Variability in morphological, yield and nutritional attributes of ginger (Zingiber officinale) germplasm in Nigeria

Article in Research on Crops - September 2020
DOI: 10.31830/2348-7542.2020.099

CITATION
1

READS
81

6 authors, including:

Uchechukwu Paschal Chukwudi
North-West University
23 PUBLICATIONS 88 CITATIONS

Emmanuel Ikechukwu Eze
University of Nigeria
19 PUBLICATIONS 74 CITATIONS

Christian Agbo
University of Nigeria
42 PUBLICATIONS 364 CITATIONS

Funso Raphael Kutu
University of Mpumalanga South Africa
39 PUBLICATIONS 132 CITATIONS

Some of the authors of this publication are also working on these related projects:

Project Landscape change in Venda View project

Project Molecular Plant-Microbe Interactions / Rhizosphere Microbial Ecology View project
Variability in morphological, yield and nutritional attributes of ginger (Zingiber officinale) germplasm in Nigeria

U. P. CHUKWUDI1,3,*, C. U. AGBO1, B. C. ECHEZONA1, E. I. EZE1, F. R. KUTU2 AND S. MAVENGAHAMA3

1Department of Crop Science
University of Nigeria, Nsukka, Enugu State, Nigeria
*(e-mail : upchukwudi@gmail.com)

(Received : April 09, 2020/Accepted : August 10, 2020)

ABSTRACT

Ginger is a spice cum medicinal plant with fluctuating price and consumer demands that depends on the varietal qualities. Ten ginger genotypes were evaluated in 2017 and 2018 at the Department of Crop Science, University of Nigeria for variation in their morphological, yield and nutritional attributes. Data were collected on seedling emergence, number of leaves, leaf length, leaf width, plant height, pseudo-stem diameter and rhizome yield. The harvested rhizomes were analyzed for proximate, minerals and phytochemical compositions. Genotype EN-1 gave the best rhizome yield of 18 t/ha followed by KD-2 (16.5 t/ha), KD-1 (14.5 t/ha) and KD-3 (14 t/ha) while lower yield of 3.3 t/ha was obtained in RT-3 genotype. The results of proximate analysis revealed a high variation in nutritional contents with a range of 1.31 to 3.17% protein, 0.88 to 1.33% ash, 2.22 to 4.97% fiber, 0.25 to 0.60% fats and 8.3 to 12.0% carbohydrate contents in the different genotypes. Significant variation among the mineral and phytochemical attributes of the studied genotypes was also observed. The desirable growth, yield and nutritional attributes identified in different genotypes calls for gene mapping in these genotypes to establish their genetic diversity. The premium price placed on ginger rhizome is dependent on its quality and yield hence, grower should consider quality as well as the rhizome quantity accruable from each genotype in deciding which genotype to grow.

Key words : Genetic diversity, ginger, growth, phytochemicals, rhizome

INTRODUCTION

The importance of a plant depends on its identified benefits. Ginger (Zingiber officinale Roscoe) is a spice as well as a medicinal plant. Its global recognition stands more for its spicy properties than its medicinal properties. Studies on ginger’s medicinal properties indicated its ability to prevent skin, breast and prostate cancers (Ling et al., 2010; Karna et al., 2012). Ginger derivatives can scavenge reactive oxygen species, free radicals, peroxides, and various other damaging oxidants (Eleazu and Eleazu, 2012; Rajan et al., 2013). Dhanik et al. (2017) described ginger as the storehouse of antioxidant. Most of the bioactive components responsible for spicy quality of ginger also contributes to its medicinal usage. Therefore, consuming ginger as a spice has the additional benefit of improving the health of the consumer.

