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RESEARCH ARTICLE

EVALUATION OF THE EFFECTS OF DRY AND RAINY SEASONS ON CASSAVA ROOTSNUTRITIONAL CONTENTS AND TUBER ROT DISEASE

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ABSTRACT

Background: Cassava, (*Manihotesculenta Crantz*), is a crucial crop for ensuring food security in sub-Saharan Africa, and intermittent drought conditions affect its proximate composition and disease susceptibility. **Methods:** A field experiment was carried out at the National Root Crop Research Institute, Umudike, Umuahia in Abia State, Nigeria, and at the Department of Plant Science and Biotechnology, Imo State University to evaluate the cassava root proximate composition, and tuber rot incidence. The experimental field was arranged in a randomized complete block design with three replications. Four varieties of cassava, which include enhanced cultivars, TME419, NR87/184, UMUCAS 46, or 07/0539, as well as two indigenous varieties, L1 and L2, were cultivated for a duration of 12 and15 months. The cassava roots were harvested in July (wet season) and in December (dry season). **Results:** The results indicated that there were statistically significant variations ($P \leq 0.005$) in the cassava's root proximate composition, and rot incidence in different varieties and monitoring periods. All varieties exhibited greater accumulation of crude protein, crude starch, and carbohydrates during the dry season compared to the rainy season. All the varieties saw more ash buildup during the rainy season compared to the dry season. The fungal pathogens responsible for cassava rot are Botryiodiplodiatheobromae (producing black rot), Fusariumoxysporium (causing dry rot), Aspergillusflavus (associated with soft rot), Rhizopusstolonifer, and Sclerotiumrolfsii. During the rainy season, B.theobromae had the highest percentage incidence at (34.78%), while S. rolsfii had the lowest percentage incidence (8.70%).During the dry season, F. oxysporium had the highest percentage incidence (26.3%), while S. rolsfii had the lowest percentage incidence (10.52%). Rainy season recorded higher rot incidence than dry season**. Conclusion:** The study demonstrates that the proximate composition of cassava root is influenced by factors such as age, the season of harvest, and variety, and these provide a better understanding of the proximate composition response of cassavavarieties under dry and wet growing conditions, which can be recognized and used integrally to improve food quality.

INTRODUCTION

Cassava, (*Manihotesculenta* Crantz), holds the sixth position in terms of agricultural significance. It serves as the primary staple crop for more than two billion individuals in sub-Saharan Africa, ensuring their food security (Jarvis *et al*., 2012). The plant exhibits high resilience and may thrive in many soil and climatic situations (Burns *et al*. 2010). The average cassava root yields in certain regions of Africa were 60 metric tonnes per hectare,(Fermont*et al*., 2009). Cassava has been found to have greater resilience to climate change compared to other basic crops (Jarvis *et al*., 2012). Cassava and its derivatives are abundant in carbohydrates, and the insufficiency of certain nutritional components is mostly influenced by the variations in variety and geographical conditions (Laya*et al*., 2018). Fungal diseases are the primary reason for the significant decline in cassava yield and post-harvest degradation.

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Climatic changes are projected to impact the growth and survival rates of pathogens, as well as alter the plant susceptibility to pathogens (Elad and Pertot 2014). The vast root system of cassava plants allows them to remain upright and show no symptoms even when highly infected with root rotting diseases (Msikita *et al*, 2005). This characteristic further conceals the impact of these pathogens until the tubers are harvested. Hence, the objective of the study was to measure the impact of wet and dry seasons on the nutritional composition of cassava, as well as the presence of fungal pathogens causing tuber rot disease, across the cassava varieties

MATERIALS AND METHODS

Study area and Experimental Design: The study was carried out at the National Root Crop Research Institute in Umudike, Umuahia, Abia State, Nigeria, as well as in the Department of Plant Science and Biotechnology at Imo State University in Owerri.The region is situated in the humid rainforest agroecological zone of Nigeria, namely between longitude 3° E to 12°E and latitude 4°N to 9°N (Ogungbenro and Morakinyo,

2014), known for being the leading producer of cassava. The experimental field was arranged in a randomised complete block design, with three replications. Each iteration encompassed an area of 50 square metres, with 50 cassava plants evenly spaced at a distance of 1 metre from each other. The enhanced cultivars include TME419, NR87/184, UMUCAS 46 or 07/0539, as well as two indigenous variants L1 and L2. The native varieties, L1 and L2, are much esteemed by the inhabitants of Imo State. The cassava cultivars were cultivated for a duration of either 12 or 15 months after being planted. Their store roots were collected in July (during the rainy season) and December (during the dry season), respectively, in order to measure all the parameters.

