IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 16, Issue 2 Ser. I (February. 2023), PP 20-27
www.iosrjournals.org

Multivariate Analyses of the 18 Rice Plant Variables and Hierarchical Cluster Analysis Based Rice Field Establishment in Planting Pattern Techniques and Seed Rates

Raheem R. A.[1], Chuwang P. Z.[2], Korie S.[3], Anyaegbu P. O.[4], Ojo P. O.[5], Zidafamor E. S. J.[6]

*raheemakolawole@gmail.com*Pam.chuwang@uniabuja.edu.ng*samkorie2016@gmail.com*anyaegbupoly@yahoo.com*dr.poojo@gmail.com* esjzidafamor@gmail.com*
[1,5&6](National Agricultural Seeds Council, Nigeria)
[2&4](Crop Science Department, Faculty of Agriculture, University of Abuja, Nigeria)
[3](Consultant, Biometrician, Nigeria)

Field trials were conducted during the 2019, 2020 and 2021 rainy seasons at the research field of the National Agricultural Seeds Council, Sheda, Abuja, Federal Capital Territory, Guinea savannah zone, Nigeria. A split-split plot design in three randomized blocks (replicates) was employed to study theunderlying interrelationships among the rice variables experimented, select the best linear combination of traits and determine the cluster of planting techniques with corresponding optimum seed rates for optimal yield. The four (4) varieties used (FARO 44, FARO 59, FARO 66 and FARO 67) were laid out as main plot; Planting pattern techniques at three (3) different planting patterns: dibbling, broadcasting and transplanting) as sub-plot; and seed rate at three (3) levels (25, 50 and 75kg/ha) as sub-subplot. A multi-dimensional scale analysis was explored to look at different dimensions of the result for 2019, 2020, 2021 and combined-years analysis. From the result of the Principal Component Analysis (PCA), 5 principal component (PCs) were identified and together accounted for 84% of the total variation in the data matrix of the 18 traits studied as follows: PC1 (33%), PC2 (27%), PC3 (11%), PC4 (8%) and PC5 (5%). Eigenvectors equal to or greater than |0.25| (absolute value) were considered as the logical cut-off points where each selected trait made an important contribution to the PC axes. Further result of the multivariate cluster analysis conducted to group observations into clusters or groups revealed that seed rates of 50 – 75 kg/ha had a strong degree of association with the transplant planting pattern technique from cluster 'A' while cluster 'B' group revealed a strong degree of association between dibbling and broadcast planting pattern techniques and 75 kg/ha; dibbling planting pattern technique with seed rates of 25 and 50 kg/ha; and broadcast planting pattern technique had similarity with 50 kg/ha. The findings of the Principal component Analysis (PCA) was concluded with the identification of 5 principal component (PCs) which together accounted for 84% of the total variations in the data matrix of the 18 traits studied as PC1 (33%), PC2 (27%), PC3 (11%), PC4 (8%) and PC5 (5%). The most important rice plants variates and covariates in PCA were found in the first three PC axes which accounting for a total of 71% of the multivariate variation in the data matrix. The important rice plants variates and covariates in the first three principle component were PH at maturity, PW, RL, 1000 SW, LAI, PC, PL, SY/Plant, %MC, SC, PT, NOT, HI and TWC which should be taken into consideration in the agronomic and morphological breeding studies. Also, from the cluster analysis, it is concluded that the planting pattern techniques sharing similar strong degree of association with the seed rates were the clustered resourceful planting techniques and seed rates for rice field establishment.

Date of Submission: 01-02-2023 Date of Acceptance: 11-02-2023

I. INTRODUCTION

Biologically, rice is the seed of monocot plant *Oryza sativa* of the grass family *Gramineae*. (Kuldeep, 2006). Millions of households around the globe take rice cultivation as the principal activity and source of income. Rice remains the source of foreign exchange earnings and government revenue for several countries of Africa and Asia. Rice is the second largest produced cereal in the world after wheat it cuts across regional, religious, cultural, national and international boundaries with very high demand (Rice Trade, 2011).

Rice production is geographically concentrated in Western and Eastern Asia. Asia is the largest rice producer, accounting for 90% of the world production and consumption of rice (Kadiri, 2014). Today, with the exception of Antarctica where conditions make its growth impossible, rice is grown and harvested on every continent (Rice Trade, 2011). Asian farmers (India, China, Indonesia, Vietnam, and Bangladesh) account for 92% of the world's total rice production. More than 661 million tons of rice is produced annually around the globe (United States Development Agency, 2009).

