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STUDIES ON GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR QUANTITATIVE TRAITS IN CASSAVA (*MANIHOT ESCULENTA* CRANTZ.)

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ABSTRACT
The present investigation was under taken to estimate the genetic variability, heritability and genetic advance for fourteen quantitative traits with 18 genotypes of cassava (*Manihot esculenta* Crantz.) in a randomized block design with three replications during kharif 2012-13 at HC and RI, Venkataramannagudem, Dr.Y.S.R.H.U. Analysis of variance revealed significant differences among the genotypes for all the traits studied indicating the presence of sufficient variability in the studied material. High magnitude of PCV and GCV were observed for number of leaves per plant, total leaf area, height of first branching, HCN content suggesting the existence of wide range of genetic variability in the germplasm for these traits and thus the scope for improvement of these characters through simple selection would be better. High heritability (h_b^2) estimates (>60%) coupled with high estimates from genetic gain as percent of mean (>20%) were observed for number of leaves per plant, total leaf area, height of first branching, stem diameter, tuber dry matter content, starch content, HCN content and tuber yield per hectare indicated that the heritability is due to additive gene effects which may be improved through simple plant selection methods.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) has been an important crop in South India as a subsidiary food as well as an industrial raw material especially in Kerala, Tamil Nadu and Andhra Pradesh. Genetic variability available within the cassava germplasm has not been fully explored and screened. The genetics of various yield attributing and qualitative traits in cassava remains poorly understood because of the heterozygous nature of the crop and its long life cycle of 9-12 months. Breeding progress is primarily determined by the magnitude, nature and inter-relations of genotypic and phenotypic variations in the various characters. Many of the economic traits of cassava are quantitatively inherited and are highly influenced by environmental conditions (Akinwale *et al.,* 2010). This necessitates partitioning of the overall variability into its heritable and non-heritable components with the use of suitable genetic parameters, such as genetic coefficient of variation, heritability estimates and genetic advance. Heritability estimates in the broad sense quantifies the relative magnitudes of genotypic and phenotypic variances for traits and serves as a predictive role in selection procedures (Allard, 1960). This gives an idea of the total variation ascribable to genotypic effects, which are exploitable portion of variation, (Mba and Dixon, 1995). Knowledge of the variability and heritability of various characters contributing to yield and to develop optimal breeding procedure is needed by cassava breeders. Yield is a complex character controlled by many quantitative genes. Its expression is therefore highly variable and it is improved by selecting for the components to yield (Akinyele and Osekita, 2006; Odeleye *et al.,* 2007; Osekita and Akinyele, 2008). The objective of this paper, therefore, is to estimate genetic parameters of some important quantitative characters and their implications in selection. Keeping in view of this, an attempt was made to know the nature and magnitude of genetic variability existing for yield and its contributing characters in 18 cassava genotypes.

MATERIALS AND METHODS

The experiment was conducted with 18 genotypes of(Table 1) cassava from July 2012 to February 2013 at the experimental farm of the Dept. of Vegetable Science, Horticultural College and Research Institute of Dr. Y.S.R. Horticultural University, Andhra Pradesh, India. This location, at 16º83′ N latitude, 81º50′ E longitude, is 34 m above mean sea level. Nursery beds were prepared with dimensions of 500 × 100 × 15 cm in length, width and height. Well matured healthy and disease free stems of previous season of each genotype were used as planting material for the experiment. The bottom (5 to 10 cm) and top 1/3rd portion of the stems were discarded and the remaining part was cut into setts of 20 cm length. These setts were planted in the nursery at 5 x 5 cm spacing on a raised nursery bed and watered regularly. The main field was thoroughly ploughed to a depth of 30 cm and brought to good tilth. The recommended synthetic fertilizer rate of

