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VARIATIONS IN YIELD TRAITS AND NUTRITIONAL QUALITIES, OF WHITE TURMERIC *Curcuma zedoaria* RHIZOME SIZES GROWN IN GUINEA SAVANNA ECOLOGY

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Abstract

White turmetic curcuma zedoaria is a medicinal spice perennial crop popularly grown for its rhizome yield. Both the rhizomes and leafy stems contain nutritional qualities that ascribe whole plant use to the crop. Rhizome yield is a function of tillering ability and nodal numbers from rhizome sizes. This experiment determined the variations in yield and nutritional qualities of white turmeric using four different rhizome sizes. A field experiment was conducted at Landmark University Teaching and Research Farm, Omu-Aran, Kwara State, Nigeria. The study comprised of four seed rhizome sizes of 2cm (5.5g), 4cm (11g), 6cm (27.24g) and 8cm (47.34g). The experiment was laid out in a Randomized Complete Block Design with three replications. The rhizome size of 6cm (27.24g) had the highest number of tillers at 10,15 and 20 weeks after planting (WAP) followed by 8cm; 47.34 g (T4) while 2cm size produced the least number of tillers per plant across the planting weeks. Rhizome size of 8cm with 47.34g weight produced more open and long leaves with wide stem while the least size (2cm) had the least leaf length and stem width. Number of fingers, rhizome size and nodes per rhizome were highest for rhizome size of 6cm except for rhizome width which recorded highest width for 8cm rhizome length. Rhizome yield per plant and hectare was same for 6cm (1058.00g; 1.47t/ha) and 8cm (1049.60; 1.51t/ha). Rhizome size of 6cm (27.24g) is found appropriate for high economic yield and explorable size for planting. Nutritional quality did not vary among the rhizome sizes. However, both the fresh, dry rhizomes and leaves have high free radical scavenging activity.

Key words: Variation, white turmeric, rhizome size, weight, tillering, nutritional quality, yield

INTRODUCTION

White Tumeric as popularly called has a scientific name *Curcuma zedoaria* is a perennial herb. It belongs to the family Zingiberaceae and made up of two types – the white and yellow turmeric (Khare, 2007). It is one of the oldest spices with a distinct flavor and pungency used as both spice and medicine (Sharma *et al.*, 2010). It is a root crop and a typical herb extensively grown across the world for its pungent aromatic under-ground stem or rhizome which makes it an important export commodity in world trade (NEPC, 1999; Erinle, 1989; Ajibade and Dauda, 2005). It is a perennial and reed-like, with annual leafy stems which are about a meter (3 to 4 feet) tall. White turmeric is propagated vegetatively. The mature roots of white turmeric are fibrous and the juice from fresh roots is extremely potent and often used as spices and medicinal purpose in Bangladesh, India and Sri lanka (Richard *et al.*, 2008). It is also used largely as recipes such as ginger bread, cookies, crackers, cakes, ginger-ale and ginger beer (Richard et al., 2008; Jakes, 2007). It is cultivated in the tropical and subtropical regions of the world. Internationally, processed ginger "root" (rhizome) is the standard of commerce and is traded as a dried spice or candied. India and Sri lanka are the largest producers of white turmeric and ginger in the world accounting for 49% of white turmeric area and 72% of ginger production. North-eastern India has greater production in the county registering record productivity level in the world (5.8 t/ha as against national average of 3.7 t/ha), and is emerging as India's organic turmeric hub (Rahman *et al.*, 2009). Nigeria ranked 10th in terms of the percentage of total hectares of white turmeric under cultivation but her contribution to total world output is low compared to India. This may be due to the fact production is left in the hands of pro-poor smallholder and traditional farmers. The constrains are adduced to lack of knowledge on the nutritional values of the crop, sourcing for planting stock etc (Shinwari, 2010). Emmanuel (2008) opined that Nigeria has the potential to expand production in a medium to long-term investment strategy that can develop into self-sufficient industry (FAO, 2010). Ginger is produced in some states of Nigeria namely; Kaduna, Nassarawa, Benue, Niger and Gombe with Kaduna as the major producer while turmeric is produced in some parts of these northern states and some parts of Oyo state. According to FAO, Nigeria's production in 2005 was estimated at 110,000metric tonnes and out of this, 10% is locally consumed as fresh white turmeric while 90% is dried primarily for the export markets.