The cluster analysis is a multivariate procedure for segmentation applications in research and it is an exploratory statistical technique to group observations into clusters or groups so that the degree of association is strong between members of the same cluster and weak between members of different clusters (Han *et al*., 2000). Cluster analysis is a group of multivariate techniques whose major objective is to combine observations/object/cases into groups or clusters, such that each group or cluster formed is homogeneous or similar with respect to some certain characteristics and these groups should be different from other groups with respect to same characteristics. In cluster analysis, the researcher can classifies objects, such as respondents, products or other entities and cases or events, based on a set of selected variables or characteristics. Cluster analysis works based on certain set of variables, called "Cluster variate", which form the basis for comparing the objects in the cluster analysis. In cluster analysis, the selection of cluster variate is very important, because in cluster analysis the focus is for comparing the objects in each cluster based on variate, rather than the estimation of the variate itself. This difference makes cluster analysis different from other multivariate techniques. Therefore, the researcher's definition of the cluster variate plays a crucial role in cluster analysis (Sreejesh *et al.,* 2014).

Crop establishment is one of the key factors that affect the success of grain crops (Oghalo, 2011) and has great impact on plant density, the competitiveness of the crop stand, tillering, time to maturity and yield. Therefore, high establishment rate improves yield, crops compete better against weeds and provides uniform growth and maturity. Efficient crop establishment not only ensures improved crop performance but also reduces seeding rates needed for field planting (Harris and Vijayaragavan, 2015).

The decrease in plant density causes significant reduction in yield. Optimal plant density and proper sowing method are important agronomic factors for obtaining higher yields and have a positive influence on the yield of rice. (Baloch et al., 2002; Harris and Vijayaragavan, 2015).

The choice of planting technique may depend on the availability of man power and technology, especially, in developed countries where labour is very limited; and in other developing countries like Nigeria where the manpower is not limiting.

In Nigeria today, majority of the rice farmers sow their seeds through conventional direct seeding (broadcasting) because it is cheap and faster while few consider the method of transplanting and direct seeding (line seeding) techniques as their choice of planting.

Profitable planting techniques and seed rates for higher productivity, weed management and pests and disease control are very necessary to investigate and recommend to Nigerian rice farmers to minimize the many problems being faced during the production like high cost of quality seed, inappropriate establishment techniques, pests and disease incidence, reduction in seed quality and lodging.

Therefore, the objectives of this research were to access and determine (i) the inter-relationship of different planting pattern techniques and seed rates in rice (O*ryza sativa* L.) field establishment. (ii) the cluster of planting pattern techniques with optimum seed rates for optimal yield.

II. MATERIALS AND METHODS

Location of Study

Field experiment was conducted during the rainy season for three consecutive years from 2019 to 2021 in the Federal Capital Territory (FCT), Nigeria. The study was located at the research field of National Agricultural Seeds Council (NASC), Corporate Headquarters, Sheda, Abuja (08°53’7.56 N, 007°03' 58 E. 104; 212m above the sea level).

Materials used

Rice seed varieties (FARO 44, FARO 59, FARO 66 and FARO 67) sourced from EBSU Seeds, Ebonyi State, National Cereals Research Institute, Badeggi, Niger State and National Agricultural Seeds Council through seeds produced from its seed increase establishment, tractor, tray, NPK 15:15:15 fertilizer, Urea (46%), herbicides, tag, peg, cutlass, hoe, meter rule, net, seed laboratory equipment (drying oven, sensitive weighing balance, moisture content meter, etc.), book and pen (for data collection) were the materials used for the experiment.

Experimental treatment and experimental design

Experimental area was marked into plots in a split-split plot design in three randomized blocks (replicates). The layout is as follows: Main-plot factor (Variety): Four (4) varieties – FARO 44, FARO 59, FARO 66 and FARO 67 – Subplot factor: Planting pattern techniques. Three (3) planting pattern techniques which are practicable by the majority local farmers – direct seed dibbling, broadcasting and transplanting; and sub-subplot factor (seed rate): Three (3) levels of seed rate – 25, 50 and 75 kg/ha. Refer to Figure 1 for the experimental field layout with appropriate plot dimensions.

Each plot within main plot measuring 7.4 m x 6.4 m (47.36 m2) was separated with 1.5m distance while each sub-plot within the main plot measuring 1.8 m x 1.8 m (3.24 m2) was separated by 1m bound and sub-sub plot measuring 1.8 m x 1.8 m (3.24 m2was separated 0.5m bound. Gap of about 1.5 m separated each main-plot in the block and between each block (replicate). Therefore, the total number of sub-plots in a main plot will be three (3) with each split into three (3) sub-sub plots totaling nine (9) plots in in each of the four (4) main-plots. The total size of the field which was measured by a tape was 757.02 m2 (34.1m x 22.2m). Each experimental sub-sub plot received same fertilizer application – 100 kg N, 30 kg P2O5 and 30 kg K2O per hectare.

Data collection and measurement

The following rice growth variables, phenological, yield and yield components were collected, measured and recorded both on the experimental field and in the laboratory.

Rice growth variable

Plant height (PH)

Measurement of the distance between the upper boundary of the main photosynthetic tissues (excluding inflorescences) of a plant and the ground level was measured in centimeter. Plant height was taken at 2 weeks intervals from 4 weeks after planting (WAP) to 14 weeks after planting (WAP) until harvesting depending on the maturity period of different varieties used. This was done on randomly selected 5 plants per plot.

