NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 55 Number 1, April 2024 Pg. 216-223
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

Genetic Diversity and Cluster Analysis of Selected M6 Ofada Rice Mutants and Parents For Agronomic and Yield-Related Traits

***[1]Adewusi, K. M., [2]Showemimo, F. A., [1]Nassir, A. L., [1]Olagunju, S. O., [3]Sanusi, A. S. and [1]Abifarin-Adegbenro, R. O.**

[1]Department of Crop Production, College of Agricultural Sciences, Olabisi Onabanjo University, P.M.B 2002, Ago-Iwoye, Ogun State, Nigeria
[2]Department of Plant Breeding and Seed Technology, College of Plant Science and Crop Production, Federal University of Agriculture (FUNAAB), P.M.B 2240, Abeokuta, Ogun State, Nigeria
[3]Department of Plant Science, Faculty of Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria
Corresponding auuthor's email: kayode.adewusi@oouagoiwoye.edu.ng

Abstract

Ofada rice is one of the indigenous rice extensively cultivated in South-Western Nigeria where its prominence in the last few decades is possibly due to its peculiar taste, natural flavour, higher nutritive value and higher fibre compared to polished rice. Efforts towards its improvement for yield indices have nonetheless been minimal; hence yield is the basis of this research. Twenty-five genotypes comprising twenty-three (23) promising M_6Ofada rice selections from a mutation breeding programme and 2 parent lines were planted in a randomized complete block design (RCBD) with three replications to assess genetic variation as a guide for distinctness, hybridization and further selection. Analysis of variance (ANOVA) revealed highly significant ($P < 0.01$) variation among genotypes for all the studied traits. Mean plant height ranged between 112.33cm (OG13608_300) to 133.00cm (OW13615_100). The highest mean tiller number (18.33) was from OG13605_200 while 0G13606_250 had the least mean value for days to 50% flowering (74) and days to maturity (92). The highest mean number of days to maturity (108 days) was recorded by (FUNAABOR 2 and OW13614_100. OW13620_250 had the highest grain weight per/panicle (10.87g) and the highest grain weight per plant (104.93g). The dendrogram grouped the genotypes into 3 clusters and recorded a high level of diversity. Cluster I incorporated the highest number of selections with the highest cluster mean for grain weight per panicle (9.46g) Cluster III entries had the highest mean for tiller number (13), panicle length (28.85cm) and grain weight per plant (64.84g). Therefore, hybridization of promising selections from Cluster I with appropriate members from Cluster III could offer higher heterosis among the ensuing progenies.

Keywords: FUNAABOR, mutant selections, dendrogram, hybridization and cluster analysis

Introduction

Rice production in Nigeria has increased over the years; rising from 4.82 million metric tonnes in 2013 to 8.17 million metric tonnes in the year 2020 (FAOSTAT, 2020). Despite this increase, the production level has not met the increasing demand with consequent massive importation to meet the shortfall, even with the attendant detrimental effect on the nation's economy. Rice is grown in almost all the agro-ecological zones of the country (Akande, 2003), with many varieties, some of which were introduced, while some are traditional indigenous varieties. Ofada rice, one of the popular traditional rice in South-West, Nigeria has gained more prominence in the last few decades, possibly because of its applicability, taste, and natural flavour and health benefits (Akinbode *et al*., 2011). Despite the relevance of Ofada rice in local production, efforts towards its improvement have not been commensurate with its economic potential. Even with the release of FUNAABOR 1 and FUNAABOR 2 varieties with yields of 2.2 t/ha – 2.7 t/ha and 2.1 t/ha – 2.5 t/ha respectively (Showemimo *et al*., 2011), the necessity for yield increase is still compelling.

Rice grain yield, according to Huang *et al*. (2013) is a complex trait with many contributory traits known as yield-related traits. Indirect traits like plant height, growth period, tillering ability, grain per panicle, seed seedling rate and direct traits like panicle number per plant, filled grain per panicle and 1000 grain weight play prominent roles in the magnitude of grain production by single plants. Consequently, it is difficult to increase rice yield potential by improving a single yield trait (Zeng *et al*., 2017) and as such, an increase or decrease in one component may not necessarily result in a significant overall increase in grain yield. For direct improvement of any agronomic trait, the basic requirement is the availability of of adequate genetic variability. Mutation breeding is a well-known tool to create additional desirable genetic variability and break the yield ceiling in traditional rice varieties. The use of induced mutation in crop improvement is profitable, (Jain, 2005) with hundreds of rice varieties (828) cultivars advantageously improved for characters such as high yield, a shorter duration and even shorter height (FAO/IAEA-MVD, 2019). China, Japan, India, Russia and the Netherlands are the first five ranked countries in terms of released mutant varieties (IAEA, 2015) but very little attention has been given to the use of mutation breeding in Africa particularly in Nigeria. Globally, according to IAEA, 2015, 3,222 cultivars were released between 1950 – 2011,

