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# ASSESSMENT OF SEED YIELD AND YIELD RELATED CHARACTERS AMONG 22 NIGERIAN CULTIVATED RICE (*Oryza sativa* L.) VARIETIES GROWN IN GUINEA SAVANNAH AGRO-ECOLOGY, ABUJA, OVER TWO CROPPING YEARS

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## ABTRACT

Twenty-two rice varieties were evaluated in a field trial under rain-fed conditions at the National Agricultural Seeds Council, Sheda, Abuja (Latitudes 8°53'7" – 8º45'3N and Longitudes 7°3'56" – 7º3.01'E) in 2017 and 2018 cropping years to provide a comparative measure for seed yield and yield related components of cultivated rice varieties in guinea savannah agro-ecology of Nigeria. The experimental field was laid out using Randomized Complete Block Design in three replicates. Seeds of the 22 varieties were assessed for seedling emergence, days to 50% flowering, plant height, number of panicles/plant, seed yield/plot, seed yield/ha, 100 seed weight and seed weight/ plant. Data obtained were subjected to Analysis of Variance and means were separated using Tukey's HSD at 5% probability level. Pearson's correlation coefficient and principal component analyses were also used. Higher panicle length, number of panicles/plot, seed weight/plant and 100-seed weight were observed in year 2017 compared to 2018. FARO 48, FARO 59, FARO 58 and PAC 832 had highest seed yield (10.19 - 11.09 $tha^{-1}$) while FARO 62, FARO 22 and FARO 21 performed poorly. Plant height, number of panicles/plant, panicle height, seed yield/plant mainly contributed to the variation within the rice varieties. Seed germination was positively related to other seed quality attributes (r=0.36 – 0.84**). The study concluded that FARO 48, FARO 59, FARO 58, PAC 832, FARO 44 and FARO 45 with highest seed yield components are recommended for cultivation and could be used for future yield improvement.

**Keywords:** FARO, Seed yield, Seasonal variation, Variability, Yield components.

  

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## INTRODUCTION

Rice (Oryza sativa L.) is one of the most important food crops for more than 50% of the world population (Atera *et al.*, 2018). Globally, about 160 million hectares are estimated to be under rice production with an annual production of approximately 500 million metric tons (Kirby *et al.*, 2017). The demand for rice has increased steadily over the years, thus playing a major role in many countries in terms of strategic food security planning policies. In recent years, rice crop yield has slowed considerably therefore failing to keep up with the population growth thus leading to shortages and higher prices that have adversely affected smallholder rice farmers (Denkyirah, 2015; Lee and Kobayashi, 2017). Rice has the potential to improve nutrition, boost food security, foster rural development and support sustainable land use in Africa (Imolehin and Wada, 2000).

In Nigeria, rice consumption complements other staples, such as sorghum and millet, as these foods tend to be consumed at different times of the day. Variants of sorghum, millet and rice are also consumed as cakes or fritters, mostly as street food or snacks. The main substitutes for rice in urban areas are cassava (gari, fufu) or pounded yam and banku (made with maize) or acheke. Considering the levels of production and consumption, an acute demand for rice in the country continues. Thus, it is evident that demand for rice is to be met through domestic intensification of rice cultivation by increasing yield and the area planted to rice. Furthermore, in sub-Saharan Africa, West Africa is the leading producer and consumer of rice and accounting for about 64.2 and 61.92 of total rice production and consumption, respectively. Nigeria has a leading role in rice production in West Africa, ranking highest as both the producer and the consumer of rice in the Sub-region with production figures slightly above 50% (Oko *et al.*, 2012).

Crop improvement depends upon the magnitude of genetic variability present in the base population. Adebisi *et al.* (2012) reported that variability existed among NERICA rice varieties studied for seed yield characters and observed highly significant seasonal variability for seed yield traits evaluated in the field tests in the varieties studied, indicating that the seasons differed from each other and therefore offered an opportunity of two environments for evaluation. They also reported that a non-significant season (year) X variety interval for seed yield/plant of the varieties did not vary with changes in the growing conditions of 2003 and 2004.

Seasonal variation has been identified as one of the factors of seed yield and related characters (Okelola, 2005). The success of any crop improvement depends largely on the crop species. The selection of yield and quality related traits is key for the breeding of superior varieties as reported by various scholars (Adekoya *et al*., 2010 and Ariyo and Ayo-Vaughan, 2000). Acqnah (2007) reported that environment is used to represent the condition under which plant grow and includes locations, years and management practices adopted among others.

  

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Grain yield depends on various component characters and knowledge of correlations among yield component traits (Sameera *et al*. 2016). Such studies can provide reliable information on the nature, extent and direction of selection. Information on character association between yield and yield related characters in crop is important for effective and rapid progress in selection and crop improvement (Denton and Nwagburuka, 2011). This will indicate the interrelationship between two or more plant characters and yield, providing suitable means for indirect selection for yield. Correlation coefficient is a statistical measure which is used to find out degree and direction of relationship between two or more variables. A positive value of correlation shows that changes of two variables are in the same direction whereas in the negative correlation, movements of two variables are in the opposite direction (Okelola, 2021).

Yield is a complex character and is the end product of multiplicative interaction between various yield components (Lawal, 2020). Information on the nature and extent of association among yield and yield component characters is therefore essential for systematic crop improvement. Sameera *et al.* (2016) reported that grain yield per plant was observed to be positively and significantly associated with number of tillers per plant, productive tillers per plant, number of grains per panicle and number of filled grains per panicle indicating an increase in grain yield with an increase in these characters. Therefore, priority should be given to these traits, while making selection for yield improvement.

Low yields per hectare and variation in growth parameters have been reported by farmers on the field which could be due to differences in the genetic constitution apart from other several factors ranging from biotic and abiotic. Variation in agronomic traits and seed yield components have also been observed within and among varieties (Okelola, 2005). Proper genetic evaluation of rice should, therefore, be done to carry out selection, as good selection of rice varieties would lead to improve agronomic and seed yield performance, consequently resulting in good yield. Hence, it is imperative to determine the seed yield and yield related characteristics of commonly cultivated rice varieties in Nigerian grown under Guinea savannah ecology and for identification of promising varieties across two cropping years which can be recommended to rice farmers in this agro-ecology.

