



Plant Archives

Journal homepage: <http://www.plantarchives.org>DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.178>

VARIABILITY STUDIES FOR YIELD AND QUALITY TRAITS IN CASSAVA (*MANIHOT ESCULENTA* CRANTZ)

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(Date of Receiving-05-07-2025; Date of Acceptance-09-09-2025)

ABSTRACT

The present investigation was carried out at Dr. YSRHU - Horticultural Research Station, Peddapuram, Kakinada District, Andhra Pradesh during *Kharif* season, 2024-25 in augmented design of seven blocks with sixty-one genotypes including three checks (PDP CMR-1, Sree Reksha and Local farmer variety). Analysis of variance revealed significant differences for all characters except for plant height, petiole length and total sugars. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for all traits. The characters *viz.* leaf area index, number of storage roots per plant, number of commercial roots per plant, harvest index, starch content, HCN content, mean tuber weight and tuber yield per plant and cassava mosaic incidence were exhibited high magnitude for both PCV and GCV indicating the existence of wide range of genetic variability among the genotypes and the environment has minimal impact on these parameters and making selection based on these traits will be rewarding. High Heritability (h_p^2) coupled with high genetic advance as per cent of mean were observed for leaf area index, tuber and plant dry matter (%), number of storage roots per plant, number of commercial roots per plant, tuber length, harvest index, starch content (%), mean tuber weight (g), tuber yield per plant (kg), tuber yield (t/ha) and cassava mosaic disease incidence(%) indicating the preponderance of additive gene action making the direct selection based on these traits is more effective.

Key words: Cassava, Phenotypic coefficient of variation, genotypic coefficient of variation, Heritability and genetic advance

Introduction

Cassava (*Manihot esculenta* Crantz) is a perennial shrub, belong to Euphorbiaceae family having chromosome number of $2n=2x=36$, widely cultivated across the tropical regions of the world starting from Southern America to South East Asia through Sub-Saharan Africa. It is known to produce more energy per unit area per unit time and it has become an important source of energy for millions of people in the tropical and subtropical parts of the world (Yan *et al.*, 2013). The Brazilian-Bolivian Centre is the primary cassava diversity Centre. It was introduced to India (Kerala) during the 17th century by the Portuguese from Brazil (Edison *et al.*, 2006). It is highly drought tolerant crop and can be

successfully grown even in marginal soils where many other crops are less able to grow well. It requires minimum care during entire period of cultivation which makes it a suitable crop for many small and marginal farming communities (Janaki *et al.*, 2023). It has moved from being a subsistence crop to a fully commercial crop, due to its income generating capacity and enormous potential for animal feed, raw material for various starch-based industries *viz.* manufacturing of sago, paper, textile, sweeteners, confectionary, cosmetics, wood, pharmaceutical, bio-ethanol, biodegradable plastics, super absorbent polymers, adhesives, hydrogels and small-scale industries (snack items) (Janaki *et al.*, 2024). Thus, this tuber crop is not only a poor man's food but also a cash crop for millions of people living in rural areas.

Table 1: List of genotypes under study.

BLOCK-1	BLOCK-2	BLOCK-3	BLOCK-4	BLOCK-5	BLOCK-6	BLOCK-7
Ca op-1	Ca op-9	Ca op-30	Ca op-12	PDP CMR-1	Ca op-63	Local
Ca op-4	PDP CMR-1	Ca op-38	Ca op-17	Ca op-40	Local	Ca op-34
Sree Reksha	Ca op-23	Local	Sree Reksha	Ca op-44	Ca op-21	Sree Reksha Ca op-15
Ca op-51	Ca op-57	Ca op-24	Ca op-58	Ca op-46	Ca op-11	Ca op-13
Ca op-54	Local	Ca op-2	Ca op-6	Local	Ca op-18	PDP CMR-1
Ca op-55	Ca op-60	Ca op-14	Ca op-39	Ca op-53	PDP CMR-1	Ca op-22
PDP CMR-1	Ca op-7	Sree Reksha	Local	Ca op-28	Ca op-31	
Ca op-72	Ca op-29	Ca op-52	Ca op-8	Ca op-70	Ca op-49	
Ca op-32	Ca op-16	Ca op-56	Ca op-66	Ca op-37	Sree Reksha	
Local	Ca op-21	Ca op-62	PDP CMR-1	Ca op-50	Ca op-35	
Ca op-3	Ca op-42	PDP CMR-1	Ca op-47	Sree Reksha	Ca op-61	
Ca op-20	Sree Reksha	Ca op-26	Ca op-43	Ca op-33	Ca op-10	

