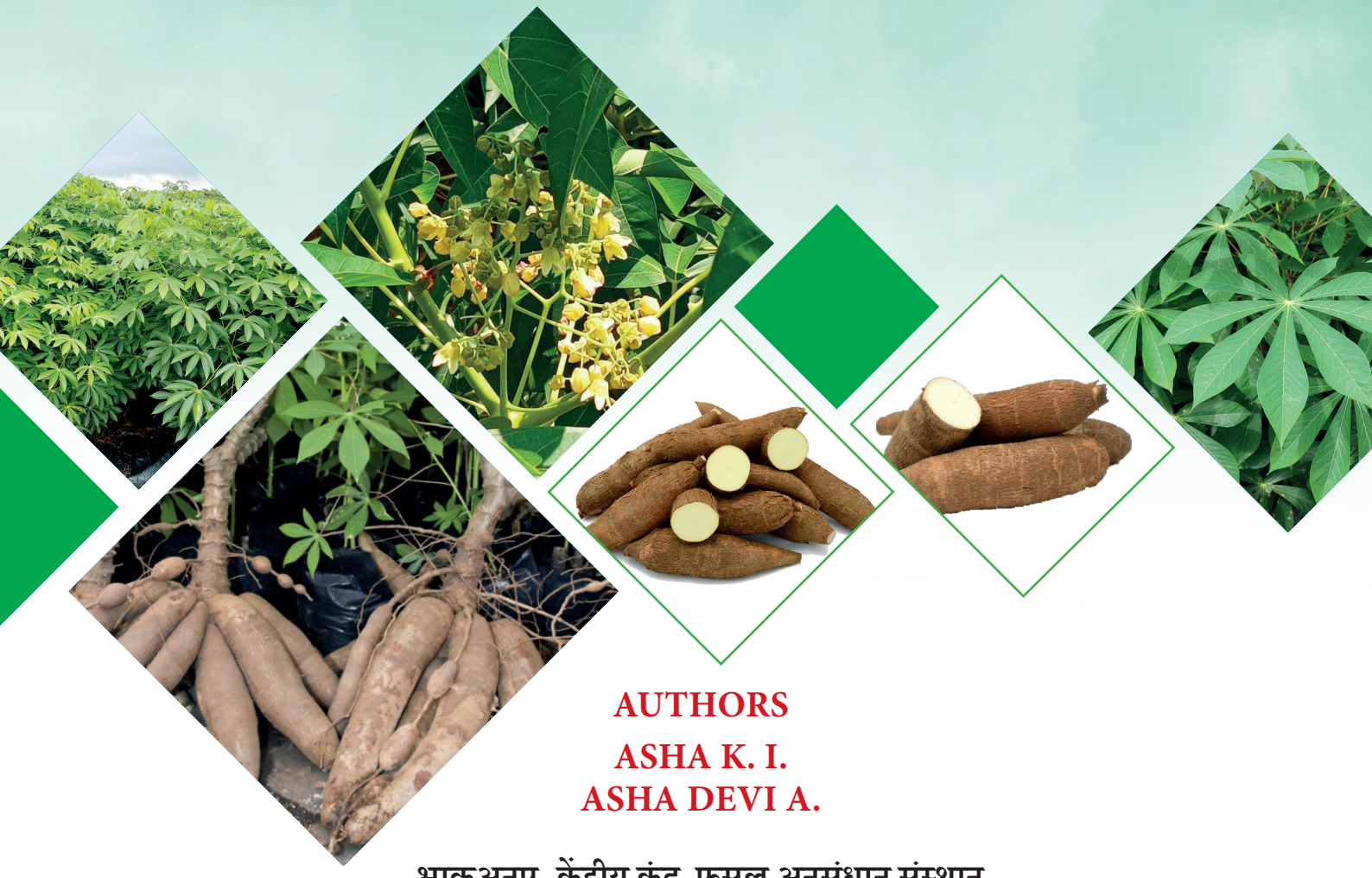
ICAR-CTCRI

कसावा आनुवंशिक संसाधनों की सूची संशोधित (भाग-2)

CATALOGUE OF CASSAVA GENETIC RESOURCES (PART-2)



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CONTENTS

PREFACE

Cassava (*Manihot esculenta* Crantz*)* is a vital tropical tuber crop that plays a significant role in global food security, particularly in regions with marginal soils and erratic rainfall. Often underrated, cassava is a primary source of calories for over 800 million people worldwide, especially in Africa, Asia and Latin America. Its ability to thrive under stress conditions, including drought and low soil fertility, makes it a dependable crop for smallholder farmers. As the demand for climate-resilient crops grows, cassava continues to gain importance in addressing hunger and ensuring nutritional security.

Introduced to India by the Portuguese in the 17th century, cassava quickly adapted to Indian agro-climatic conditions, especially in Kerala, Tamil Nadu, Andhra Pradesh, the North Eastern states and the Andaman and Nicobar Islands. With its high starch content, cassava has diversified uses: from culinary staples like sago and vermicelli to industrial applications such as textiles, biodegradable plastics, particle boards and bio-ethanol. Its use as animal and poultry feed further highlights its economic value.

As the nodal institution for tropical tuber crop research in India, the ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) has made significant strides in conserving cassava genetic resources. Although cassava is an introduced crop it displays considerable genetic diversity in both above-ground and tuber traits under Indian conditions. This variability is a valuable resource for crop improvement, particularly for enhancing yield, stress tolerance and industrial suitability.

The catalogue presents the characterization of data of 100 accessions of cassava for 46 morphological traits maintained in the Institute field genebank. This documented data aims to support researchers, breeders and policymakers in the effective utilization of cassava germplasm. This publication is expected to significantly contribute to the sustainable development of cassava and promote its wider recognition as an essential component of the global food system.

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Director

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AUTHORS

ABSTRACT

The present catalogue documents the characterization of one hundred accessions of cassava (*Manihot esculenta* Crantz) conserved at ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI). These accessions were evaluated over the last three years for 46 morphological and agronomic traits encompassing both above-ground and below-ground characters. Considerable variation was observed among the accessions for both qualitative and quantitative traits. The data have been systematically organized into three sections: stem characters, leaf and flower characters, tuber and yield characters. Seventy-nine accessions were found flowering. Among the characterized accessions, 25 genotypes including CE-28A, CE-38, CE-48, CE-50, CE-89, CE-90,CE-97, CE-99, CE-108, CE-114, CE-127, CE-142, CE-144, CE-152, CE-166, CE-272, CE-273, CE-279, CE-326, CE-331, CE-338, CE-394A, CE-403, CE-428 and CE-456 showed resistance to cassava mosaic disease (CMD). Additionally, three accessions namely CE-174, CE-348 and CE-430A were identified as carotene-rich with yellow-fleshed tubers. Tuber weight among the accessions varied widely, ranging from 0.23 kg in CE-331 to 27.28 kg in CE-71. Notably, six accessions CE-14, CE-25, CE-34, CE-48, CE-89 and CE-71 recorded high tuber yields above 15 kg plant^{-1}, indicating their potential for use in crop improvement programs. This highlights the diversity and uniqueness of the germplasm maintained in the field genebank.

1. Introduction

Cassava (*Manihot esculenta* Crantz) is a major tropical tuber crop providing essential sustenance to over 800 million people globally, especially in major tropical tuber crop grown regions, from Southern America to Southeast Asia and Sub-Saharan Africa (Ceballos et al., 2010). Its ability to thrive in marginal soils, resist drought and requirement of minimal agricultural inputs makes it indispensable for smallholder farmers. Its starchy roots containing 20-40% starch serve as a critical energy source for human consumption and industrial applications, including biofuel production (Balat and Balat, 2009; Schmitz and Kavallari, 2009).

Cassava has become a vital energy source for millions in these regions and is known for producing more energy per unit area per unit time. India leads the world in cassava yield with a productivity of 30 t ha^{-1}. The crop is primarily grown for its starch rich tubers valued both for consumption and commercial use. Its starch free of proteins and lipids is a raw material for industries producing sago, biodegradable plastics, starch-coated slow-releasing fertilizers and processed products such as baby food, vermicelli, chips and pappads.

In Africa, cassava provides essential calories to more than 500 million people, whereas in Asia, its primary utility has shifted from a subsistence crop to an industrial feedstock (Howeler et al., 2013). Cassava has resilience to environmental fluctuations ability to grow in nutrient-poor soils and role in addressing climate-induced agricultural challenges underscore its importance in global food systems (Jarvis et al., 2012).

Despite these attributes, cassava exhibits significant limitations. Nutritionally, its roots are low in protein and micronutrients while containing high levels of cyanogenic glycosides, compounds that pose toxicity risks if improperly processed (Ceballos et al., 2010). The crop is also highly susceptible to bacterial infections (Boher and Verdier, 1994) and insect-transmitted viral diseases (Hillocks and Jennings, 2003; Hill and Fauquet, 2009). Post-harvest deterioration remains a persistent challenge significantly limiting its economic potential and marketability. Genetic complexity of cassava as a result of its outcrossing, heterozygous nature and its vegetative propagation present barriers to traditional breeding efforts aimed at enhancing yield, disease resistance and nutritional quality. Addressing these challenges is critical for realizing the crop's potential to contribute to global food and nutritional security (Ceballos et al., 2010).

Origin and distribution

Cassava (*Manihot esculenta* Crantz), a member of the Euphorbiaceae family is believed to have been domesticated in the Amazon Basin over 6000 years ago (Olsen and Schaal, 1999; Olsen, 2004). Its domestication marked a significant milestone in the development of tropical agriculture, as the crop transformed from its wild progenitor into a critical source of sustenance for millions. Wild relatives of cassava such as *Manihot flabellifolia* have been identified in South America, particularly in regions spanning Brazil, Venezuela and Colombia. These wild species are thought to have contributed genetic diversity to modern cassava cultivars through natural hybridization.

The domestication process of cassava primarily involved the selection of plants with desirable traits including higher starch content, reduced cyanogenic compounds and greater yield potential. Early cultivation likely focused on tuberous roots, which provided a reliable source of calories in regions characterized by nutrient-poor soils and fluctuating environmental conditions. The inherent ability of cassava to grow under marginal conditions and its resilience to drought and low fertility soils made it a favourable crop for early agricultural societies (Lebot, 2009).