## MATERIALS AND METHODS

### Seed materials and sources

The seeds of twenty-two released and marketed rice varieties used in the study were sourced from the National Cereals Research Institute (NCRI), Badeggi.

### Experimental site and cropping year

  

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The trials were conducted at the Research Field of the National Agricultural Seeds Council of Nigeria, Sheda, Abuja, a Guinea savannah ecology with Latitude N8°53'7" and longitude E7°3'56" during rainy seasons; June 2017 and 2018 cropping years. Weather data at the experimental site in each of the cropping years were collected.

**Land preparation and experimental design**

The trial plots were cleared and ploughed manually, using hoe and cutlass and field was laid out in a randomized complete block design with three replications. The seed of rice varieties was sown in June 2017 for first trial and the same period in 2018 in the second trial. The total number of plot for each year's trial was 22 cultivars and 3 replications (66 plots per year). Size of each plot was 2 x 2 m and 1m space was used to separate each plot within the block. Spacing between the plants was 20 cm interval in 10 rows and giving a plant population of 100 hills per plot size. The total experimental plot size was 520$m^2$.

**Crop management**

Three seeds of each variety were sown per hill and later thinned to one stand per hill at three weeks after seedling emergence and establishment. Weeding using hoe and cutlass was carried out as at when due and this was maintained throughout 2017 and 2018 early cropping years. The planting was repeated in 2018 to revalidate data collected in 2017 cropping year.

Fertilizer application was done as recommended by Karmal, *et al.* (2020) (60 – 80kg of nitrogen and 13 kg of phosphorus (i.e. 30 kg P205/ha) and 25 kg potassium/ha (30 kg K2O/ha). The nitrogen was applied in two doses in between stands, properly incorporated in the soil to avoid leaching. This relates to applying 4 bags of NPK 15: 15: 15/ha. Fertilizer application was in two splits (first and second applications were done at 4 and 8 weeks after sowing, respectively).

**Data collection**

Data were collected from plants in the three middle rows for the following agro-morphological and seed yield characters following the procedures outlined by Okelola (2005).

**Seedling emergence (%):** The proportion of emerged seedlings after 8 days expressed as emergence percentage of total number of seed sown.

**Days to 50% flowering:** Number of days to when 50% of the plants had flowers.

**Plant height/plant (cm):** Average height of 10 randomly selected plants in centimeter per replicate.

  

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**Panicle length/plant (cm):** Average number of panicle lengths from 10 randomly selected plant per replicate in centimeter.

**Number of panicles/plan:** Average number of panicles from 10 randomly selected plant per replicate.

**Seed yield per plot (g):** Average seed yield per plot was determined in grammes.

**Seed yield per ha (ton):** Seed yield per plot was expressed in ton per hectare.

**Seed weight per plant (g):** Average weight (gramme) of seeds from 10 randomly selected plant per replicate.

**100 seed weight (g):** Mass of 100 clean seeds randomly selected from three replicate were measured using sensitive weighing scale.

**Statistical analysis**

Data obtained from the above experiment were subjected to 2-way Analysis of Variance using SAS statistical analytical software. Treatment means were separated using Duncan's multiple Range test at 5% probability level. Association between various agro morphological characteristics were determined using Pearson correlation coefficient analysis. Principal Component Analysis (PCA) was used to identify major characters that contributed to the variation within the entries across cropping seasons.

## RESULTS

The mean square values from the combined analysis of variance of seed yield and related components of 22 cultivated rice varieties over two cropping years are presented in Table 1. From the result, the cropping year effect was highly significant ($P<0.01$) for seedling emergence, number of panicles per plant, panicle length per plant and 100 seed weight. Variety effect was highly significant ($P<0.01$) on seedling emergence, days to 50% flowering, seed yield per plot, seed yield per ha, 100 seed weight and seed weight per plant. The result further indicates that cropping year by variety interaction effect was highly significant ($P<0.01$) for days to 50% flowering, number of panicles per plant, seed yield per plot, seed yield per ha, 100 seed weight and seed weight per plant. However, replication effect was significant on seed yield per plot, seed yield per ha and seed weight per plant.

  

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**Table 1: Mean square values for seed yield and related components in Nigerian cultivated rice varieties under two cropping years under guinea savannah ecology**

| Source of variation | DF | Seedling emergence | Days to 50% flowering | Plant height | Number of panicles/ plant | Panicle length | Seed yield per plot | Seed yield per ha | 100 seed weight | Seed weight per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| Replicate | 2 | 181.12$^{ns}$ | 248.45 | 0.50$^{ns}$ | 1.12ns | 226.75$^{ns}$ | 16.76** | 104.45** | 0.10ns | 15063.30* |
| Cropping year | 1 | 645.54** | 23.76$^{ns}$ | 110.11$^{ns}$ | 40.37** | 462.56** | 1.59$^{ns}$ | 10.45$^{ns}$ | 3.04** | 3433.77$^{ns}$ |
| Variety (V) | 21 | 384.42** | 309.00** | 392.55$^{ns}$ | 5.80* | 6.62$^{ns}$ | 7.46** | 146.67** | 0.50** | 4330.49** |
| Y×V | 21 | 8.58 | 240.06** | 127.4$^{ns}$ | 11.40** | 5.57$^{ns}$ | 4.04* | 30.26** | 0.12** | 1583.79* |
| Error | 86 | 154.28 | 141.21 | 260.66 | 2.04 | 5.16 | 1.51 | 9.54 | 0.01 | 557.88 |

** Significant at 1% probability level, *significant at 5% probability level, Ns not significant

The effect of cropping years on seed yield and related components across Nigerian cultivated rice varieties is presented in Table 2. The data reveal variability in some seed yield and related components between the two cropping years. A cursory look of the data shows that longer days to flowering (88.76 days), panicle length (26.85cm), number of panicle per plant (11.88) seed weight per plant (45.10g) and 100 seed weight (2.86g) occurred in 2017 cropping year compared to the corresponding 2018 year. On the contrary, higher seedling emergence occurred in 2018 cropping year. Also, the seed weight per plant (45.10g) and 100 seed weight (2.86g) values in 2017 were greater than the mean values of the two cropping years of 43.29g (2017) and 2.71g (2018).

