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Research Note

Exploration, collection and characterization of cassava landraces (*Manihot esculenta* Crantz.) grown in western ghats region

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Abstract
Fifty six land races of Cassava (*Manihot esculenta* Crantz.) from Western Ghats of Tamil Nadu exhibited significant variability for root morphological and biochemical traits studied. Amylose and starch contents varied from 14.4 to 30.4% and 10.0 to 39.7% respectively. Among the collections, 50% landraces had yellow colour pulp, indicated the possibility for selection and gene manipulation to improve the carotenoid content of cassava tuberous roots and thereby enhance its nutritive value. The cluster analysis revealed two major clusters and three minor clusters based on outer skin, cortex and pulp colours, texture and taste. The wide genetic diversity suggests that the evaluated germplasm can be used to identifying superior genotypes towards high yield with improved nutritive value.

Key words: Cassava, exploration, landrace, morphological traits, amylose content.

Cassava (*Manihot esculenta* Crantz.) is a perennial woody shrub of the Euphorbiaceae, native of South America. It is extensively cultivated as an annual tuberous root crop in the tropical regions of Africa, Asia and Latin America. It is a favoured root crop among all the root and tuber crops (Fregene *et al*., 2000). Cassava constitutes the staple food for nearly a billion people in tropical and subtropical countries (FAO, 2008).

Cassava production at global level is 230.27 million tones from 18.57 million hectares with a productivity of 12.4 t/ha (FAO, 2010). India is one of the major Asian country growing cassava with almost three times higher than the average global productivity. With reference to Indian scenario, cassava cultivating area, production and productivity were 0.23 million ha, 8.06 million tones and 34.75 t/ha respectively (FAO, 2010). Genetic variability is the essence for any plant-breeding program and to utilise maximum potential of a crop, a wide knowledge on available diversity is essential. Existence of variability in quality parameters will aid in developing trait-specific cassava populations for food, feed and industrial purposes. Commercialisation of cassava and adoption of improved varieties increases production and income however at the cost of genetic erosion (Raji *et al*., 2001; Benesi *et al*., 2004). This calls for the collection, characterisation and conservation of local germplasm for use in crop improvement programmes at global level. The aim of present study was (1) to explore and collect the farmer-grown cassava landraces in Western Ghats region of Tamil Nadu (2) to study the extent of diversity of these landraces based on selected qualitative traits and (3) to characterise the existing variability for biochemical characteristics in order to increase the utilization specificity in food and non food industries.

An exploration was conducted during Sept-Oct 2011 in the Western Ghats region, covering 32 villages in the southern region of Western Ghats with altitude ranging from 250-2552 feet above MSL. The planning and logistics (Engels *et al.*, 1995) and the sampling procedure (Brown and Marshall, 1995) for the collection of germplasm were made as per the reported protocols. A total of 56 landraces adapted to various rainfed situations with unique distinct morphological features were collected and are being maintained at Horticulturl Research Station, Tamil Nadu Agricultural University, Pechiparai, Tamil Nadu.

The fresh roots of 56 cassava landraces were washed, peeled manually, cut into small pieces with chips maker and dried. The dried chips were grounded finely with a coffee grinder (Model KFA 903, Elpack Ltd., Toronto, Ont., Canada) and pass through a 300-µm sieve. The flour was then

packed in an airtight container and stored under dry conditions at room temperature until used for further analysis. The harvested tuber from all the accessions were morphologically characterized using the cassava descriptors recommended by Fukuda *et al.* (2010). The six morphological characters *viz.,* external (outer skin) colour, pulp colour, cortex colour, cortex peeling, texture of root epidermis and taste were recorded and converted into binary data using the method developed by Benesi (2002). The apparent amylose content was determined using colorimetric method (Juliano, 1971) and the starch content was analysed using anthrone reagent method of Sadasivam and Manickam (1996).

All experiments were performed in triplicate. Data obtained was subjected to analysis of variance (ANOVA) using AGRES software (Agres Statistical Software, Version 3.01. USA). Least significant difference (LSD) was used to compare means at $p<0.05$. The binary data were used to generate similarity matrix and construction of cluster tree using NTSYS-pc software, version 2.02i (Rohlf, 1998).