From its centre of origin, cassava spread across the tropical regions of South and Central America. The crop was introduced to Africa and Asia during the 16th and 17th centuries via the transatlantic slave trade and colonial agricultural systems following European exploration and colonization. In these regions, cassava rapidly adapted to diverse agro-ecological conditions eventually becoming a staple food crop. Its wide adoption was due to its capacity to provide food security during periods of drought or crop failure hence called as 'famine crop' (Nassar and Ortiz, 2010).

In Africa, cassava became integrated into traditional farming systems along with crops such as millet and sorghum. Over centuries, indigenous farmers selected for cassava varieties that were better suited to local environmental conditions and culinary preferences leading to the development of region-specific landraces. Similarly in Asia, the role of cassava evolved from a subsistence crop to a raw material for industrial starch production particularly in countries like Thailand, Indonesia and India (Howeler et al., 2013).

Genetic studies have provided insights into the crop's evolutionary history and domestication. Molecular analyses reveal that cultivated cassava possesses a narrow genetic base, a consequence of its clonal propagation and domestication bottlenecks. Despite this limitation, the crop has benefited from the introgression of alleles from wild relatives enhancing its adaptability and resilience (Olsen, 2004). Advances in genomics and molecular breeding are now being leveraged to further explore the genetic diversity of cassava and optimize its agronomic traits.

Botany

Cassava is a perennial shrub characterized by an erect or branched stem with young shoots displaying either straight or zigzag growth patterns. The mature stem colour contrasts with that of the young shoots. The leaves are palmately lobed and contain glucosides, with margins that may be either smooth or undulating. Typically, the leaves are green though the apical portion may exhibit varying colours from purple to green. Senescence of the leaves in the lower part of the plant results in their abscission, leaving scars on the stem, a trait associated with drought tolerance. There is considerable variability in leaf petiole colour and leaf angle across different accessions.

In flowering accessions of cassava, the inflorescence is a panicle exhibiting monoecy and protogyny. The calyx is green, while the petals range in colour from white to pink or purple. Male flowers are located at the upper portion of the peduncle with female flowers at the lower end. The flowers contain nectar glands that attract pollinating bees, thus facilitating cross-pollination. The ovary is trilocular with each locule containing a single ovule. The fruit is a capsule typically containing one to three seeds. Seed dormancy persists for approximately three months. Cassava possesses a fibrous root system with modified storage organs namely tubers that grow in clusters and contain

secondary roots. In certain accessions, tubers may display a constriction referred to as the neck. The skin colour of the tuber varies from cream to dark brown while the flesh ranges in colour from white to yellow.

Cytogenetics

Cassava belongs to the species *esculenta*, the genus *Manihot* (Crantz, 1766) of the tribe *Manihoteae* and the sub family *Crotonoideae* of the family *Euphorbiaceae*. The exact number of the species in the genus *Manihot* is not yet known as they are distributed widely over the American continents (Rogers and Appan, 1973). There were 150-160 as per Perry (1943) and 100-200 species as per Purseglove (1968). Pax (1910) recognized 11 sections in the genus *Manihot*. Rogers and Appan (1973) characterized about 98 species which includes 24 tall shrubs and tree species and classified them into 19 sections. *Manihot esculenta* belongs to the section *Parvibracteatae,* which includes shrubs or vines with small fruits having length less than 1.75 cm and small seeds with less than 1.5 cm length.

Cassava is predominantly diploid, having a chromosome number of 2n=36 (Kawano et al., 2004). Its genome map is complex influenced by polyploidy and significant genetic diversity across various accessions reflecting the extensive domestication and selection processes (Pereira et al., 2017).

Cytogenetic studies employing techniques such as karyotyping and fluorescence *in situ* hybridization (FISH) have illuminated the chromosomal arrangements and localization of specific genes in cassava. Karyotyping has revealed a relatively symmetrical arrangement of chromosomes indicative of evolutionary stability (Almeida et al., 2020). Additionally recent advances in genetic mapping have identified quantitative trait loci (QTL) associated with crucial agronomic traits including root yield, disease resistance and drought tolerance (Ceballos et al., 2016). These findings have significant implications in breeding programs, facilitating marker-assisted selection to improve the cassava varieties.

Hybrid vigor or heterosis is another critical aspect of cytogenetics of cassava. Crosses between diverse accessions frequently result in hybrids exhibiting enhanced traits highlights the importance of broad genetic bases in breeding strategies (Oka et al., 2019). However, cytogenetic abnormalities such as aneuploidy and chromosomal abberations can affect plant development and yield makes the need of comprehensive cytogenetic analyses in breeding programs.

In vitro techniques including tissue culture and somatic embryogenesis have been pivotal for studying cytogenetics in cassava allowing for the regeneration of plants from various tissues and the propagation of desirable traits (López et al., 2019).

Phylogeny and molecular approaches

The molecular systematics of *Manihot* and its relatives have been extensively studied using chloroplast DNA (cpDNA) markers and nuclear ribosomal DNA. Next-generation sequencing technologies used to resolve phylogenetic relationships within the genus and its close relatives. Pennington et al. (2009) and Lachenaud et al. (2012) used molecular techniques to clarify the taxonomic boundaries and evolutionary patterns of *Manihot* focusing on the species origin and domestication history.

Studies by Sauer (1957) have used molecular markers to understand the evolution of the species and highlight the role of polyploidy in its diversification. Specifically, the domesticated *M. esculenta* is thought to have arisen through hybridization between different wild species which is consistent with its current genetic variability. Polyploid nature of cassava has been explored in numerous studies such as those by Ogundipe et al. (2019) emphasizing how these genetic features influence its root and shoot development as well as its resistance to pests and diseases.

Cultivation

Cassava is adaptable to a broad range of environments from semi-arid regions with annual rainfall between 1500-2000 mm per annum. It can be cultivated up to altitudes of 2000 meters, although it performs optimally at lower elevations. The plant thrives in tropical humid climate i.e., between 25-32°C and is intolerant to low temperatures with growth ceasing below 10°C. Cassava can be grown in marginal dry soils as a rain-fed crop; however, higher yields are achieved under irrigated conditions. It is noted for its drought tolerance and can withstand moderate soil acidity.

Propagation is vegetatively through stem cuttings usually called 'setts' or 'stakes'. Stem cuttings of 20-30 cm, taken from the middle third of the stem, should be planted in mounds or ridges at a depth of 5 cm with spacing of 75x75 cm or 90x75 cm for non-branching varieties and 90x90 cm for branching varieties. Approximately 12,350 to 17,780 cuttings are required per hectare. Irrigation is necessary during the initial three months post-planting to support crop establishment. The minisett technology utilizes small stem sets (3-5 cm) containing 2-3 nodes replacing the traditional 20-30 cm cuttings. This method significantly enhances the seed multiplication ratio from 1:10 to 1:60.

Cassava thrives on marginal soils with low fertility. However, for optimal root yield and quality a fertilizer application of 100:50:100 kg ha^{-1} of nitrogen (N), phosphorus (P) and potassium (K) is recommended. Nitrogen and potassium can be applied in split doses as a basal application and at 45-60 days after planting. Short-duration cultivars require a fertilizer ratio of 75:25:75 kg ha^{-1}. Well-rotted farm yard manure at a rate of 10-15 t ha^{-1} should be incorporated into the soil at planting. Micronutrient deficiencies are more prevalent in cassava grown on eroded or contoured soils. To correct boron deficiency a foliar spray of 0.1-0.5% borax combined with 0.5% calcium nitrate is recommended. Zinc deficiency can be addressed by applying zinc sulphate to the soil at 12.5 kg ha^{-1}.

Harvesting times for cassava vary with cultivar duration. Long-duration varieties are typically harvested 9-10 months after planting while short-duration varieties are harvested 6-8 months after planting. Under optimal crop management practices tuber yields of 25-40 t ha^{-1} can are achieved. Cassava tubers are susceptible to vascular blue-lining or blue-streaking a post-harvest physiological disorder that limits their storage under ambient conditions. Without this disorder tubers can be stored for up to two days at ambient room temperature.

Research and development

Intensive research and development efforts over the last decade have transformed cassava from a subsistence crop to one with significant industrial and nutritional potential. Advances in breeding strategies have resulted in the development of high-yielding, disease-resistant and biofortified

cassava varieties (Friedmann et al., 2018; Okwuonu et al., 2021). Institutions such as the International Center for Tropical Agriculture (CIAT) and the International Institute of Tropical Agriculture (IITA) have been instrumental in spearheading these innovations.

Biofortification has emerged as a pivotal focus area to address the nutritional deficiencies in regions where cassava serves as a staple food. Improved varieties have been introduced to mitigate malnutrition particularly in sub-Saharan Africa where vitamin A deficiency is endemic (Howeler et al., 2013). Genomic and molecular breeding tools have facilitated the identification and incorporation of traits give resistance to major diseases including cassava mosaic disease and cassava brown streak disease which reduces production (Patil and Fauquet, 2009).

Industrial applications of cassava have expanded significantly in Asia where its starch-rich roots are utilized for biofuels animal feed and other industrial products. Research efforts have focused on optimizing starch extraction and processing techniques to enhance the efficiency and economic viability of industrial cassava production (Schmitz and Kavallari, 2009). The development of cassava-derived products such as ethanol and biodegradable plastics emphasizes its growing importance in sustainable industrial applications.

Addressing the challenge of post-harvest deterioration has also been a priority. Innovations in storage, drying and fermentation techniques have extended shelf life reduced post-harvest losses and increased its marketability of cassava. Diverse cassava-based food products including flours, bread and snacks has expanded its utility and commercial value particularly in urban markets (FAO, 2012).

Despite these advancements, the spread of improved cassava varieties remains uneven. Farmers often prioritize organoleptic qualities such as taste and texture over agronomic traits like yield and disease resistance complicating the propagation of new varieties (Ceballos et al., 2010). The potential to serve as an alternative to wheat and maize makes cassava a critical crop for mitigating food shortages and enhancing the resilience of agricultural systems (The Guardian, 2022). Future researches prioritize the integration of climate resilience, nutritional enhancement and industrial applicability of cassava as a sustainable food system component (Ray et al., 2022).