  

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**Table 2: Effect of cropping years on seed yield and related components among 22 Nigerian cultivated rice varieties**

| Seed yield and related components | 2017 cropping year | 2018 cropping year | Superiority advantage (%) | S.E | Mean |
|---|---|---|---|---|---|
| Seedling emergence (%) | 71.06[b] | 75.50[a] | 6.0 | 1.53 | 73.29 |
| Days to 50% flowering | 88.76[a] | 87.91[a] | 2.0 | 1.46 | 88.33 |
| Plant height/plant (cm) | 77.29[a] | 81.04[a] | 5.0 | 1.99 | 79.16 |
| Panicle length/plant (cm) | 26.85[a] | 25.02[b] | 7.0 | 0.28 | 25.04 |
| Number of panicles/plant | 11.88[a] | 10.77[b] | 10.0 | 0.18 | 11.33 |
| Seed yield per plot (g) | 2.80[a] | 3.02[a] | 7.0 | 0.15 | 2.91 |
| Seed yield per ha (ton) | 6.99[a] | 7.56[a] | 7.54 | 3.78 | 7.28 |
| Seed weight per plant (g) | 45.10[a] | 41.47[b] | 8.0 | 4.56 | 43.29 |
| 100 seed weight (g) | 2.86[a] | 2.56[b] | 11.0 | 0.01 | 2.71 |

Mean values followed by the same alphabet along the row are not different from another at 5% probability level.
S.E. = Standard error

In Table 3, the mean performance of 22 Nigerian cultivated rice varieties for seedling emergence under two cropping years reveals that in 2017, FARO 58 had highest seedling emergence of 83% which was not significantly different from values of 75 to 79% recorded in FARO 22, FARO 21, FARO 64, FARO 50, FARO 27 and FARO 59. The values of seedling emergence in other varieties were between 62 to 76% except in FARO 62 (56.33%) and FARO 44 (46.33%) which had the lowest values. In 2018, the seedling emergence values varied among the 22 rice varieties with highest values in FARO 27, FARO 50, FARO 64, FARO 22 and FARO 60 with the values ranging from 81.33 to 83.67, which in most cases, were not statistically different from many of other varieties except FARO 31, FARO 44, FARO 44, FARO 41 and FARO 62 (54.67 – 66%). The varietal means vividly reveal that FARO22, FARO 27 and FARO 58 had distinct emergence values of between 80 and 81.83%, though not statistically different from values of 72 – 79% obtained in many other varieties except FARO 41 (64.17%), FARO 65 (63.88%) and FARO 62 (57.83%).

Also in Table 3, the result shows that in 2017, FARO 62, FARO 60, FARO 21, FARO 59, FARO 58 and PAC 832 had significantly longest days to 50% flowering of between 97 and 103.67 days. The other varieties were statistically similar in days to flowering (73 to 91 days) except FARO 27 with the shortest days (68 days). In the corresponding 2018, variability in days to flowering was also observed among the varieties, with seven varieties (FARO 60, FARO 50, FARO21, FARO 59, FARO 58, FARO 31 and FARO 45) showing highest days to flowering of

  

between 93 and 104 days while the flowering days of other varieties were between 90and 91days. Lowest days to flowering of 72 – 78 days occurred in FARO 22, WAB 189 and FARO 50. The varietal mean across the years shows that FARO 62, FARO 60, FARO 21, and FARO 69 were with highest days to flowering (97 – 103 days) while FARO 27 showed the least days (68days) to flowering. However, FARO 61, FARO 41, WAB189 and FARO 31 had less than 80 days to flowering.

**Table 3: Mean performance of 22 Nigerian cultivated rice varieties for seedling emergence (%) and days to 50% flowering under two cropping years in guinea savannah ecology**

| | Seedling emergence (%) | | | Days to 50% flowering | | |
|---|---|---|---|---|---|---|
| Variety | **2017 cropping year** | **2018 cropping year** | **Varietal Mean** | **2017 cropping year** | **2018 cropping year** | **Varietal mean** |
| FARO 62 | $56.33^{d}$ | $59.33^{cd}$ | $57.83^{cd}$ | $103.67^{a}$ | $101.33^{a}$ | $102.33^{a}$ |
| FARO 60 | $76.00^{b}$ | $83.67^{a}$ | $79.83^{ab}$ | $102.33^{a}$ | $104.33^{a}$ | $103.33^{a}$ |
| FARO 52 | $76.33^{b}$ | $79.33^{ab}$ | $77.63^{ab}$ | $85.67^{bc}$ | $95.00^{ab}$ | $90.33^{b}$ |
| FARO 61 | $73.67^{b}$ | $79.00^{ab}$ | $78.33^{ab}$ | $74.67^{c}$ | $84.00^{cd}$ | $79.33^{d}$ |
| FARO 41 | $62.67^{c}$ | $65.67^{ab}$ | $64.17^{bc}$ | $73.33^{c}$ | $83.67^{cd}$ | $78.50^{d}$ |
| FARO 22 | $78.38^{ab}$ | $81.67^{a}$ | $80.00^{a}$ | $91.00^{b}$ | $72.33^{d}$ | $81.67^{c}$ |
| WAB 189 | $71.00^{c}$ | $77.33^{ab}$ | $74.17^{ab}$ | $80.00^{c}$ | $78.33^{d}$ | $79.17^{d}$ |
| FARO 21 | $75.83^{ab}$ | $78.00^{ab}$ | $76.67^{ab}$ | $106.0^{a}$ | $93.33^{abc}$ | $99.67^{a}$ |
| FARO 63 | $70.33^{b}$ | $77.33^{ab}$ | $73.88^{ab}$ | $89.00^{bc}$ | $90.33^{bc}$ | $89.67^{bc}$ |
| FARO 64 | $75.67^{ab}$ | $81.33^{a}$ | $78.50^{ab}$ | $87.00^{bc}$ | $87.00^{cd}$ | $87.00^{bc}$ |
| FARO 50 | $75.00^{ab}$ | $81.33^{a}$ | $78.17^{ab}$ | $88.00^{bc}$ | $78.67^{d}$ | $83.50^{c}$ |
| FARO 27 | $79.00^{ab}$ | $82.00^{a}$ | $80.50^{a}$ | $66.00^{d}$ | $70.00^{de}$ | $68.00^{e}$ |
| FARO 57 | $73.33^{b}$ | $78.33^{ab}$ | $75.83^{ab}$ | $91.00^{b}$ | $88.00^{cd}$ | $89.67^{bc}$ |
| FARO 48 | $74.67^{ab}$ | $79.00^{ab}$ | $76.88^{ab}$ | $85.33^{bc}$ | $91.00^{bc}$ | $88.17^{bc}$ |
| FARO 47 | $62.00^{c}$ | $69.00^{b}$ | $65.50^{bc}$ | $84.00^{bc}$ | $82.33^{cd}$ | $83.14^{c}$ |
| FARO 59 | $77.33^{ab}$ | $79.00^{ab}$ | $78.17^{ab}$ | $97.00^{ab}$ | $97.00^{ab}$ | $97.00^{a}$ |
| FARO 44 | $46.33^{d}$ | $54.67^{d}$ | $50.50^{d}$ | $80.33^{bc}$ | $83.67^{cd}$ | $82.00^{c}$ |
| FARO 58 | $83.00^{a}$ | $80.67^{a}$ | $81.83^{a}$ | $94.00^{a}$ | $96.53^{ab}$ | $95.11^{b}$ |
| FARO 65 | $61.00^{c}$ | $66.67^{c}$ | $63.88^{bc}$ | $84.67^{bc}$ | $85.33^{cd}$ | $85.50^{bc}$ |