The demand for a specific ginger variety depends on its quality. India, the world leading ginger producer has the best ginger quality along with Jamaica while West African gingers ranked second in quality (Dhanik et al., 2017). Sensory qualities of a crop can be influenced by the interaction of its gene with weather, soil type, available nutrients and management practices (Mncwango et al., 2019; Pallavi and Anuja, 2019). This interaction often confers unique advantage to a location in producing crop qualities that meet specific consumer demands. Nigeria enjoys this advantage as her ginger quality is very good in oleoresin and essential oils (SPA, 2017). Nigeria is the leading

2University of Mpumalanga, School of Agricultural Sciences, Mbombela, South Africa.
3North-West University, Food Security and Safety Niche Area Research Group, Faculty of Natural and Agricultural Sciences, P/Bag X2046, Mmabatho 2735, South Africa.
Variability in Nigerian ginger

635

MATERIALS AND METHODS

Description of Study Site

The experiment was conducted at the research farm of University of Nigeria, Nsukka Enugu State Nigeria during 2017 and 2018 planting seasons. The research farm (06° 52’N, 07° 24’E, 447.26 m above sea-level) is located within the derived savannah zone of Nigeria with bimodal rainfall pattern that is obtained during April and October with peaks during the months of July and October. Relative humidity (%), maximum and minimum temperatures (°C), rainfall amount (mm) and rainfall days for 2017 and 2018 were obtained from the Meteorological Unit of University of Nigeria and are presented in Figs. 1a and 1b.

The soil at the experimental site, classified as Ultisol according to the soil taxonomy of the USDA (Soil Survey Staff, 2003), is sandy clay loam, contains low organic carbon (=1.46%), and low contents of nitrogen, phosphorous, basic cations (potassium, magnesium, calcium) and base saturation contents but high exchangeable acidity (Chukwudi and Agbo, 2014). However, the soil is deep, well drained and coarse textured with leaching as a major problem (Igwe, 2004).

Fig. 1a. Weather data at experimental site for 2017.

Fig. 1b. Weather data at experimental site for 2018.
Planting Materials

Ten ginger genotypes utilized in this study were sourced from different parts of Nigeria. Six genotypes namely ‘HPL’ [RT-1], ‘Maran’ [RT-2], ‘St. Vincent’ [RT-3], ‘UG I’ [RT-4], ‘UG II’ [RT-5] and ‘Wynad’ [RT-6] were obtained from the National Root Crops Research Institute Umudike, Abia State. Three others identified by farmers as ‘Elephant palm’ [KD-1], ‘Jumbo or Chinese ginger’ [KD-2] and ‘Monkey fingers’ [KD-3] were sourced from commercial ginger growers in Kaduna State where commercial ginger production and export ranks first (Folorunso and Adenuga, 2013). The remaining genotype [EN-1] was obtained locally from a farmer’s field in Enugu State. To increase uniformity and eliminate storage effect on the ginger sett emergence, only healthy matured plants were harvested from the donors’ field.

Field Preparation, Treatments, Experimental Design, Layout and Cultural Practices

The land was mechanically cleared, ploughed, and harrowed after which planting beds (75 x 100 cm) were manually raised 15 cm using a handheld hoe. A pathway of 100 cm was maintained between and within blocks. Three blocks (replications) were made, and each contained ten plots for each genotype. The study was fitted into randomized complete block design. Dried pig manure was applied on each raised bed at the rate of 15 t/ha after land preparation while a further 120 kg/ha NPK inorganic fertilizer (15:15:15) was band placed at 12 weeks after planting (WAP) along each planted row. Ginger setts each containing two to three buds were planted at 20 cm by 15 cm inter-and intra-row spacing, respectively on each bed (plot) according to genotypes. A total of 25 setts per genotype were planted per plot representing a plant population of 333,333 plants per hectare. The field was manually weeded without pesticide application.

Trait measurements

The plots were monitored for seedling emergence after planting. Approximately 3 WAP, the first set of emergences were observed. Thereafter, the plots were monitored to determine the number of days to attain half (50%) and complete setts emergence in each plot. These attributes were recorded as days to 50% emergence (D50E) and final emergence (FE). The FE description was used as most of the genotypes did not attain complete or 100% emergence. Hence, FE represents the percentage of emerged seedlings over planted setts per treatment. The emergence characteristic of the seedlings across the different genotypes was erratic.

By the sixth WAP, data collection on the morphological attributes started and three middle plants in each plot were randomly selected and tagged for this purpose. The number of leaves per tiler was counted. Leaf length and width of the second fully opened leaf was measured with a meter rule from one end to other end in a straight line and recorded in centimeter (cm). The plant height was measured with a flexible meter rule from soil level to the tip of the plant while the pseudo-stem diameter was measured with a micrometer screw gauge (Outside© Micrometer, Nigeria) 2 cm above the soil level. Data collection on morphological attributes was performed at bi-weekly intervals and ended 12 WAP.