Leaf Area Index (LAI)

This was to track the growth and health of plants over time; it was done on randomly selected 5 plants per plot through a direct non-destructive measurements which involved taking the length and width of a leaf and then using weighted regression equations for rice species to get the leaf area. The equation used is: $A = b \times l \times w$; where l is the length, w is the width of the leaf at its widest point, b is the leaf shape coefficient that varies from species to species, and A is the leaf area. The general coefficient of 0.78 from the study carried out by Bruno et al. (2019) was very close from those found in IRRI’s Rice Experimental Station, Los Baños, for dry (0.73) and wet season (0.75) (Palaniswamy & Gomez 1974). In other words, similar leaf shape between old and modern cultivars allows to use the general coefficient (0.78) for new cultivars LAI estimation, with no need to estimate new specific coefficients for new cultivars.

Number of Tillers (NOT)
The total number of tillers produced were counted on randomly selected 5 plants per plot and recorded at dough stage to determine total tillers.
Productive tillers (PT)
The number of effective tillers produced were counted on randomly selected 5 plants per plot and recorded at dough stage to determine productive tillers.
Unproductive tillers (UPT)
The total number of tillers recorded less the number of productive tillers recorded at dough stage was calculated to determine the unproductive tillers on randomly selected 5 plants per plot.
Root length (RL)
The procedure was to trace and measure the roots on paper. This was done after harvesting and recorded in centimeter on randomly selected 3 plants per plot.
Dry weight of rice straw
The straw yields was presented on oven-dry weight basis while dry the straw samples at 80 degree Celsius for more than 48 hours (max. 72 0hours) until a constant weight was attained. This was done after harvest for 3 randomly selected plant per plot.

$$\text{Dry Matter:}\frac{\text{Dry Sample Weight}}{\text{Wet Sample Weight}}$$

Total weed count
All weed types within the quadrant of 0.1m2 in a sample plot were identified, counted and recorded. Total count (about 20 plants per quadrant) of each species were added together to give relative abundance of each specie per plot. This was estimated in percentage (%) of each weed type. Weed Count was taken and weeds were classified into broadleaved, grasses and sedges.

Rice phenological variable
Days to first heading (DTFH)
Days to first heading was counted and recorded from seed sowing date to the first day of reproductive heading as determined by visual observation on randomly selected 5 plants per plot.
Days to 50% heading (DT50%H)
Days to 50% heading was counted and recorded from seed sowing date to days of 50% reproductive heading attainment as determined by visual observation on randomly selected 5 plants per plot.
Rice yield and other yield variables
Spikelet count (SC)
Spikelet was counted and recorded after 50% heading attainment on randomly selected 5 plants per plot.
Panicle count (PC)
The number of panicle on each tiller was counted and recorded on randomly selected 5 plants per plot.
Panicle length (PL)
The length of the panicle was measured in centimeter from the node where the first panicle branch starts to the tip of the panicle of the main shoot and recorded as the average of 5 randomly selected plants per plot.
Panicle weight (PW)
The average weight of the main shoot panicle at harvest in gram was measured using a laboratory sensitive scale on 5 randomly selected plants and the average was taken for analysis.
Seed Moisture Content (MC)
Weight of water contained in rice seed expressed in percentage. MC is usually referred to the wet basis or the total weight of the grain including the water. This was determined using the moisture meter on randomly selected 3 plants per plot.
Harvest index
Harvest index is defined as the pounds of seed divided by the total pounds of above ground biomass (stover plus seed/grain). It was calculated according to the equation of Kemanian et al. (2007), done for each plot and expressed in percentage.
Seed harvest index (%) = Grain yield/Total biomass x100.
1000 seed weight
1000 seed weight helps a producer to account for seed size variations when calculating seeding rates, calibrating seed drills and estimating shattering and combine losses. The weight of counted 1000 seeds was recorded at harvest on each plot using sensitive scale.
Seed yield per plant
Seed yield per plant was weighed and recorded in grams using sensitive scale after harvest and processing on randomly selected 3 plants per plot.
Seed yield per hectare
Seed yield per hectare was done after harvest by the plot yield calculated and extrapolated into tons per hectare.

Statistical analysis
Standard procedures were adopted to record the data on various growth, yield and other covariates during the course of study. All data from the growth, phenology, yield and other covariates were subjected to analysis of variance (ANOVA) using SAS statistical software package (SAS Institute, 2012. Cary, NC). For significant main effects, means separation was performed using the Duncan Multiple Range Test (DMRT) tests at $P < 0.05$. Count data were subjected to log10(x+1) transformation before the analysis (Gomez K. A and Gomez A, 1984). Simple linear correlation was explored to examine the (pairwise) relationship between two quantitative variables, x and y. Hierarchical cluster analysis (HCA) was performed on the mean values of the treatments (or treatment combinations) to identify groups of treatments that accounted for most of the variance in the dataset and was used to rank the treatments for their performance.

III. Results

Principal Component Analysis (PCA) Biplot

Principal component analysis (PCA) biplot: plotted with treatment combination codes and variety codes.