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| | | | | | | |
|---|---|---|---|---|---|---|
| FARO31 | 71.67$^{b}$ | 73.33$^{ab}$ | 72.50$^{ab}$ | 71.00$^{c}$ | 99.67$^{ab}$ | 78.50$^{d}$ |
| PAC 832 | 72.33$^{b}$ | 77.33$^{ab}$ | 74.83$^{ab}$ | 97.33$^{ab}$ | 85.33$^{cd}$ | 91.33$^{b}$ |
| FARO 45 | 72.33$^{b}$ | 77.00$^{ab}$ | 74.67$^{ab}$ | 90.67$^{b}$ | 99.67$^{ab}$ | 95.17$^{b}$ |

Mean values followed by the same alphabet along the column are not different from another at 5% probability level.

In Table 4, in 2017 cropping year, the number of panicles per plant shows that FARO 22, FARO 64 had highest number of panicle per plant (14) which was not different from values of 13 in FARO 22 and FARO 50 while the other varieties had similar panicles number of between 11 and 12. In the corresponding 2018 cropping year, the highest number of panicles per plant was obtained in FARO 52, FARO 41, and FARO 64 with 12 panicles per plant while the values in most of other varieties were statistically similar with between 10 and 11 panicles per plant but FARO 63 showed lowest panicles per plant (9). On the varietal mean across years, two varieties (FARO 61 and FARO64) were found with distinct values of 13 panicles per plant whereas other varieties had statistically similar values of 11 – 12 panicles per plant but FARO 64 and FARO 44 showed lowest panicles (10.0).

Still in Table 4, a perusal of the table shows that in 2017 year, FARO 57, FARO 48, FARO 57 and PAC 832 had distinct highest seed yield per plot of 4.07, 4.38, 4.41 and 4.23kg, respectively though was not significantly different from values of 3.13 to 3.87kg in FARO 27, FARO 44, FARO 58, FARO 65 and FARO 45 while other varieties had seed yield per plot of between 2.13 and 2.90kg but FARO 62 (0.97kg), FARO 61 (1.83kg), FARO 22(1.20kg), FARO 21 (1.20kg) and FARO 31(1.83kg) had the least seed yield per plot. In the same vein in 2018 cropping year, variability also existed among the varieties with FARO 57, FARO 48, FARO 59, FARO 58 and PAC 832 showing highest values of seed yield per plot of between 4.30 and 4.84kg, though not statistically different from values of 3.97, 3.47 and 3.77kg recorded in FARO44, FARO 65 and FARO 45, respectively. Most of other varieties had statistically similar values of between 1.13 and 3.33kg while FARO62 showed lowest seed yield of 1.07kg per plot. On the overall performance (varietal mean), FARO 48 and FARO 59 showed the highest seed yield per plot of 4.60kg closely followed by FARO 58 (4.08kg), PAC 832 (4.43kg) and FARO 57 (4.25kg) while FARO 44 was intermediate in seed yield per plot performance with 3.76kg but FARO 22 and FARO 62 had the least values of 1.17 and 1.02kg, respectively.

  

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**Table 4: Mean performance of 22 Nigerian cultivated rice varieties for number of panicles per plant and seed yield per plot (kg) in two cropping years under guinea savannah ecology**