Morphological description of characterised landraces

In the present study, an attempt has been made to determine the extent of diversity using the six morphological root traits among 56 cassava accessions (Table 1). The easily observable root traits are useful for preliminary evaluation as they offer a fast and useful approach for assessing the extent of diversity in cassava. Descriptors based root outer skin colour study revealed the presence of significant variability in the experimental material. More than 60% of the 56 characterised accessions had brown outer skin colour (Table 2). However, some were yellow in colour and 30% of the accessions were white to cream in colour. Hence, the germplasm was diverse with reference to external skin colour of tuberous roots and farmers mostly preferred brown and cream colour roots for table purpose. Regarding the pulp colour, 19 accessions were of white to cream pulp and 26 were of yellow pulp. Malverhas (1964) and Jos *et al.* (1990) reported yellow flesh cassava cultivars contain more carotene content than others. Chavez *et al*. (2005) grouped 25 accessions possessing high carotene lines from 93 accessions. Ukenye *et al.* (2013) studied the physical properties of cassava roots and revealed that those with yellow pulp have high carotene content (>3 µg/g) compared to cream colour (1.9 µg/g). Results indicated the possibility for screening, selection and gene manipulation to improve or elicit the carotenoid content of cassava tuberous roots and thereby enhancing its nutritive value.

About 60% of analysed accessions are of pink colour root cortex but diverse cortex colour existed in the collection, white to cream (19) and yellow colour (3). With respect to peeling of cortex, 49 accessions could be peeled off easily and 7 accessions were difficult to peel off the cortex. Regarding the tuber surface texture, 4 accessions were of smooth, 45 accessions were of intermediate and 7 accessions found to possess rough surface (Table 2). Descriptor based root diversity study revealed the presence of diversity for tuberous root colour, cortex colour, pulp colour as well as texture and taste. The reason may be, a farmer very rarely discards even a low-yielding landrace, but maintains it at low frequency for its other quality or adaptability traits. This corresponds to a strategy of risk management in uncertain farming conditions, but the practice is also motivated by social or cultural reasons because diversity is prized for its own sake. This much variability would have been possible primly through exchange of clones between the community or with other villages.

Preferences of cassava varieties by farmers and cyanogenesis

Exploration of the cassava collection revealed that preferences of cassava varieties by farmers in terms of taste, which varied according to the intended use and modes of utilisation of cassava in that particular locality (Table 1 and 2). Nearly 90% of collection consists bitter to slightly bitter and 6 were sweet in taste. From the study, farmers and consumers preferred very bitter to sweet cassava landraces, although the usage and areas planted to bitter varieties in the field were larger. Results agreed with previous studies of Kapinga *et al.* (1997), Chiwona-Karltun *et al.* (1998; 2000) and Benesi (2005). This is because bitterness is directly related to toxicity or cyanogenic potential levels.

In addition, cyanogenesis is no longer an issue under farmers' conditions since they have processing methods for turning toxic cassava to safe levels (Mkumbira *et al*. 2001; Benesi, 2005). In the present study, the similar landraces collected from different areas behave differently in case of taste indicates bitter or sweet taste of tuberous roots of cassava is not only a varietal factor, but it is more environmentally than genotypically controlled (Benesi, 2005).

Variation in biochemical composition

The amylose and starch content among the 56 collected landraces showed the presence of significant variation among genotypes. Starch is an important raw material for industrial applications, such as in the paper, textile, plastics, food and pharmaceutical industry. Amylose content is important starch property and low amylose starch gelatinise easily, yielding clear pastes. The average contents of amylose and starch were 22.2 and 24.9 per cent respectively. In this study, landraces *Krialai Porian (Tall)* and *Yeathan Chivalai* possessed lower amylose contents of 14.4 per cent which can be a suitable genotype for paper and

textile industries (Table 1). It also used as a stabiliser and thickener in food products and as an emulsifier for salad dressings (Jobling, 2004). The landraces, *Karialai Porian* and *Kaichi Kuttai* with high amylose content of 30.4 per cent and starch content of above 30 per cent can be a best genotype for food industries like production of resistant starch, which has nutritional benefits (Richardson *et al*., 2000). The above genotypes may be utilized as good donors for cassava improvement.