$N:P_2O_5:K_2O$ at 60:60:60 kg·ha^{-1} was applied as urea (130.4 kg·ha^{-1}), single-superphosphate (375 kg·ha^{-1}) and muriate of potash (100 kg·ha^{-1}), respectively. In which single-superphosphate was applied as basal dose where as urea and muriate of potash were applied in three equal split doses at 30, 60 and 90 days after transplanting. The experiment was arranged in a randomized complete block design with three replications in 4.5 × 4.5 m plots. Plantings were affected in the plots with the young healthy one week old sprouted settlings obtained from the nursery at a spacing of 90 x 90 cm between and with-in rows and 5 cm depth. Plots were kept free from weeds by regular hand weeding. Five plants of each genotype in each replication were randomly chosen and labeled for recording observations. Single plant observations were recorded on 14 quantitative characters (petiole length, number of leaves per plant, total leaf area, plant height, height to first branching, stem diameter, number of tubers per plant, tuber length, tuber diameter, plant dry matter, tuber dry matter, starch content, HCN content and tuber yield per hectare) by using the descriptors suggested by Fukuda *et al.* (2010) and the means of 5 plants were used for statistical analysis. Tuber samples were taken at the time of harvest for determination of starch percentage, cyanogenic potential (HCN), dry matter content. Percentage of starch content was determined by using the method outlined by Mccready *et al.* (1950), cyanogenic potential in tubers was estimated by the method described by Indira and Sinha (1969) and the dry matter content was determined based on the specific gravity method (Kawano *et al.,* 1987). Phenotypic and genotypic coefficients of variation (PCV and GCV) were computed according to Burton and Devane (1953). Heritability in broad sense was estimated as per Allard (1960). Genetic advance was estimated as per the formula proposed by Lush (1940). The range of genetic advance as per cent of mean was classified as low (Less than 10%), moderate (10 - 20%) and high (more than 20%) suggested by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) showed highly significant differences ($P < 0.01$) among the genotypes for the entire yield and yield component traits studied (Table 2). These findings are in line with earlier reports of Rajendran *et al.* (1985), Sree kumari and Abraham (1991), Aina *et al.* (2007), Sankaran *et al.* (2008) Ntawuruhunga and Dixon (2010), Ashok *et al.* (2013), Boakye *et al.* (2013), Okpara *et al.* (2014), Om Prakash Meena and Vijay Bahadur, (2014) and Janaki *et al.* (2015). The studies suggested that it is possible to isolate superior genotypes during the selection process. Genetic variability is a basic information needed for the breeders to improve the crops by adopting appropriate method of selection based on variability that exist in the material. In the present study, wide variability was recorded for number of leaves per plant, total leaf area, height of first branching, number of tubers per plant and HCN content (Table 3). Higher magnitude of PCV (phenotypic coefficient of variation) and GCV (genotypic coefficient of variation) (> 20%) were observed for number of leaves per plant (40.86 and 40.63), total leaf area (57.09 & 55.94), height to first branching (26.94 and 26.87) and HCN content (51.26 and 39.28) indicating the existence of wide range of genetic variability in the germplasm for these traits (Table 3). High GCV and PCV values indicating large amount of variation and consequently more scope for their improvement through selection (Biradar *et al.* 1978). These findings are in agreement with results of Ntui *et al.* (2006) for number of leaves per plant, Ntawuruhunga and Dixon (2010) for total leaf area.

The estimates of PCV and GCV were moderate for plant height (14.05 and 10.56 cm), stem diameter (14.96 and 14.82), tuber length (18.62 and11.72), tuber diameter (13.97 and 11.60), tuber dry matter content (13.53 and 13.52), starch content (11.24 and 11.16) and tuber yield per hactare (16.71 and 15.17). These results are in accordance with the findings of Suryakumari and Anuradha (2000) for stem diameter, tuber length and tuber dry matter content, Akinwale *et al.* (2010) and Ashok *et al.* (2013) for plant height, Nageswari and Palanisamy (2011) for tuber diameter and tuber dry matter content. With the genotypic coefficient of variation alone, it is difficult to determine the relative amount of heritable and non-heritable components of variations present in the population. Estimates of heritability and genetic advance would supplement this parameter.

The heritability in broad sense ranged for the characters from 40 per cent for tuber length to 100 per cent for the plant and tuber dry matter content. In general the values of heritability in broad sense were high for petiole length (92.58), number of leaves per plant (99.00), total leaf area (96.01), height of first branching (99.45), stem diameter (98.03), plant dry matter content (100), tuber dry matter content (100), starch content (99.00) and tuber yield per hectare (82.50) indicating that the characters were least influenced by the environmental effects, but the selection for the improvement of such characters may not be useful, because broad sense heritability is based on genetic variance which includes both fixable (additive) and non fixable (dominance and epistatic) variances. These results are in concurrence with the findings of Naskar *et al.* (1991) and Adeniji *et al.* (2011) for petiole length, Biradar *et al.* (1978),

Table 1 : List of cassava genotypes used in the experiment and their source

Treatment	Accession number	Source
T_1	CI – 800	HRS, AICRP On Tuber Crops,Venkata ramannagudem
T_2	CMR – 15	-do-
T_3	H - 740/92	-do-
T_4	CMR – 21	-do-
T_5	CMR – 1	-do-
T_6	PDP accession – 1	-do-
T_7	PDP accession – 2	-do-
T_8	PDP accession – 3	-do-
T_9	PDP accession -4	-do-
T_{10}	PDP accession – 5	-do-
T_{11}	PDP accession – 6	-do-
T_{12}	PDP accession -7	-do-
T_{13}	PDP accession – 8	-do-
T_{14}	PDP accession – 9	-do-
T_{15}	PDP accession – 10	-do-
T_{16}	H – 165	-do-
T_{17}	Sree Jaya (CI – 649)	-do-
T_{18}	Sree Padmanabha (MNga – 1)	-do-