At 30 WAP, most of the plants’ leaves had turned yellow and withered; suggesting that the rhizomes are ready for harvest. During harvesting, holes were carefully and manually dug round the root zone and the rhizomes were carefully lifted with the aid of hand fork to reduce rhizome damages. Harvested rhizomes per plot were placed in paper bags with proper labels before been moved to the laboratory. All adhering soil particles to the rhizomes were gently removed prior to weighing. To obtain yield on dry basis, 500 g of rhizomes from each replicate was air-dried to constant weight before fresh and dry weights per plot were converted into yield per hectare.

Laboratory Analyses

The protein, fat, fiber, ash, and moisture percentages of the proximate composition of the ginger genotypes were analyzed using the methods described in AOAC (2005). The carbohydrate content was obtained by subtracting the sum values of protein, fat, fiber, ash, and moisture from 100. Magnesium, calcium, sodium, potassium, phosphorous and iron contents were determined using atomic-absorption spectrophotometry (Shimadzu
Model AA-7000). The alkaloid, flavonoid and tannin contents were also analyzed as described by AOAC (2005).

Data Analysis

One-way analysis of variance for randomized complete block design was done on the collected data using GenStat Software (VSN Int. Ltd., Rothamsted Experimental Station, UK). When the F-value in the ANOVA Table is significant, Fisher’s protected least significant difference (F-LSD) was used in means separation at p = 0.05. Line graphs and bar charts were plotted using Microsoft Excel spreadsheet. The two years data were pooled together for data analysis.

RESULTS AND DISCUSSION

The observed significant variation in seedling emergence and morphological characteristics among the ginger genotypes is an indication of their genetic differences. These differences may have also contributed to the variation observed in the yield. The number of days to first seedling emergence ranged from 24 to 30 days after planting (DAP). EN-1 attained 50% seedling emergence at 24 DAP (Fig. 2) while RT-1 attained at 31 DAP. The result of final percentage emergence showed that only EN-1 and KD-2 attained 100% emergence at 12 and 7 days after emergence, respectively. The ginger genotypes studied had good emergence capacities. Only two genotypes had emergence lower than 80%. The reported average number of days for the first seedling emergence in this study is higher than 15 days reported in Ethiopia (Wolde et al., 2016) but lower than the 59 days reported in Manipur (Jyotsna et al., 2012).

Fig. 2. Impact of genotype on final emergence and days to 50% emergence in ginger.

Results revealed that KD-1 produced the longest leaf length at 6 (18 cm), 8 (21 cm) and 10 (22 cm) WAP while RT-1 produced it (22.3 cm) at 12 WAP (Fig. 3). RT-3 and RT-6 produced the shortest leaf lengths at 6 and 8 WAP; 10 and 12 WAP, respectively. There was no statistical difference among the measured leaf lengths in KD-1, KD-2, KD-3 and EN-1 at 6, 8, 10 and 12 WAP. KD-2 and EN-1 gave the broadest leaf widths that were significantly higher than the other genotypes at 6 (6.2, 7.4 cm), 8 (6.6, 6.3 cm), 10 (5.7, 5.7 cm) and 12 (5.2, 4.8 cm) WAP (Fig. 4) while RT-3 and RT-6 had the least leaf widths at 6 (1.9 cm) and 10 (1.9 cm) WAP. The leaf traits measured showed morphological differences in the ginger germplasm. Leaf width was more distinct in differentiating the genotypes than leaf length. Leaf width distinguished KD-2 and EN-1 from other genotypes while leaf length categorized them as similar with KD-1 and KD-3. Chukwudi et al. (2017) identified leaf broadness as the most representative trait in leaf study of Fluted pumpkins (Telfairia occidentalis). Broad leaves tend to intercept more light energy needed for photosynthesis. The photosynthetic capacity of plants is determined by both its number and the spread of the leaves. Average number of leaves per tiller and number of tillers per plant contributes to the final number of leaves per plant. The genotypes RT-6, RT-2 and RT-3 that had low number of leaves per tiller and low number of tillers per plant produced the least number of leaves per plant and also had short heights. All these growth attributes

Fig. 3. Leaf length [cm] trend from 6 to 12 weeks after planting of ginger genotypes.