White turmeric rhizome serves as planting stock and economic part of the plant. When large rhizome size is used, there is greater loss of the commercial product and when small seed rhizome is used, there is reduction in the growth and yield. Therefore, selecting the appropriate size of planting material is a critical factor in the cultivation of rhizomatous spices such as turmeric and ginger.

Several studies have been conducted to determine the optimum seed rhizome of different rhizomatous crops. The use of large seed rhizomes is generally found to increase the final yield of all rhizomatous spices such as ginger (Whiley, 1990; Borget, 1993). In India Nybe and Raj (2004) indicated that large rhizome size gave significantly higher yields than small pieces. An increase in the yield of ginger rhizomes with an increase in seed rhizome size was also reported in Ghana (Blay *et al.*, 1998) and Australia (Whiley, 1990). Hossain *et al.* (2005) found high yield of turmeric from using 30-40 g seed rhizomes weight compared to 10 and 20 g rhizome size. A yield advantage of more than 90% was also reported for turmeric in Ethiopia from using larger (6-8 cm) rhizome size than smaller (2-4 cm) ones (Woldu, 1993).

The high demand for the crop on the international market creates a wide gap in production. Identification of adequate quantities of planting materials remains a dearth limiting the expansion of the production area. The minisett/microsett technology could offer an appropriate and sustainable means of addressing the scarcity of planting material. Several workers have reported a direct relationship between sett size and rhizome yield. However, most of these reports did not make any reference to the economic return. Moreover, there is no recommendation on the optimum seed rhizome size of turmeric for its production. Efforts have been made to boost ginger production in Nigeria since 1988; however there has been high fluctuation of output. The increase experienced since then is too low to make a meaningful change in the income and standard of living of the farmers (FAO, 2010). Therefore, the objective of this study was to determine the optimum seed rhizome size of turmeric with respect to its growth, quality, yield and economic returns in the Derived savanna agro-ecological zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at Landmark University Teaching and Research Farm, Omu-Aran, Kwara State. The climate is tropical maritime with a long-wet season, the wet season was moderate and subject to modest variation of hot and cold as the season change. It has an annual rainfall pattern which extends between the month of April and October with the average annual rainfall of between 600mm-1500mm. The peak rainfall is in May-June and September-October while the dry season is between November and March. The area has maximum temperature of 33^0C to 36^0C and the minimum temperature of 22^0C to 28^0C. Humidity of this area is high (43-49%) all year round except in January when the dry wind blows from the North. The experiment was laid out in a randomized complete block design with four turmeric seed rhizome sizes of 2cm (5.5g), 4cm (11g), 6cm (27.24g) and 8cm (47.34g) sourced from a local farmer's field and planted out on plot sizes of 1m x 5m ($5m^2$) each. Four treatment combinations were replicated thrice. Growth, yield and quality component data were collected at appropriate times throughout the experimental periods from six randomly selected plants per plot. The data obtained during investigation was statistically analyzed using R package. The statistical significance was tested by applying 'F' test at 0.05 level of probability and critical differences were calculated for those parameters which turned significant ($P < 0.05$) to compare the effects of different treatments.

ANALYSIS OF SOIL SAMPLE

Prior to planting, samples of the soil were taken to the laboratory for analysis. The samples were taken using an auger at a depth of 0-15 cm and 15-30 cm after which the rhizome sizes were sown. The analysis of the soil was carried out in Crop and Soil Science Laboratory of Landmark University. Soil P, PH, N, OM, Ca, mg and other exchangeable bases were analysed following the methods of Schofield and Taylor 1965; Bremner 1982; Walkley and Black 1934; Chapman 1965 respectively. The results are as presented in Table 1.

