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Effects of Two Agro-Ecological Zones on Leaf Chlorophyll Contents of Twelve Cassava Genotypes in Nigeria

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Abstract: Chlorophyll content in leaves is one of the major component in photosynthesis. Twelve cassava genotypes were evaluated in two agroecological zones (Ibadan: 25+5 C and Jos: 18+5 C), to determine the leaf chlorophyll contents at 3, 6, 9 and 12 months after planting (MAP). Plants were harvested at 12 MAP for dry tuberous root yield determination. The results showed that significant differences ($P<0.05$) in total chlorophyll contents were observed among the four environments throughout the sampling periods. Chlorophyll content at Jos plateau was significantly reduced when compared to Ibadan at all ages (3, 6, 9 and 12 MAP). The cassava leaf chlorophyll contents increased up to 6 MAP and then decreased at 9 MAP at both locations. Genotypic differences ($P<0.05$) were observed among the cassava genotypes for leaf chlorophyll contents in across locations. TMS 30001, TME1, TME11 and TMS 30572 produced the highest chlorophyll contents of 3.0, 3.9, 3.6 and 2.7 g/g fresh leaf tissue for 3, 6, 9 and 12 MAP respectively). At Ibadan, TMS 30001, TMS 30572 and TMS 50395 had the highest values for chlorophyll contents throughout the sampling periods, whereas in Jos plateau, TMS 30572, TME11, Danwaru and TME1 produced the highest values for leaf chlorophyll contents. The total dry tuberous root weight produced at Ibadan was significantly ($P<0.05$) higher than Jos plateau at 12 months after planting. Genotypic differences were observed among the genotypes either across locations or within locations for dry tuberous root weight. Genotypes TMS 91934, TMS 30572, TME1 and Danwaru performed better than other genotypes at low temperatures for dry tuberous root yield. There were correlations between chlorophyll content and dry tuberous root yield ($r=0.79$, $n=12$). The results of this study suggested that TMS 30001, TMS 30572, TME1, TME11, Danwaru and TMS 50395 had high chlorophyll content and dry tuberous root weight and these clones should be made available to farmer for planting in these locations. Also, this study indicates that cassav with high chlorophyll contents will have high tuberous root yield.

Key words: Chlorophyll content · Agro-ecological zones · Cassava genotype · Tuberous root yield

INTRODUCTION

Cassava (Manihot esculenta Crantz) is a major staple food in the sub-Saharan Africa [1]. Cassava is grown in area between the latitudes 30°N and 30°S [2]. Cassava tolerates hot climate, but a critical point exist between a daily average temperature of 18°C and 20°C, below which the plants do not grow normally and the yields decrease rapidly [2]. Research on cassava growth have been on high temperatures [3,4]. These have contributed to the successful cultivation of cassava in high temperature regions of the tropics using cultivars adapted to the environments [5].

Although, there is considerable interest in the extension of the crop into the mid- and high altitudes of Africa, less information is available on cassava responses to higher altitudes. Approximately 19% of total cassava area in Africa experiences low temperatures [6] and it is not clear how the existing clones would tolerates the low temperature experienced. The effects of low temperatures on other crops have been studied and these which include poor establishment, chlorosis, retarded growth and development and reduced yield [7,8]. Nevertheless, there are few reports on the mechanism of the effects of low temperature on cassava leaf growth and the accompanying metabolic changes. An apparent decrease in chlorophyll content in leaves exposed to low temperatures is frequently a noted symptoms of chilling stress [8,9].

The study of adaptation to low temperature in a large and diverse set of cassava clones was carried out in Nigeria, taking advantage of altitudinal variation between

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Ibadan and Jos plateau in order to create a range of thermal regimes. In this paper we tried to define how low and high temperature affect the levels of chlorophyll content and yield of cassava and hence to determine if specific genotypes may be more suitable for low temperature conditions.