Proximate composition: The nutritional makeup of both the healthy and sick samples was assessed by employing the proximate analysis methods The sample's proximate composition was determined using the standard methods of analysis established by the Association of Official Analytical Chemists (AOAC, 1999). The moisture content of the samples was assessed using the air oven (Gallenkamp) method at a temperature of 105°C. The sample's crude protein content was measured using the micro-Kjeldahl technique. The ash content was measured by subjecting the sample to a muffle furnace set at a temperature of 550°C for a duration of 4 hours, until a consistent weight of ash was achieved. The determination of crude fibre was conducted using the method described byFan-Jhenand Chi-Fai (2017). The carbohydrate content of the roots was assessed using the Orcinol colorimetric method, as described by AlphonsoLaya*et al.*, (2018). The entire carbohydrates were initially hydrolyzed using 13 M H2SO4. The sample was initially incubated at a temperature of 25°C for a duration of 30 minutes, followed by a further heating at 100°C for a period of two hours. The starch content of the cassava root samples was analysed using the iodine spectrophotometric method, following the procedure described by Jarvis and Walker in 1993. The results were quantified as grammes per 100 grammes of the material.

Sample collection: Fifty diseased improved cassava varieties tubers, including TME419, NR87/184, UMUCAS 46 or 07/0539 obtained from the National Root Research Institute in UmudikeUmuahia, Abia State, Nigeria, as well as two local varieties (L1 and L2) from a farm in Owerri, Imo State, Nigeria, were analysed in the Department of Plant Science and Biotechnology at Imo State University.

Isolation of Rot-causing fungi: Cassava root samples affected by rot disease were harvested from various varieties during dry and rainy season. A sterile knife and forceps were used to collect the tissues from spoiled cassava. The collected tissues were then cultured on potato dextrose agar (PDA) supplemented with 0.1 ml Chloramphenicol to prevent bacterial growth. The cultures were incubated for 48 hours at room temperature. In the laboratory, small pieces of approximately 0.5 cm roots were immersed in a 70% ethanol solution for a duration of 2 minutes, followed by sterilisation in a 0.5% sodium hypochlorite solution for 2 minutes. Finally, the fragments were rinsed three times with sterilised distilled water. The pieces were arranged on sterile filter paper to desiccate, and subsequently transferred onto potato dextrose agar (PDA) and subjected to incubation at a temperature of 24 °C for a duration of 5-7 days.

Identification of fungi pathogens: The fungi were identified based on their visible physical characteristics of their colonies on Potato Dextrose Agar (PDA media). The slide culture technique was used to study the microscopic features, following the guidelines provided in the Manual of Atlas of Fungi.

Pathogenicity test: Following the procedures described by Dania *et al*.,(2019), to test for the ability of the fungi to cause rot.The tubers were rinsed with sterile distilled water, and subsequently sterilised with 70% ethanol. Cylindrical discs were removed from the disinfected tubers using a sterile 4 mm cork borer, and these discs were then inoculated with test identified fungi. The cylindrical discs were replaced and the injection sites were sealed with Petroleum jelly, and incubated for 14 days.

Percentage disease incidence: During each monitoring session, Cassava tubers were selected randomly according to the protocols established by (Buaand Okello, 2011)). The disease assessment relied on the observed visual symptoms.

The percentages of rot incidence on the examined cassava samples were computed as,

$$\textbf{Percentage incidence} = \frac{\text{Total number of diseased samples}}{\text{Total number of examined samples}} \times 100$$

Data analysis: The collected data were subjected to statistical analysis using analysis of variance (ANOVA).The significance of differences between means was assessed using Tukey's HSD test ($p < 0.05$) with the use of MINITAB 19 software.

