Original Research Article

Studies on Genetic Variability, Correlation Analysis in Cassava (*Manihot esculenta* Crantz) Accessions

ABSTRACT

The study was carried out in Tapioca and Castor Research Station, Yethapur to study the" GeneticVariabilty and Correlation analysis in Cassava (*Manihot esculenta* Crantz) accessions". Observations on plant height, stem girth, number of tiers, intermodal length, number of leaves per plant, Leaf area index (LAI), chlorophyll content, height at first branching, number of tubers per plant, length of tuber, girth of tuber, yield of tuber per plant, dry matter content, starch content, severity score of CMD (Cassava Mosaic Disease were recorded. Genetic Variability and Genotypic correlation among the cassava accessions were analyzed. High Genotypic coefficients of variation (GCV) were found for LAI, height at first branching, number of leaves per plant, number of tiers, yield of tuber per plant and severity scores of CMD whereas low GCV were found for Chlorophyll content. Phenotypic Coefficients of Variation were higher than Genotypic coefficients of Variation for all the observed characters. Plant height, number of tiers, internodal length, number of leaves per plant, LAI, height at first branching, length of tubers, dry matter content, severity scores of CMD, tuber yield recorded high heritability with high GAM suggesting that these characters are under the additive gene control and selection for genetic improvement would be successful. Chlorophyll content, girth of tuber and starch content recorded high heritability coupled with moderate GAM whereas stem girth recorded moderate heritability and GAM which offers only less scope for selection that is due to non-additive gene actions. The correlation analysis results showed that yield of tuber per plant had high positive and high significant correlation with plant height, number of tubers per plant, starch content, length of tuber, girth of tuber and weight of tuber. Genetic variability and correlation analysis provides a knowledge which would be helpful in selecting the cassava accessions with greater yield potential.

Keywords: Cassava; PCV; GCV; genetic advance; correlation; tuber yield

1. INTRODUCTION

Starchy root and tuber crops are pivotal globally, serving as significant sources of carbohydrates, ranking just behind cereals. These crops, including cassava, sweet potatoes, yams, aroids (such as taro and elephant foot yam), and various minor tuber crops like arrowroot and Chinese potato, are essential for ensuring food security and bolstering economic stability in numerous regions. Annually, these crops collectively yield approximately 836 million tonnes worldwide [1]. These crops not only fulfill crucial dietary needs but also furnish raw materials for industry and significantly contribute to animal feed production [2]. The wide variety of tropical tuber crops underscores their adaptability to diverse climates, making them indispensable for maintaining agricultural diversity and enhancing global food security.

The Manihot genus, consisting of around 300 genera and approximately 8000 species, is considered one of the largest families among flowering plants [3]. Cassava (*Manihot esculenta* Crantz) is a highly heterozygous, perennial tropical tuber crop belongs to the family Euphorbiaceae with chromosome number 2n= 36, which provides source of energy for more than 800 million people worldwide [4]. Because of its diverse applications in the food industry as additives, ingredients in livestock feed, and industrial processing for the production of starch, sago, various sweeteners, and ethanol, cassava has emerged as a major crop for international trade [5].India ranks fifth globally in cassava cultivation, following Brazil, Zaire, Nigeria, and Indonesia. The country produces 6853 thousand metric tonnes (MT) of tapioca on approximately 186 thousand hectares of land [6]. Tamil Nadu alone contributes 83.75% to India's total production. Cassava cultivation is also practiced in Kerala, Karnataka, Andhra Pradesh, Maharashtra, Assam, and Nagaland.

The Tapioca and Castor Research Station (TCRS), Tamil Nadu Agricultural University (TNAU) in Yethapur, developed cassava hybrids for evaluating and aimed to enhance the yield of this tuber crop. In this study, the assessment of genetic variability and correlation among 11 cassava hybrids and 2 check varieties helps in selecting superior cassava varieties that can significantly enhance yield through breeding strategies. These genetic variability and correlation studies are essential for discerning the range of genetic traits within the hybrids and their association with yield-related characteristics.

2. MATERIAL AND METHODS

2.1 Plant Materials and Experimental Design

The study on genetic variability and correlation on cassava accessions was carried out at Tapioca and Castor Research Station, TNAU, Yethapur. Totally 11 cassava hybrids developed from TCRS, Yethapur and 2 check varieties viz., Sree Kaveri (National Check) and YTP-2 (Local check) were evaluated in this study (Table 1).