Nigeria is the leading producer and consumer of cassava. Tamil Nadu is the major cassava producing state in India followed by Kerala and Andhra Pradesh. The average productivity of cassava in India is 36.66 t/ha with 6856000 MT production from 187000 ha area (Agricultural Statistics at a Glance, 2022). In Andhra Pradesh it is about 12.60 t/ha with 47124 tonnes of production from 3739 ha area (Season and Crop Report, AP, 2022-23). In Andhra Pradesh, the area under cassava cultivation gradually decreasing year by year from 7433 ha (2018-19) to 3739 ha (2021-22) due to many reasons such as replacement of area by other commercial crops like oil palm, lack of minimum support price *etc.* Thus, there is need to develop high yielding and less input responsive varieties coupled with CMD resistance, high starch content *etc.* for sustainable production system. Germplasm characterization and evaluation for genetic diversity studies is the prerequisite to identify the highly heritable traits that are generally important to breeders and researches in crop improvement.

Improvement in any crop is proportional to the magnitude of its genetic variability present in germplasm. Greater the variability in a population, there are the greater chance for effective selection for desirable types (Vavilov, 1951). Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. Higher the heritable variation, greater will be the possibility of fixing the characters by selection. Hence, heritability studies are of foremost importance to judge whether the observed variation for a particular character is due to genotype or due to environment. Heritability estimates may not provide clear predictability of the breeding value. Thus, estimation of heritability accompanied with genetic advance is generally more useful than heritability alone in prediction of the resultant effect for selecting the best individuals (Johnson *et al.*, 1955). Therefore, the present investigation was carried out with a view to study the

genetic variability, heritability and genetic advance for yield and yield component characters in 61 cassava genotypes.

Material and Methods

The present investigation in cassava was carried out at Dr. YSRHU- Horticultural Research Station, Peddapuram, Kakinada Dist., Andhra Pradesh During *Kharif*, 2024. The experiment was laid out in Augmented design with seven blocks using 58 genotypes along with three checks (Table 1). It is propagated vegetatively through stem cuttings /stakes /setts. The nursery was raised during third week of June and transplanted during last week of June at a spacing of 90 cm × 90 cm in a row of 13 m length (experimental unit). Each row consisted of 13 plants, of which five competitive plants were selected at random for recording the observations on plant height (m), stem girth (cm), petiole length (cm), leaf area index, number of storage roots per plant, number of commercial roots per plant, tuber length (cm), tuber girth (cm), harvest index, mean tuber weight (g), tuber yield per plant (kg), tuber yield (t/ha), plant dry matter (%) and tuber dry matter (%). The crop was raised as per the recommended package of practices.

The percent of starch content and per cent of total sugars were estimated by using the method outlined by Moorthy and Padmaja (2002). The hydrogen cyanide content (HCN) in tubers was estimated by the method described by Indira and Sinha (1969) and expressed in ppm.

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1985). The magnitude of phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) present in a trait was calculated by using the formula suggested by Burton (1952). Genotypic variance and phenotypic variances are calculated using the method suggested by

Falconer (1981). The GCV and PCV values were classified as described by Sivasubramanian and Madhavamenon (1973). Heritability (broad sense) is calculated as per the procedure developed by Hanson *et al.*, (1956) and categorized as per the classification given by Johnson *et al.*, (1955). Genetic advance as per cent of mean selection intensity was worked out by using the formula given by Johnson *et al.*, (1955).