NUTRITIONAL COMPOSITION ANALYSIS OF HARVESTED TUMERICRHIZOME

Fresh and dried ginger rhizomes were collected and proximate analysis for its nutrients were determined based on the official methods of analysis was followed.

PHYTOCHEMICAL AND FREE RADICAL SCAVENGING ACTIVITY ANALYSIS

Method of Sample Extraction

About 2g of fresh and dry leaves; fresh and dry rhizomes were used. The dry components were gotten by oven-drying the rhizomes at 28°C. Phytochemical screening of the extracts was done using established procedures of Scartezzini and Speroni (2000).

DPPH Assay

The 2,2-Diphenyl-1-picryl hydrazyl radical assay described by Ayoola *et al.*, 2008 with slight modification was used to evaluate the free radical scavenging activity of the extracts. The following concentrations of the extracts were prepared: 0.02, 0.1 and 0.5 mg/ml in ethanol with Ascorbic acid as the antioxidant standard at the same concentrations. 1ml of the extract was placed in a test tube, 3ml of 1mM DPPH in methanol was added and the mixture was incubated in the dark for 30 minutes after which the absorbance of each solution was taken by using a UV spectrophotometer at 517nm. A blank solution was prepared containing only DPPH in ethanol. The free radical scavenging activity was calculated using the formula:

$\% \text{ inhibition} = \{[A_b - A_a]/A_b\} \times 100$

Where A_b is the absorption of the blank solution and A_a is the absorption of the solutions containing the extracts.

RESULTS AND DISCUSSIONS

Soil Properties

Properties of the soil before planting are as presented in Table 1. From the analysis, it was observed that the soil is slightly acidic and relatively high in organic matter component, available phosphorus and nitrogen.

Vegetative growth parameters

Rhizome size had significant influence on number of tillers per plant (Table 2). Seed rhizome size 6cm (27.24g) recorded highest number of tillers at 10 (5.28); 15 (6.78) and 20 (7.28) WAP. Highest number of tillers (5.25) followed by 8cm (47.34g) recording (4.52; 5.86 and 6.87 respectively. These variations might be as a result of different number of nodes per each rhizome planted. Turmeric rhizome size had significant effect on the length of fully opened leaves. Seed rhizome size significantly affected most of the turmeric plant growth parameters studied. These could be due to number of nodes, larger buds and large amount of food reserves in the larger seed rhizomes. Nodal points indicate number of sprouting points hence number of eventual tillers. Rhizome yield per hectare also significantly increased with an increase in seed rhizome sizes. This is in agreement with previous findings in ginger (Blay *et al.*, 1998) and turmeric (Hossain *et al.*, 2005) and clearly explains the role of food reserves in supporting source to sink metabolic activities.

This is also true for ginger (Blay *et al.*, 1988) and turmeric (Hossain *et al.*, 2005). Number of tillers increased with increase in rhizome size. This result is in line with the work of Misra and Nedunchezs (2004) and Ravindran and Bacu (2005) who reported that the number of tillers per plant in ginger increased when sett size increased.

Seed rhizome size of 8cm (47.34g) recorded longest fully opened leaves with thickest stem girth at, 10, 15 and 20 WAP (14.70cm, 43.46cm and 57.45cm respectively) followed by seed rhizome size of 6cm (27.24g) even as 2cm size produced the shortest fully opened leaves with least stem width (Table 3 and 4). These variations in length of fully opened leaves might be due to variations in the food reserves of the leaves. From the statistical values, seed rhizome size of 6cm (27.24g) had the highest number of fingers, nodes and rhizome sizes 3.67; 8.90, and 11.08 respectively. This was followed by 8cm rhizome size. This shows that rhizome width are invariably the same for the variety used length notwithstanding. There was also significant difference in length and width of leaves as both increased with increase in the rhizome size. According to AoI (1992); Preter (2001), there were correlations between the leaf number and the weights of the primary fingers. This finding is very similar to the work of Chaveerach *et al.*, (2008) who reported that *Curcuma sattayasaii* and *C.zedoaroides* bract size ranged between 4-5 -3.2cm and 4.2-5.3cm, respectively. Variations in node numbers of ginger sizes might be as a result of different length sizes bearing the nodal points on the rhizome planting stock.

