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CHARACTERIZATION OF CASSAVA [*Manihot esculenta* (Crantz)] GERMPLASM FOR EFFECTIVE CONSERVATION

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ABSTRACT
An experiment was conducted to characterize the cassava germplasm of the Council for Scientific and Industrial Research, Plant Genetic Resources Research Institute (CSIR-PGRRI), Ghana to help in effective conservation. A total of 210 cassava accessions being conserved at the field genebank of the CSIR – PGRRI were used for the experiment in October, 2014 and data collected in October, 2015 on five morphological traits comprising of plant height, growth type, height of first branch, levels of branching and branch angle. The five traits revealed variability among the cassava accessions. Based on the variability, the 210 accessions were classified into four categories namely short-spreading, tall-spreading, short-non-spreading and tall-non-spreading. Four different planting distances were suggested for the different groups for effective conservation. The recommended planting distances were 75 x 75 cm, 75 x 100 cm, 100 x 100 cm and 100 x 150 cm groups based on height and spreading nature of the cassava accessions. Cassava accessions from different planting distances groups should not be planted adjacent each other to avoid suppressing of weaker ones.

Key words: Branching, Genebank, Growth type, Morphological traits, Planting distance

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INTRODUCTION
Cassava is the most important non-cereal source of calories in the tropics consumed by man (FAO, 2015a). Ghana is ranked the 6th largest producer of cassava in the world (FAO 2015b) and its cultivation contributes about 22% of the country's Gross Domestic Product (Angelucci, 2013). The estimated production of cassava in Ghana in 2014 was 16.5 Million Ton, following a steady increase from 13.5 Million Ton in 2010 (FAO, 2015b). Cassava is eaten in different forms across Ghana and this makes the crop a staple food for many of the over 30 million people in the country. It is widely eaten as 'garri', a special processed food from cassava dough. Two other common forms in which cassava is consumed in many localities in Ghana and other West African countries are fufu and tapioca. Cassava is also used as raw material in the starch industry. Preparation of these food items is, however, dependent on root quality. A good fufu quality cassava may not give high tuberous root yield and or good quality starch (Amarullah, 2020).

Cassava is one of most easy-to cultivate crop plants due to its hardiness and drought adaptation, performing well even in marginal soils. The climate of Ghana is generally suitable for cassava cultivation (Ceballos *et al*., 2011). The crop is cultivated in all the administrative regions of the country in the exception of Upper East and West due to its wide climatic adaptation (Angelucci, 2013). Cultivars of cassava varied within and across farms. Intense planting material exchange

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system exists between farmers in Ghana, and could be one cause of the varied cultivars found within farms (Mezette *et al*, 2013). Similarly, wide morphological variability is found within the cassava germplasm of the Council for Scientific and Industrial Research, Plant Genetic Resources Research Institute (CSIR-PGRRI) and this warrants its characterization as different cultivars require different spacing for optimum growth and yield (Cock *et al*. 1977). Cassava characterization that have been done elsewhere were useful in management of the crop (Fadhillah, *et al*., 2021; Nadjiam *et al*., 2016; Boni *et al*., 2014). Apart from management and conservation purposes, characterization is also useful for decision making on usage of crops (Brito *et al*, 2013) The characterization of the cassava germplasm under conservation at CSIR-PGRRI therefore, became imperative.

The usual planting distance of cassava in Ghana and some parts of the world is 100 cm by 100 cm (Perez *et al*., 2010) and this has also been used at the CSIR – PGRRI over the years. Recent observations led to the suggestion that some of the accessions could be planted with closer distances and others with wider distances, not only to express their genetic potential but also to prevent their loss in the field gene bank and to ensure an effective and efficient use of resources. The objective therefore, was to characterize the plant genetic resources of the CSIR – PGRRI and group the accessions into different planting distance groups.

MATERIALS AND METHODS

The project involved the characterization of 210 accessions of cassava (Table 1). These are the cassava germplasm being conserved at the field gene bank of CSIR – PGRRI, Bunso, 82 km north east of Accra. The research institution is located in a moist-deciduous rainforest with a mean annual minimum and maximum temperatures of 21.4°C and 31.3°C respectively. The raining season is bi-modal at Bunso with annual average precipitation of 1,455 mm (Boateng and Tetteh, 2020). The experimental site (N 06º 17.839, W 000º 27.595, Alt 198.3 m above sea level), which had been fallowed three years after cultivating cowpea was cleared using cutlasses. Trees were chopped and the logs removed. The debris was further chopped and pressed to the ground before planting, without burning or making of mounds.