Fig. 4. Leaf width [cm] trend from 6 to 12 weeks after planting of ginger genotypes.
may have resulted in reduced photosynthetic capacity that possibly contributed to the low rhizome yield obtained from them. The genotypes that produced more tillers and higher number of leaves per plant gave the best rhizome yields.

The highest number of leaves/tiller was observed in EN-1 (7) at 6 WAP however, at 10 and 12 WAP KD-1 (15 and 20) gave the highest number of leaves per tiller (Fig. 5). Significant differences were observed among the ginger plant heights with KD-1 and KD-3 producing the tallest plants at 6 (31.3 cm) and 12 (56.3 cm) WAP; 8 (38.7 cm) and 10 (48.8 cm) WAP, respectively (Fig. 6). KD-3 was significantly higher than the other genotypes at 10 WAP except KD-1 and EN-1 genotypes. The plant height results revealed that RT-3 genotype produced the shortest plants at 6 and 8 WAP while RT-6 genotype gave shortest plants as 10 and 12 WAP.

The pseudo-stem diameter of the ginger genotypes showed significant variations. KD-2 had significantly higher pseudo-stem diameter (6.9 mm, 7.8 mm) than RT-1, RT-2, KD-3, RT-3, RT-4, RT-5 and RT-6 genotypes at 6 and 8 WAP while EN-1 produced the widest diameter at 10 (8.2 mm) and 12 (9.0 mm) WAP (Fig. 7). KD-2 produced significantly higher number of leaves per plant (31 and 64) than RT-1, RT-2, RT-3 and RT-6 at 10 and 12 WAP while the lowest number of leaves per plant was recorded in RT-2 genotype (11 and 24) during both periods (Fig. 8). RT-3 produced the least pseudo-stem diameter at 6 and 8 WAP and RT-2 at 10 and 12 WAP. The number of tillers per plant differed significantly among the genotypes with the highest observed in KD-3 (6 and 9) and the least (2 and 4) in RT-2 and RT-3 at 10 and 12 WAP (Fig. 9).

The rhizome yield of the ten ginger genotypes differed significantly (Fig. 10) with the highest fresh yield of 98.7 t/ha and dry yield of 18 t/ha produced by EN-1. This was followed by KD-2, KD-1 and KD-3 genotypes. The yield of EN-1 was statistically different from those of RT-4, RT-6, RT-5, RT-1, RT-2 and RT-3 genotypes with the least yield of 18.8 t/ha (fresh) and 3.3 t/ha (dry) obtained from RT-3 genotype. The observed morphological variabilities alone did not explain the differences observed in the yield. The genetic make-up and the interaction of the genetic make-up with the environment may have played some roles in the difference in yield. The genotypes RT-4 and RT-5 that shared similar growth features with the KD series, and EN-1 genotype had huge yield variations with the later. When different crop varieties are grown under identical conditions it is genetic factor that explains the morphological differences (Goudar et al., 2017). Understanding the dry matter partitioning in these ginger genotypes can help explain the observed differences in
Yield in plant is a complex trait affected by genotype and genotype-by-environment interaction. The proximate analysis revealed significant differences in the nutritional quality of the ten ginger genotypes except for their carbohydrate content (Table 1). The RT-1 genotype had the highest protein (3.17%) while RT-3 genotype had the highest ash content (1.33%). Moisture content was highest in RT-6 genotype (86%) while KD-2 (4.97%) and EN-1 (0.6%) contained significantly highest fiber and fat content, respectively. However, the fat content of EN-1 genotype was significantly comparable to those of RT-1 and RT-5 genotypes. The ash (0.88%) and carbohydrate (8.27%) percentages of RT-6 genotype was the least among the ten ginger genotypes while genotype KD-2 gave the lowest fat (0.25%) and protein (1.31%) contents. The least fiber and moisture contents were obtained from RT-3 and RT-4 genotypes, respectively.