| | Panicles per plant | | | Seed yield per plot (kg) | | |
|---|---|---|---|---|---|---|
| Variety | **2017 cropping year** | **2018 cropping year** | **Varietal mean** | **2017 cropping year** | **2018 cropping year** | **Varietal mean** |
| FARO 62 | $11^{bc}$ | $10^{bc}$ | $11^{ab}$ | $0.97^{cd}$ | $1.07^{d}$ | $1.02^{cd}$ |
| FARO 60 | $11^{bc}$ | $11^{ab}$ | $11^{ab}$ | $2.13^{bc}$ | $2.27^{bcd}$ | $2.20^{abcd}$ |
| FARO 52 | $11^{bc}$ | $12^{a}$ | $12^{ab}$ | $2.87^{bc}$ | $3.17^{bc}$ | $3.02^{abcd}$ |
| FARO 61 | $14^{a}$ | $11^{ab}$ | $13^{a}$ | $1.83^{c}$ | $1.93^{cd}$ | $1.88^{b}$ |
| FARO 41 | $11^{bc}$ | $12^{a}$ | $12^{ab}$ | $2.70^{b}$ | $2.80^{bc}$ | $2.75^{a}$ |
| FARO 22 | $13^{a}$ | $11^{ab}$ | $12^{ab}$ | $1.20^{c}$ | $1.20^{cd}$ | $1.20^{cd}$ |
| WAB 189 | $12^{b}$ | $11^{ab}$ | $11^{ab}$ | $2.10^{b}$ | $2.20^{bcd}$ | $2.15^{abcd}$ |
| FARO 21 | $11^{bc}$ | $10^{bc}$ | $11^{ab}$ | $1.20^{c}$ | $1.13^{bc}$ | $1.17^{cd}$ |
| FARO 63 | $10^{c}$ | $9^{c}$ | $10^{b}$ | $2.47^{bc}$ | $3.03^{bc}$ | $2.76^{abcd}$ |
| FARO 64 | $14^{a}$ | $12^{a}$ | $13^{a}$ | $2.40^{bc}$ | $2.53^{bc}$ | $2.47^{abcd}$ |
| FARO 50 | $13^{a}$ | $11^{ab}$ | $12^{ab}$ | $2.90^{b}$ | $3.10^{b}$ | $3.00^{abcd}$ |
| FARO 27 | $11^{bc}$ | $11^{ab}$ | $11^{ab}$ | $3.13^{ab}$ | $3.33^{bc}$ | $3.23^{abcd}$ |
| FARO 57 | $12^{b}$ | $10^{bc}$ | $11^{ab}$ | $4.07^{a}$ | $4.43^{a}$ | $4.25^{ab}$ |
| FARO 48 | $12^{b}$ | $11^{ab}$ | $11^{ab}$ | $4.38^{a}$ | $4.84^{a}$ | $4.60^{a}$ |
| FARO 47 | $12^{b}$ | $11^{ab}$ | $11^{ab}$ | $2.50^{bc}$ | $2.67^{bcd}$ | $2.53^{abc}$ |
| FARO 59 | $12^{b}$ | $11^{ab}$ | $12^{ab}$ | $4.41^{a}$ | $4.80^{a}$ | $4.60^{a}$ |
| FARO 44 | $11^{bc}$ | $10^{bc}$ | $10^{b}$ | $3.61^{ab}$ | $3.97^{ab}$ | $3.76^{abc}$ |
| FARO 58 | $11^{bc}$ | $11^{ab}$ | $11^{ab}$ | $3.87^{ab}$ | $4.30^{a}$ | $4.08^{ab}$ |
| FARO 65 | $12^{b}$ | $10^{bc}$ | $11^{ab}$ | $3.37^{ab}$ | $3.47^{abc}$ | $3.42^{abcd}$ |
| FARO31 | $12^{b}$ | $10^{bc}$ | $11^{ab}$ | $1.83^{c}$ | $1.87^{cd}$ | $1.85^{b}$ |
| PAC 832 | $12^{b}$ | $11^{ab}$ | $12^{ab}$ | $4.23^{a}$ | $4.63^{a}$ | $4.43^{ab}$ |
| FARO 45 | $11b^{c}$ | $11^{ab}$ | $12^{ab}$ | $3.53^{a}$ | $3.77^{ab}$ | $3.65^{abcd}$ |

Mean values followed by the same alphabet along the column are not different from another at 5% probability level.

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In Table 5, the mean performance of the 22 cultivated rice varieties for seed 100 seed weight in 2017 cropping year shows that FARO 52 (3.60g) had highest value, closely followed by FARO 22 (3.41g), FARO 61 (3.11g) and FARO47 (3.23g). The 100 seed weight of most of other varieties were between 2.72 and 3.09g except for varieties FARO 50 (1.77g) and then WAB 189 (2.53g), FARO 64 (2.20g) and FARO 31(2.43g) which showed lowest values. For the 2018 cropping year performance, the 100 seed weight values were variable among some varieties with FARO 41 with highest value of 3.22g, followed by FARO 57 (2.87g), FARO 44 (2.83g) and FARO 45 (2.88g), whereas FARO 63 and FARO 50 showed the least values of 1.79g. On the varietal mean performance, FARO 52 (3.11g) had highest 100 seed weight followed by FARO 47 (2.82g) while the 100 seed weight of other varieties were between 2.52 and 2.90g but FARO 50 (1.99g) and FARO 27 (1.96g) had least 100 seed weights.

**Table 5: Mean performance of 22 Nigerian cultivated rice varieties for 100 seed weight (g) and seed weight per plant (g) in two cropping years under guinea savanna ecology**