Results and Discussion

Analysis of variance (Table 2) revealed significant differences for all the characters except for plant height, petiole length and total sugars. The significant differences in various traits indicated the presence of considerable genetic variability among the genotypes. These results are in accordance with the earlier reports of Surya kumari and Anuradha (2000), Babu Rao *et al.*, (2016), Danquah *et al.*, (2016) in cassava. The extent of variability with respect to 17 characters measured in terms of mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) along with the amount of heritability (h), expected genetic advance and genetic advance as per cent of mean (GAM) are presented in Table 3.

The plant height ranged from 1.70 m to 3.01 m with a mean of 2.44 m. Stem girth was varied from 5.60 cm to 10.66 cm with an average of 8.54 cm. Petiole length was observed with range of 20.66 cm to 39.33 cm with a mean of 28.46 cm. Leaf area index was varied from 1.02 to 11.86 with an average of 6.03. The number of storage roots per plant had a range of 2.00 to 10.66 with a mean of 6.54. Number of commercial roots per plant varied from 1.25 to 9.33 with an average of 4.56. Tuber length had a wide variation from 16.00 cm to 45.93 cm with a mean of 29.17 cm. The tuber girth was in the range of 7.94 cm to 19.00 cm with a mean of 14.21 cm. The mean tuber weight was varied from 64.40 g to 951.76 g with a mean tuber weight of 371.25 g. With respect to plant dry matter per cent, the observed range was 17.98 per cent to 44.33 per cent with a mean of 27.17 per cent. The range of tuber dry matter per cent varied from 11.66 per cent to 41.00 per cent with a mean of 30.29 per cent. The range of tuber yield per plant varied from 0.30 kg to 5.25 kg with a mean of 2.36 kg. Tuber yield per hectare ranged from 3.73 t to 64.81 t with a mean of tuber yield per hectare of 29.15 t. Harvest index ranged from 0.12 to 0.51 with a mean of 0.30. For starch content, the observed range varied from 9.40 per cent to 28.75 per cent with a mean of 19.04 per cent. The total sugars had a range of 1.47 per cent to 6.25 per cent with a mean of 3.39 per cent. HCN content was ranged from 43.16 ppm to 226.90 ppm with a mean of 115.36 ppm. These results

Table 2: Analysis of variance for 17 characters in 61 genotypes of cassava.

Character	Treatment means sum of square
Plant height (m)	0.098
Stem girth (cm)	1.575*
Petiole length (cm)	20.725
Leaf area index	6.947**
Tuber dry matter (%)	27.16**
Plant dry matter (%)	26.166**
No of storage roots per plant	5.077**
No of commercial roots per plant	3.336**
Tuber length (cm)	43.294**
Tuber girth (cm)	5.438*
Harvest index	0.007**
Starch content (%)	23.258**
Total Sugars (%)	0.75
HCN content (ppm)	2163.327*
Mean tuber weight (g)	33108.632***
Tuber yield per plant	1.318**
Tuber yield per hectare (t)	200.929**
*5% probability level ** 1% probability level	

are in concurrence with the findings of Aina *et al.*, (2007), Surya kumari and Anuradha (2000) and Babu Rao *et al.*, (2016).