Despite being an introduced crop, cassava in India has adapted to diverse agro-climatic conditions since its introduction in the 17th century resulting in notable genetic variability. At the ICAR-Central Tuber Crops Research Institute (CTCRI) germplasm collection comprising 1,216 genetic stocks including indigenous, exotic, landraces and breeding lines is being maintained. From these valuable resources, ICAR-CTCRI has developed many high yielding varieties in cassava due to which India is the world leader in cassava productivity. Apart from high yield, many improved varieties viz., Sree Athulya and Sree Apoorva having high extractable starch (28–32%) content were also released. Recently many high yielding improved CMD resistant varieties viz., Sree Raksha, Sree Sakthi, Sree Suvarna and Sree Kaveri were also released for the sub continent especially for the industrial sectors.

2. Descriptors

Characterization of cassava involves the systematic observation and documentation of its morphological, agronomic and sometimes molecular traits using standard descriptors. These descriptors are typically developed by organizations like Bioversity International and serves as a guideline for consistent data collection across genotypes. Characterization using descriptors is essential for identifying genetic diversity, selecting desirable traits for breeding and conserving germplasm in gene banks. It provides a basis for comparing varieties and understanding their adaptability to different environments. The following descriptors were used for the characterization of indigenous cassava germplasm numbered 100 based on various qualitative and quantitative traits. Qualitative traits are most important in the classification of accessions as they are not influenced by the environment. Cassava exhibits a wide range of variation in qualitative traits. The descriptors along with the descriptor states are presented below. All the qualitative traits were recorded visibly in the field. Four sets of descriptor characters and traits were recorded i.e. for stem (11), leaf (15), flower and fruit (3) and tuber (17).

Table 2.1: Stem characters

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-1	Plant type	Based on the appearance of the plant at maturity	Compact	1
			Open	2
			Umbrella	3
			Cylindrical	4
P-2	Growth habit of young stem	At 3-4 months after planting	Straight	1
			Zigzag	2
P-3	Levels of branching	At maturity	Levels	1-4
P-4	Branching habit	At maturity	Erect	1
			Dichotomous	2
			Trichotomous	3
			Tetrachotomous	4
P-5	Young stem colour	At 3-4 months after planting	Light green	1
			Dark green	2
			Greenish red	3
			Greenish purple	4
			Purple	5
P-6	Colour of stem epidermis	At maturity	Cream	1
			Light brown	2
			Dark brown	3
			Orange	4
P-7	Colour of stem cortex	At maturity	Orange	1
			Light green	2
			Dark green	3

P-8 Plant height (cm):

Plant height is measured at the time of harvesting from the sprouting region to the tip of the plant, with the help of a measuring tape.

P-9 Stem perimeter at base (cm):

Stem perimeter at the basal region where sprouting began, was measured with the help of a measuring tape.

P-10 Distance between leaf scar (cm):

The distance between the leaf scar was measured from the central portion of the stem.

P-11 Height at first branching (cm):

In branched accessions, the height of the stem at which first branching occurred was measured with the help of a measuring tape.

Table 2.2: Leaf characters

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-12	Colour of apical leaves	At 3-4 months after planting	Light green	3
			Dark green	5
			Purplish green	7
			Purple	9
P-13	Pubescence on apical leaf	At 3-4 months after planting	Glabrous	3
			Moderate	5
			High	7
P-14	Mature leaf colour	At maturity	Light green	3
			Dark green	5
			Purplish Green	7
			Purple	9
P-15	Shape of central leaf lobe	At maturity	Ovoid	1
			Elliptic lanceolate	2
			Obovate lanceolate	3
			Oblong lanceolate	4
			Lanceolate	5
			Linear	6
			Pandurate	7
			Linear pyramidal	8
			Linear pandurate	9
			Linear-hostatilobalate	10

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-16	Leaf lobe margin	At maturity	Smooth	3
			Winding	7
P-17	Leaf vein colour	At maturity	Green	3
			Reddish-green in less than half of the lobe	5
			Reddish-green in more than half of the lobe	7
			Red	9
P-18	Orientation of petiole	At maturity	Inclined upwards	1
			Horizontal	3
			Inclined downwards	5
			Irregular	7
P-19	Prominence of leaf scar	At maturity	Semi-prominent	3
			Prominent	5
P-20	Petiole colour	At maturity	Yellowish green	1
			Green	2
			Reddish green	3
			Greenish red	5
			Red	7
			Purple	9

P-21 Petiole length (cm):

The length of the petiole from the axil to the lamina-petiole joint was measured in 3 to 5 leaves of different plants.

P-22 Number of leaf lobes:

Number of leaf lobes was counted from different leaves on the same plant.

P-23 Length of central leaf lobe (cm):

Length of central leaf lobe was measured from lamina-petiole joint to tip in 3 to 5 leaves of different plants.

P-24 Width of central leaf lobe (cm):

Width of central leaf lobe was measured at the point where the width is more in 3 to 5 leaves of different plants.

P-25 Ratio of lobe length to lobe width

Table 2.3: Flower characters

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-26	Flowering	From 3-4 months after planting to harvest	Absent	0
			Present	1
P-27	Fruit set	From 3-4 months after planting to harvest	Absent	0
			Present	1
P-28	Fruit colour	From 3-4 months after planting to harvest	Light green	1
			Green	2
			Green with purple border	3

Table 2.4: Tuber characters

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-29	Tuber growth attitude	At harvest	Vertical	1
			Horizontal	2
			Irregular	3
P-30	Tuber constrictions	At harvest	Absent	0
			Few	1
			Many	2
P-31	Extent of root peduncle	At harvest	Sessile	0
			Mixed	1
			Pedunculate	2
P-32	Tuber shape	At harvest	Conical	1
			Conical-cylindrical	2
			Cylindrical	3
			Fusiform	4
			Irregular	5
P-33	External colour of tuber	At harvest	Cream	1
			Light brown	2
			Brown	3
			Dark brown	4
P-34	Tuber cortex colour	At harvest	White	1
			Cream	2
			Light yellow	3
			Yellow	4
			Pink	5
			Purple	6

Sl. No.	Descriptor	Time of observation	Descriptor states	Score
P-35	Tuber flesh colour	At harvest	White	1
			Cream	2
			Light yellow	3
			Yellow	4
P-36	Texture of tuber rind	At harvest	Smooth	3
			Intermediate	5
			Rough	7
P-37	Ease of tuber rind removal	At harvest	Easy	3
			Intermediate	5
			Difficult	7
P-38	Taste of the tuber	At harvest	Good	1
			Intermediate	2
			Bitter	3
P-39	Tuber length	At harvest	Short	1
			Medium	2
			Long	3
P-40	Tuber diameter	At harvest	Narrow	3
			Medium	5
			Wide	7

P-41 Number of tubers per plant:

Total number of tubers present in a plant was counted.

P-42 Number of commercial tubers per plant:

Total number of marketable tubers of good length and width in a plant were counted.

P-43 Total fresh weight of tubers per plant (kg):

Total fresh weight of the tubers harvested from a plant was recorded.

P-44 Single biggest tuber weight (kg):

Out of all the tubers formed in a plant, the weight of the single biggest tuber was recorded.

P-45 Total fresh weight of foliage per plant (kg):

Total fresh weight of the foliage harvested from a plant was recorded.

P-46 Harvest Index:

Ratio of the total weight of tubers to that of combined weight of entire biomass was recorded.

3. Stem characters

A total of 6 qualitative and 5 quantitative traits of the stem were recorded. Among 100 plants, 47 were having compact growth habit followed by 44 accessions shown umbrella type, 4 accessions in cylindrical type and 5 accessions were in open type. Characteristically 96 accessions had straight young stem and 4 were having zigzag growth. Branched accessions (96) were found to be more than the unbranched ones (4). Four types of branching were observed. Dichotomous (49) form was present in a large number of accessions followed by trichotomous (46), erect (4) and tetrachotomous (1) types.

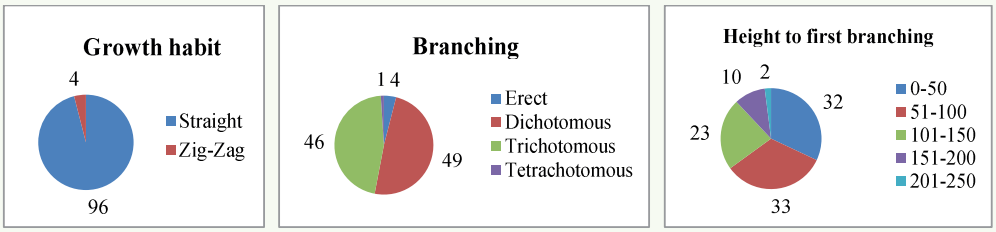

Fig. 3.1: Frequencies of various growth and branching patterns of stems in cassava

Young stem colour varies among the accessions as 5 different colours are found. Majority of the accessions had dark green coloured young stem (38) followed by greenish purple (34). Greenish red young stem colour was present in 14 accessions while 13 had light green and only one accession showed purple colour. Colour of stem epidermis was light brown in 38 accessions, dark brown in 35 accessions, cream in 18 accessions and orange in 9 accessions. Colour of stem cortex ranges from dark green (72), light green (27) and orange (1).

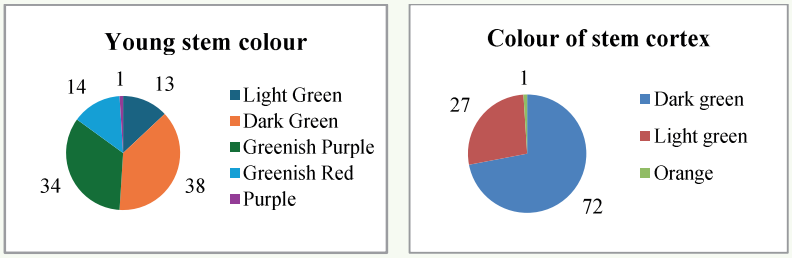

Fig. 3.2: Frequencies of stem colour variations

The plant height ranged from 146 to 310 cm with a mean value of 230.2 cm. 4 accessions possessed height above 300 (CE-71, CE-273, CE-456, CE-594A) followed by 23 accessions in range of 251-300, 48 accessions in 201-250 range, 23 accessions in 151-200 range and 2 accessions in 100-150 range. CE-71, CE-273 and CE-594A were tallest accessions with a height of 310 cm while CE-8 was the shortest accession (146 cm). The height at first branching ranged from 0 to 228 cm with a mean value of 85.32 cm. CE-141 had branching at 228 cm height from base implying the top branching nature of the accession. Height of first branching ranged from 0-228 cm as 0-50 (32), 51-100 (33), 101-150 (23), 151-200 (10) and 201-250 (2).