| | 100 seed weight (g) | | | Seed weight per plant (g) | | |
|---|---|---|---|---|---|---|
| **Variety** | **2017 cropping year** | **2018 cropping year** | **Varietal mean** | **2017 cropping year** | **2018 cropping year** | **Varietal mean** |
| **FARO 62** | 2.82$^{cd}$ | 2.67$^{c}$ | 2.70$^{bcdef}$ | 16.92$^{d}$ | 17.943$^{e}$ | 17.42$^{de}$ |
| **FARO 60** | 2.97$^{c}$ | 2.61$^{c}$ | 2.79$^{bcdef}$ | 27.91$^{cd}$ | 26.407$^{cde}$ | 27.16$^{d}$ |
| **FARO 52** | 3.60$^{a}$ | 2.61$^{c}$ | 3.11$^{a}$ | 37.00$^{c}$ | 38.737$^{cde}$ | 37.56$^{cd}$ |
| **FARO 61** | 3.11$^{b}$ | 2.78$^{bc}$ | 2.90$^{bc}$ | 29.53$^{cd}$ | 24.35$^{de}$ | 24.79$^{d}$ |
| **FARO 41** | 2.98$^{c}$ | 3.22$^{a}$ | 2.88$^{bcde}$ | 44.09$^{b}$ | 44.06$^{bc}$ | 44.08$^{c}$ |
| **FARO 22** | 3.41$^{b}$ | 2.05$^{c}$ | 3.31$^{a}$ | 15.11$^{d}$ | 14.72$^{e}$ | 14.52$^{e}$ |
| **NAB 189** | 2.53$^{e}$ | 2.65$^{c}$ | 2.29$^{i}$ | 29.53$^{cd}$ | 29.02$^{cd}$ | 29.28$^{d}$ |
| **FARO 21** | 2.81$^{cd}$ | 2.66$^{c}$ | 2.73$^{bcdefg}$ | 14.60$^{d}$ | 13.78$^{e}$ | 14.18$^{e}$ |
| **FARO 63** | 2.73$^{d}$ | 1.79$^{f}$ | 2.67$^{de}$ | 35.06$^{c}$ | 38.87$^{cde}$ | 6.97e |
| **FARO 64** | 2.20$^{e}$ | 2.23$^{e}$ | 1.99$^{j}$ | 31.63$^{c}$ | 30.893$^{cde}$ | 31.26$^{cd}$ |
| **FARO 50** | 2.92$^{c}$ | 1.77$^{f}$ | 2.60$^{gh}$ | 38.26$^{c}$ | 38.16$^{cde}$ | 38.24$^{cd}$ |
| **FARO 27** | 2.18$^{f}$ | 2.77$^{bc}$ | 1.96$^{j}$ | 39.70$^{c}$ | 40.72$^{bc}$ | 40.23$^{c}$ |
| **FARO 57** | 2.98$^{c}$ | 2.87$^{b}$ | 2.87$^{bc}$ | 56.52$^{b}$ | 57.59$^{b}$ | 57.05$^{b}$ |
| **FARO 48** | 2.95$^{c}$ | 2.50$^{d}$ | 2.91$^{bc}$ | 56.40$^{b}$ | 59.27$^{b}$ | 57.84$^{b}$ |
| **FARO 47** | 3.13$^{b}$ | 2.78$^{bc}$ | 2.82$^{b}$ | 40.06$^{b}$ | 38.43$^{cde}$ | 35.84$^{c}$ |

  

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| | | | | | | |
|---|---|---|---|---|---|---|
| **FARO 59** | 2.78$^{d}$ | 2.38$^{e}$ | 2.76$^{bcdef}$ | 56.67$^{b}$ | 60.54$^{b}$ | 58.61$^{b}$ |
| **FARO 44** | 2.66$^{d}$ | 2.83$^{b}$ | 2.52$^{gh}$ | 90.84$^{a}$ | 99.41$^{a}$ | 95.12$^{a}$ |
| **FARO 58** | 3.09$^{c}$ | 2.27$^{e}$ | 2.96$^{bc}$ | 46.77$^{b}$ | 53.91$^{b}$ | 50.34$^{b}$ |
| **FARO 65** | 2.98$^{c}$ | 2.72$^{c}$ | 2.62$^{efgh}$ | 57.43$^{b}$ | 52.25$^{b}$ | 54.84$^{b}$ |
| **FARO31** | 2.43$^{e}$ | 2.70$^{c}$ | 2.57$^{gh}$ | 25.58$^{cd}$ | 25.41$^{cde}$ | 25.49$^{d}$ |
| **PAC 832** | 2.72$^{d}$ | 2.71$^{c}$ | 2.71$^{bcdef}$ | 57.94$^{b}$ | 59.25$^{b}$ | 58.59$^{b}$ |
| **FARO 45** | 2.99$^{c}$ | 2.88$^{b}$ | 2.94$^{bc}$ | 48.94$^{b}$ | 48.72$^{b}$ | 48.53$^{b}$ |

Mean values followed by the same alphabet along the column are not different from another at 5% probability level.

In Table 5, data in 2017 cropping year shows that FARO 44 had highest seed weight per plant (90.84g) while other varieties (FARO 41, FARO 57, FARO 48, FARO 47, FARO 59, FARO 58, FARO 65, FARO 45 and PAC 832) had intermediate values of between 44.09 and 57.94g but FARO 62, FARO 22, and FARO 21 recorded lowest values of between 14.60 and 16.92g.In the corresponding 2018, FARO 44 (99.41g) showed highest value, closely followed by FARO 57, FARO 48, FARO 58, FARO 59, FARO 65, FARO 45, and PAC 832 with values of between 48.72 and 60.54g while FARO 62 (17.94g), FARO 22 (14.72g) and FARO 21 (13.78g) were found with lowest values. The overall performance (varietal mean) shows that FARO 44 had highest seed weight per plant (95.12g). This was followed by FARO57, FARO 48, FARO 49, FARO 58, FARO 65, FARO 45 and PAC 832 with values of between 48.53 and 58.61 while FARO 22 (14.52g) and FARO 21 (14.18g) had lowest values.

Seed yield per ha values varied among the 22 cultivated rice varieties under each of the two cropping years (Table 6). In 2017, FARO 57, FARO 48, FARO 47, FARO 58, PAC 1061 and FARO 45 were with highest values of between 8.84 and 10.61 ton, though not statistically different from values of 8.08 cm obtained in FARO 44. The lowest seed yield per ha was obtained in FARO 62, FARO 61, FARO 22, FARO 21, and FARO 31 with values of between 2.03 to 4.58 ton. In the same vein, in 2018, PAC 832 (11.58 ton), FARO 47 (12 ton) had highest values of 11.05, 9.92, 10.75 and 9.42 ton recorded in FARO 57, FARO 44, FARO 58 and FARO 45, respectively, while FARO 62, FARO 22, FARO 21 and FARO 31 were with lowest values (2.67 – 4.67 ton). On the overall performance (varietal mean), five varieties (FARO 48, FARO 59, FARO 58 and PAC 832) were with highest values of between 10.19 and 11.09 ton which were not significant different from values of 9.13 and 9.45 ton obtained in FARO 44 and FARO 45, respectively, whereas FARO 62 (2.51 ton), FARO 22 (2.99 ton) and FARO 21 (2.88) had lowest seed yield per ha.