From the result of the Principal Component Analysis (PCA), 5 principal component (PCs) were identified and together accounted for 84% of the total variation in the data matrix of the 18 traits studied (Table 1) as follows: PC1 (33%), PC2 (27%), PC3 (11%), PC4 (8%) and PC5 (5%). Eigenvectors equal to or greater than |0.25| (absolute value) were considered as the logical cut-off points where each selected trait made an important contribution to the PC axes.

Days to first heading and days to 50% heading had negative loadings on PC1, whereas plant height at maturity, panicle weight, root length and 1000 seed weight had a positive loading on the axis. PC1 axis is a contrast between some yield traits and phenological traits. The varieties with taller plant heights at maturity, higher panicle weights, longer root lengths and higher 1000 seed weights tend to flower late. Leaf area index, panicle count, panicle length, seed yield per plant, percentage seed moisture content and spikelet count had positive loading on PC2. PC2 axis is a weighted average of these traits, hence, strong positive association among these traits. Dry matter weight had negative loadings on PC3, whereas productive tillers, number of tillers, harvest index, spikelet count and total weed count had positive loadings on this axis. These traits with high positive loadings (viz: high productive tillers, greater number of tillers produced, high percentage harvest index, greater spikelet count and higher total weed count) seem to suppress dry matter weight produced. Again, PC4 axis is a weighted average of seed yield per hectare and harvest index (all with positive loadings) indicating a positive association between these two traits. A first set of traits, leaf area index and total weed count, had negative loadings on PC5 axis, while a second set of traits, panicle weight, number of tillers, seed yield per plant and seed yield per hectare, had positive loadings on this axis (PC5). Again, PC5 axis is a contrast between these two sets of traits, though with a very low eigen value (about 5%).

The first three PC axes, accounting for a total of 71% of the multivariate variation in the data matrix of the rice plants variates and covariates, were the most important. However, PC1 and PC2 scores were used for the biplots to examine the pattern of the relationships between and within the traits measured and the treatments and/or treatment combinations (Figure 1 and Figure 2).

The result of the biplot with treatment combinations and traits (Figure 3) revealed three major groups associated (or discriminated) by varieties. FARO-44 clustered in one group (Group-1), FARO-59 clustered in another group (Group-2), while FARO-66 and FARO-67 clustered in one group (Group-3). These major groupings associated with varieties were more discernible in Figure 4 (biplot with varieties and traits).

Cluster group-1 (FARO-44) is more associated with high number of Tillers as well as high number of productive Tillers. This variety is also associated with lower seed yield per plant, shorter plant height at maturity, lower panicle weight, shorter Root length, lower 1000-Seed weight, and smaller Leaf Area Index when compared to the other varieties.

Cluster group-2 (FARO-59) is more associated with higher panicle weight, longer Root length, higher 1000-Seed weight, and higher Harvest Index. This variety is also associated with lower number of days to first heading and lower days to 50% heading when compared to the other varieties.

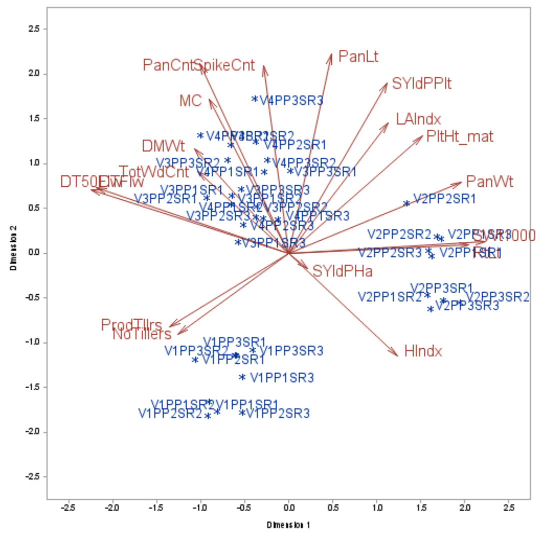
Cluster group-3 (FARO-66 and FARO-67) are more associated with higher number of days to first heading, higher number of days to 50% heading, higher panicle weight, higher panicle length, higher Spike Count and higher dry matter weight; these varieties also are associated with lower harvest Index, lower number of tillers as well as lower number of productive tillers.

Table 1:Eigenvectors of the first five principal components (PC1, PC2, PC3, PC4 and PC5) axes for eighteen (18) rice plants variables and covariates in Abuja field experiment in 2019, 2020, 2021 and their combined years. Only eigenvectors with values equal to or higher than 0.25 are shown.