Table. 1 Details and sources of Cassava accessions

Accessions	Source	Accessions	Source
TCS 1	TCRS, Yethapur	TCS 8	TCRS, Yethapur
TCS 2	TCRS, Yethapur	TCS 9	TCRS, Yethapur
TCS3	TCRS, Yethapur	TCS 10	TCRS, Yethapur
TCS 4	TCRS, Yethapur	TCS 11	TCRS, Yethapur
TCS 5	TCRS, Yethapur	Sree Kaveri(National Check)	CTCRI, Thiruvananthapuram
TCS 6	TCRS, Yethapur	YTP 2 (Local check)	TCRS, Yethapur
TCS 7	TCRS, Yethapur		

These accessions were grown in Randomized block design and they were replicated thrice, with the spacing of 90x90 cm apart. The plot was ploughed and tilled finely. Following the standard recommendation of crop production guide (2020), fertilizers were applied at rates of 45:90:120 kg/ha with 25 tonnes of FYM as basal dressing. Setts, 15 cm in length with 6-8 nodes, were taken from 12-month-old parent stem. In the third month, weeding, hoeing, and earthing up were done. A top dressing of 45:0:120 kg/ha of NPK was applied during earthing up. Observations on plant height, stem girth, number of tiers, intermodal length, number of leaves per plant, Leaf area index (LAI), chlorophyll content, height at first branching, number of tubers per plant, length of tuber, girth of tuber, yield of tuber per plant, dry matter content, starch content, severity score of CMD (Cassava Mosaic Disease) were recorded. Genetic parameters such as coefficients of variation *viz*., (Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), broad-sense heritability, and genetic advance were calculated.

Phenotypic coefficient of variation and Genotypic coefficient of variation is calculated as given by Burton (1952) [7]. PCV and GCV estimates were categorized into low (0-10%), moderate (10-20%), and high (>20%) ranges following the criteria established by Sivasubramanian and Madhavamenon [8]. Broad-sense heritability (h2b) was determined using the formula proposed by Johnson et al.,[9] and Hanson et al., [10]. Broad-sense heritability (h2b) were categorized into low (0-30%), moderate (30-60%), and high (>60%) Genetic advance was calculated using the formula provided by Johnson et al., [9].Genetic advance as percent mean estimates were categorized into low (0-10%), moderate (10-20%), and high (>20%) ranges. The equation provided by Weber and Moorthy [11]was utilized to calculate simple correlations. The statistical analysis was carried out in R 4.1.2 Software using the package 'agricolae' for genetic variability and 'corrplot' for correlation analysis.

3. RESULTS AND DISCUSSION

3.1. Genetic parameters

3.1.1.Phenotypic and Genotypic Coefficient Variation

The amount of variability available within the genotype indicates the potentiality that could be exploited further. A larger phenotypic coefficient of variation was found than its genotypic coefficient of variation indicating that the major role of genetic factors in the expression of variability of these characters. There is only marginal difference found between the characters between PCV and GCV taken in study. Among characters studied number of tiers, internodal length, number of leaves per plant, Leaf area index, height at first branching, severity scores of CMD and tuber yield per plant showed high PCV and GCV. These are in accordance with Revathi et al., [12],Koundinya et al., [13], Babu Rao et al., [14],Polamuri et al., [15]. Plant height, stem girth, number of tubers, length of tuber, girth of tuber, dry matter content content and starch content showed moderate GCV and PCV whereas chlorophyll content showed low GCV and PCV. The traits with lower PCV and GCV show that it has limited potential for improvement.

3.1.2. Heritability and Genetic Advance

Genetic advance represents the inherited improvement in offspring compared to the original population due to selection, providing insight into the efficacy of selection processes. Due to the influence of environmental factors on traits, the magnitude of genetic advance can vary significantly. Therefore, genetic advance as a percentage of the mean was computed to predict the potential genetic gain, facilitating relative comparisons of traits under varying environmental conditions. Traits with high heritability and substantial genetic advance indicate a significant proportion of additive genetic variance, leading to higher genetic gains through selection [16]. Conversely, traits characterized by low heritability coupled with high genetic advance are likely influenced by non-additive genetic effects, suggesting limited effectiveness in selection [17]. In general, most traits exhibited high heritability values, emphasizing their potential for effective breeding programs.

Traits such as plant height, number of tiers, internodal length, number of leaves per plant, leaf area index, height at first branching, number of tubers, length of tuber, girth of tuber, starch content, dry matter content, severity scores of CMD incidence, tuber yield per plant recorded high heritability coupled with high genetic advance as a percentage of mean. The results indicate that these characteristics exhibit significant selection responses and are predominantly governed by additive genetic mechanisms. The finding is in the line of Perpahet al., [18] in cassava, Babu Rao et al., [14], Polamuri et al., [15]and Akinwale et al., [19]in cassava. The character stem girth shows moderate heritability coupled with genetic advance as percentage of mean whereas chlorophyll content showed high heritability with moderate genetic advance as percentage of mean. It is rational to infer that non-additive genetic factors govern this trait, making selection for such traits less productive. Heritability is positively influenced by the environment rather than genotype alone, thus direct selection methods may not be effective. However, improvements can be achieved through hybridization or utilizing transgressive segregants in heterosis breeding programs.