Diversity studies in 56 morphologically characterised accessions

The clustering of accessions and resulting dendrogram revealed two major clusters (I and III) and three minor clusters (II, IV and V) (Figure 1 and Table 3). Cluster I consisted of maximum number of genotypes (63%). Within cluster I, there were different sub-clusters and groups (Figure 1). Among the different clusters, the cluster size varied from 1 to 35. The cluster I possessed a maximum of 35 landraces. Accessions in this cluster were characterised by pink cortex, intermediate texture of root epidermis and easy peeling of cortex. Most accessions which were morphologically similar were found in this group, indicating low levels of morphological diversity for most of the accessions which belonged to this cluster. Four accessions with characters like white/cream outer skin, yellow pulp and rough texture were grouped in Cluster II. The unique trait for cluster III was white to cream cortex of accessions belonging to this cluster. A minimum of one genotype represented in cluster IV and V. The landrace CL18 possess white pulp and yellow cortex had separate cluster (cluster V). Similar studies have been carried out previously for the estimation of genetic diversity in cassava (Cordeiro *et al.,* 1995 and Fregene *et al*. (2000). Raghu *et al.* (2007) studied the morphological diversity in 58 cassava accessions and indicated the existence of genetic diversity among accessions. This trait based clustering will be helpful in handling large populations and to develop core collections and to enhance trait based collections for the breeders to develop a working germplasm. Also, cassava hybrid breeding programme involving parents from diverse amylose content clusters will be useful in exploiting and fixing heterosis. Benesi (2005) and Chavez *et al.* (2005) characterized cassava accessions and revealed diversity present in the collection providing an opportunity for selection and exploitation in a breeding programme.

The yellow pulp landraces, *Karialai Porian* and *Kaichi Kuttai* possessing high amylose and starch can be utilized for development of food products with enhanced nutritional value. The wide genetic diversity suggested that the local germplasm can be evaluated to identify superior genotypes for farmers towards increased production and income.

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Table 1. Details of cassava landraces collected from Western Ghats with some tuberous root traits and biochemical characters

Ac. No.	Cassava Landrace	Collection site	Skin colour	Pulp colour	Cortex colour	Cortex peeling	Root texture	Root taste	Amylose content(%)	Starch content(%)
CL1	*Ullii Chigappan*	*Pechiparai*	Light	Yellow	Pink	Easy	Smooth	Intermediate	25.4	39.0
CL2	*Laxhmi Vellai*	*Tiruvarambu*	Cream	Yellow	Cream	Difficult	Rough	Intermediate	20.0	18.5
CL3	*Karialai Porian*	*Pechiparai*	Light	Yellow	Pink	Easy	Rough	Intermediate	24.4	17.5
CL4	*Ottai Moodu*	*Koruvakkuzhi*	Light	Yellow	Pink	Difficult	Intermediate	Bitter	23.4	10.4
CL5	*Karialai Porian*	*Thanikunndu*	Light	Yellow	Pink	Easy	Intermediate	Intermediate	21.2	18.4
CL6	*Karialai Porian*	*Mothiramalai*	Light	Yellow	Pink	Easy	Intermediate	Sweet	30.4	39.7
CL7	*Karialai Porian*	*Vazhibattu kadavu*	Cream	White	Cream	Easy	Intermediate	Intermediate	25.4	32.4
CL8	*Karialai Porian*	*EB.Pachiparai*	Dark	Cream	Pink	Easy	Intermediate	Bitter	22.4	15.4
CL9	*Dwarf Vellai*	*Maramalai*	Cream	White	Cream	Easy	Intermediate	Bitter	22.4	25.3
CL10	*Ullii Chigappan*	*Navalkadu*	Cream	White	Cream	Easy	Intermediate	Intermediate	25.4	34.0
CL11	*Kattu*	*Koruvakkuzhi*	Light	Yellow	Pink	Difficult	Intermediate	Bitter	17.2	16.7
CL12	*Ullii Chigappan*	*Koruvakkuzhi*	Light	White	Pink	Easy	Intermediate	Intermediate	14.4	14.5
CL13	*Thadimuttan*	*Pathanamthittai*	Cream	Cream	Pink	Easy	Smooth	Sweet	18.4	22.1
CL14	*Ullii Chigappan(T)*	*Thanikunndu*	Cream	Cream	Pink	Easy	Intermediate	Intermediate	15.2	16.0
CL15	*Adukku Muttan(T)*	*Thanikunndu*	Cream	Yellow	Cream	Easy	Rough	Intermediate	14.4	10.4
CL16	*Karialai porian*	*Mookirakall*	Cream	Yellow	Pink	Difficult	Rough	Intermediate	14.4	13.4
CL17	*Laxhmi Vellai*	*Mallamuthankarai*	Cream	Cream	Cream	Easy	Intermediate	Sweet	17.2	12.9
CL18	*Tall-Kattu*	*Mallamuthankarai*	Dark	White	Yellow	Difficult	Smooth	Bitter	14.4	19.1
CL19	*Tall-Chilly Kallan*	*Mallamuthankarai*	Cream	White	Cream	Easy	Intermediate	Intermediate	16.0	11.1
CL20	*Karialai Porian*	*Mallamuthankarai*	Cream	Yellow	Cream	Easy	Rough	Intermediate	20.0	14.7
CL21	*Tall-Adukku Muttan*	*Mallamuthankarai*	Cream	White	Cream	Easy	Intermediate	Intermediate	26.4	35.3
CL22	*Yeathan Chivalai*	*Vaiyanachallai*	Cream	Cream	Pink	Easy	Intermediate	Intermediate	14.4	10.7
CL23	*Pachai Konntai*	*Koruvakkuzhi*	Dark	White	Cream	Easy	Smooth	Intermediate	16.0	25.7
CL24	*Nadan Karialai*	*Chittar*	Light	Cream	Cream	Easy	Intermediate	Intermediate	20.4	20.9
CL25	*Allanchollai local*	*Allanchollai*	Dark	Cream	Pink	Easy	Intermediate	Intermediate	16.0	15.8
CL26	*Laxhmi Vellai*	*Chittar*	Dark	Yellow	Yellow	Easy	Intermediate	Intermediate	25.4	38.1
CL27	*Kaichi Kuttai*	*Chittardam*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	30.4	32.4
CL28	*Nooru Muttan*	*Allanchollai*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	20.4	20.5
CL29	*Aana Karialai*	*Nedumankaadu*	Dark	Cream	Cream	Difficult	Intermediate	Intermediate	22.4	21.0