Stem perimeter at base ranged from 5.5 to 26 cm with a mean value of 12.7 cm. CE-38 had the thickest stem (26 cm), whereas CE-192 and CE-231 had the thinnest stem perimeter (5.5 cm) at base. Prominent leaf scar was found in 98 accessions while it was semi prominent in 2 accessions. The distance between leaf scars were found to be short in 55, medium in 41 and long in 4 accessions.

4. Leaf and flower characters

Cassava leaves also exhibits a good amount of variation in colour and shape among 100 indigenous cassava accessions. Four colour variations were observed in the colour of apical leaves. Of the 100 accessions studied, 50 accessions had purplish green colour apical leaves followed by 40 accessions with dark green apical leaves. Purple and light green coloured apical leaves were present in 8 and 2 accessions, respectively. All the accessions had pubescence on the apical leaves. The presence of pubescence was glabrous in maximum number of accessions (68) and the rest had them in moderate (18) and high (14) amount.

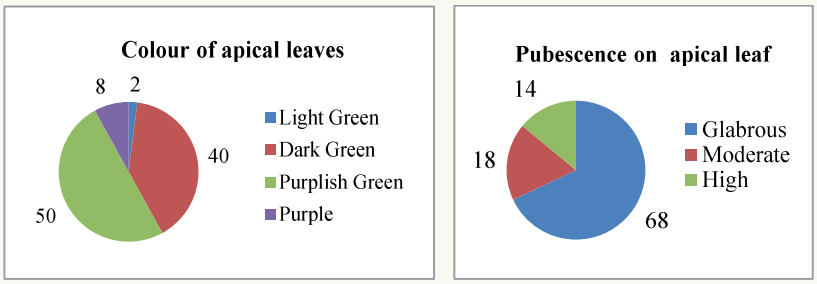

Fig. 4.1: Genotypic frequencies for colour of apical leaves and pubescence

In case of mature leaf pigmentation, most of it showed dark green colour (92) followed by purplish green (5), light green (2) and purple (1). Shape of central leaf lobe also followed the same trend. Lanceolate was the predominant shape with 97 accessions showing it while elliptical shape was found in two accessions and an accession with ovoid shape. Two forms of leaf lobe margin were observed. Majority of the accessions (81) had smooth lobe margin and the rest of the accessions (19) had winding type of leaf margin. Four different colours of leaf veins were observed. Green was the major colour present in 61 accessions followed by 22 accessions having reddish green in less than half of the lobe, 10 accessions have reddish green in more than half of the lobe and red found in 7 accessions.

Four categories of petiole orientation viz., horizontal, inclined upwards, inclined downward and irregular. Petiole orientation was found mostly inclined upwards (62). It is followed by horizontal (22), irregular (10) and inclined downward (6). Difference between leaf scar was short in 55 accessions. It was medium in 41 and high in 4 accessions. Petiole colour ranges from green (27), greenish red (9), reddish green (2), yellowish green (7), red (53) and purple (2).

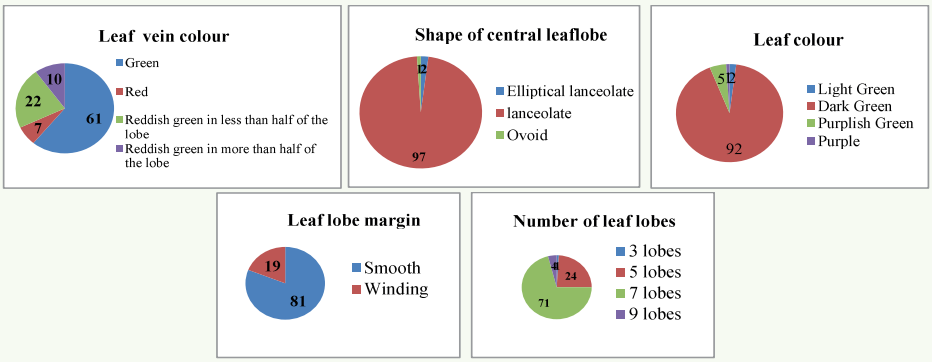

Fig. 4.2: Genotypic frequencies for leaf colour and shape

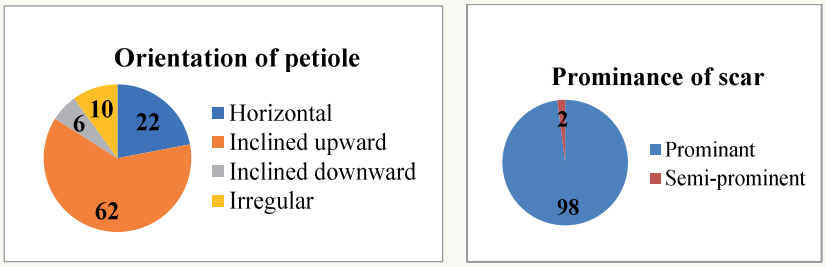

Fig. 4.3: Genotype frequencies for petiole orientation and leaf scar

Petiole length varied among the accessions starting from 10.5 to 38 cm with a grand mean value of 21.62 cm. CE-8 and CE-172 were having the shortest petiole with 10.5 cm. CE-34 having the longest petiole with 38 cm. Length of central leaf lobe also varied from 10.0 to 25.5 cm. CE-8 and CE-9 were having the shortest central leaf lobe with 10 cm and CE-34was having the longest central leaf lobe with 24 cm. It ranged from 1.50 to 6.5 cm with a grand mean value of 4.065 cm. The ratio between length to width ranges from 2.89 to 6.67 and its mean value of 3.87.

The accessions of flowering and non-flowering accessions were observed as 79 and 21, respectively. In 79 accessions flowered, fruit set was observed in 77 accessions. Out of these accessions, 30 had light green, 2 had green and 45 had dark green coloured fruits.

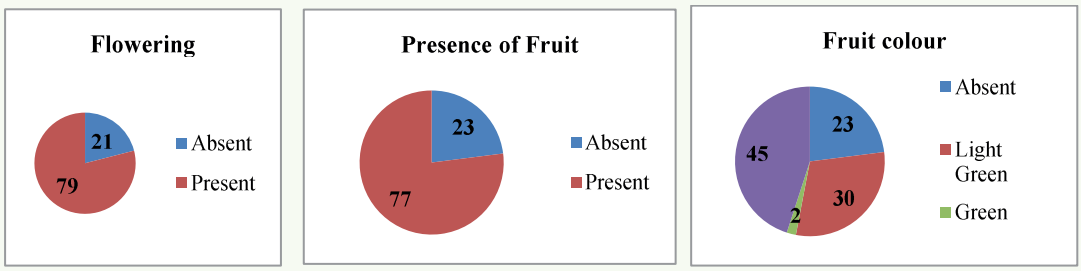

Fig. 4.4: Genotypic frequencies for floral traits

5. Tuber and yield characters

Cassava tubers exhibit different morphological variations. Based on tuber growth attitude, the accessions were classified into three groups namely, vertical, horizontal and irregular. Tuber growth attitude was horizontal in 70 accessions, vertical in 13 and irregular in 17 accessions. Based on the number of roots and constrictions on the tuber the accessions were divided into three groups. Majority of the accessions had few roots (78) and constrictions (20) on the tuber. Many constrictions were present in 2 accessions, respectively. Roots and constrictions were not present in 97 and 22 accessions respectively. A minimum of 39 accessions produced sessile tubers while 43 had pedunculate tubers. Mixed (sessile + pedunculate) form was present in 18 accessions.

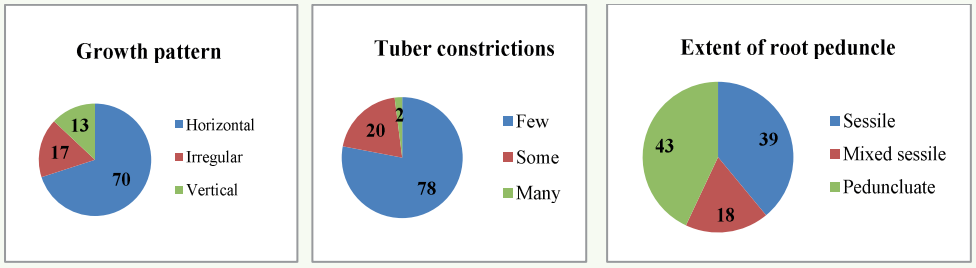

Fig. 5.1: Genotypic frequencies for tuber morphological traits

Four different variations were observed in tuber shape. Cylindrical shape was significantly high with 42 accessions showing it followed by conical (31), conical-cylindrical (19) and irregular (8). In external colour of tuber three variations were observed. Majority of the accessions (62) had dark brown colour. Light brown was the second highest colour (32) followed by cream (6). Cream was the predominant tuber cortex colour present in 48 accessions. Pink and purple colour tuber cortex was present in 33 and 18 accessions, respectively. Only one accession showed yellow coloured cortex. A large number of accessions possessed cream colour flesh (88) while few had white (9) and yellow (3) colour in tuber flesh. Three forms of tuber rind texture were identified. Tuber rind texture was rough in a major proportion of accessions (42) followed by intermediate (37) and smooth (21) forms. Peeling of cortex was easy in 83 accessions and difficult in 17 accessions.