Table 2. Genotypic and phenotypic coefficient of variations, heritability, genetic advance and genetic advance as percent mean of Cassava accessions

Parameters	Genotypic coefficient of variations	Phenotypic coefficient of variations	Heritability %	Genetic advance value % means
Plant height	12.42	14.76	70.82	21.53
Stem Girth	13.32	19.93	44.71	18.35
Number of tiers	40.24	41.48	94.09	80.40
Internodal Length	25.42	26.03	95.31	51.11
Number of leaves per plant	49.65	57.16	75.44	88.83
LAI	73.35	78.66	86.95	140.90
Chlorophyll content	6.63	8.54	60.32	10.61
Height at first branching	54.24	54.66	98.46	110.88

Number of tubers	13.92	15.31	82.60	26.06
Length of tubers	17.43	19.99	76.07	31.32
Girth of tubers	15.89	17.71	80.49	29.36
Dry matter content	15.12	15.23	98.53	30.92
Starch content	11.61	11.75	97.72	23.65
Severity scores of CMD Incidence	26.97	28.07	92.36	53.40
Tuber yield per plant	33.30	35.87	86.20	63.69

3.2. Correlation studies

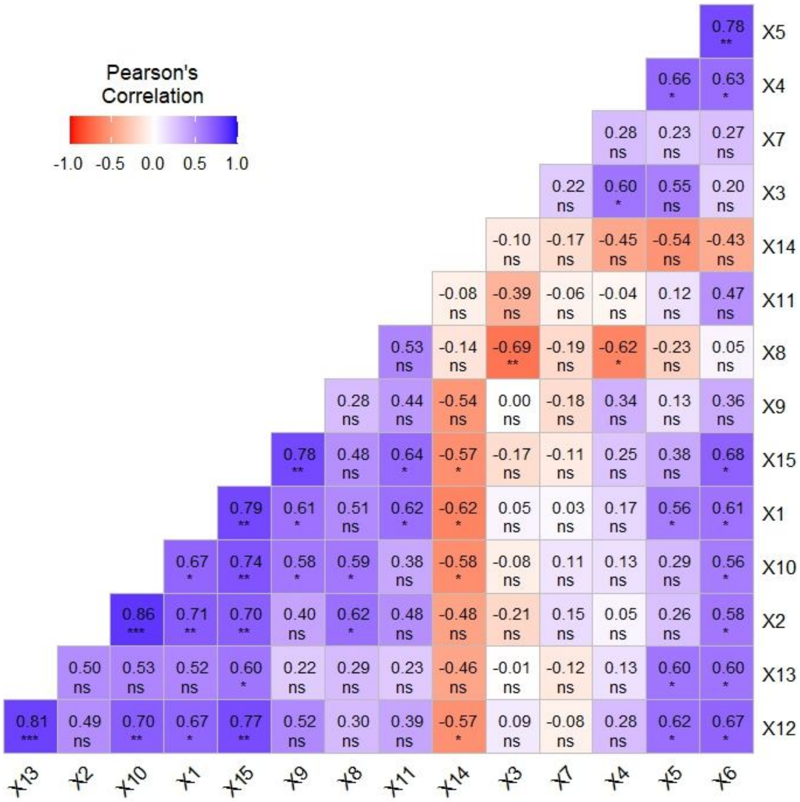
The genetic enhancement of tuber yield, a primary focus for plant breeders, is governed by multiple genes. According to Graffing (1956), any changes in tuber yield must coincide with alterations in one or more traits, although modifications in individual components do not necessarily affect the overall yield. This is because of diverse degrees of positive and negative correlations among yield, its components, and their interrelationships. In this context, simple correlation coefficients between tuber yield and its components were computed (Fig.1).

The traits such as plant height, stem girth, number of tubers, length of tuber showed highly significant and positive genotypic correlation with yield of the tuber per plant. These reports are in agreement with findings Revathi et al., [12] in cassava. Starch content also showed highly significant and positive correlation with tuber yield per plant which is in line with the report of Babu Rao et al., [14] and Ntwuruhunga and Dixon [20] in cassava.However, it is contrary to the report of Swati sivan. Leaf area index, girth of the tuber, dry matter content is significant and positively correlated with tuber yield which is in accordance with the result of Njoku and Mbah [21] in cassava. Severity scores of CMD is significant and negatively correlated with tuber yield which is in the line of the report of Adeniji et al., [22]in cassava.