Rhizome size of 6cm and 8cm produced highest rhizome yield per plant (1058.00g and 1049.60) and per hectare (1.47t and 1.53t), while rhizome size of 2cm recorded least yield. Elizabeth (2007) who worked on garlic reported bulb size to affect the yield. The variation in yield from seed rhizome sizes might be due to the fact that the plants produced from the largest rhizome size emerged earlier and showed more vigorous development using initial food reserves and resulting into higher yield and yield traits than the smaller rhizome sizes. According to Hartmann *et al.* (2002); Balakrishnan (2007) selecting a seed, quality and quantity is one major criterium to get optimum yield and quality of product. The result in this experiment showed that different seed rhizome sizes had significant ($P < 0.05$) and positive effect on fresh rhizome yield per plant. The possible reason for the result obtained might be that the ability for larger sett sizes to produce a vigorous initial growth of organs due to available food reserves and to maintain such vigorous growth through the growing season will contribute to the final higher weight. These results are in conformism with the findings of Ahmad *et al.*, (2009); Tesfaye, et al. (1999) on potato; Misra and Nedunchezhezhiyan (2004) on yam; Ravindran and Bacu (2005) on ginger. The result obtained in the study are very related to the findings of Weiss (2002). Castellanos et al. (2004) and Muhammad (2004) who worked on onion and reported that the bulb dry yield increased with increased sett size.

Nutrient composition of fresh turmeric

Seed rhizome sizes showed significant differences in the nutrient composition of fresh ginger. Rhizome size 8cm (47.34g) had the highest moisture content (64%) even as other nutrient values were the same across the sizes. The dry rhizome sizes also did not differ in nutrient quality and quantity across the rhizome sizes used (Table 6). It was however observed that ash content decreased with increase in size of ginger seed rhizome size. Variations in quality attributes of turmeric as a result of the rhizome size were similar to the findings of B. Mahender et al. (2015).From this study, it was observed that phytochemicals are present in fresh and dry ginger rhizomes and also in the leaves. Betterstill, free radical scavenging activity was also possible. Alkaloids, flavonoids and phenolics were detected in dry and fresh tumeric rhizomes and leaves (Table 7).

Conclusion

It can be concluded that the larger the seed rhizome size planted, the better the yield and quality of ginger. Betterstill an appropriate rhizome size will prevent planting stock wastage during planting as well as maximize the yield potential. White tumeric can be a good source of phytochemicals and it can scavenge free radicals. Hence, apart from its nutritional and medicinal properties, white tumeric can also be used as an antioxidant supplement. Betterstill, White turmeric is a whole plant with multipurpose function. The rhizome is a planting stock, as well as the economic yield portion with the leaves and rhizomes used for medicinal purposes. White turmeric, therefore remains a miracle crop yet untapped.

Table 1: Table 1: Properties of soil samples used for the experiment

Chemical Soil Properties	Mean Value (0-15cm)	Mean Value (15-30cm)
Total Nitrogen (%)	0.34	0.52
Na (mg/l)	0.04	0.09
K^+ (mg/l)	5.18	2.31
Ca^{2+} (mg/l)	4.80	4.32
pH (H2O)	6.04	6.02
pH ($CaCl_2$)	5.10	5.06
Organic Matter (%)	4.40	3.07
P	5.99	6.87
Mg^{2+}	0.88	1.28
Al+H	1.5	2.96
ECEC	12.4	10.96

N.B collected at a depth of 0-15cm and 15-30cm before planting

Table 2: Effect of rhizome sizes of turmeric on the number of tillers per plant.