  

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**Table 6: Mean performance of cultivated rice varieties for seed yield per ha (ton) in two cropping year under guinea savanna environment**

| Variety | 2017 cropping year | 2018 cropping year | Varietal Mean |
|---|---|---|---|
| FARO 62 | 2.35$^{d}$ | 2.67$^{d}$ | 2.51$^{e}$ |
| FARO 60 | 5.33$^{cd}$ | 5.67$^{cd}$ | 5.50$^{cd}$ |
| FARO 52 | 7.18$^{bc}$ | 7.92$^{bc}$ | 7.55$^{bc}$ |
| FARO 61 | 4.58$^{d}$ | 4.83$^{cd}$ | 4.71$^{c}$ |
| FARO 41 | 6.78$^{bc}$ | 7.00$^{bc}$ | 6.89$^{bc}$ |
| FARO 22 | 2.98$^{d}$ | 3.00$^{d}$ | 2.99$^{e}$ |
| NAB 189 | 5.23$^{cd}$ | 5.55$^{cd}$ | 5.37$^{b}$ |
| FARO 21 | 2.03$^{d}$ | 2.83$^{d}$ | 2.88$^{e}$ |
| FARO 63 | 6.17$^{bc}$ | 7.58$^{bc}$ | 6.88$^{bc}$ |
| FARO 64 | 6.00$^{bc}$ | 6.33$^{c}$ | 6.17$^{bc}$ |
| FARO 50 | 7.21$^{bc}$ | 7.75$^{bc}$ | 7.48$^{bc}$ |
| FARO 27 | 7.85$^{bc}$ | 8.33$^{b}$ | 8.09$^{abc}$ |
| FARO 57 | 10.18$^{a}$ | 11.05$^{ab}$ | 10.63$^{a}$ |
| FARO 48 | 10.18$^{a}$ | 6.67$^{c}$ | 8.43$^{abc}$ |
| FARO 47 | 10.12$^{a}$ | 12.00$^{a}$ | 11.06$^{a}$ |
| FARO 59 | 6.28$^{bc}$ | 6.67$^{c}$ | 6.48$^{bc}$ |
| FARO 44 | 8.08$^{ab}$ | 9.92$^{ab}$ | 9.45$^{ab}$ |
| FARO 58 | 9.63$^{a}$ | 10.75$^{ab}$ | 10.19$^{a}$ |
| FARO 65 | 8.38$^{a}$ | 8.67$^{b}$ | 8.53$^{abc}$ |
| FARO31 | 4.58$^{d}$ | 4.67$^{d}$ | 4.62$^{de}$ |
| PAC 832 | 10.61$^{a}$ | 11.58$^{a}$ | 11.09$^{a}$ |
| FARO 45 | 8.84$^{a}$ | 9.42 | 9.13$^{a}$ |

Mean values followed by the same alphabet along the column are not different from another at 5% probability level.

  

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The correlation coefficients among seed yield and related components over cultivated rice varieties across two cropping years are presented in Table 7. Seedling emergence showed a negative and highly significant correlation with seed weight per plant in both season (r=-0.58 and r=-0.32**). It however showed a highly significant and positive correlation with days to 50% flowering (r=0.28**) in 2017. Also in 2017, days to 50% flowering recorded highly significant correlation with plant height (r=0.29*), seed yield per plot (r=0.29*) and seed yield per ha (r=0.30*). While plant height showed positive and highly significant correlation with number of panicles (r=0.50**) and panicle height (r=0.70**) in 2017. Also, plant height showed positive and significant correlation with number of panicle in the second season (r=0.31**). Number of panicle showed positive and significant correlation with plant height in both season. Similarly, seed yield per plot showed highly significant positive correlations with seed yield per ha (r=1.00**) in both seasons, whereas seed weight per plant was positively and significantly correlated with seed yield per plot in both seasons. Also, seed yield per ha was significantly correlated with seed weight per plant (r=0.38 and 0.76**) in 2017 and 2018, respectively.

  

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**Table 7: Correlation coefficients among seed yield and related components across cultivated rice varieties under two cropping years**

**(N=65)**

| Characters | Cropping year | Days to 50% flower | Plant height | Number of panicle | Panicle height | Seed yield per plot | Seed Yield / ha | Seed weight/ plant | 100 seed weight |
|---|---|---|---|---|---|---|---|---|---|
| Seedling emergence | 1 | 0.11 | 0.06 | 0.16 | 0.22 | 0.20 | 0.19 | -0.58** | 0.04 |
| | 2 | 0.28* | -0.07 | 0.14 | 0.18 | 0.21 | 0.21 | -0.32** | 0.01 |
| Days to 50% flower | 1 | | -0.15 | -0.18 | -0.07 | -0.09 | -0.10 | -0.12 | -0.02 |
| | 2 | | 0.29** | -0.04 | 0.04 | 0.29* | 0.30* | 0.08 | 0.06 |
| Plant height | 1 | | | 0.50** | 0.70** | 0.12 | 0.13 | -0.01 | -0.18 |
| | 2 | | | 0.31** | 0.14 | 0.09 | 0.08 | 0.17 | -0.10 |
| Number of panicle/plant | 1 | | | | 0.50** | 0.02 | 0.03 | -0.13 | -0.01 |
| | 2 | | | | 0.31** | 0.03 | 0.03 | 0.01 | -0.10 |
| Panicle height | 1 | | | | | 0.09 | 0.10 | -0.14 | -0.01 |
| | 2 | | | | | 0.04 | 0.03 | -0.02 | -0.18 |
| Seed yield per plot | 1 | | | | | | 1.00** | 0.38** | 0.12 |
| | 2 | | | | | | 1.00** | 0.77** | 0.04 |
| Seed yield/ ha | 1 | | | | | | | 0.38** | -0.12 |
| | 2 | | | | | | | 0.76** | 0.04 |
| Seed weight/plant | 1 | | | | | | | | -0.08 |
| | 2 | | | | | | | | -0.01 |

*, **correlation is significant at 0.05 and 0.01 level, respectively.