Variables	PCA Component-1	PCA Component-2	PCA Component-3	PCA Component-4	PCA Component-5
Plant height at maturity	0.250	_	_	_	_
Days to first heading	-0.359	¬	_	_	_
Days to 50% heading	-0.369	_	_	_	_
Leaf area index	_	0.261	_	_	-0.323
Panicle count	_	0.380	_	_	_
Panicle length	_	0.400	_	_	_
Panicle weight	0.322	_	_	_	0.396
Root length	0.337	_	_	_	_
Productive tillers	_	_	0.468	_	_
Number of tillers	_	_	0.459	_	0.322
Seed yield / Plant	_	0.342	_	_	0.361
Seed yield /Ha	_	_	_	0.725	0.373
1000 seed weight	0.367	_	_	_	_
Dry matter weight	_	_	-0.288	_	_
% Moisture content	_	0.310	_	_	_
Harvest index	_	_	0.308	0.385	_
Spikelet count	_	0.376	0.267	_	_
Total weed count	_	_	0.314	_	-0.383
Eigenvalue	5.93	4.94	2.06	1.35	0.87
Proportion (%)	32.96	27.46	11.44	7.5	4.84

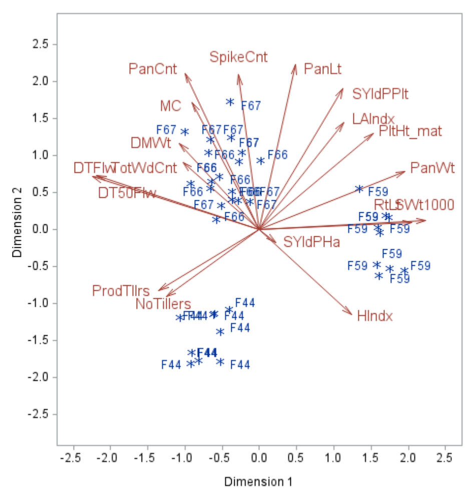
Cumulative (%)	32.96	60.42	71.86	79.35	84.19

Figure 1: Principal Component Analysis (PCA) Biplot: Plotted with Treatment combination codes



Note: SYldPPlt = Seed yield per plant; SYldPHa = Seed yield per hectare; PltHt_mat = Plant height maturity; DTFlw = Days to first flowering; DT50Flw = Days to 50% flowering; LAIndx = Leaf area index; PanWt = Panicle weight; PanCnt = Panicle count; PanLt = Panicle length; RtL = Root length; SWt1000 = 1000 seed weight; HIndx = Harvest index; NoTillers = Number of tillers; ProdTllrs = Productive tillers; SpikeCnt = Spikelet count; MC = Moisture content; DMWt = Dry matter weight; WdCnt = Weed count; F = FARO; V1 = FARO 44; V2 = FARO 59; V3 = FARO 66; V4 = FARO 67; PP1 = Dibbling planting pattern; PP2 = Broadcast planting pattern; PP3 = Transplant planting pattern; SR1 = Seed rate at 25kg/Ha; SR2 = Seed rate at 50kg/Ha and SR3 = Seed rate at 75kg/Ha.

Figure 2: Principal Component Analysis (PCA) Biplot: Plotted with variety codes



Note: SYldPPlt = Seed yield per plant; SYldPHa = Seed yield per hectare; PltHt_mat = Plant height maturity; DTFlw = Days to first flowering; DT50Flw = Days to 50% flowering; LAIndx = Leaf area index; PanWt = Panicle weight; PanCnt = Panicle count; PanLt = Panicle length; RtL = Root length; SWt1000 = 1000 seed weight; HIndx = Harvest index; NoTillers = Number of tillers; ProdTllrs = Productive tillers; SpikeCnt = Spikelet count; MC = Moisture content; DMWt = Dry matter weight; WdCnt = Weed count; F = FARO.

Cluster analysis of combined rice varieties

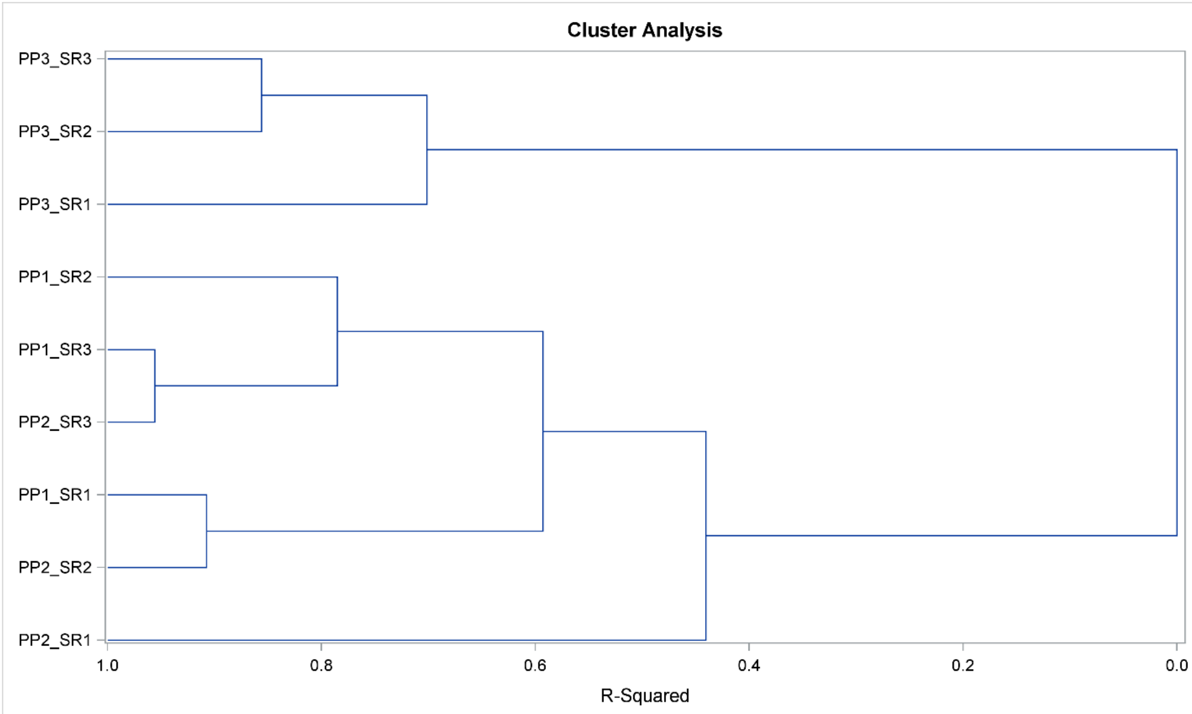
Cluster analysis all varieties (Combined)