CL30	*Tall-Laxhmi Vellai*	*Allanchollai*	Light	Yellow	Pink	Difficult	Intermediate	Bitter	24.7	32.2
CL31	*Karu Mundan*	*Mantharamputhur*	Light	Cream	Pink	Easy	Intermediate	Sweet	19.8	13.6
CL32	*Kailady*	*Valiayela*	Light	Cream	Pink	Easy	Intermediate	Bitter	19.4	10.0
CL33	*Black Karialai*	*Valiayela*	Light	Yellow	Pink	Easy	Intermediate	Bitter	26.4	33.2
CL34	*Mantharam 1*	*Mantharamputhur*	Dark	Yellow	Yellow	Easy	Intermediate	Bitter	27.4	36.9
CL35	*Kottaram 1*	*Kottaram*	Dark	Cream	Pink	Easy	Intermediate	Bitter	22.4	15.2
CL36	*Kottaram 2*	*Kottaram*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	14.4	19.8
CL37	*Achankulam 1*	*Achankulam*	Dark	Cream	Pink	Easy	Intermediate	Bitter	24.4	24.7
CL38	*AzhakappapuramL*	*Azhakappa puram*	Light	Yellow	Pink	Easy	Intermediate	Sweet	20.4	15.2
CL39	*Arriam Vellai*	*Kaatavilai*	Light	Cream	Pink	Easy	Intermediate	Bitter	25.4	36.7
CL40	*Tall-Muttan*	*Kaatavilai*	Dark	Yellow	Pink	Easy	Intermediate	Bitter	20.4	19.1
CL41	*Olly Muttan*	*Kaatavilai*	Cream	White	Cream	Easy	Intermediate	Intermediate	19.6	22.8
CL42	*Tall Marungu*	*Thumbally*	Cream	white	Cream	Easy	Intermediate	Bitter	25.7	30.6
CL43	*Olly Marungu*	*Thumbally*	Light	Cream	Pink	Easy	Intermediate	Sweet	28.4	35.3
CL44	*Karun Karialai*	*Mudavanpottai*	Dark	Cream	Cream	Easy	Rough	Bitter	20.4	31.3
CL45	*Chengambai*	*Valayamthukki*	Yellow	Cream	Cream	Easy	Smooth	Bitter	22.4	34.4
CL46	*Pachaikonda*	*Valayamthukki*	Yellow	Yellow	Pink	Easy	Intermediate	Intermediate	24.4	33.1
CL47	*Vellai Porian*	*Valayamthukki*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	23.4	23.0
CL48	*Karialai Porian*	*Kayarkarai*	Dark	Cream	Cream	Easy	Intermediate	Intermediate	26.4	36.5
CL40	*Adukku Muttan*	*Kayarkarai*	Dark	Yellow	Cream	Easy	Intermediate	Bitter	24.4	35.6
CL50	*Chengambai*	*Kayarkarai*	Cream	Yellow	Pink	Easy	Intermediate	Bitter	26.4	39.7
CL51	*Pachaikonda*	*Kayarkarai*	Dark	Yellow	Pink	Easy	Rough	Intermediate	24.4	19.5
CL52	*Karialai Porian*	*Kayarkarai*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	28.4	27.4
CL53	*Adukku Muttan*	*Arasanseri*	Dark	Yellow	Pink	Easy	Intermediate	Intermediate	24.4	36.1
CL54	*Mathur local*	*Mathur*	Light	Yellow	Pink	Easy	Intermediate	Bitter	28.4	38.9
CL55	*Ullii Chigappan*	*Mathur*	Dark	Cream	Pink	Easy	Intermediate	Bitter	28.4	37.4
CL56	*Whiterose*	*Verkilambi*	Cream	Cream	Cream	Easy	Intermediate	Bitter	28.5	37.0
	CV(%)								**2.73**	**5.44**