MATERIALS AND METHODS

These experiments were conducted in Nigeria at Jos plateau (mid-altitude) and Ibadan (lowland savanna zone). Two experiments were conducted during 1994/95 and 1995/96 crop seasons at International Institute of Tropical Agriculture (IITA), Ibadan and National Root Crop Research Institute field stations (Vom and Heipang) in Jos plateau. In 1994/1995 crop season, cassava stem cuttings were planted on May 5, 1994 and May 13, 1994 at Ibadan and Jos plateau respectively while in 1995/1996 crop season, cassava stem cuttings were planted on May 10, 1995 and May 20, 1995 respectively, at Ibadan and Jos. These two locations represent contrasting agroecological zones: Ibadan (altitude: 210 metres above sea level (masl), relative humidity: 65-90%, latitude: 4°46'N, longitude: 2°34'E, temperature: 28±6°C, rainfall: 1545mm) and Jos plateau ((a) Vom: altitude: 1280 masl, latitude: 9°55'N, longitude: 9°E, relative humidity: 55-85%, rainfall: 1099mm, temperature: 18±5°C, (b) Heipang: altitude: 1290 masl, latitude: 9°38'N, longitude: 8°9'E, relative humidity: 60-85%, temperature: 18±6°C, rainfall: 1153mm). The soil at Ibadan is classified as Oxic Paleuestalf, Alagba soil series [10] while in Jos plateau the soil is Ferruginous tropical soils [11].

Experimental Design: Twelve cassava clones (six improved IITA clones: TMS 30001, TMS 91934, TMS 4(2)1425, TMS 30572, TMS 50395, TMS 30555; four landraces (local clones) commonly grown in southwestern Nigeria: TME1, TME2, Isunikankiyan and Oko-Iyawo; two landraces (local clones) adapted to mid-altitudes: Danduala and Danwaru). Cassava stem cuttings of 0.20m length were obtained from 12 month old mother plants at the middle part of the stem and were immersed in 0.05% of fungicidal Benlate (a.i.= methyl 1-(butyl carbatomyl)-2-benzimidazole carbamate) solution.

The experiments were set up in each location in a completely randomized block design with three replications. Each plot had 6 rows, 10m long and spacing was 1m between rows and 0.8m within a row. Each plot contained 72 plants. Fields were kept free of weeds by regular hand-weeding.

Data Collection and Analyses: Sampling was done at 3, 6, 9 and 12 months after planting. Two grammes of fresh leaf tissue were crushed in mortar with pestle. Thereafter, 80% acetone was added to allow the tissue to be thoroughly homogenized and then the supernatant was decanted through a filter paper into a 100 ml volumetric flask; made up to volume (100 ml) with 80% acetone. 5 ml of this solution was transferred into a 50 ml volumetric flask and made-up to volume with 80% acetone. The chlorophyll contents at different sampling periods (3, 6, 9 and 12 MAP) were determined by extracting the chlorophyll. Absorbance was measured at 645, 663 and 652 nm using a suitable spectrophotometer (Model Spectronic, 21, Bausch and Lomb, U.S.A). The amount of chlorophyll a and b in the leaves of the plants were calculated based on the formula of Mackinney [12]. Thus:

Total chlorophyll (c) = $D652/34.5$ (mg per litre)
= $d652 x 1000/34.5$ (grammes per litre)

D652 is absorbance at 652nm.

It can also be calculated from this equation: $c=20.2 \times D645 + 8.02 \times D663$. The data collected was subjected to statistical analysis using SAS [13].

RESULTS AND DISCUSSION

The data revealed significant differences ($P<0.05$) in total leaf chlorophyll content among the four environments tested, throughout the sampling periods (Fig. 1). The chlorophyll content production followed a similar trend in Ibadan, 1994/95 and 1995/96 where there were continous increases in cassava leaf chlorophyll content up to 6 MAP and then decreased with plant age. At Jos plateau, 1994/95, there were increase in leaf chlorophyll content upto 6 MAP and thereafter decreased with at 9 MAP and later gradual increased at 12 MAP (Fig. 1). Also, at Jos plateau, 1995/96, the leaf chlorophyll content increased upto 6 MAP and thereafter remain almost constant with plant age. The low leaf chlorophyll content values observed at 9 MAP in both locations coincided with dry season which suggests influence of environmental conditions particularly rainfall on leaf chlorophyll content production. Similar results have been observed in cassava genotypes [14] who reported that environmental factors have strong influences on the physiological processes of cassava plants. The implication is that genotype performance will be enhanced by planting certain genotypes in particular locations.