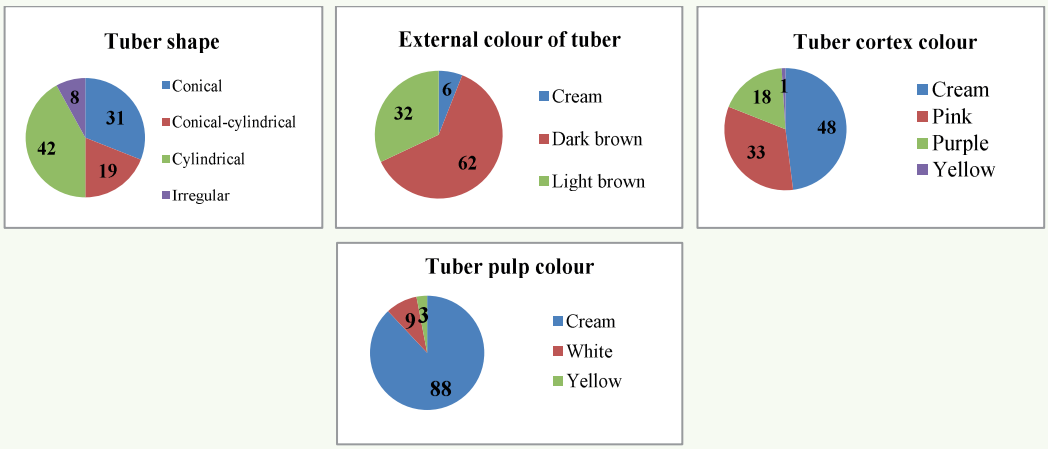

Fig. 5.2: Genotypic frequencies for tuber shape and colour

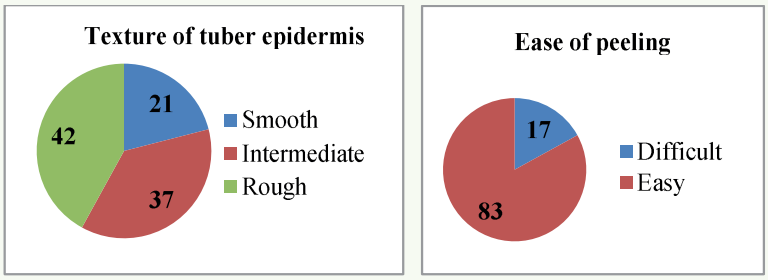

Fig. 5.3: Genotypic frequencies for tuber texture and ease of peeling

Taste of the raw tuber was recorded organoleptically. The accessions were classified into three groups based on the taste of raw tuber viz., good, slightly bitter and bitter. Tubers were good in 36 accessions while slightly bitter (intermediate) taste was observed in 30 accessions. The tubers were bitter and unfit for consumption in 34 accessions.

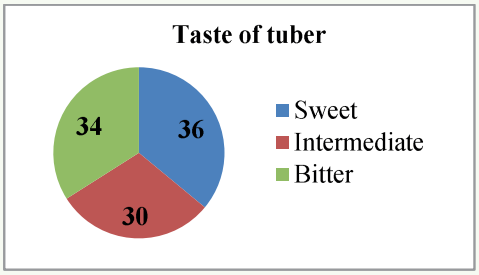

Fig. 5.4: Genotypic frequencies for tuber taste

The length of the tuber in the accessions was found short in 5, moderate in 10 and long in 85 (majority). Tuber diameter was divided into three groups namely narrow, medium and wide with 11, 26 and 6 accessions having them respectively.

Number of tubers per plant ranged from 2 tubers plant^{-1} to as high as 26 tubers plant^{-1} with a grand mean value of 10 tubers plant^{-1}. The outlier accessions identified for numbers of tubers were CE-108 (26), CE-198 (22), CE-152 (21), CE-144 (20) and CE-38 (20). Number of commercial tubers per plant ranged from 1 to 22 with a mean value of 8 tubers per plant. The accessions CE-108 (22), CE-38 (20), CE-152 (19) and CE-198 (18) were diverse accessions and had the highest number of commercial tubers plant^{-1}.

The minimum single biggest tuber weight was recorded in CE-331 (0.08 kg) and the maximum was found in CE-71 (10.13 kg) followed by CE-48 (7.25 kg), CE-34 (5.83 kg) and CE-219 (5.47 kg). The mean biggest tuber weight was noted as 1.42 kg. Though the internal variation for single biggest tuber weight was low, a good number of outliers were found. The diverse accessions for single biggest tuber weight were CI-10, CI-433, CI-20, CI-565, CI-5, CI-405, CI-576, CI-28, CI-531, CI-421A, CI-588 and CI-435. Total fresh tuber yield per plant varied from 0.23 kg in CE-331 to 27.28 kg in CE-71. The mean fresh tuber weight per plant was 6.43 kg. The outlier accessions identified were CE-89 (25.34 kg), CE-48 (21.77 kg), CE-34 (17.87 kg), CE-14(16.77 kg), CE-25 (15.25 kg) and CE-39 (14.73 kg).

Total stem and foliage weight per plant had variation among the 100 accessions of cassava. The minimum and maximum total stem and foliage weight per plant were recorded in CE-109 (0.96) and CE-198 (11.94) respectively. The mean stem and foliage weight per plant was 3.93 kg. Outlier accessions were CE-152 (11.39 kg) and CE-219 (11.39 kg). The harvest index ranged between 0.16 (CE-331) to 0.87 (CE-52). Mean harvest index is 0.58. Five superior accessions were identified for harvest index above 0.8 and among this CE-52 recorded the highest value of 0.87 followed by CE-48 (0.84), CE-82 (0.83), CE-39 and CE-140 (0.82) and CE-23 and CE-76 (0.80).

6. Tabulation of data

Table 6.1: Stem characters

Coll. No.	Acc. No.	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
CE-1	IC652563	1	1	4	2	1	2	2	200	9.00	3	30
CE-2	IC652564	1	1	4	2	3	2	2	226	7.50	3	63
CE-3	IC652565	1	1	4	2	3	2	2	205	9.00	3	35
CE-8	IC652566	3	1	2	3	3	2	2	146	9.50	3	18
CE-9	IC652567	3	1	2	3	3	2	2	181	8.50	3	106
CE-10	IC652568	3	1	4	3	3	2	2	186	7.50	3	94
CE-12	IC652569	1	1	4	3	4	2	2	205	8.00	5	55
CE-14	IC652570	1	1	6	2	4	2	3	210	11.50	5	38
CE-15	IC652571	4	1	0	1	2	4	2	166	6.00	3	166
CE-16	IC652572	1	1	6	2	4	3	2	253	9.50	5	34
CE-18	IC652574	3	1	4	3	4	2	3	184	7.50	5	120
CE-23	IC652577	1	1	5	3	2	2	3	220	8.50	3	40
CE-25	IC652578	1	1	4	3	2	2	3	224	10.0	5	53
CE-27	IC652580	3	1	4	3	2	2	3	240	7.50	3	162
CE-31	IC652584	1	1	5	3	4	2	2	234	9.50	5	120
CE-33	IC652585	1	1	4	2	2	2	3	205	10.00	7	120
CE-34	IC652586	3	1	5	3	4	2	3	260	16.50	3	110
CE-36	IC652588	1	1	4	3	2	2	3	252	14.20	5	30
CE-38	IC652590	1	1	4	3	4	1	3	295	19.00	5	110
CE-39	IC652592	3	1	4	3	1	2	2	230	12.00	5	85
CE-47	IC652594	2	2	4	3	4	2	3	201	12.00	5	50
CE-48	IC652595	1	1	4	4	4	4	3	290	15.50	7	100
CE-50	IC652596	1	1	5	3	4	3	3	262	12.50	5	60
CE-52	IC652598	3	1	3	3	2	1	3	300	9.00	5	155
CE-55	IC652599	3	1	5	3	2	4	3	240	12.00	5	138
CE-56	IC652600	1	1	5	3	4	4	3	263	15.00	5	86
CE-58	IC652601	1	1	5	3	2	1	3	200	11.00	5	70
CE-62	IC652602	3	1	3	3	4	1	3	240	11.80	5	147
CE-64	IC652603	1	1	5	2	1	4	2	260	14.00	5	30
CE-71	IC652604	1	1	1	3	1	1	2	310	16.00	3	70
CE-74	IC652606	1	1	6	2	2	4	3	200	12.50	5	45
CE-76	IC652607	1	1	3	2	1	1	2	180	10.00	3	30
CE-82	IC652608	1	1	4	3	1	2	3	210	10.50	3	55
CE-83	IC652610	1	1	3	3	2	3	3	200	11.50	5	30
CE-84	IC652611	3	1	4	2	4	2	3	240	8.00	3	150
CE-89	IC652612	1	1	4	3	4	1	3	237	13.00	3	100
CE-90	IC652613	3	1	5	2	4	2	3	190	8.50	3	60
CE-92	IC652614	1	1	6	2	2	2	3	190	9.50	3	43
CE-93	IC652615	1	1	4	2	1	1	2	210	9.00	5	42
CE-95	IC652617	4	1	0	1	2	2	3	202	6.50	3	0