RESULTS

Moisture content: A significant difference ($P \leq 0.005$) was seen in the moisture contents among cassava varieties and monitoring periods. (Table 1). All the cassava varieties experienced more moisture accumulation during the rainy season compared to the dry season. During the dry season, UMUCAS 46 exhibited the maximum moisture level (51.25%,) whilst L 2 had the lowest moisture content (4.29%). There were no notable disparities in moisture levels between TME 419 and NR87/184, regardless of whether it was the rainy or dry season. During both the rainy and dry seasons, L 2 exhibited the lowest moisture content.

Protein content: There were significant differences in the levels of crude protein among cassava varieties and monitoring periods. (Table 1). All varieties experienced more protein accumulation during the dry season compared to the wet season. During the dry season, L2 had the greatest percentage protein content (4.51%), while L1 had (4.19%). Protein accumulation did not show any notable variations among TME 419(2.66), NR87/184 (2.9), and UMUCAS 46(2.73). During the dry season, UMUCAS 46 had the greatest concentration of crude protein (4.66%). Except for UMUCAS 46 there were no significant differences in the levels of crude protein found in the other cassava varieties.

Crude Ash content: There were high significant disparities in the levels of unrefined ash present among cassava varieties and monitoring periods. (Table 1)

Table 1. Effects of climatic factors on cassava proximate composition

Variety	Moisture (%)		Crude Protein (%)		Crude Ash (%)		Crude Starch (%)		Crude CHO (%)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry Season	Wet season	Dry Season	Wet season
TME419	50.07(0.03)b	69.13 (0.04)a	3.38 (0.5)b	2.66 (0.032)c	0.24(0.04)c	1.36(0.07)b	30.68 (0.197)b	20.79 (0.60)c	98.60 (0.04)b	9 5.09 (1.15)b
NR 87/184	49.70(0.20)b	69.07(0.02)a	2.79(0.03)c	3.84 (0.02)b	0..33(0.03c	1.53 (0.13)b	30.30 (0.08)bc	20.27 (0.03)cd	98.97 (0.38)b	94.03(0.02)b
UMUCA S46	51.25(0.13)a	67.17(0.03)b	2.73 (0.07c	4.66 (0.03)a	0.41 (0.02)c	1.56 (0.03)b	29.74 (0.07) c	19.60 (0.02)d	98.84 (0.45)b	91.94 (0.03)c
L 1	48.20(0.20)c	63.67(0.40)c	4.19 (0.16)b	3.29(0.4)b	0.98 (0.09)b	2.68 (0.06)a	35.15 (0.23) a	25.18 (25.18)a	100.23 a(0.33)a	98.74 (0.23)a
L 2	47.29 (0.30)d	62.0 (0.40)d	4.51(0.11a	3.36 (0.06) b	1.22 (0.14)a	2.63 (0.07)a	34.55 (0.43) a	24.11 (24.11)b	100.28 (0.35)a	99.21 (1.20)a
F- value	222.30	513.41	276.02	11.97	95.98	202.69	338.66	216.53	16.69	51.50
P- value	0.000	0.001	0.002	0.001	0.001	0.002	0.002	0.001	0.002	0.001

Table 2. Percentage incidence of fungi isolates in the rainy and dry seasons

S/no.	Isolates	Average no. of each colony	Percentage Incidence
Rainy season			
1	*B. theorbromae*	8.0	34.78a
2	*F.oxysporium*	6.0	26.09b
3	*A. flavus*	3.0	13.04d
4	*R. stolonifer*	4.0	17.39c
5	*S.rolfsii*	2.0	8.70e
Total no. of colonies		23.0	
Dry season			
1	*B. theorbromae*	9.0	24.0b
2	*F.oxysporium*	10.0	26.3a
3	*A. flavus*	7.0	18.42d
4	*R. stolonifer*	8.0	21.05c
5	*S.rolfsii*	4 .0	10.52e
Total no. of colonies		38.0	

All the varieties recorded more ash content during the rainy season compared to the dry season. During both rainy and dry seasons, the L1 and L2 varieties had the highest levels of crude ash, whereas the TME 419 and NR87/184 types had the lowest levels of ash, (Table 1). Except L1 and L2, there were no notable differences in the levels of crude ash concentration among the other variations.