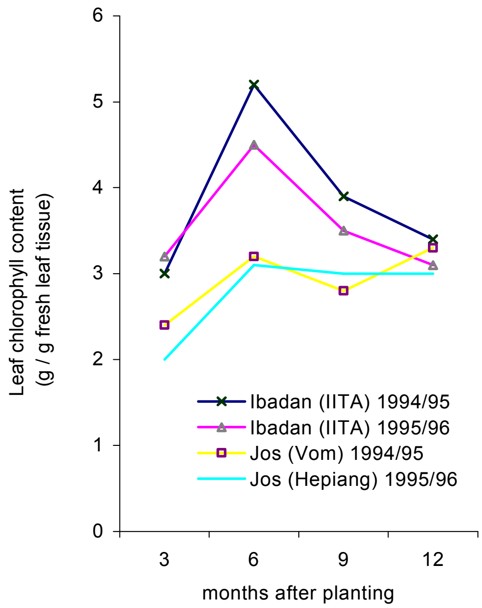

Fig. 1: Effects of different locations and years on leaf chlorophyll contents of cassava genotypes

The leaf chlorophyll content at Ibadan was significantly higher than at Jos at 3, 6, 9 and 12 MAP respectively (Fig. 1). Similar results have been reported on chilling stress plants [7,8] who reported that chlorophyll synthesis is severely depressed at low temperature in many chilling sensitive species. An apparent decrease in leaf chlorophyll content exposed to low temperatures has been suggested to be the results of photo-oxidation [8,15]. The chlorophyll content is markedly decreased by exposure of rice [16] to low temperatures.

Genotypic differences (P<0.05) were observed across locations for total leaf chlorophyll contents throughout the sampling periods (Table 1). TMS 30001, TME11, Danwaru and TMS 30572 produced the highest leaf chlorophyll content values of 3.0, 3.9, 3.6 and 2.7 g per fresh leaf tissue weight for 3, 6, 9 and 12 MAP respectively.

Significant differences (P<0.05) occured in total leaf chlorophyll contents within locations (Table 2). At Ibadan, TMS 30001, TMS 30572 and TMS 50395 had the highest values for leaf chlorophyll contents throughout the sampling periods whereas in Jos plateau, TMS 30572, TME11, Danwaru and TME1 produced the highest values for leaf chlorophyll contents throughout the sampling periods. In overall, TMS 30572, TME11, Danwaru and TME1 produced the highest values for leaf chlorophyll contents throughout the sampling periods. TMS 30572 had the highest value of 5.0 g per g fresh leaf tissue

Table 1: Combined analysis of 12 cassava genotypes as affected by chlorophyll content at two agroecological zones at 3, 6, 9 and 12 MAP from 1994 to 1996

	Chlorophyll content (g/g fresh leaf tissue weight)				
Genotype	3MAP	6MAP	9MAP	12MAP	Total dry tuberous roots weight (t/ha)
Isunikankiyan	2.7ab	2.8d	1.6c	1.9c	1.8c
TMS 30001	3.0a	3.5a-c	2.3ab	2.3ab	4.5ab
TME2	2.9ab	3.9a	2.1ab	2.2ab	4.4a-c
TMS 30572	2.8ab	3.6ab	2.3ab	2.3ab	7.0a
TMS 4(2)1425	2.7ab	3.1b-d	2.0bc	2.2ab	5.0a
Danwaru	2.4b	3.4a-c	2.6a	2.6a	5.0a
TMS 50395	2.5ab	2.8d	2.0bc	2.0b	5.0a
TMS 91934	2.8ab	3.5ab	2.0bc	2.0b	6.0a
Danduala	2.7ab	2.9cd	2.0bc	2.0b	1.6c
Oko-Iyawo	2.6ab	3.3b-d	2.2ab	2.0b	5.0a
TME1	2.6ab	3.1b-d	2.1ab	2.2ab	6.0a
TMS 30555	2.5ab	2.8d	1.9c	1.9c	4.4a-c

Means in the same column with the same letter (s) and within the same MAP are not significantly different (P = 0.05), using DMRT. MAP = months after planting.