Nigeria has recorded only 3 released mutants between 1980 – 1988 while in recent times, according to Kharkwal and Shu (2009), Egypt, Sudan and Ghana in Africa made significant achievement in food security through mutagenesis. Giza 176 and Sakha 101 are two mutant varieties of rice (semi-dwarf) released in Egypt between 1989 – 1997, Sudan released a banana mutant cultivar (Albeely) in 2003, Ghana developed cassava with high matter content (40%) and cocoa resistant to cocoa swollen shoot virus through mutation breeding (Danso *et al*., 2008). Also, according to González *et al*., 2008, Egypt developed rice mutant varieties with increased yield from 3.8 t/ha to 8 t/ha. Hence, the continued reliance of Africa especially Nigeria on rice imports is potentially precarious and unnecessary. There is a pressing need to develop production capacity for rice in the Africa region and mutation breeding still has a space in innovative technology to break the yield ceiling in traditional rice cultivars. Therefore, the main objective of this study is to characterize and assess the extent of variability among 23 promising Ofada rice mutants derived from FUNAABOR 1 and FUNAABOR 2 Ofada rice varieties for trait improvement purposes.

Materials and Methods

The seeds of the two selected Ofada rice varieties (FUNAABOR 1 and FUNAABOR 2) developed by the Federal University of Agriculture, Abeokuta were subjected to nine doses of irradiation 0, 50, 100, 150, 200, 250, 300, 350, 400 Gy at the RTC, Kwambenya, Accra, Ghana. The seeds of all treatments were sown in a nursery to raise M_1 plants. Seedlings were transplanted to properly tilled soil at a spacing of 25cm x 25cm in 3m x 4m plots arranged following the Randomized Complete Block Design (RCBD) with three replications. Regular cultural practices on weeding, fertilizer application and insect control were similarly done for each planting. At maturity, three (3) panicles were harvested from the control (0Gy) and each M_1 treated plant population was based on high-yield traits. The M_2 plant generation was established from seeds obtained from each of the selected panicles. Data were taken on M_2 and control plants were visually adjudged to have high yield mutant traits in terms of agronomic, panicle and grain characters. Selection of desirable traits, genetic confirmation, multiplication and stabilization of field performance of mutants were carried out continuously from $M_3 – M_5$ generation. At the M_6 plant generation, comparative analyses of selected mutant lines were conducted to isolate mutants with desirable traits for high yield. All data were taken on both agronomic, panicle and grain traits according to IRRI, 2013.

Data analysis

Field and laboratory data were subjected to Analysis of Variance (ANOVA) using SAS software version 9.1 (SAS Institute, 1998) Means of the different mutants were compared with respective control using Duncan Multiple Range Test (DMRT). Cluster analysis also was used to assess the genetic diversity of the quantitative traits studied.

Results and Discussion

The analyses of variance of the parent lines and the 23 M_6 *Ofada* rice selections for agronomic and yield-related traits revealed that the mean square values due to genotypes were highly significant ($P \leq 0.001$) for all the studied traits (Table 2). Similar results were reported by previous works of Konate *et al*., (2016); Iqbal *et al*. (2018) and Hannan *et al*. (2020) for other mutant selections. The results revealed high variability among the selected mutants and parents and affirmed the potential of mutagenesis to create exploitable variation through selection and hybridization. The mean performance of the parents and selections (Table 3) show that mean values for plant height ranged from 112cm to 133cm. By implication, the height range of the selections cuts across intermediate and tall height classification as semi-dwarf (<90cm), intermediate (90-125cm) and tall (>125cm) as published by IRRI (2013). Most of the selected Ofada rice mutant selections and the two parents were grouped as intermediate with mutant OG13608_300 having the least mean height of 112.33cm. The selection (OG13608_300) was 18cm (13.8%) shorter than the parent, FUNAABOR 1 has plant height of 130.33cm. Mutant selections with reduced height have also been reported by Sao *et al*. (2022) from three traditional landraces of rice through gamma rays.

The mean number of tillers per plant from this study varied from OG13609_300 (6.67) to the highest mean of OG13605_200 (18.33) though not significantly different from, OW13615_100 (17.67). Similar varietal variation in the tiller number of selection was reported by Ramasamy *et al*. (1997). Also, the result of an evaluation of 40 rice genotypes by Shrestha *et al*. (2021) revealed variation in tiller number from 6 in NR1141-0-B-B-9 to 15 in Sunaulo sugandha. Number of tillers according to Pandey *et al*. (2009) is of great importance in determining the yield of the rice grain. It is directly related to panicle number that will be produced in a unit area of land; excess of it causes tiller abortions, small panicles, poor grain filling and ultimately reduction in grain yield.