Coll. No.	Acc. No.	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
CE-97	IC652618	3	1	4	2	4	2	3	230	10.50	5	110
CE-99	IC652619	3	1	5	3	4	2	3	235	10.00	5	110
CE-102	IC652621	3	1	4	2	4	3	3	230	10.30	5	135
CE-105	IC652623	3	1	4	3	4	3	3	260	9.00	3	186
CE-108	IC652624	1	1	4	2	4	2	2	280	8.50	3	62
CE-109	IC652625	3	1	4	2	2	4	3	230	7.00	3	37
CE-113	IC652626	3	1	4	2	2	2	3	240	8.00	3	165
CE-114	IC652627	4	1	0	1	3	2	2	300	10.00	3	0
CE-117	IC652628	3	1	3	3	4	2	3	220	7.00	3	150
CE-120	IC652629	3	1	5	3	1	2	3	280	15.00	3	160
CE-122	IC652631	1	1	4	2	1	1	2	180	7.00	3	30
CE-125	IC652632	3	1	4	2	4	4	3	260	7.00	3	140
CE-127	IC652633	1	1	5	3	1	3	3	240	13.00	3	38
CE-131	IC652634	1	1	4	2	2	3	3	210	9.00	3	50
CE-139	IC652635	4	1	0	1	4	4	3	230	8.00	3	0
CE-140	IC652636	1	1	6	3	4	1	3	245	12.00	3	40
CE-141	IC652637	3	1	3	2	2	2	3	265	8.00	3	228
CE-142	IC652638	1	1	6	3	4	3	3	220	12.00	5	40
CE-143	IC652639	3	1	4	2	4	3	2	220	7.00	3	100
CE-144	IC652640	2	2	6	2	3	3	3	250	9.50	3	23
CE-145	IC652641	3	1	2	3	3	1	2	235	7.00	3	200
CE-146	IC652642	3	1	4	3	2	2	3	270	11.00	3	130
CE-147	IC652644	1	1	6	2	2	3	3	210	8.00	3	205
CE-152	IC652646	3	1	5	2	4	1	3	250	9.50	3	120
CE-157	IC652647	3	1	4	2	2	3	3	190	9.00	3	110
CE-160	IC652649	3	1	3	2	2	2	3	200	8.50	3	110
CE-166	IC652651	1	1	5	3	4	3	3	300	12.00	3	100
CE-172	IC652656	1	1	5	3	3	3	3	233	9.00	3	38
CE-174	IC652660	3	1	4	3	2	3	3	200	8.00	3	103
CE-175	IC652663	3	1	4	2	1	3	2	168	7.00	3	75
CE-176	IC652664	3	1	3	3	2	3	3	224	7.50	5	138
CE-178	IC652665	3	1	2	2	2	3	3	217	7.00	3	168
CE-181	IC652666	3	1	4	3	4	3	3	235	8.00	5	87
CE-182	IC652667	1	1	5	2	3	3	2	170	6.00	5	25
CE-186	IC652669	2	2	3	2	2	2	3	210	8.00	5	36
CE-187	IC652670	3	1	2	2	2	3	3	278	7.50	5	197
CE-188	IC652671	3	1	4	2	4	2	3	210	9.00	5	76
CE-192	IC652672	3	1	3	3	3	2	2	180	5.50	3	100
CE-198	IC652673	3	1	5	3	2	1	3	208	7.00	5	84
CE-206	IC652674	1	1	4	2	1	2	2	198	8.00	5	51
CE-209	IC652675	1	1	5	2	2	1	3	200	6.50	5	64
CE-210	IC652677	3	1	4	2	2	3	3	221	7.50	3	86
CE-219	IC652678	3	1	5	2	2	3	3	285	11.00	3	98
CE-230	IC652679	1	1	4	2	2	3	3	264	9.00	3	61

Coll. No.	Acc. No.	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
CE-231	IC652680	3	1	1	2	3	1	2	150	5.50	3	93
CE-235	IC652682	3	1	3	3	2	3	3	186	7.00	5	101
CE-236	IC652683	3	1	4	2	2	3	3	230	8.00	5	128
CE-272	IC652707	1	1	7	2	2	3	3	300	10.00	5	38
CE-273	IC652708	1	1	6	3	2	3	3	310	10.50	7	45
CE-279	IC652711	1	1	6	3	4	3	3	280	12.00	3	36
CE-326	IC652732	1	1	6	2	1	3	2	225	13.00	5	50
CE-331	IC652736	1	1	6	3	5	3	3	270	12.00	5	62
CE-338	IC652740	1	1	5	2	1	1	3	246	9.50	5	87
CE-403	IC652774	3	1	5	2	4	1	3	248	12.50	3	156
CE-428	IC652789	2	2	5	2	2	3	3	233	11.00	7	52
CE-456	IC652810	1	1	5	2	2	3	3	304	13.50	3	40
CE-28A	IC652581	1	1	4	3	2	1	3	190	12.00	3	67
CE-594A	IC652859	2	1	5	3	3	3	2	310	11.00	5	85
CE-348	IC652744	3	1	5	2	4	3	3	200	8.00	5	120
CE-430A	IC652792	1	1	4	2	3	2	1	210	10.50	3	56

Table 6.2: Leaf and flower characters

Coll. No.	Acc. No.	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	P-28
CE-1	IC652563	3	3	5	5	7	3	3	5	1	17.00	7	13.00	4.00	3.25	1	1	1
CE-2	IC652564	5	3	5	5	7	5	1	5	7	22.00	7	13.00	3.00	4.33	1	1	1
CE-3	IC652565	5	3	5	5	7	5	1	5	7	16.00	7	12.00	3.00	4.00	1	1	1
CE-8	IC652566	5	3	5	5	7	3	3	5	7	10.50	7	10.00	1.50	6.67	1	1	2
CE-9	IC652567	7	3	5	5	7	9	3	5	7	15.00	7	10.00	2.00	5.00	1	1	2
CE-10	IC652568	5	3	5	5	7	3	3	5	7	13.00	7	12.00	3.00	4.00	1	1	1
CE-12	IC652569	7	3	3	5	7	9	1	5	7	18.00	5	17.00	4.00	4.25	1	1	1
CE-14	IC652570	9	5	5	5	3	3	3	5	2	12.00	5	12.00	3.00	4.00	1	1	3
CE-15	IC652571	5	5	5	2	7	3	3	5	5	19.00	5	13.00	3.00	4.33	0	0	0
CE-16	IC652572	7	3	3	5	7	5	3	5	7	26.00	7	19.00	3.50	5.43	0	0	0
CE-18	IC652574	9	7	5	5	7	3	3	5	5	21.50	7	15.50	3.50	4.43	1	1	3
CE-23	IC652577	7	5	5	5	3	3	3	5	1	19.00	5	13.00	4.00	3.25	1	1	3
CE-25	IC652578	7	7	5	5	3	3	3	5	2	14.00	7	14.00	4.00	3.50	1	1	3
CE-27	IC652580	5	3	5	5	7	3	3	5	7	19.50	7	11.50	3.50	3.29	1	1	3
CE-31	IC652584	5	3	5	5	3	3	7	5	5	27.50	7	17.00	4.00	4.25	1	1	3
CE-33	IC652585	5	3	5	5	3	3	1	5	2	24.50	7	17.00	4.00	4.25	0	0	0
CE-34	IC652586	7	3	5	5	3	7	5	5	7	38.00	7	24.50	5.50	4.45	1	1	1
CE-36	IC652588	7	3	5	1	7	3	5	5	5	28.50	7	18.00	3.50	5.14	1	1	1
CE-38	IC652590	7	3	5	5	3	5	1	5	7	25.00	7	19.00	4.50	4.22	1	1	3
CE-39	IC652592	7	5	5	5	3	3	1	5	2	19.50	7	17.50	5.00	3.50	0	0	0
CE-47	IC652594	7	5	5	5	3	5	3	5	7	18.00	7	15.50	4.50	3.44	1	1	1
CE-48	IC652595	7	3	5	5	3	3	1	5	5	28.00	9	20.00	5.50	3.64	1	1	3
CE-50	IC652596	9	3	5	5	3	3	1	5	5	25.00	7	18.50	5.50	3.36	1	1	3
CE-52	IC652598	7	3	5	5	3	3	1	5	3	25.00	7	16.00	4.50	3.56	1	1	3
CE-55	IC652599	7	3	5	5	3	5	1	5	7	22.00	7	15.50	4.50	3.44	1	1	3

Coll. No.	Acc. No.	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	P-28
CE-56	IC652600	5	3	5	5	3	3	7	5	7	22.50	7	18.00	5.00	3.60	1	1	1
CE-58	IC652601	5	7	5	5	3	3	1	5	7	22.00	7	13.50	4.50	3.00	1	1	1
CE-62	IC652602	5	3	5	5	3	3	5	5	5	28.00	9	14.50	4.50	3.22	1	1	1
CE-64	IC652603	7	3	5	5	3	3	7	5	2	28.00	7	16.00	5.00	3.20	1	1	1
CE-71	IC652604	5	3	5	5	3	7	7	5	7	31.00	7	20.00	5.00	4.00	0	0	0
CE-74	IC652606	7	5	5	5	3	3	1	5	2	14.00	7	14.50	4.50	3.22	1	1	1
CE-76	IC652607	5	3	5	5	3	3	1	5	1	21.00	7	17.50	4.00	4.38	1	1	3
CE-82	IC652608	7	5	5	5	3	3	1	5	1	20.00	7	15.00	4.00	3.75	1	1	1
CE-83	IC652610	7	3	5	5	3	3	1	5	2	16.00	5	14.00	4.50	3.11	1	1	3
CE-84	IC652611	5	3	5	5	3	5	7	5	7	17.50	7	14.50	4.50	3.22	1	1	3
CE-89	IC652612	7	3	7	5	3	3	3	5	7	22.00	7	18.00	4.00	4.50	0	0	0
CE-90	IC652613	7	7	5	5	3	3	1	5	2	19.00	7	17.00	3.00	5.67	0	0	0
CE-92	IC652614	7	3	5	5	3	3	7	5	2	17.50	7	14.00	3.50	4.00	1	0	0
CE-93	IC652615	7	3	5	5	3	3	1	5	1	14.50	7	15.50	3.50	4.43	1	1	3
CE-95	IC652617	5	5	5	5	3	5	1	5	5	20.50	7	14.00	4.50	3.11	1	0	0
CE-97	IC652618	7	7	5	5	3	3	1	5	2	19.50	7	17.50	3.50	5.00	1	1	3
CE-99	IC652619	7	7	5	5	3	3	1	5	2	23.00	7	18.50	3.50	5.29	1	1	3
CE-102	IC652621	7	3	5	5	3	3	3	5	7	26.50	7	18.50	5.00	3.70	1	1	3
CE-105	IC652623	7	3	7	5	3	5	1	5	5	25.00	7	17.00	4.00	4.25	1	1	1
CE-108	IC652624	9	3	5	5	3	5	7	3	7	29.50	9	19.00	5.00	3.80	0	0	0
CE-109	IC652625	5	3	5	5	7	5	1	5	7	27.00	7	16.50	4.00	4.13	0	0	0
CE-113	IC652626	5	3	5	5	3	9	1	5	7	20.50	7	16.00	4.00	4.00	1	1	3
CE-114	IC652627	5	7	5	5	3	7	1	5	7	28.00	7	22.00	4.50	4.89	1	1	3
CE-117	IC652628	5	3	5	2	3	7	5	5	7	27.50	7	19.00	6.50	2.92	0	0	0
CE-120	IC652629	5	7	5	5	3	3	5	5	2	26.50	7	19.00	5.00	3.80	0	0	0
CE-122	IC652631	7	5	5	5	3	3	1	5	2	28.00	7	13.50	3.50	3.86	1	1	3
CE-125	IC652632	7	3	7	5	3	3	1	5	7	26.50	7	17.00	4.00	4.25	1	1	1
CE-127	IC652633	7	5	5	5	3	3	1	3	2	21.00	7	15.50	4.50	3.44	1	1	3
CE-131	IC652634	7	3	5	5	3	3	1	5	2	21.50	7	14.00	4.50	3.11	1	1	3
CE-139	IC652635	3	7	5	5	3	9	1	5	7	22.00	7	16.00	4.50	3.56	1	1	3
CE-140	IC652636	7	3	5	5	3	3	1	5	7	18.50	5	15.00	3.50	4.29	0	0	0
CE-141	IC652637	5	3	5	5	3	3	1	5	2	22.50	7	19.50	5.50	3.55	0	0	0
CE-142	IC652638	9	3	5	5	3	3	7	5	7	30.00	7	18.00	4.50	4.00	0	0	0
CE-143	IC652639	7	7	7	5	3	3	1	5	7	16.50	5	12.00	4.00	3.00	1	1	3
CE-144	IC652640	9	3	5	5	3	3	7	5	7	21.00	5	17.00	4.50	3.78	0	0	0
CE-145	IC652641	5	7	5	5	7	3	5	5	3	22.00	7	16.00	4.00	4.00	1	1	3
CE-146	IC652642	5	3	5	5	3	5	1	5	7	19.00	7	14.00	4.00	3.50	0	0	0
CE-147	IC652644	5	3	5	5	7	7	1	5	7	19.00	7	12.50	3.50	3.57	1	1	1
CE-152	IC652646	7	3	5	5	3	3	1	5	7	23.50	7	16.50	4.00	4.13	1	1	1
CE-157	IC652647	5	3	5	5	7	3	1	5	1	21.50	5	14.50	4.00	3.63	0	0	0
CE-160	IC652649	5	3	5	5	3	5	1	5	7	15.50	7	13.00	3.50	3.71	1	1	3
CE-166	IC652651	7	3	7	5	3	5	3	5	7	26.17	7	19.50	5.00	3.90	1	1	3
CE-172	IC652656	9	3	5	5	3	5	1	5	7	10.50	5	11.00	3.50	3.14	1	1	3