Table 2. Cassava variability for root morphological and sensorial traits

Characters	Category (No. of Genotypes)		
Root external colour	White or cream (17)	Yellow (3)	Brown (36)
Root pulp colour	White (1)	Cream (19)	Yellow (26)
Root cortex colour	White or cream (19)	Yellow (3)	Pink (34)
Cortex peeling	Easy (49)	Difficult (7)	
Texture of root	Smooth (4)	Intermediate (45)	Rough (7)
Root taste	Sweet (6)	Intermediate (29)	Bitter (21)

Table 3. Cluster composition of cassava accessions for root morphological traits

Cluster	No. of Genotypes	Code No.	Root traits represented
I	35	CL1, CL3, CL4, CL5, CL6, CL8, CL11, CL12, CL14, CL22, CL25, CL26, CL27, CL28, CL30, CL31, CL32, CL33, CL34, CL35, CL36, CL37, CL38, CL39, CL40, CL43, CL46, CL47, CL49, CL50, CL51, CL52, CL53, CL54 and CL55	1. Easy cortex peeling 2. Pink colour cortex 3. Intermediate texture
II	4	CL2, CL15, CL16 and CL20	1. White/cream skin 2. Yellow pulp 3. Rough texture
III	15	CL7, CL9, CL10, CL17, CL19, CL21, CL23, CL24, CL29, CL41, CL42, CL44, CL45, CL48 and CL56	1. White/cream cortex
IV	1	CL13	1. Smooth texture 2. Sweet taste
V	1	CL18	1. Dark brown skin 2. White pulp 3. Yellow cortex 4. Bitter taste

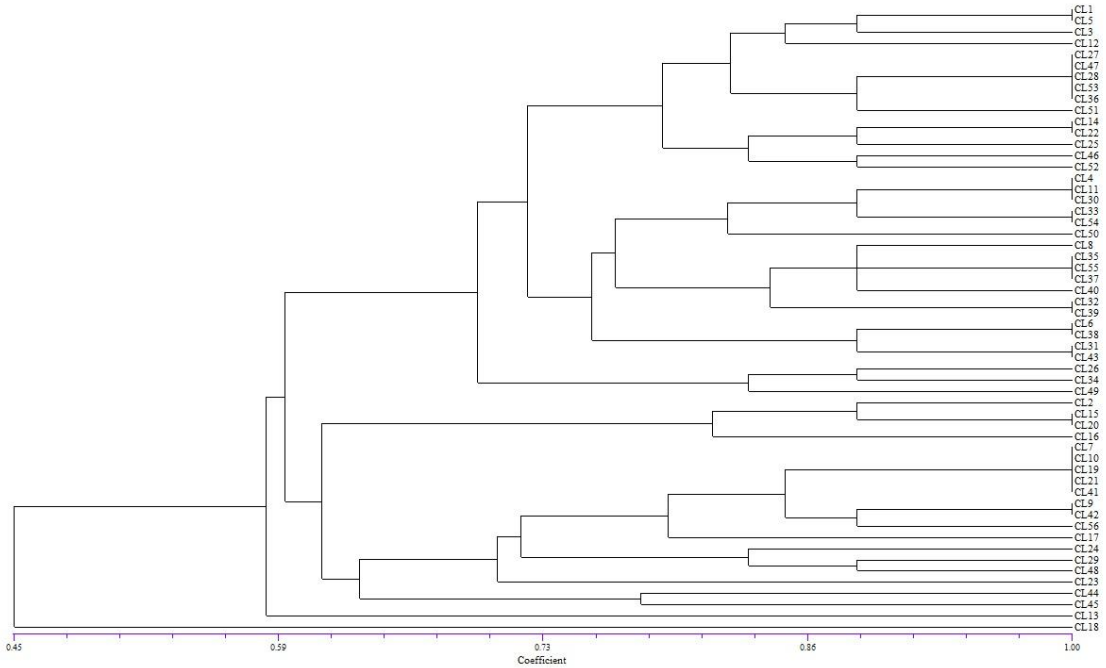

Figure 1. Dendrogram showing relationship among 56 cassava accessions based on root morphological and sensorial traits

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