The starch content showed a highly significant and positive correlation with the dry matter content. This is in accordance with the study of Abebe et al., [23] in potato.

Leaf area index is positively correlated with plant height, stem girth, internodal length, length of tuber, starch content and dry matter content. Number of tubers is positively correlated with plant height and length of the tuber. Cassava mosaic disease severity score showed a negative correlation with plant height, length of tuber and starch content is in accordance with the results of Elegba et al., [24].

Identifying traits that show both a positive and significant correlation with yield and are interconnected would be advantageous in a breeding program focused on enhancing multiple characteristics concurrently. Consequently, selecting for these traits in high-yielding accessions would lead to the identification and release of superior individual plant selections, paving the way for the development of new and improved varieties in the future.



	X13	X2	X10	X1	X15	X9	X8	X11	X14	X3	X7	X4	X5	X6
X5														0.78 **
X4													0.66 *	0.63 *
X7												0.28 ns	0.23 ns	0.27 ns
X3											0.22 ns	0.60 *	0.55 ns	0.20 ns
X14										-0.10 ns	-0.17 ns	-0.45 ns	-0.54 ns	-0.43 ns
X11									-0.08 ns	-0.39 ns	-0.06 ns	-0.04 ns	0.12 ns	0.47 ns
X8								0.53 ns	-0.14 ns	-0.69 **	-0.19 ns	-0.62 *	-0.23 ns	0.05 ns
X9							0.28 ns	0.44 ns	-0.54 ns	0.00 ns	-0.18 ns	0.34 ns	0.13 ns	0.36 ns
X15						0.78 **	0.48 ns	0.64 *	-0.57 *	-0.17 ns	-0.11 ns	0.25 ns	0.38 ns	0.68 *
X1					0.79 **	0.61 *	0.51 ns	0.62 *	-0.62 *	0.05 ns	0.03 ns	0.17 ns	0.56 *	0.61 *
X10				0.67 *	0.74 **	0.58 *	0.59 *	0.38 ns	-0.58 *	-0.08 ns	0.11 ns	0.13 ns	0.29 ns	0.56 *
X2			0.86 ***	0.71 **	0.70 **	0.40 ns	0.62 *	0.48 ns	-0.48 ns	-0.21 ns	0.15 ns	0.05 ns	0.26 ns	0.58 *
X13		0.50 ns	0.53 ns	0.52 ns	0.60 *	0.22 ns	0.29 ns	0.23 ns	-0.46 ns	-0.01 ns	-0.12 ns	0.13 ns	0.60 *	0.60 *
X12	0.81 ***	0.49 ns	0.70 **	0.67 *	0.77 **	0.52 ns	0.30 ns	0.39 ns	-0.57 *	0.09 ns	-0.08 ns	0.28 ns	0.62 *	0.67 *

ns p >= 0.05; * p < 0.05; ** p < 0.01; and *** p < 0.001

Fig.1. Pearson correlation matrix of different cassava quantitative traits

X1- Plant height (cm)
X2- Stem girth (cm)
X3- Number of tiers
X4- Internodal length (cm)
X5- Number of leaves per plant
X6- Leaf area index
X7- Chlorophyll content (SPAD value)
X8- Height at first branching (cm)
X9- Number of tubers
X10- Length of tuber (cm)
X11- Girth of tuber (cm)
X12- Starch content (%)
X13-Dry matter content (%)
X14- Severity scores of CMD
X15- Tuber yield per plant (Kg)

4. CONCLUSION

Based on this study, it is concluded that in breeding programs aimed at improving multiple traits simultaneously, traits that exhibit positive and significant correlations with yield, as well as among themselves, are considered desirable. Traits such as plant height, number of tubers per plant, starch content, tuber length, tuber girth, and tuber weight contribute to the simultaneous enhancement of tuber yield per plant and are mutually correlated. The highest levels of both genotypic and phenotypic variation were observed in traits such as leaf area index (LAI), height at first branching, number of leaves per plant, number of tiers, tuber yield per plant, and severity scores of CMD (Cassava Mosaic Disease). Traits such as plant height, number of tiers, internodal length, number of leaves per plant, LAI, height at first branching, tuber length, dry matter content, severity scores of CMD, and tuber yield showed the highest heritability and genetic advancement. Furthermore, these traits are reliable predictors of tuber production and can serve as markers for yield in the selection process.

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