Coll. No.	Acc. No.	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	P-28
CE-174	IC652660	7	3	5	5	3	3	1	5	2	19.00	7	16.00	4.00	4.00	1	1	3
CE-175	IC652663	5	3	5	5	3	3	1	5	1	20.00	5	15.00	4.00	3.75	1	1	3
CE-176	IC652664	7	3	5	5	3	3	1	5	2	19.00	7	16.00	4.00	4.00	1	1	1
CE-178	IC652665	5	3	5	5	3	5	1	5	7	19.00	5	13.00	4.50	2.89	0	0	0
CE-181	IC652666	5	3	5	5	3	5	1	5	7	13.00	5	14.00	4.00	3.50	1	1	3
CE-182	IC652667	5	3	5	5	3	9	3	5	7	19.50	7	16.00	4.50	3.56	1	1	3
CE-186	IC652669	7	7	5	5	3	3	1	5	2	20.00	5	12.50	4.00	3.13	0	0	0
CE-187	IC652670	5	5	5	5	3	3	1	5	2	16.00	7	13.00	3.50	3.71	1	1	3
CE-188	IC652671	5	7	5	5	3	3	1	5	7	28.50	7	17.50	5.00	3.50	1	1	1
CE-192	IC652672	5	5	5	5	7	7	3	5	7	19.00	7	12.00	3.50	3.43	1	1	3
CE-198	IC652673	7	3	5	5	3	3	1	5	7	21.00	5	16.00	4.50	3.56	1	1	1
CE-206	IC652674	5	3	5	5	3	7	1	5	7	13.50	5	12.50	4.00	3.13	1	1	3
CE-209	IC652675	5	3	5	5	3	5	1	5	7	14.00	5	12.50	2.50	5.00	1	1	1
CE-210	IC652677	5	3	5	5	3	7	1	5	7	13.00	5	10.50	2.50	4.20	1	1	1
CE-219	IC652678	7	3	5	5	3	3	1	5	2	26	9	19	4.50	4.22	1	1	1
CE-230	IC652679	5	5	5	5	3	3	1	5	2	20	7	16	4.00	4.00	1	1	1
CE-231	IC652680	5	7	5	5	7	7	3	5	7	12.5	5	11.5	2.50	4.60	1	1	1
CE-235	IC652682	7	5	5	5	3	3	1	5	7	13.5	7	14.5	4.00	3.63	0	0	0
CE-236	IC652683	7	3	5	5	3	3	1	5	7	14	7	13	4.00	3.25	1	1	3
CE-272	IC652707	5	5	5	5	3	5	1	5	7	14	5	12	3.50	3.43	0	0	0
CE-273	IC652708	7	5	5	5	3	5	1	5	7	18	5	14.5	4.50	3.22	1	1	1
CE-279	IC652711	5	5	5	5	3	9	1	5	7	20	7	15	5.00	3.00	1	1	1
CE-326	IC652732	7	3	5	5	3	3	1	5	2	17	5	16	3.50	4.57	1	1	1
CE-331	IC652736	7	3	9	5	3	7	3	5	9	15	5	14	4.00	3.50	1	1	1
CE-338	IC652740	7	3	3	5	3	3	1	5	1	13	3	14	4.50	3.11	1	1	3
CE-403	IC652774	7	3	5	5	3	5	1	5	7	15.5	7	13	4.00	3.25	1	1	3
CE-428	IC652789	7	5	5	5	3	3	7	5	2	19.5	5	17	4.50	3.78	1	1	3
CE-456	IC652810	7	3	5	5	3	3	1	5	7	19.5	7	16.5	4.50	3.67	1	1	3
CE-28A	IC652581	7	3	5	5	3	3	3	5	2	24.5	7	20	5.50	3.64	1	1	3
CE-594A	IC652859	7	3	5	5	3	5	3	5	7	24	7	15	3.50	4.29	1	1	3
CE-348	IC652744	9	3	5	5	3	3	3	5	2	20	7	13	4.00	3.25	1	1	3
CE-430A	IC652792	7	3	5	5	7	9	1	5	9	17	7	15	2.50	6.00	1	1	3

Table 6.4: Tuber characters

Coll. No.	Acc. No.	P-29	P-30	P-31	P-32	P-33	P-34	P-35	P-36	P-37	P-38	P-39	P-40	P-41	P-42	P-43	P-44	P-45	P-46
CE-1	IC652563	2	1	0	3	2	6	1	5	3	3	3	7	7	6	11.75	2.43	5.07	0.70
CE-2	IC652564	2	0	0	2	2	5	2	5	7	2	2	5	12	12	3.90	1.70	1.73	0.69
CE-3	IC652565	2	0	1	1	2	5	1	5	7	2	2	5	13	11	5.12	0.73	2.25	0.69
CE-8	IC652566	2	0	1	2	2	2	2	3	7	3	3	5	12	9	4.93	0.57	2.05	0.71
CE-9	IC652567	2	1	2	5	4	2	2	7	3	1	3	5	10	9	5.13	1.00	3.07	0.63
CE-10	IC652568	2	0	0	1	4	5	2	5	3	3	3	5	12	8	3.32	0.90	1.37	0.71
CE-12	IC652569	2	0	2	2	2	6	2	5	3	2	3	5	7	5	4.35	1.80	4.55	0.49
CE-14	IC652570	2	1	1	3	2	5	2	7	3	2	3	7	8	7	16.77	4.09	6.77	0.71
CE-15	IC652571	2	1	0	2	2	2	2	5	3	3	2	5	6	5	1.39	0.29	1.23	0.53