Rhizome size (cm)	Weight (g)	TPP 10WAP	TPP 15WAP	TPP 20WAP
2	5.50	3.72^{b}	4.39^{c}	5.72^{b}
4	11.30	4.34^{b}	5.43^{b}	6.34^{ab}
6	27.24	5.28^{b}	6.78^{bc}	7.28^{a}
8	47.34	4.52^{a}	5.86^{a}	6.87^{ab}

TPP= Tillers per plant, WAP= Weeks after planting

Table 3: Effect of turmeric rhizome size on the length of fully opened leaves of ginger

			CM	
Rhizome sizes (cm)	Weight (g)	LOL 10WAP	LOL 15WAP	LOL 20WAP
2	5.50	9.04^{c}	25.03^{c}	45.44^{c}
4	11.30	11.32^{b}	35.90^{b}	49.48^{bc}
6	27.24	11.60^{b}	37.69^{b}	53.68^{ab}
8	47.34	14.70^{a}	43.46^{a}	57.45^{a}

LOL = Length of fully opened leaves, WAP= Weeks after planting

Table 4: Effect of turmeric rhizome sizes on the stem diameter

Rhizome sizes	Weight (g)	STD 10WAP	STD 15WAP	STD 20WAP

Rhizome sizes (cm)	Weight (g)	STD 10WAP	STD 15WAP	STD 20WAP
2	5.50	5.62[d]	9.23[c]	9.87
4	11.30	7.44[c]	10.27[bc]	12.57
6	27.24	8.18[b]	11.20[b]	12.95
8	47.34	8.91[a]	12.38[a]	13.31

STD= Stem diameter, WAP= Weeks after planting

Table 5: Effect of turmeric rhizome size on some rhizome traits

Rhizome sizes (cm)	Weight (g)	NFR	LOR	WOR	NPR
2	5.50	3.42[a]	8.15[ab]	2.42[a]	8.25[b]
4	11.30	3.25[a]	7.55[c]	2.70[a]	11.00[a]
6	27.24	3.67[a]	8.90[a]	2.88[a]	11.08[a]
8	47.34	3.33[a]	8.63[a]	2.95[a]	9.58[ab]

NFR= Number of finger per rhizome, LOR= Length of rhizome, WOR= Width of rhizome, NPR= Nodes per rhizome.

Table 6: Effect of turmeric rhizome size on fresh yield

Rhizome sizes (cm)	Weight (g)	yield per plant (g)	yield per hectare (t)
2	5.50	682.60[bc]	0.64[b]
4	11.30	654.00[c]	0.79[b]
6	27.24	1058.00[a]	1.47[a]
8	47.34	988.60[ab]	1.57[a]

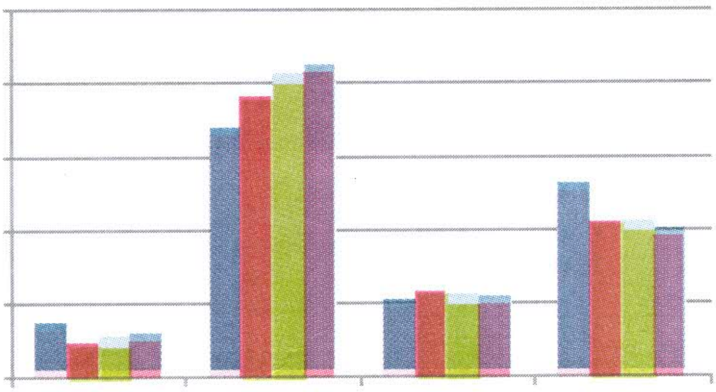

Table 7: Phytochemical screening of fresh and dry turmeric rhizomes and leaves

Phytochemical Screening				
	DL	FL	FR	DR

Alkaloids	+	+	+	+
Phenolics	+	+	-	+
Flavonoids	-	+	+	+
Saponins	-	+	+	-
Cardiac Glycosides	Nd	Nd	Nd	Nd
Steroids	-	-	-	-
Triterpenes	-	-	+	+

DL= Dry leaves, FL= Fresh leaves, FR= Fresh rhizomes, DR= Dry rhizomes

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