The mineral and phytochemical composition of the ten ginger genotypes showed significant differences in magnesium, calcium, phosphorus, iron, potassium, sodium, alkaloid, tannin and flavonoid contents of the ginger genotypes (Tables 2 and 3). The RT-6 genotype had the highest phosphorus (0.543), calcium (0.009), potassium (24.45) and flavonoid (1.6) concentrations while genotype RT-1 gave the highest values for iron (0.986), sodium (1.433), flavonoid (1.6) and tannin (0.924) contents. The highest amount of alkaloid and lowest sodium content were observed in KD-1 genotype. The highest amount of magnesium and the lowest sodium content were extracted from EN-1 genotype. The KD-2 genotype contained least phosphorus, iron, potassium, alkaloid and flavonoid while RT-4 genotype similarly had the lowest calcium and magnesium content. RT-3 genotype had the lowest iron concentration among all ten genotypes.

The variabilities witnessed in the growth and yield attributes of the ginger genotypes manifested in the nutritional composition of the ginger germplasm. Variation in the nutritional composition of ginger genotypes had been reported (Eleazu et al. 2012; Ravindran and Babu, 2016). In this present study, the variation in the proximate analysis results ranged from 1.31 to 3.17% for protein, 0.88 to 1.33% for ash, 79.4 to 86.0% for moisture, 2.22 to 4.97% for fiber, 0.25 to 0.60% for fats and 8.3 to 12.0% for carbohydrate. These values are in line with ginger rhizome proximate analysis on wet basis reported by El-Ghorab et
al. (2010) but differed from the values reported by Okolo et al. (2012) on ginger proximate analysis on wet basis. Moisture content of the ginger rhizome can influence the concentrations of other proximate contents (El-Ghorab et al., 2010; Okolo et al., 2012). Reduced moisture content will result in increased concentrates of flavonoid, phosphorus and protein contents in ginger rhizomes. Shirin and Jamuna (2010) had reported many health benefits of tannins and flavonoids extracted from ginger rhizome. Eze and Orjioke (2010) associated the antimicrobial activities of ginger to its tannins. Flavonoids have been implicated in the antioxidant properties of ginger (Eleazu and Eleazu, 2012; Dhanik et al., 2017). In addition, the sedative and analgesic effects produced by ginger alkaloid may be useful for the pharmaceutical sector. Eze and Orjioke (2010) recommended that alkaloids can be used in the production of pain-relieving drugs.

The correlation coefficients among selected mineral, nutritional and phytochemical composition of fresh ginger genotypes revealed that alkaloid had positive significant relationship with ash \( r = 0.37 \) and fat \( r = 0.39 \) (Table 4). Tannin had positive significant relationship with flavonoid, phosphorus, iron