Table 2 : Analysis of variance for quantitative traits in cassava genotypes

S.No	Character	Mean sum of squares		
		Replications (df = 2)	Treatments (df = 17)	Error (df = 34)
1.	Petiole length (cm)	0.38	37.01**	0.96
2.	Number of leaves per plant	1091.35	4071524.50**	15144.23
3.	Total leaf area (cm^2)	303157088.00	72140939264.00**	984320896.00
4.	Plant height (cm)	1096.30	8863.94**	1808.06
5.	Height of first branching (cm)	21.99	5439.22**	9.94
6.	Stem diameter (cm)	0.16*	5.93**	0.04
7.	Number of tubers per plant	12.17	33.92**	8.72
8.	Tuber length (cm)	22.04	95.78**	32.29
9.	Tuber diameter (cm)	2.25	18.18**	2.37
10.	Plant dry matter content (%)	0.05	21.46**	0.03
11.	Tuber dry matter content (%)	0.08	84.59**	0.04
12.	Starch content (%)	0.13	21.75**	0.10
13.	HCN content (ppm)	2520.91	5217.74**	990.13
14.	Tuber yield (t/ha)	5.46	78.01**	5.15

Table 3 : Estimates of variability, heritability and genetic advance as per cent of mean for different characters in cassava genotypes

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	h^2 (%)	Genetic	GA as %
		Minimum	Maximum		Phenotypic	Genotypic				Advance	of mean
1	Petiole length (cm)	32.56	45.14	36.95	12.98	12.02	9.75	9.38	92.58	6.87	18.59
2	Number of leaves per plant	1045	4299.33	2861.63	1367271	1352127	40.86	40.63	99	2382.09	83.24
3	Total leaf area (cm^2)	123920.3	700483.4	275289.8	2.47E+10	2.37E+10	57.09	55.94	96.01	310874.2	112.93
4	Plant height (cm)	355	556.67	459.07	4160.02	2351.96	14.05	10.56	57	75.12	16.36
5	Height of first branching (cm)	71.2	259.33	158.33	1819.7	1809.76	26.94	26.87	99.45	87.4	55.2
6	Stem diameter (cm)	7.54	12.76	9.46	2	1.96	14.96	14.82	98.03	2.86	30.22
7	Number of tubers / plant	11.67	23	17.11	17.12	8.4	24.18	16.94	49.08	4.18	24.45
8	Tuber length (cm)	30.73	52.01	39.26	53.45	21.16	18.62	11.72	40	5.96	15.19
9	Tuber diameter (cm)	15.62	25.23	19.79	7.64	5.27	13.97	11.6	68.95	3.93	19.84
10	Plant dry matter content (%)	24.54	33.78	28.82	7.17	7.14	9.29	9.27	100	5.5	19.07
11	Tuber dry matter content (%)	29.45	46.82	39.28	28.22	28.18	13.53	13.52	100	10.93	27.82
12	Starch content (%)	20.8	30.07	24.06	7.32	7.22	11.24	11.16	99	5.5	22.84
13	HCN content (ppm)	48.1	197.3	95.56	2399.33	1409.2	51.26	39.28	59	59.26	62.02
14	Tuber yield per ha (t/ha)	25.27	44.93	32.48	29.44	24.29	16.71	15.17	82.5	9.22	28.39

Suryakumari and Anuradha, (2000) and Adeniji *et al*. (2011) for number of leaves, Ntawuruhunga and Dixon (2010) for total leaf area, Aina *et al*. (2007) and Adeniji *et al*. (2011) for stem diameter and tuber dry matter content, Nageswari and Palanisamy (2011) for tuber diameter and starch content, Biradar *et al*. (1978), Naskar *et al*. (1991), Suryakumari and Anuradha (2000) and Aina *et al*. (2007) for tuber yield for hectare.

Plant height (57.00), number of tubers per plant (49.08), tuber length (40.00) and HCN content (59.00) recorded moderate value of heritability (30-60 %) indicating the role of non-additive gene action which includes dominance and epistasis. Presence of moderate heritability for plant height is in agreement with Biradar *et al*. (1978), Suryakumari and Anuradha (2000), Ntawuruhunga and Dixon (2010) and Ashok *et al*. (2013) for number of tubers per plant. Heritability estimates alone are not of any use in predicting the results about the selection unless it is accompanied by genetic advance (Johnson *et al*., 1955). The expected genetic advance (EGA) expressed as percentage of mean ranged from 15.19 per cent (Tuber length) to 112.93 per cent (Total leaf area).

In the present study high value of EGA was observed for the character total leaf area (112.93), followed by number of leaves per plant (83.24), HCN content (62.02), height of first branching (55.20), stem diameter (55.20), tuber yield per hectare (28.39), tuber dry matter (27.82), number of tubers per plant (24.45) and starch content (22.84) indicating the role of additive gene action and hence, selection is more effective. While moderate value of EGA was recorded for tuber length (15.19), plant height (16.36), plant dry matter (19.07) and tuber diameter (19.84), indicating the role of non-additive gene action. The characters which were observed high to moderate estimates of EGA are indicative of the fact that improvement could be quickly achieved in these characters through selection.

The findings indicate that there exists adequate genotypic variation in the genotypes for number of leaves per plant, total leaf area, height of first branching, number of tubers per plant and HCN content showing high PCV,GCV and high heritability coupled with high estimates from genetic gain as percent of mean for number of leaves per plant, total leaf area, height of first branching, stem diameter, root dry matter, starch content, HCN content and tuber yield per hectare suggesting predominance of additive gene action and lower influence of environmental factors in the expression of these traits with possibility for improvement through selection.

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