Planting materials from 2013 cassava germplasm were planted in October, 2014 with a spacing of 1 m between and within rows. Each accession was planted in a single row with ten cuttings. The cuttings were expurgated from hardwood sections of cassava stems with sharp cutlass. The cuttings were about 30 cm long and had six to eight nodes depending on the cultivar.

Planting holes of about 10 cm deep into which cuttings were planted, were dug with cutlass. The cuttings were inserted into the planting holes at an angle of about 45° and the soil firmed around them using the foot. Weed control was carried out after planting by slashing with cutlass to the time of data collection in October, 2015. The experiment depended on rainfall and there was no application of fertilizer or agro-chemicals.

Data analysis

Five traits (plant height, growth type, height of first branch, levels of branching and branch angle) were scored according to cassava descriptors (Fukuda *et al*, 2010). Analysis of the data was carried out using statistical software (GenStat 15th edition). Multi-variate principal components bi-plot was generated for the cassava accessions. Significance was accepted at $p \leq 0.001$.

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RESULTS AND DISCUSSION

Principal component bi-plot (Figure 1) showed diversity in the cassava germplasm based on the five morphological traits scored. The five traits scored were sufficient to separate most of the accessions characterized. Depending on the trait and the purpose of the characterization, a single trait could be used to characterize germplasm (Brito *et al*, 2013). It is advisable to use fewer characters if enough information can be obtained to avoid waste of resources (Afonso *et al*, 2014). The cassava accessions clustered based on plant height on one hand and the spread of canopy on the other hand, which was influenced by the traits scored. The principal component bi-plot provided adequate information to help group the cassava germplasm into different planting distances groups for effective conservation.

The cassava germplasm were classified into four groups, namely, short spreading, tall spreading, short non-spreading and tall non-spreading. Measurement on plant height contributed to the plant height making 28.62 % of total variation observed in the collection (Fig. 1). The other four characters, growth type, height of first branch, levels of branching and branch angle contributed to the spread (the second principal component), cumulatively 98.96 % of total variation.

Accessions shorter than 300 cm were considered short while those above 300 cm considered as tall. Within accession variability in plant height with different planting distance is usually insignificant (Streck *et al*, 2014). Plants classified as short or otherwise are therefore, expected to be similar in subsequent generations unless they were influenced by inter-accession competition. Accessions with a score of above 10 for plant type were considered spreading while those with a score of less than 10 were considered to be non-spreading. The short spreading accessions are partitioned at the top right of the principal component bi-plot while the short non-spreading are in the bottom right. The tall spreading and tall non spreading are found in the top left and bottom left respectively. The number of accessions considered as short non-spreading, short spreading, tall non-spreading and tall spreading were 49, 80, 27 and 54 respectively.

The tallest accession (UCC2001111) was more than four times taller than the shortest accession which was UCC2001296 (95 cm). However, UCC2001296 was exceptionally short as all the other accessions were taller than 100 cm. The second shortest was 140 cm (1224). In the same way, some plants were more than four times spreading than others exhibiting the wide morphological diversity known in the plant (Perez *et al*., 2010). The expression of these traits may partly be due to inter-accession competition.

The diversity exhibited by the cassava accessions in terms of plant height and spread indicated that the use of the same planting distance for all of them could not be appropriate. Planting distance which is too close would lead to weak plants and competition which may lead to loss of some accessions. The use of wider spacing for some accessions would also be a waste of space and resources in the conservation activities. In farm conditions cassava can compensate for space where too narrow or wide spacing is used (Perez *et al*., 2010). The case is, however, different if different accessions are planted for conservation. Effort to classify the germplasm into different planting distance groups would lead to better plant health and judicious use of resources.

Four different planting distances have been proposed based on the outcome of the experiment. Planting distance of 75 cm by 75

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cm is proposed for the short non-spreading accessions, whilst a wider spacing of 100 cm by 75 cm is proposed for the tall non-spreading types. Depending on the cassava accession and the planting system, a distance of 70 cm by 70 cm or less can be used in some cases (Hauser *et al*., 2014). Whilst some cassava accessions can be grown under taller plants, some plants can be grown under some other cassava accessions. Wider spacing is preferred for cassava accessions under which other crops are grown. Spacing of 100 cm by 100 cm, which is the normal for most cases in Ghana, and 100 cm by 150 cm are proposed for the short spreading and tall spreading accessions respectively in this experiment.