### Table 2. Mineral contents (ppm) of fresh ginger genotypes

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Magnesium</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Iron</th>
<th>Potassium</th>
<th>Sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN-1</td>
<td>0.0138 ± 0.006</td>
<td>0.006 ± 0.002</td>
<td>0.296 ± 0.04</td>
<td>0.197 ± 0.23</td>
<td>18.29 ± 1.17</td>
<td>1.274 ± 0.07</td>
</tr>
<tr>
<td>KD-1</td>
<td>0.0096 ± 0.001</td>
<td>0.004 ± 0.002</td>
<td>0.309 ± 0.08</td>
<td>0.394 ± 0.46</td>
<td>17.18 ± 1.64</td>
<td>0.926 ± 0.13</td>
</tr>
<tr>
<td>KD-2</td>
<td>0.0108 ± 0.001</td>
<td>0.007 ± 0.003</td>
<td>0.209 ± 0.01</td>
<td>0.099 ± 0.11</td>
<td>13.52 ± 0.88</td>
<td>1.013 ± 0.00</td>
</tr>
<tr>
<td>KD-3</td>
<td>0.0102 ± 0.002</td>
<td>0.004 ± 0.002</td>
<td>0.330 ± 0.01</td>
<td>0.197 ± 0.00</td>
<td>15.79 ± 0.91</td>
<td>1.086 ± 0.02</td>
</tr>
<tr>
<td>RT-1</td>
<td>0.0126 ± 0.001</td>
<td>0.007 ± 0.001</td>
<td>0.465 ± 0.08</td>
<td>0.985 ± 0.00</td>
<td>17.48 ± 1.62</td>
<td>1.433 ± 0.08</td>
</tr>
<tr>
<td>RT-2</td>
<td>0.0096 ± 0.001</td>
<td>0.007 ± 0.001</td>
<td>0.374 ± 0.05</td>
<td>0.197 ± 0.23</td>
<td>19.90 ± 2.26</td>
<td>1.361 ± 0.13</td>
</tr>
<tr>
<td>RT-3</td>
<td>0.0066 ± 0.001</td>
<td>0.008 ± 0.000</td>
<td>0.330 ± 0.10</td>
<td>0.099 ± 0.11</td>
<td>17.39 ± 2.46</td>
<td>1.086 ± 0.35</td>
</tr>
<tr>
<td>RT-4</td>
<td>0.0054 ± 0.002</td>
<td>0.002 ± 0.000</td>
<td>0.317 ± 0.01</td>
<td>0.197 ± 0.00</td>
<td>19.22 ± 2.46</td>
<td>1.245 ± 0.23</td>
</tr>
<tr>
<td>RT-5</td>
<td>0.0090 ± 0.001</td>
<td>0.007 ± 0.001</td>
<td>0.383 ± 0.06</td>
<td>0.493 ± 0.11</td>
<td>16.90 ± 0.66</td>
<td>1.129 ± 0.03</td>
</tr>
<tr>
<td>RT-6</td>
<td>0.0096 ± 0.003</td>
<td>0.009 ± 0.003</td>
<td>0.543 ± 0.15</td>
<td>0.887 ± 0.57</td>
<td>24.45 ± 0.62</td>
<td>1.201 ± 0.05</td>
</tr>
<tr>
<td>F-LSD (p=0.05)</td>
<td>0.0038</td>
<td>0.003</td>
<td>0.102</td>
<td>0.372</td>
<td>3.77</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Mean ± Standard deviation.

### Table 3. Phytochemical contents (%) of fresh ginger genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Alkaloid</th>
<th>Tannin</th>
<th>Flavonoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN-1</td>
<td>1.78 ± 0.49</td>
<td>0.257 ± 0.08</td>
<td>1.25 ± 0.29</td>
</tr>
<tr>
<td>KD-1</td>
<td>2.05 ± 0.06</td>
<td>0.563 ± 0.14</td>
<td>1.45 ± 0.17</td>
</tr>
<tr>
<td>KD-2</td>
<td>1.33 ± 0.28</td>
<td>0.379 ± 0.01</td>
<td>0.45 ± 0.17</td>
</tr>
<tr>
<td>KD-3</td>
<td>1.73 ± 0.32</td>
<td>0.508 ± 0.01</td>
<td>1.00 ± 0.23</td>
</tr>
<tr>
<td>RT-1</td>
<td>1.75 ± 0.52</td>
<td>0.924 ± 0.02</td>
<td>1.60 ± 0.35</td>
</tr>
<tr>
<td>RT-2</td>
<td>1.60 ± 0.12</td>
<td>0.410 ± 0.16</td>
<td>1.30 ± 0.00</td>
</tr>
<tr>
<td>RT-3</td>
<td>1.85 ± 0.23</td>
<td>0.483 ± 0.23</td>
<td>1.45 ± 0.06</td>
</tr>
<tr>
<td>RT-4</td>
<td>1.73 ± 0.49</td>
<td>0.441 ± 0.16</td>
<td>1.05 ± 0.29</td>
</tr>
<tr>
<td>RT-5</td>
<td>1.80 ± 0.35</td>
<td>0.618 ± 0.09</td>
<td>1.55 ± 0.29</td>
</tr>
<tr>
<td>RT-6</td>
<td>1.50 ± 0.00</td>
<td>0.845 ± 0.23</td>
<td>1.60 ± 0.81</td>
</tr>
<tr>
<td>F-LSD (p=0.05)</td>
<td>0.405</td>
<td>0.121</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Mean ± Standard deviation.