Cluster analysis depicted the combined V1-V4 rice varieties (FARO 44, FARO 59, FARO 66 and FARO 67), different planting pattern techniques (broadcast, dibbling and transplant) and seed rates (25, 50 and 75kg/ha) in the experimental investigation carried out in Abuja for a combined period of 3 years from 2019 to 2021 (Figure 3). There were two (2) clusters (one major and one minor) – A and B with no isolated treatment combination.

Cluster "A" comprises of all rice varieties planted through transplant planting pattern techniques (PP3) with seed rates of 25, 50 and 75kg/ha (SR1, SR2 and SR3). Cluster "A" had three different seed rates (25, 50 and 75kg/ha) with seed rates of 50kg/ha and 75kg/ha (PP3SR2 and PP3SR3) had approximate similarity of 0.85 r-squared with transplant planting pattern technique and 25kg/ha seed rate (PP3SR1) had approximate similarity of 0.7 r-squared with transplant planting pattern technique.

Cluster "B" comprises of all rice varieties planted through dibbling and broadcast planting pattern techniques (PP1 and PP2) with seed rates of 25, 50 and 75kg/ha (SR1, SR2 and SR3); and had partitioned them into two distinct intra-clusters. Dibbling and broadcast planting pattern technique at 75 kg/ha (PP1SR3 and PP2SR3) had approximate similarity of 0.95 r-squared. Dibbling planting pattern technique at 50 kg/ha (PP1SR2) had approximate similarity of 0.75 r-squared. At the same time, cluster B with dibbling and broadcast planting pattern techniques (PPSR1, PP2SR2) had approximate similarity of 0.90 r-squared with 25 kg/ha and 50/ha respectively.

Figure 3: The Dendrogram showing the graphical representation of the results of hierarchical cluster analysis of all combined rice varieties



VtyClustr_1	VtyClustr_2
PP3_SR3	PP2_SR3
PP3_SR2	PP1_SR3
PP3_SR1	PP2_SR2
	PP1_SR1
	PP1_SR2
	PP2_SR1

Note: VtyClustr_1 = All Planting Pattern 3 Treatments (Transplanting);
VtyClustr_2 = All Planting Pattern 1 & 2 Treatments (Dibbling & Broadcasting)

IV. Discussion

Principal component analysis (PCA) Biplot: Plotted with treatment combination codes and variety codes.

Correlation analysis alone could not reveal a complete picture of interrelations because it considers only two traits at a time, regardless of the interrelationship with other traits in the data matrix. However, PCA considers the underlying interrelationships in the data matrix as a whole, selects the best linear combination of traits that explains the largest proportion of the variance in the dataset.

In this study, 5 principal component (PCs) were identified and together accounted for 84% of the total variation in the data matrix of the 18 traits studied as follows: PC1 (33%), PC2 (27%), PC3 (11%), PC4 (8%) and PC5 (5%). Eigenvectors equal to or greater than |0.25| (absolute value) were considered as the logical cut-off points where each selected trait made an important contribution to the PC axes. This decision was based on the knowledge of linear correlation of the 18 traits studied in this experiment. Girgel (2021) had reported that due to the PCA analysis, 6 principle component axes were obtained and these axes represented and explained all of the total variations (100% of the total variation) in an experiment involving Principle component analysis (PCA) of 20 bean genotypes (*Phaseolus vulgaris* L.) concerning agronomic, morphological and biochemical characteristics. Similar result was reported by Madakbas and Ergin (2011) that all variations were explained with the first 6 principle components in their work.