Early maturing and high-yielding varieties are very useful for increasing rice production (Fatimah *et al.* (2014) as early maturing varieties allow farmers to increase the number of plants from two to three, and even to four per year. From this study, there was significant variation in days to 50% flowering and maturity among the selected selections and parents. Days to 50% flowering ranged between 74.33 days after sowing (DAS) to 87 DAS. OG13606_350 derived from FUNAABOR 1 recorded the least mean days to flowering (74.33 days) while mutant OW13614_100 recorded the highest mean of 87.33 days. These values were lower than the result reported by Lestari *et al.* (2011) but similar to the results of Akinwale *et al.* (2011) who reported the average days to flowering of rice lines to be 85 days. Mutants OG13606_250 and OG13611_350 with 74 and 75 days to 50% flowering recorded 92 and 93 days to maturity respectively compared to the parent, FUNAABOR 1 with 79 days to 50% flowering and 100 days to maturity. A similar reduction in maturity from mutant selections is consistent with the findings of Oladosu *et al.* (2014). Early flowering and maturity revealed short life cycle and are useful in the improvement of rice.

Productive tillers are one of the most important yield components, according to Roy *et al.* (2014). This is because the final yield is mostly determined by the number of panicles bearing the tillers per unit area. Among the selected 23 Ofada rice mutants and the 2 parents. The mean values for fertile tillers ranged between 4.33 – 16.00. OG13605_200 recorded the highest mean number of fertile tillers of 16.00, which was significantly higher relative to that of parent FUNAABOR 1 (8.67). The range was within the values reported by Hannan *et al*. (2020) and Sadmantara *et al*., (2018) from some new plant types of upland rice lines derived from cross-breeding for growth and yield characteristics.

Selected promising Ofada lines and parents from this study recorded high range of values of 22.57cm – 32.20cm. Selections OW13623_300 from FUNAABOR 2 had the highest mean panicle length of 32.20cm compared to the two parents, FUNAABOR 1 and FUNAABOR 2 with 26.37cm and 29.47 respectively. This result was within the range of 18cm – 35cm reported by Hannan *et al*. (2020) on agro-morphological traits of local rice germplasm in Bangladesh. The mean hundred-grain weight among the entries varied significantly from 2.77g for OW13623_300 to 3.57g for OG13612_350. Rice plants with long panicles have the potential for higher number of grains and yield since there is a positive correlation between the panicle length and the number of grains per panicle, according to Haryanto *et al*. (2008) and even with 100 grain weight. Selection of genotypes with long panicles is thus achievable with mutation breeding coupled with carefully planned hybridization and further selection.

Breeders are interested in the improvement of rice varieties with high-yield performance. Grain yield (g) per plant from the 23 Ofada rice mutants and parents from this study revealed a high mean value of 104.93g from mutant OW13620_250. The yield, however ranged between 29.33g for OG13609_300 from FUNAABOR 1 mutants to 104.93g of OW13620_250 from FUNAABOR 2 mutants. The selection, OW13620_250 produced 96% and 82% higher average grain yields than the parent FUNAABOR 2 and FUNAABOR 1 respectively. This may have been aided by its high tillering ability, grain weight per panicle and even reduced plant height compared to the two parents and many of the selections (Table 3). The reduced height possibly encouraged more photosynthates partitioning to reproductive rather than vegetative parts. This is consistent with the assertion of Guimaraes *et al*. (2013) and Phapumma *et al*. (2020) which emanated from over three years of study on agronomic traits and yield of 48 Thai Indigenous upland rice varieties, that high tiller number and low plant height promote high grain yields of upland rice.

The dendrogram derived from the average linkage between groups of selected Ofada rice mutant selections and parents with the cluster membership and mean for agronomic and yield-related characters are presented in Figure 1 and Table 4 respectively. Selected promising Ofada mutants and parents were clustered into three distinct groups, I to III at a distance coefficient of 7.5. Clusters I, II and III contained 10, 6 and 9 selected mutants and parents, respectively. This alludes to the presence of genetic divergence, which is crucial for discerning the genetically diverse parent for an effective hybridization programme (Thippeswamy *et al*., 2016). Cluster analysis is most important to select parents for high heterotic gain. The importance of the separation of divergent genotypes into clusters for ease of genotype selection and hybridization to expand trait variation has been reported by Fentie *et al*. (2021) and Shrestha *et al*. (2021). The cluster membership and mean from this study show that cluster I had the highest spikelet number per panicle and grain weight per panicle. Cluster II with a lower grain weight per plant, spikelet number per panicle and grain weight per panicle recorded the least days to 50% flowering and days to maturity respectively. The highest value for tillering ability and fertile (effective) tiller were recorded by the selections in cluster III. Hybridization of mutants from cluster I with selected mutants from cluster III with high tiller numbers and long panicles could be used to attain higher heterosis or vigour among the genotypes. Specific crosses involving genotypes from the two clusters could also be useful in developing a reliable selection index for important agronomic and yield-related traits in rice.