### Table 4. Correlation coefficients of proximate, mineral and phytochemical composition of fresh ginger genotypes

<table>
<thead>
<tr>
<th>Alk</th>
<th>Tannin</th>
<th>Fla</th>
<th>Mg</th>
<th>Ca</th>
<th>P</th>
<th>Fe</th>
<th>K</th>
<th>Na</th>
<th>Protein</th>
<th>Ash</th>
<th>MC</th>
<th>Fiber</th>
<th>Fat</th>
<th>CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alk</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tannin</td>
<td>-0.17</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fla</td>
<td>0.11</td>
<td>0.58**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>-0.29</td>
<td>0.05</td>
<td>-0.06</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>-0.22</td>
<td>0.13</td>
<td>0.06</td>
<td>0.42*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>-0.03</td>
<td>0.76**</td>
<td>0.70**</td>
<td>0.10</td>
<td>0.18</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.08</td>
<td>0.83**</td>
<td>0.59**</td>
<td>0.05</td>
<td>0.03</td>
<td>0.79**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.13</td>
<td>0.34</td>
<td>0.55**</td>
<td>-0.27</td>
<td>0.09</td>
<td>0.73**</td>
<td>0.45*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>0.05</td>
<td>0.17</td>
<td>0.24</td>
<td>0.09</td>
<td>0.16</td>
<td>0.45*</td>
<td>0.17</td>
<td>0.43*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>0.05</td>
<td>0.41*</td>
<td>0.40*</td>
<td>-0.06</td>
<td>-0.45*</td>
<td>0.27</td>
<td>0.32</td>
<td>-0.10</td>
<td>0.23</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>0.37*</td>
<td>-0.20</td>
<td>-0.27</td>
<td>-0.12</td>
<td>-0.05</td>
<td>-0.46*</td>
<td>-0.24</td>
<td>-0.44*</td>
<td>-0.38*</td>
<td>-0.19</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>0.28</td>
<td>0.12</td>
<td>0.09</td>
<td>-0.09</td>
<td>0.15</td>
<td>0.18</td>
<td>0.02</td>
<td>0.31</td>
<td>0.12</td>
<td>0.08</td>
<td>-0.39*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>0.06</td>
<td>-0.28</td>
<td>-0.46*</td>
<td>0.43*</td>
<td>0.04</td>
<td>-0.39*</td>
<td>-0.10</td>
<td>-0.34</td>
<td>-0.20</td>
<td>-0.45*</td>
<td>0.15</td>
<td>-0.52**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>0.39*</td>
<td>-0.18</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.03</td>
<td>0.12</td>
<td>0.14</td>
<td>0.04</td>
<td>0.10</td>
<td>0.01</td>
<td>0.14</td>
<td>0.001</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>CHO</td>
<td>0.24</td>
<td>-0.13</td>
<td>-0.04</td>
<td>-0.02</td>
<td>-0.06</td>
<td>0.13</td>
<td>-0.07</td>
<td>-0.19</td>
<td>-0.12</td>
<td>-0.20</td>
<td>0.37*</td>
<td>-0.96**</td>
<td>0.37*</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

** and * : Correlation significant at p=0.01 and p=0.05 levels (2-tailed), respectively.
and protein ($r = 0.41-0.83; \ p<0.05$) with the highest correlation obtained in iron. Similarly, the content of flavonoid had positive significant relationship with phosphorus, iron, potassium and protein ($r = 0.40-0.70; \ p<0.05$). Fiber content showed negative correlation with flavonoid ($r = -0.46$), protein ($r = -0.45$), and moisture content ($r = -0.52$) but had positive correlation with the content of carbohydrate ($r = 0.37$) and magnesium ($r = 0.43$). There was a negative significant relationship between calcium and protein ($r = -0.45$). Ash showed negative significant correlation with phosphorus, potassium, sodium and moisture content ($r = -0.38$ to $-0.46$) but had positive correlation with carbohydrate ($r = 0.37$). Moisture content showed highly significant and negative correlation with carbohydrate ($r = -0.96$).

**CONCLUSION**

This study unveil the differences in the morphological, yield and nutritional attributes of ginger genotypes in Nigeria. Significant variations were observed in seedling emergence, plant height, pseudo-stem diameter, leaf length, width, number of tillers per plant, rhizome yield and nutritional compositions in the ginger germplasm evaluated. There is need for gene mapping in these genotypes to establish their actual genetic diversity. Since the premium price placed on ginger rhizome depend on its quality, growers should consider quality as well as the rhizome quantity accruable from each genotype in deciding which genotype(s) to grow.

**REFERENCES**