The first three PC axes, accounting for a total of 71% of the multivariate variation in the data matrix of the rice plants variates and covariates, were the most important. However, PC1 and PC2 scores were used for the biplots to examine the pattern of the relationships between and within the traits measured and the treatments and/or treatment combinations (Fig 3 and Fig 4). This is synonymous with the findings of Pragya *et al.* (2020) who reported that on the basis of PCA, most of the important yield attributing and quality traits were present in PC1 and PC2. The result of the present findings is also similar to the findings of Rana *et al.* (2014) who had revealed that fruit length, fruit breadth, average fruit weight and fruit yield per plant resulted in the highest positive values.

However, when biplots was examined with treatment combinations and traits (Figure 3), it however revealed three major groups associated (or discriminated) by varieties. FARO-44 clustered in one group (Group-1), FARO-59 clustered in another group (Group-2), while FARO-66 and FARO-67 clustered in one group (Group-3). These major groupings associated with varieties were more discernible in Fig. 2 (biplot with varieties and traits). This is in agreement with the report of Badu-Apraku *et al.* (2005) who reported grouping of 47 inbred lines evaluated under artificial *Striga* infestation at Ferkessedougou, Cote d'Ivoire. Yan and Rajcan (2002) also reported that the biplot technique enables the determination of the relationships between the variables as well as the detailed description of a multivariate data set.

Cluster analysis of major factors: Combined varieties

From the result, there was a tree-like plot where each step of hierarchical clustering was represented as a fusion of two branches of the tree into a single one (Han et al., 2000). Ward's method of clustering under hierarchical cluster analysis was used to form similarity based on different plating patterns and seed rates for different rice varieties experimented in 2019, 2020 and 2021. This coincides with work of Guptha and Tewari (2004). From the obtained dendrogram in Figure 2, 3 different planting pattern techniques (broadcast, dibbling and transplant) and 3 different seed rates (25, 50 and 75kg/ha) were investigated for grouping on the basis of their degree of association with combined varieties (V1-FARO 44, V2-FARO 59, V3-FARO 66 and V4-FARO 67)) which comprises of both upland rainfed, rainfed lowland and irrigated lowland in Abuja for a combined period of 3 years from 2019 to 2021. The study revealed that there were two clusters (one major and one minor) otherwise referred to as cluster A and cluster B with no isolated treatment combination. Cluster A comprises of all rice varieties (V1-V4) planted through transplant planting pattern techniques (PP3 - transplant) with seed rates of 25, 50 and 75 kg/ha (SR1, SR2 and SR3). Transplant planting pattern technique has a high similarity (0.85) with 50 and 75 kg/ha (PP3SR2 and PP3SR3) for the combined rice varieties and also has a low similarity (0.7) with 25 kg/ha (V1PP3SR1), indicating that transplant planting pattern technique with minimum seed rate of 25 kg/ha and maximum of 50 - 75 kg/ha can be grouped together.

Cluster B also comprises of all rice varieties planted through dibbling and broadcast planting pattern techniques (PP1 – dibbling and PP2 - broadcast) with seed rates of 25, 50 and 75 kg/ha (SR1, SR2 and SR3). Cluster B has different shades of disjointed intra-clusters groupings. Dibbling and broadcast planting pattern techniques have a high similarity (0.95) with 75 kg/ha (PP1SR3. PP2SR3) for the combined rice varieties and low similarity (0.75) with dibbling planting pattern techniques at 50 kg/ha (PP1SR2). There was also a high similarity (0.90) of dibbling and broadcast planting pattern techniques at 25 kg/ha and 50 kg/ha respectively. Okogbenin *et al.* (2013) stated that high tuber yield plants are associated with high levels of bulking ability over a long period of time, whereas plants with low tuber yield are associated with low bulking rates for a short or long period of time.

V. Conclusion

The findings of the PCA was concluded with the identification of 5 principal component (PCs) which together accounted for 84% of the total variations in the data matrix of the 18 traits studied as PC1 (33%), PC2 (27%), PC3 (11%), PC4 (8%) and PC5 (5%). However, the most important rice plants variates and covariates in PCA were found in the first three PC axes which accounting for a total of 71% of the multivariate variation in the data matrix. It is also concluded that the important rice plants variates and covariates in the first three principle component were PH at maturity, PW, RL, 1000 SW, LAI, PC, PL, SY/Plant, %MC, SC, PT, NOT, HI and TWC which should be taken into consideration in the agronomic and morphological breeding studies. This research contributed to the agronomic literature as it perceived to be one of the first applications of PCA to estimate the interrelationships among the rice varieties, planting pattern techniques and seed rates. The findings can now be used as an agronomic protocol for rice seed or paddy rice establishment by different stakeholders and also by breeders to develop high yielding rice varieties as well as new breeding protocols for rice improvement.

From the result of the multivariate cluster analysis conducted to group observations into clusters or groups. It was concluded that the seed rates of 50 – 75 kg/ha had a strong degree of association with the transplant planting pattern technique from one cluster while from another cluster group, establishment of dibbling and broadcast planting pattern techniques had a strong degree of association with 75 kg/ha; dibbling planting pattern technique with seed rates of 25 and 50 kg/ha; and broadcast planting pattern technique had similarity with 50 kg/ha. The implication was that, the planting pattern techniques identified which have strong degree of association with the seed rates similar to them were the resourceful planting techniques with their various optimum seed rates for rice field establishment.