The PCV and GCV had a range of 11.64 per cent (plant height) to 47.89 per cent (mean tuber weight) and 8.10 per cent (plant height) to 42.30 per cent (mean tuber weight) respectively. The results revealed that the PCV was higher than GCV for all traits studied indicating the influence of the environment in the expression of these traits. The PCV and GCV were high for leaf area index (39.55% and 34.72%), number of storage roots per plant (29.77% and 24.01%), number of commercial per plant (37.92% and 32.01%), mean tuber weight (47.89% and 42.30%), harvest index (26.31% and 26.28%), tuber yield per plant (kg) (40.20% and 33.44%), tuber yield (t/ha) (40.20% and 33.44%), starch content (22.60% and 20.60%) and HCN content (36.68% and 27.23%) respectively indicating the existence of wide range of genetic variability among the genotypes and the environment has minimal impact on these parameters and making selection based on these traits will be rewarding. These results are in conformity with the earlier reports of Surya kumari and Anuradha (2000), Babu Rao *et al.*, (2016), Danquah *et al.*, (2016) in cassava.

The traits viz. stem girth (13.11% and 13.11%), plant dry matter (19.29% and 19.23%), tuber dry matter (16.76 % and 14.65%), tuber girth (15.21% and 11.88%) exhibited moderate PCV and moderate GCV

Table 3: Estimates of variability, heritability and genetic advance as per cent of mean for different characters of 61 genotypes.

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	h ² (%)	Ge. Ad.	GA %
		Min.	Max.		δ^2_{ph}	δ^2_g					
1.	Plant height (m)	1.70	3.11	2.44	0.08	0.03	11.64	8.10	48.38	0.28	11.61
2.	Stem girth (cm)	5.60	11.16	8.54	1.25	0.77	13.11	10.30	61.74	1.42	16.68
3.	Petiole length (cm)	20.66	39.33	28.46	20.87	7.80	16.04	9.81	37.40	3.52	12.36
4.	Leaf area index	1.02	11.86	6.03	5.70	4.39	39.55	34.72	77.08	3.79	62.81
5.	Tuber dry matter (%)	11.66	41.00	30.29	25.77	19.69	16.76	14.65	76.41	7.99	26.38
6.	Plant dry matter (%)	17.98	44.33	27.17	27.48	27.31	19.29	19.23	99.35	10.73	39.49
7.	Number of storage roots per plant	2.00	11.00	6.54	3.79	2.47	29.77	24.01	65.06	2.61	39.91
8.	Number of commercial roots per plant	1.25	9.33	4.56	2.99	2.13	37.92	32.01	71.26	2.54	55.68
9.	Tuber length (cm)	16.00	45.93	29.17	43.14	32.99	22.51	19.68	76.47	10.34	35.46
10.	Tuber girth (cm)	7.94	19.00	14.21	4.67	2.85	15.21	11.88	60.98	2.71	19.12
11.	Harvest index (%)	0.12	0.51	0.30	0.007	0.007	26.31	26.28	99.74	0.16	54.07
12.	Starch content (%)	9.40	28.75	19.04	18.53	15.40	22.60	20.60	83.12	7.37	38.70
13.	Total sugars	1.47	6.25	3.39	0.78	0.44	26.10	19.58	56.31	1.02	30.28
14.	HCN content (ppm)	43.16	230.86	115.36	1,791.12	987.46	36.68	27.23	55.13	48.06	41.66
15.	Mean tuber weight (g)	64.40	951.76	371.25	31,613.05	24,661.07	47.89	42.30	78.00	285.72	76.96
16.	Tuber yield per plant	0.30	5.25	2.36	0.90	0.62	40.20	33.44	69.21	1.35	57.32
17.	Tuber yield (t/ha)	3.73	64.81	29.15	137.42	95.11	40.20	33.44	69.21	16.71	57.32
Ge. Ad.: Genetic advance; GA: GA as % of mean											

respectively; high PCV and moderate GCV was observed for tuber length (22.51% and 19.68%), total sugars (26.10% and 19.58%) respectively while, plant height (11.64% and 8.10%) and petiole length (16.04% and 9.81%) recorded moderate PCV and low GCV respectively. These results are in line with findings of Surya kumari and Anuradha (2000), Akinwale *et al.*, (2010), Ntawuruhunga and Dixon (2010), Adeniji *et al.*, (2011), Ashok *et al.*, (2013), Babu Rao *et al.*, (2016a) and Babu Rao *et al.*, (2018) in cassava.