1 = 2017 cropping year

2 = 2018 cropping year

  

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Values of principal component analysis for seed yield and related components of cultivated rice varieties over two cropping years (Table 8) shows four principal components (PC1, PC2, PC3 and PC4) had eigen values greater than 1 with eigen values of 2.37, 1.79, 1.50 and 1.34, respectively and jointly accounted for 75.55% of total variation among the varieties. The first PC (PC1) accounted for 26.34% of the variability and was mostly related to seed yield per plot (0.97), seed yield per ha (0.98) and seed weight per plant (0.64). The second PC (PC2) accounted for 19.86% of the total variation and was mostly dominated by days to 50% flowering (-0.32), plant height (0.69), number of panicles (0.74) and panicle height (0.73). The third PC (PC3) was mostly dominated by seedling emergence (0.86), days to 50% flowering (0.55) and seed weight per plant (-0.60). This principal component explained an additional 16.69% of the variability. The fourth PC (PC4) accounted for an additional 12.66% of total variation and was largely dominated by plant height/plant (-0.34), number of panicles per plant (0.31) and 100 seed weight (0.92).

**Table 8: Values from principal component analysis for seed yield and yield related components across two cropping years and rice varieties under guinea savannah ecology**

| Variables | PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|---|
| Eigen value | **2.37** | **1.79** | **1.50** | **1.34** |
| % of variance | **26.34** | **19.86** | **16.69** | **12.66** |
| % cumulative variance | **26.34** | **46.19** | **62.88** | **7.54** |
| Seedling emergence | 0.11 | 0.25 | **0.86** | -0.17 |
| Days to 50% flowering | 0.10 | **-0.32** | **0.55** | -0.18 |
| Plant height | 0.20 | **0.69** | -0.24 | **-0.34** |
| Number of panicles | 0.02 | **0.74** | 0.04 | **0.31** |
| Panicle height | 0.07 | **0.73** | 0.05 | -0.12 |
| Seed yield per plot | **0.97** | -0.02 | 0.15 | 0.01 |
| Seed yield per ha | **0.98** | -0.02 | 0.16 | 0.02 |
| Seed weight per plant | **0.64** | -0.24 | **-0.60** | 0.12 |
| 100- seed weight | -0.05 | 0.05 | 0.05 | **0.92** |

Bolded: Significant contribution (0.30 and above). PC - Principal Component

  

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## DISCUSSION

The main objective of seed production programme is to produce seed of highest quality in terms of yield and yield related characters. However, in attaining this, several factors such as climatic conditions and the genetic material among others must be given due considerations. Crop genotype and cropping years were considered among factors that contribute to attainment of good seed yields in crop species and varieties (Adebisi *et al.*, 2012; Mishra *et al.*, 2016).

The present study indicated that considerable variability existed among the rice varieties studied within and between cropping years for days to 50% flowering, number of panicle per plant, seed yield per plot, seed yield per ha, 100-seed weight and seed weight per plant. Consequently, attention should be given to genetic makeup (varieties) and the production year/season. This implies that the variability is providing opportunity for selecting Nigerian cultivated rice varieties with superior seed yield attributes. Furthermore, the variability in some of the seed yield components between the two cropping years shows that the panicle length, number of panicle per plant, seed weight per plant and 100-seed weight were 7, 10, 8 and 11% higher, respectively in 2017 cropping year over 2018 cropping year data.

The weather conditions for the two growing years showed that temperature values for the two year were relatively different (average value of 35.51 for 2017 and 33.09 for 2018). The rainfall recorded during the 2017 and 2018 cropping years reveal that the total rainfall was higher in the 2017 (1205.7mm) than in 2018 (898.2mm). The relative humidity values were 30.83% for 2017 and 31.41% for the 2018 cropping year. The differences in these cropping years possibly might have caused the responses of the 22 Nigerian cultivated rice varieties in the two cropping years in relation to days to flowering, panicle length per plant, number of panicle per plant, seed weight per plant and 100 seed weight.

From the result, the relative variability in these cropping years might have, possibly, caused the different responses of the 22 rice varieties in the two years in relation to the characters evaluated except days to flowering, plant height per plant, seed yield per plot and seed yield per plant. The result implies that rice production in Nigeria should be concentrated where there is moderately and evenly distribution pattern of rainfall with favorable relative humidity. Similar observations were reported by Adebisi (2010) in seed yield of rice genotypes under derived savannah ecology.

Knowledge of the degree of associations between seed yield components provides a strategy for effective selection (Adebisi, 2004). The positive and strong association between seed yield per plot and seed yield per ha implies that the higher the seed yield per plot, the higher the seed yield per ha and these two characters are closely related with seed yield per ha in cultivated rice varieties. Also, significant and positive relationship between plant height and number of panicles or the panicle height revealed that the height of the evaluated rice plant is directly proportional to the number of panicle and

  

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height and by implication can be used as a selection criteria for high panicle characters in crop improvement.

In this research work, the principal component analysis identified first four principal axes contributing a cumulative variance of 78.35% among the entries across the two cropping years. The major seed yield components of the cultivated rice varieties that significantly contributed to major variation in the varieties were plant height, number of panicles per plant, panicle height per plant, seed yield per plot and seed yield per plant. Therefore, selection based on these yield components in Nigerian cultivated rice varieties would bring improvement in the desirable genotypes. Abdul Rafiu (2015) and Lawal (2020) have also identified different seed yield components in the different crop species as major characters contributing to variability observed in egg-plant, cayenne pepper and soybean genotypes, respectively.

The highest percentage loading recorded in the traits especially in the first principal axis indicated that selection based on them could bring about meaningful improvement in the average value of the desirable trait. The findings are in consonance with the reports of Adebisi (2004) in sesame, Okelola *et al*. (2019) in rice.

## CONCLUSIONS

- Variability observed between cropping years revealed that higher panicle length, number of panicles per plot, seed weight per plant and 100 seed weight with advantage of 7, 10, 8 and 11%, respectively occurred in the 2017 cropping year as against the corresponding 2018 cropping year.
- In terms of seed yield performance, FARO 48, FARO 59, FARO 58, PAC 832 (10.19 – 11.09 ton/ha) as well as FARO 44 and FARO 45 9.13 – 9.45 tons/ha recorded best performance while FARO 21 and FARO 22 were identified to have performed poorly in all seed yield characters evaluated.
- Plant height, number of panicles per plant, panicle height per plant, seed yield per plot and seed yield per plant were major characters that contributed significantly to major variation within the rice varieties evaluated.

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