Reference

[1]. Kuldeep, S. (2006): "A Handbook of Agriculture". Directorate of information and Publications of Agriculture, Indian Council of Agricultural Research, New Delhi, 110012, Pg 818.

[2]. Badu-Apraku B., Menkir A., Fakorede M. A. B., Fontem L. A. and Obeng-Antwi K. (2005). Multivariate analysis of the genetic diversity of fort-seven Striga resistant tropical early maturing maize inbred lines. Maydica: Vol. 51: 551-559.

[3]. Baloch M. J., Lakho A. R., Bhutto H. and Solangi M. Y (2001). Path Coefficient Analysis for Assessing Direct and Indirect Effects of Yield Components on Seed Cotton Yield in Gossypium hirsutum L.OnLine Journal of Biological Sciences 1 (5), 354-355.

[4]. Girgel U. (2021). Principle component analysis (PCA) of bean genotypes (Phaseolus vulgaris l.) concerning agronomic, morphological and biochemical characteristics. Applied ecology and environmental research. 19(3):1999-2011.

[5]. Guptha R.P. and Tewari S.K. (2004). Examined that the Factors Affecting Crop Diversification: An Empirical Analysis, Indian Journal of Agril. Economics, 45 (3), 304-307.

[6]. Han J., Kamber and M., Data Mining, (2000). Concepts and Techniques (The Morgan Kaufmann Series in Data Management Systems). Morgan Kaufmann.

[7]. Harris K. D. and VijayaragavanR. (2015). Optimum Seed Rate for Maximum yield in Rice (Oryza sativa L.). Research Journal of Agriculture and Forestry Sciences. Vol. 3(11), 1-5. ISSN 2320-6063.

[8]. Kadiri F. A. (2014). Evaluation of Paddy Rice Production in Niger Delta Region: A Strategy for Sustainable Rural Development. An unpublished Ph.D. Thesis submitted to the Post Graduate School, Federal University of Technology Owerri.

[9]. Kemanian A.R., Stockle C.O., Huggins D.R. and Viega L.M. (2007). A simple method to estimate harvest index in grain crops. Field Crop. Res., 103, 208–216. [**Google Scholar**] [**CrossRef**]

[10]. Madakbas S. Y., Ergin M. (2011): Morphological and Phenological Characterization of Turkish Bean (Phaseolus vulgaris L.) Genotypes and Their Present Variation States. – African Journal of Agricultural Research 6(28): 6155-6166.

[11]. Okogbenin, E., Setter T.L., Ferguson M., Mutegi R., Ceballos H., Olasanmi B. and Fregene M. (2013). Phenotypic approaches to drought in cassava: Review. Front Physiol., 4(93): 1–15. doi.org/10.3389/fphys.2013.00093

[12]. Oghalo S. O. (2011). Effect of population density on the performance of upland rice (Oryza Sativa) in a forestSavanna transition zone, Int. J. of Sustainable Agric., 3(2), 44-48.

[13]. Palaniswamy KM. and Gomez KA. (1974) Length-width method for estimating leaf area of rice. Agronomy Journal, 66:430-3.

[14]. Pragya S., Jain P.K. and Akanksha T. (2020). Principal Component Analysis Approach for Yield Attributing Traits in Chilli (Capsicum annum L.) Genotypes. Chemical Science Review and Letters. Vol. 9 (33), 87-91.

[15]. Rana M. M., Al Mamun M. A., Zahan A., Ahmed M. N., and Mridha M. A. J. (2014). Effect of Planting Methods on the Yield and Yield Attributes of Short Duration Aman Rice. American Journal of Plant Sciences, 5(3), 251-255. doi:10.4236/ajps.2014.53033.

[16]. Rice Trade (2011): Rice Production (http://www.ricetrade.com/articles/riceproduction.html;1-03- 11,11.00am).

[17]. SAS (2012). Statistical Analysis System (Version 8). SAS Institute Incorporated, Cary, NC, USA.

[18]. Sreejesh S., Mohapatra S., Anusree M.R. (2014). Cluster Analysis. In: Business Research Methods.Springer,Cham. https://doi.org/10.1007/978-3-319-00539-3_10
[19]. United State Development Agency (2009):http://www.Rice Trade B2B market place.com
[20]. VSN International (2019). Genstat for Windows 20th Edition. VSN International, Hemel Hempstead, UK. Web page: Genstat.co.uk.
[21]. Yan, W., Rajcan I. (2002): Biplot analysis of test sites and trait relations of soybean in Ontario.– Crop Science 42: 11-20

Raheem R. A, et. al. "Multivariate Analyses of the 18 Rice Plant Variables and Hierarchical Cluster Analysis Based Rice Field Establishment in Planting Pattern Techniques and Seed Rates." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS),* 16(2), 2023, pp. 20-27.