Heritability (broad sense) estimates ranged from 37.40 per cent (petiole length) to 99.74 per cent (harvest index) whereas, the genetic advance as per cent of mean had a range of 11.61 per cent (plant height) to 76.96 per cent (mean tuber weight). High heritability and high genetic advance as per cent of mean were observed for leaf area index (77.08% and 62.81%), number of storage roots per plant (65.06% and 39.91%), number of commercial roots per plant (71.26% and 55.68%), tuber length (76.47% and 35.46%), harvest index (99.74% and 54.07%), starch content (83.12% and 38.70%), mean tuber weight (78.00% and 76.96%), tuber yield per plant (69.21% and 57.32%), tuber yield per ha (69.21% and 57.32%), plant dry matter (99.35% and 39.49%) and tuber dry matter (76.41% and 26.38%) respectively. High value of heritability accompanied by high genetic advance is more useful than heritability alone and high estimates indicating that they were least affected by environment

and direct selection based on phenotypic performance would be reliable. These results are in concurrence with the findings of Aina *et al.*, (2007), Surya kumari and Anuradha (2000) and Babu Rao *et al.*, (2016) for tuber dry matter content and stem girth; Nageswari and Palaniswamy (2011), Ashok *et al.*, (2013) and Babu Rao *et al.*, (2016) for tuber girth and starch content; Surya kumari and Anuradha (2000), Aina *et al.* (2007), Babu Rao *et al.*, (2016) and Danquah *et al.*, (2016) for tuber yield; Mathew *et al.*, (2017) for tuber yield per plant, tuber length and Babu Rao *et al.*, (2018) for tuber yield, starch content, number of storage roots per plant, number of commercial roots per plant, tuber length and total leaf area.

Moderate heritability and high genetic advance as per cent of mean were recorded for total sugars (56.31% and 30.28%), HCN (55.13% and 41.66%) respectively; high heritability and moderate genetic advance as per cent of mean were observed for stem girth (61.74% and 16.68%), tuber girth (60.98% and 19.12%) respectively whereas, moderate heritability and moderate genetic advance as per cent of mean were exhibited for plant height (48.38% and 11.61%), petiole length (37.40% and 12.36%) respectively indicating the operation of both additive and non-additive gene action and further improvement of these characters would be easier through mass selection, progeny selection or any modified selection procedure aiming to exploit the additive gene effects

rather than simple selection. Similar results were observed in earlier findings of Surya kumari and Anuradha (2000), Akinwale *et al.*, (2010), Ntawurhunga and Dixon (2010), Adeniji *et al.*, (2011), Ashok *et al.*, (2013), Babu Rao *et al.*, (2016a) in cassava.

Conclusion

Analysis of variance revealed significant differences for all the characters except for plant height, petiole length and total sugars. The characters viz. leaf area index, number of storage roots per plant, number of commercial roots per plant, harvest index, starch content, HCN content, mean tuber weight and tuber yield per plant were exhibited high PCV and GCV indicating the existence of wide range of genetic variability among the genotypes and the environment has minimal impact on these parameters and making selection based on these traits will be rewarding. High Heritability (h_b^2) coupled with high genetic advance as per cent of mean were observed for leaf area index, tuber and plant dry matter (%), number of storage roots per plant, number of commercial roots per plant, tuber length, harvest index, starch content (%), mean tuber weight (g), tuber yield per plant (kg), tuber yield (t/ha) and cassava mosaic disease incidence(%) indicating the indicating the preponderance of additive gene action making the direct selection based on these traits is more effective.

Acknowledgement

We would like to express our gratitude to Dr. Y.S.R. Horticultural University Venkataramannagudem, Horticultural Research Station, Peddapuram, Andhra Pradesh for providing the research facilities.

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