Table 2: Effect of leaf chlorophyll contents on 12 cassava genotypes at two agroecological zones at 3, 6, 9 and 12 MAP from 1994 to 1996

	Chlorophyll content (g/g fresh leaf tissue weight),				
Genotype	3MAP	6MAP	9MAP	12MAP	Total dry tuberous roots weight (t/ha)
Ibadan					
Isunikankiyan	2.9ab	2.7ab	2.1b	2.2b	1.8c
TMS 30001	2.8a	3.0a	2.0b	2.0b	4.5ab
TME2	3.1a	3.3a	2.5a	2.3a	4.4a-c
TMS 30572	2.9ab	3.4a	2.2b	2.2b	7.0a
TMS 4(2)1425	2.9ab	3.1a	2.1b	2.2b	5.0a
Danwaru	2.5b	2.2b	1.9b	2.0b	5.0a
TMS 50395	2.5a	2.8ab	2.0b	2.0b	5.0a
TMS 91934	2.9ab	3.1a	2.0b	2.0b	6.0a
Danduala	2.8ab	2.9ab	1.7b	2.0b	1.6c
Oko-Iyawo	2.4b	3.4a	1.9b	1.8b	5.0a
TME1	2.7ab	3.2a	2.5a	2.3a	6.0a
TMS 30555	2.9ab	2.4b	1.9b	1.8b	4.4a-c
Jos plateau					
Isunikankiyan	2.5ab	2.2b	1.8ab	2.3ab	1.8c
TMS 30001	2.6a	2.5ab	2.3a	2.5a	4.5ab
TME2	2.7a	2.9a	2.4a	2.3ab	4.4a-c
TMS 30572	2.7a	2.6ab	2.0ab	2.2ab	7.0a
TMS 4(2)1425	2.5ab	2.3b	1.7ab	2.0b	5.0a
Danwaru	2.5ab	2.4ab	1.8ab	1.9b	5.0a
TMS 50395	2.4ab	2.8a	2.4a	2.0b	5.0a
TMS 91934	2.7a	2.5ab	2.3a	1.8b	6.0a
Danduala	2.3b	2.7a	1.5b	1.9b	1.6c
Oko-Iyawo	2.3b	2.3b	1.5b	1.8b	5.0a
TME1	2.8a	2.8a	2.3a	2.5a	6.0a
TMS 30555	2.4ab	2.6ab	1.6b	1.9b	4.4a-c

Means in the same column with the same letter (s) and within the same MAP are not significantly different (P = 0.05), using DMRT. MAP = months after planting weight at Ibadan. The result of this study suggest that six cassava genotypes (TMS 30572, TMS 30001, TME11, TME1 and TMS 50395) seems to have high leaf chlorophyll content. Also, these genotypes are relatively high yielding potential for dry tuberous root yield [17]. The total dry tuberous root weight produced at Ibadan was significantly ($P<0.05$) higher than Jos plateau at 12 months after planting (Table 2). Genotypic differences were observed among the genotypes either across locations or within locations for dry tuberous root weight. Genotypes TMS 91934, TMS 30572, TME1, TME11 and Danwaru performed better than other genotypes at low temperatures for dry tuberous root yield.

This study showed positive correlation between leaf chlorophyll contents and dry tuberous root yield ($r=0.97$, $n=12$), supports earlier reports of Cock, [2] who reported significant genotypic correlation between chlorophyll and root yield. So the selection for high yield in mid-altitude and high altitudes of Africa may be any of the five genotypes with high leaf chlorophyll contents. These genotypes may be used for further breeding programmes in mid- and high altitude of Africa.

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