (2012). Ibrahim and Hussein (2006), also detected significant differences among genotypes for plant height, number of branches per plant and weight of sepals. The change in the overall mean for these characters was recorded for the interaction of the genotypes with the environment. This shows that the observed variation among genotypes in these traits could be attributed to environmental causes as well as the interaction with the genetic makeup of the accessions.

The estimates of phenotypic variances were higher in values than their corresponding genotypic variance and environmental variance for all the characters evaluated; this agrees with the work of Jonah *et al.* (2013).

The results obtained for estimates of genotypic variances being lower than the environmental variances for some characters were in line with the work of Elsadig *et al.* (2013) on *Hibiscussabdariffa* and Mostopha *et al.* (2002) on *H. cannabinus*. An exception to this on number of seeds per capsule and plant height at flowering is in contrary with the work of Elsadig *et al.* (2013) and Mostopha *et al.* (2002); but in line with the work of Mohamed *et al.* (2012) on tomato. This differences could be attributed to the lesser effect of the environmental factors on these characters; similar conclusions have been drawn by Elsadig *et al.* (2013).

Most of the traits examined in this study showed a wide range of genetic variability among the evaluated accessions (Vijah and Manohar, 1990). The variations obtained among the genotypic coefficient of variation for most of the characters shows that the genetic advances for selection of a character depends on the amount of genetic variability of such characters. Similar inferences have been drawn by Wong and Baker (1986); Elsadig *et al.* (2013).

High values of heritability estimates recorded for most of the traits indicate that these traits possessed wide range of genetic variability and their improvement could be achieved with mass selection (Elsadig *et al.*, 2013; Mostofa *et al.*, 2002). High heritability coupled with high genetic advance (GA) for number of fruit per plant, number of branches at flowering, plant height at different stages, weight of fruit and number of seeds per capsule is an indication of additive gene effects on such traits (Mostofa *et al.*, 2002). The high heritability indicates that this character is highly genetically controlled and less affected by environment (Abou El-Nasr *et al.*, 2014). Jalal and Ahmad (2012), emphasized the importance of heritability and genetic advance as selection parameters. High values of GA are indication of additive gene action while low GA values are indication of non-additive gene action (Singh and Narayanan, 1993). Genotypic coefficient of variation, which is the real indicator of the

extent of genetic variability in a population, was high for all the characters, except stem circumference at harvest. Similar results were obtained by Pradeepkumar and Tewari (1999).

However, the association of the genetic advance and heritability does not follow similar trend or pattern as observed between genotypic coefficient of variation and genetic advance; increased heritability value does not always lead to a corresponding increase in genetic advance. Similar results were obtained by Gasim and Khidir (1998); Elsadig *et al.* (2013). In this present study, characters like plant height, number of branches per plant and number of seeds per capsule have strong genetic component and therefore high heritability; similar conclusion had been made by Sadras *et al.*, (2013).

For some of the traits that were observed in this study, like plant height, number of branches per plant, number of fruits, these characters should be selected for the improvement of the crop. This is because many scientists have reported highly significant correlations among some of these parameters. Ibrahim and Hussein (2006), reported a highly significant correlation between number of branches and number of fruits per plant as well as plant height and number of branches per plant at genotypic level in *H. sabdariffa*. Ottai *et al.* (2003), also made similar assertion.

In conclusion, wide genetic variability was observed among the Roselle accessions; this variability could be exploited in different breeding program of the crop. There was no definite pattern between genetic coefficient of variation and heritability as well as genetic advance. Therefore, combination of heritability estimates with genetic advance in the selection program is important.

Table 1: Estimation of some components of genetic parameters for some agro-metrical characters among the 20 Roselle accessions

Characters	Grand mean	Genotypic variance ($\sigma^2 g$)	Phenotypic variance ($\sigma^2 P$)	Environmental variance (e^2)	Broad sense heritability (h^2)/%	Genotypic coefficient of variation (GCV)/%	Phenotypic coefficient of variation (PCV)/%	Genetic advance (GA)	GA as a % of Mean
Plant Height at 4 weeks after thinning (cm)	12.32	3.47	16.77	13.31	21.00	15.12	33.24	1.77	14.37
Plant Height at 6 weeks after thinning (cm)	18.61	26.13	39.72	13.60	66.00	27.47	33.87	8.57	46.05
Plant Height at 8 weeks after thinning (cm)	25.96	26.75	60.44	33.69	44.00	19.92	29.94	7.05	27.16
Plant Height at 50 % flower bud formation (cm)	35.41	68.82	114.19	45.37	60.00	23.43	30.18	13.21	37.31
Plant Height at 50% flowering (cm)	47.41	166.57	251.82	85.25	66.00	27.22	33.47	21.58	45.52
Plant Height at harvest (cm)	185.78	433.33	1579.67	1146.34	27.00	11.20	21.39	22.11	11.90
Number of branches per plant at 4 weeks after thinning	6.14	2.49	5.95	3.46	42.00	25.70	39.71	2.11	34.36
Number of branches per plant at 6 weeks after thinning	10.34	1.58	5.69	4.12	28.00	12.14	23.07	1.38	13.35
Number of branches per plant at 8 weeks after thinning	13.32	3.98	9.63	5.65	41.00	14.98	23.31	2.62	19.67
Number of branches per plant at 50 % flower bud formation	19.27	8.62	22.69	14.08	38.00	15.23	24.72	2.73	14.17
Number of branches per plant at 50% flowering	23.42	233.00	251.75	18.75	93.00	65.17	67.74	30.40	129.80
Number of leaves per plant at maturity	144.11	905.51	2300.44	1394.93	39.00	20.88	33.28	38.53	26.74
Number of fruits per plant	20.38	78.35	229.37	151.02	34.00	43.43	74.30	10.61	52.06
Weight of fruit (g)	6.99	2.63	5.59	2.96	47.00	23.20	33.83	2.23	31.90
Number of seeds per capsule	29.69	38.41	54.01	15.60	71.00	20.87	24.75	10.76	36.24
Stem circumference at harvest	7.706	0.44	3.30	2.86	13.00	8.61	23.59	0.49	6.36

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