Starch Content: The starch content of cassava harvested during the dry season was greater than that of cassava harvested during the rainy season. (Table 1). The dry season, which occurs 12 months following planting, is the period when cassava achieves its highest level of starch storage compared to the rainy season.

Carbohydrates content: There were significant differences in the levels of crude carbohydrates among cassava varieties and monitoring periods. (Table 1). All types exhibited greater carbohydrate buildup during the dry season compared to the wet season. During both the rainy and dry seasons, the varieties L1 and L2 exhibited the highest levels of crude carbohydrates, whereas the varieties TME 419 and NR87/184 had the lowest levels of carbohydrates (Table 1).

Pathogenicity results: The main pathogens associated with Cassava are *Fusariumoxysporum,* causing dry rot. *Aspergillusflavus* is associated with soft rot, and *Botryodiploidiatheobromae*c auses black rot. In general, dry rot is characterized by the appearance of dark brown streaks in the roots, while soft rot is characterized by the darkening of the affected tissues with liquid exudation and is foul-smelling. On the other hand, black rot is characterized by dark lesions in the roots and may evolve into soft rot but without an unpleasant odor.

Cassava tuber rot incidence: The higher cassava root rot disease incidence was recorded during rainy season, while dry season recorded lower rot incidence.

In rainy season *B.theobromae* recorded highest percentage incidence **(**34.7%**)**, while *S. rolsfii* had lowest percentage incidence (8.79%), (Table 2). In dry season *F.oxysporium* recorded highest percentage incidence (26.3%), while *S. rolsfii* had lowest percentage incidence (10.52), (Table 2).

DISCUSSION

Moisture content: Many workers have documented a reduction in moisture levels amidst drought circumstances (Wang *et al*., 2015; Abdalla and Ahmed, 2021). The variation in moisture levels across different types of Cassava can be ascribed to the genetic variability in their ability to tolerate drought conditions (Liu and Jiang, 2010).

Protein: The elevated protein content of cassava collected during the dry season may be attributed to the elevated temperature and water scarcity, which enhance the accumulation of amino acids in the storage roots (Rodrigues *et al*., 2010; Nuwamanya *et al*., 2014).Furthermore, the protein content of cassava is influenced by genetic variables and varietal variances (Oluwaniyi and Oladipo, 2017).

Crude Ash content: The age of the plant is a determining factor in the ash content of cassava roots, (Oluwaniyi and Oladipo 2017).

Content of starch: The L1 and L2 varieties exhibited the highest starch content, which may be attributed to varietal variations. The decrease in starch content in cassava produced during the rainy season might be due to factors such as the timing of harvest, the age of the plant, and its utilization for the development of new shoots in the subsequent growth cycle. This aligns with the findings documented by (Nuwamanya *et al.*, 2014). Moreover, the starch content of cassava roots may gradually decrease as the plant matures beyond its peak starch storage period.

Carbohydrates content: The elevated carbohydrate levels observed during the dry season can be attributed to variations in the types of crops and the timing of harvest. Carbohydrates are more concentrated during the dry season compared to the rainy season (Sagrilo *et al*., 2003; Adejumo and Raji, 2010). The decrease in carbohydrate content of cassava during the rainy season is likely caused by the rainfall, which aids in the breakdown of carbohydrates into sugar for the regrowth of shoots after extended water stress (Adejumo and Raji, 2010).

Pathogenicity results: The isolated cassava root pathogens in the present study were consistent with those reported by Msikita *et al*., 2005; Bandyopadhyay *et al*., 2006).

Cassava tuber rot incidence: The low incidence of some cassava rot fungal pathogens observed in the dry season collaborate with the report by (Wegulo *et al*., 2013), who stated that drought slows down or prevents the development of plant diseases caused by pathogens that thrive under moist conditions, and also predisposes plant to become more susceptible to diseases.

CONCLUSION

The study reveals that age, season at which cassava storage roots are harvested, and variety affects some proximate composition of cassava: The fungal pathogens associated with cassava rot include, *Botryiodiplodiatheorbromae, Fusariumoxysporium, Aspergillusflavus, Rhizopusstolonifera, and Sclerotiumrolfsii.* Cassava root rot incidence is higher in rainy season than in dry season.

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