Coll. No.	Acc. No.	P-29	P-30	P-31	P-32	P-33	P-34	P-35	P-36	P-37	P-38	P-39	P-40	P-41	P-42	P-43	P-44	P-45	P-46
CE-16	IC652572	2	0	1	1	2	2	2	3	3	2	3	5	13	12	5.13	1.01	4.38	0.54
CE-18	IC652574	2	0	0	3	4	2	2	7	3	3	3	5	7	6	3.64	0.36	1.30	0.74
CE-23	IC652577	2	1	1	2	4	2	1	7	7	2	3	7	15	12	8.04	1.56	1.97	0.80
CE-25	IC652578	1	1	0	2	4	2	2	5	3	2	3	7	16	14	15.25	2.70	4.88	0.76
CE-27	IC652580	2	1	0	3	2	6	1	5	3	1	3	7	9	9	3.56	0.66	1.85	0.66
CE-31	IC652584	1	0	0	3	4	5	2	5	3	3	3	7	6	6	5.70	1.50	1.84	0.76
CE-33	IC652585	2	0	1	1	4	2	2	5	3	2	2	5	10	9	2.67	0.64	3.59	0.43
CE-34	IC652586	1	2	1	5	4	6	2	7	3	2	3	7	8	8	17.87	5.83	8.58	0.68
CE-36	IC652588	3	1	2	5	4	2	2	5	3	3	3	7	18	16	8.34	1.17	4.52	0.65
CE-38	IC652590	3	1	1	2	2	2	2	5	3	1	3	7	20	20	12.28	1.73	6.10	0.67
CE-39	IC652592	2	1	1	3	2	2	2	5	7	3	3	7	19	15	14.73	1.27	3.26	0.82
CE-47	IC652594	2	1	2	5	4	5	2	7	3	3	3	5	7	5	5.44	1.38	3.80	0.59
CE-48	IC652595	2	1	0	3	4	2	2	5	3	3	3	5	5	4	21.77	7.25	4.07	0.84
CE-50	IC652596	2	1	1	1	4	2	2	7	3	2	3	7	5	5	7.80	2.10	2.50	0.76
CE-52	IC652598	3	1	0	1	2	2	1	7	3	3	3	7	13	11	7.83	0.71	1.22	0.87
CE-55	IC652599	2	1	0	3	4	6	1	7	3	3	3	7	10	8	12.54	2.09	3.74	0.77
CE-56	IC652600	2	0	0	3	4	6	1	7	3	2	3	7	11	11	12.34	1.00	5.18	0.70
CE-58	IC652601	2	0	0	1	2	5	2	3	7	2	3	5	8	8	4.62	0.58	3.78	0.55
CE-62	IC652602	2	0	0	1	4	5	2	5	3	1	3	3	3	2	1.45	0.42	1.09	0.57
CE-64	IC652603	1	1	2	5	4	2	2	7	3	3	3	3	6	4	2.76	0.57	4.72	0.37
CE-71	IC652604	2	0	0	3	2	2	1	5	3	1	3	7	9	7	27.28	10.13	7.59	0.78
CE-74	IC652606	2	0	2	1	4	5	2	7	3	1	3	7	2	2	1.68	1.00	2.77	0.38
CE-76	IC652607	2	2	2	2	2	5	2	3	7	3	3	7	5	3	7.31	2.72	1.88	0.80
CE-82	IC652608	1	0	0	3	4	5	2	7	3	3	3	7	12	11	14.04	2.39	2.82	0.83
CE-83	IC652610	3	1	2	3	4	2	2	7	3	2	3	7	6	5	4.35	0.99	2.13	0.67
CE-84	IC652611	2	0	0	3	4	6	2	7	3	2	3	7	6	4	5.85	1.26	3.39	0.63
CE-89	IC652612	2	1	1	3	4	5	2	7	3	2	3	7	12	12	25.34	4.50	7.51	0.77
CE-90	IC652613	2	0	2	3	4	2	2	7	3	3	3	5	8	6	4.22	0.81	2.32	0.65
CE-92	IC652614	2	1	0	3	4	6	1	7	3	1	3	5	4	4	2.87	0.80	1.62	0.64
CE-93	IC652615	2	0	2	3	2	5	2	5	3	2	3	7	5	4	4.84	1.54	1.44	0.77
CE-95	IC652617	2	0	2	5	2	2	2	3	7	1	3	5	5	4	2.41	0.55	2.57	0.48
CE-97	IC652618	2	0	2	5	4	5	2	5	7	1	3	7	7	5	6.68	1.37	3.20	0.68
CE-99	IC652619	2	0	2	3	4	5	2	7	7	3	3	7	7	6	5.30	2.31	3.45	0.61
CE-102	IC652621	2	0	0	1	4	5	2	7	3	2	3	3	9	7	8.43	2.07	4.19	0.67
CE-105	IC652623	2	0	0	1	4	2	2	5	3	2	3	7	8	7	6.31	1.81	4.46	0.59
CE-108	IC652624	2	0	1	5	4	2	2	5	3	2	3	7	26	22	10.53	1.22	3.30	0.76
CE-109	IC652625	2	0	1	3	2	5	2	3	3	1	1	3	11	9	1.84	0.40	0.96	0.66
CE-113	IC652626	2	0	0	3	2	5	2	3	3	2	2	3	13	10	2.33	0.35	3.76	0.38
CE-114	IC652627	2	0	2	3	4	2	2	3	3	2	3	7	16	13	10.29	1.17	3.71	0.74
CE-117	IC652628	2	0	0	1	2	2	2	3	7	1	2	5	8	6	1.49	0.39	6.51	0.19
CE-120	IC652629	2	0	2	3	4	5	2	7	3	3	3	7	14	14	9.64	0.90	5.50	0.64
CE-122	IC652631	2	0	0	1	2	2	2	3	3	1	3	7	11	10	4.35	0.89	3.39	0.56
CE-125	IC652632	2	0	2	3	4	2	2	7	3	3	3	7	12	12	6.16	1.08	3.32	0.65

Coll. No.	Acc. No.	P-29	P-30	P-31	P-32	P-33	P-34	P-35	P-36	P-37	P-38	P-39	P-40	P-41	P-42	P-43	P-44	P-45	P-46
CE-127	IC652633	2	0	2	2	2	5	2	7	3	2	1	7	15	13	10.46	1.33	3.14	0.77
CE-131	IC652634	2	0	2	1	4	6	2	7	3	3	3	5	8	7	2.72	0.50	4.84	0.36
CE-139	IC652635	2	0	2	1	4	2	2	5	3	1	3	5	10	7	3.20	0.39	2.46	0.57
CE-140	IC652636	3	0	2	2	4	2	2	5	3	1	3	7	16	16	11.51	1.12	2.59	0.82
CE-141	IC652637	2	0	0	3	4	2	2	7	3	1	3	7	8	8	4.16	1.13	6.53	0.39
CE-142	IC652638	3	0	0	1	2	2	2	5	3	1	3	5	14	13	5.31	4.11	3.51	0.60
CE-143	IC652639	2	0	2	1	2	2	2	5	7	2	2	3	4	1	0.60	0.12	1.29	0.32
CE-144	IC652640	3	0	2	1	4	2	2	3	3	3	3	5	20	12	3.36	0.25	2.87	0.54
CE-145	IC652641	2	0	0	3	4	2	2	3	7	2	3	7	6	3	1.58	0.43	1.89	0.46
CE-146	IC652642	3	0	2	3	4	6	2	7	3	1	3	7	11	11	6.14	0.93	5.86	0.51
CE-147	IC652644	2	0	2	1	4	2	2	7	3	2	3	7	8	6	3.67	1.05	3.62	0.50
CE-152	IC652646	3	0	2	1	2	2	2	3	3	3	3	7	21	19	12.59	1.30	11.39	0.53
CE-157	IC652647	3	0	0	2	4	5	2	5	3	1	3	5	11	10	2.71	0.31	2.71	0.50
CE-160	IC652649	3	0	0	1	4	6	2	7	3	2	3	7	9	8	2.73	0.36	2.48	0.52
CE-166	IC652651	2	0	0	1	4	2	2	5	3	3	3	3	10	5	3.65	0.74	3.27	0.53
CE-172	IC652656	2	0	2	1	4	2	2	3	3	3	3	5	11	9	1.40	0.30	1.57	0.47
CE-174	IC652660	2	0	0	1	2	2	4	3	3	2	3	7	10	10	3.07	0.63	2.91	0.51
CE-175	IC652663	1	0	0	1	4	2	2	7	3	1	3	7	9	9	2.38	0.67	2.51	0.49
CE-176	IC652664	1	0	1	3	4	2	2	7	3	3	3	7	6	6	3.62	0.95	3.43	0.51
CE-178	IC652665	2	0	0	3	4	5	2	7	3	3	2	5	6	4	1.44	0.33	1.23	0.54
CE-181	IC652666	2	0	2	3	4	6	2	7	3	1	3	7	10	9	4.19	0.67	3.45	0.55
CE-182	IC652667	2	0	2	3	4	5	2	7	3	1	3	7	6	4	7.73	0.74	7.56	0.51
CE-186	IC652669	1	0	2	2	2	2	2	3	3	3	3	7	12	10	2.85	1.37	2.49	0.53
CE-187	IC652670	3	0	2	3	2	6	2	7	3	1	3	7	10	10	7.22	1.35	6.79	0.52
CE-188	IC652671	2	0	2	2	2	2	2	5	3	1	3	7	5	5	3.93	1.22	3.73	0.51
CE-192	IC652672	1	0	0	3	4	4	2	7	7	1	1	5	3	3	0.84	0.27	1.27	0.40
CE-198	IC652673	2	0	2	3	1	5	2	7	3	1	3	7	22	18	12.65	1.46	11.94	0.51
CE-206	IC652674	2	0	2	1	2	5	2	5	3	3	3	7	13	12	2.63	0.43	2.36	0.53
CE-209	IC652675	3	0	2	1	2	6	2	5	3	1	3	7	9	8	3.51	0.65	3.55	0.50
CE-210	IC652677	3	0	1	3	4	6	2	7	3	2	3	7	10	9	3.82	0.82	3.37	0.53
CE-219	IC652678	2	0	2	2	4	5	2	7	3	1	3	7	6	6	11.57	5.47	11.39	0.50
CE-230	IC652679	2	0	0	2	4	5	2	7	3	1	3	7	8	6	7.45	1.38	7.78	0.49
CE-231	IC652680	1	0	0	2	1	2	2	3	7	1	2	3	4	3	1.25	0.33	1.36	0.48
CE-235	IC652682	3	0	2	3	1	2	2	5	7	3	2	5	14	10	3.50	0.25	3.47	0.50
CE-236	IC652683	1	0	2	1	1	2	2	5	3	1	3	7	13	11	5.51	0.69	5.42	0.50
CE-272	IC652707	2	1	1	3	4	6	2	5	3	1	3	7	13	13	9.70	1.74	8.60	0.53
CE-273	IC652708	3	0	0	2	4	5	2	5	3	2	3	7	11	11	5.56	1.35	4.73	0.54
CE-279	IC652711	2	0	0	1	4	6	2	5	3	3	3	7	14	12	6.43	1.04	5.89	0.52
CE-326	IC652732	1	0	0	3	4	2	2	3	3	3	1	3	3	11	0.65	0.13	2.16	0.23
CE-331	IC652736	1	0	2	3	4	5	2	7	3	3	1	3	3	2	0.23	0.08	1.22	0.16
CE-338	IC652740	2	0	2	1	4	2	2	3	7	3	3	3	8	7	0.99	0.24	1.30	0.43
CE-403	IC652774	2	0	2	3	2	5	2	5	3	3	3	7	11	11	13.28	2.31	6.20	0.68
CE-428	IC652789	2	0	1	3	4	5	2	7	3	1	3	7	5	5	6.92	5.86	5.81	0.54

Coll. No.	Acc. No.	P-29	P-30	P-31	P-32	P-33	P-34	P-35	P-36	P-37	P-38	P-39	P-40	P-41	P-42	P-43	P-44	P-45	P-46
CE-456	IC652810	2	0	2	1	4	2	2	5	3	1	3	7	6	6	4.86	1.48	5.94	0.45
CE-28A	IC652581	2	0	1	2	4	2	2	5	3	2	3	7	11	11	13.76	0.66	10.74	0.56
CE-594A	IC652859	2	0	2	2	4	6	2	7	3	1	3	7	9	7	5.52	1.27	3.61	0.60
CE-348	IC652744	3	0	0	3	1	5	4	3	3	1	3	7	7	6	3.07	1.56	1.83	0.63
CE-430A	IC652792	2	0	2	3	1	5	4	3	3	1	3	7	4	4	4.24	1.22	6.22	0.41

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