The cassava accessions that fall into the various groups are given in a supplementary document and their numbers in Table 1. The different planting distances would be used to plant the various cassava accessions subsequently. These would reduce inter-accession competition and contribute toward better conservation of the germplasm.

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APPENDICES

Table 1: Number of cassava accessions with a given recommended planting distances

Planting Distance (cm)	Number of Accessions
75 cm x 75 cm	49
100 cm x 75 cm	27
100 cm x 100 cm	80
100 cm x 150 cm	54

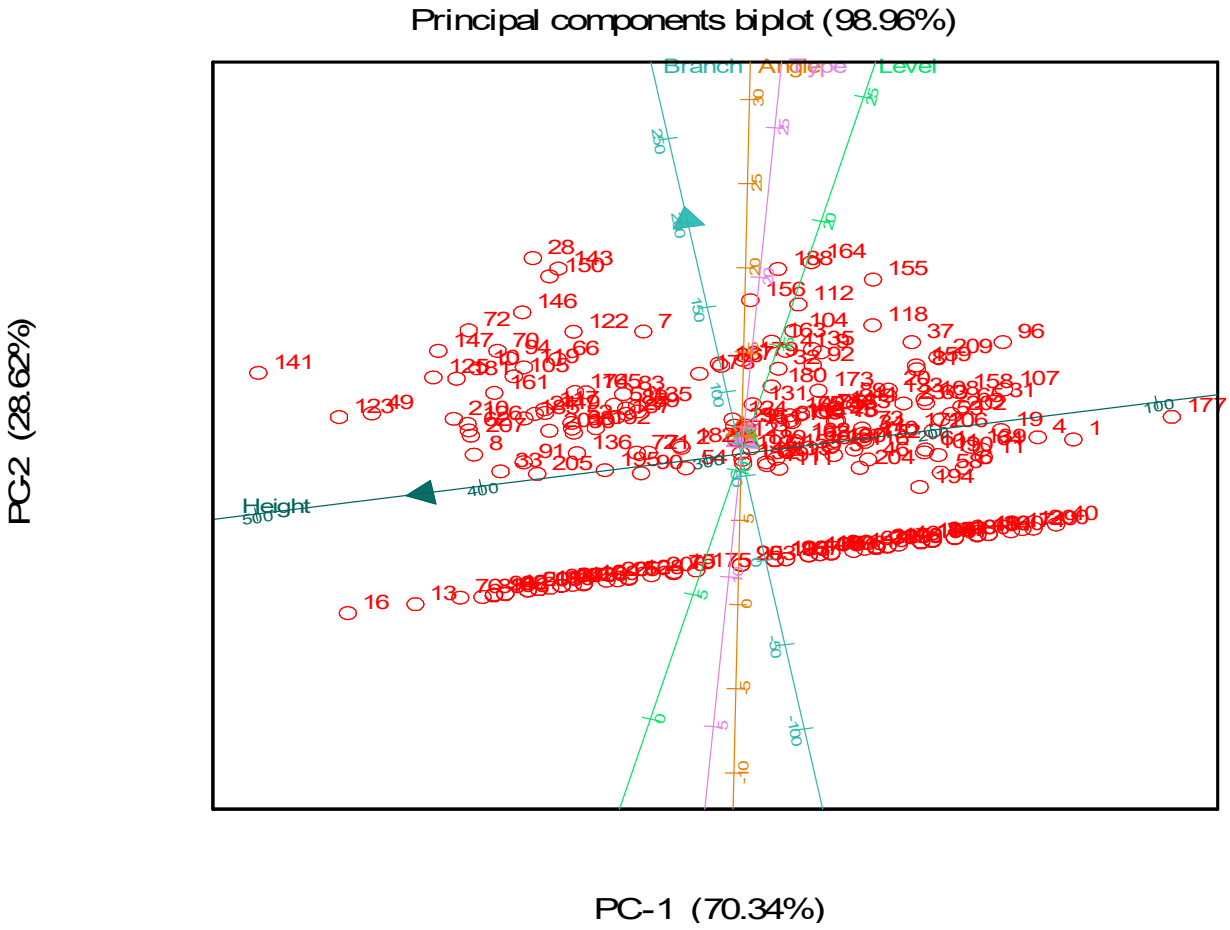

Fig. 1. Principal component bi-plot for the cassava accessions based on five morphological traits