Early maturing mutant OG13606_250 could be improved by upgrading for fertile tiller and increased grain weight per plant through careful selection and hybridization.

Conclusion

The recent study reveals considerable genetic variability for the studied characters which could be used for rice improvement. The highest tiller number (18) and grain yield per plant (104.9g) were recorded from mutant OW13620_250. Mutant OG13606_250 with the least mean value for days to maturity (92) also recorded a minimum value for grain yield (30.93g) not significantly different from OG13609_300 with 29.33g for yield per plant. Also, the lowest mean value for plant height was recorded by OG13608_300 (112.33cm) followed by OG13611_350 with a mean value of 112.67cm. The dendogram from this study revealed that potential widening of trait divergence from hybridization of cluster membership with the possibility of attaining high heterosis among the genotypes.

References

Akande, T. (2003). An Overview of Nigerian Rice Economy. Monograph published by the Nigerian Institution of Social and Economic Research (NISER), Ibadan.

Akinbode, S. O., Dipeolu, A. O., and Ayinde, I. A. (2011). An examination of technical, allocative and economic efficiencies in Ofada rice farming in Ogun State, Nigeria. *African Journal of Agricultural Research*, 6(28), 6027-6035.

Akinwale, M. G., Gregorio, G., Nwilene, F., Akinyele, B. O., Ogunbayo, S. A. and Odiyi, A. C. (2011). Heritability and correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.,). *African Journal of Plant Science*, 5(3), 207-212.

Danso, K. E., Safo-Katanka, O., Adu-Ampomah, Y., Oduro, V., Amoatey, H. M., Asare, O. K. Ofori Ayeh, E., Amenorpe, G., Amiteye, S. and Lokko, Y. (2008). Application of induced mutation techniques in Ghana: Impact, challenges and the future. In: Book of Abstracts, FAO/IAEA international symposium on induced mutations in plants 12-15 Aug., 2008, Vienna, Austria, p.108.

FAO/IAEA-MVD (2019). Food and agriculture organization of the United Nations/International atomic energy agency – mutant variety database. https://mvd.iaea.org/#!Search

FAOSTAT (2020). Statistical Database. Food and Agriculture Organization of the United Nations, Rome. http://faostat.fao.org/

Fatimah, F., Prasetiyono, J., Dadang, A., and Tasliah, T. (2014). Improvement of early maturity in rice variety by marker assisted backcross breeding of Hd2 gene. *Indonesian Journal of Agricultural Science*, 15(2), 55-64.

Fentie, D. B., Abera, B. B., and Ali, H. M. (2021). Association of agronomic traits with grain yield of lowland rice (Oryza sativa L.) genotypes. *International Journal of Research in Agricultural Sciences*, 8, 161-175.

Gonzalez, M. C., Perez, N., Cristo, E., and Ramos, M. (2008). Salinity tolerant mutant obtained from protons radiations (No. IAEA-CN—167). Abstract p.56. In: Book of Abstracts, FAO/IAEA International Symposium On Induced Mutations in Plants. 12-15 Aug., 2008, Vienna, Austria.

Guimarães, C. M., Stone, L. F., Rangel, P. H., and Silva, A. C. D. L. (2013). Tolerance of upland rice genotypes to water deficit. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 17, 805-810.

Hannan, A., Islam, M., Rahman, M. S., Hoque, N., and Sagor, G. H. M. (2020). Morpho-genetic evaluation of rice genotypes (Oryza sativa L.) including some varieties and advanced lines based on yield and its attributes. *Journal of the Bangladesh Agricultural University*, 18 (4), 923-933.

Haryanto, T. A. D., and Yoshida, T. (2008). Yield stability of aromatic upland rice with high yielding ability in Indonesia. *Plant Production Science*, 11(1), 96-103.

Huang, R., Jiang, L., Zheng, J., Wang, T., Wang, H., Huang, Y., and Hong, Z. (2013). Genetic bases of rice grain shape: so many genes, so little known. *Trends in plant science*, 18(4), 218-226.

IAEA (2015). International Atomic Energy Agency, Vienna International Centre, Austria.

Iqbal, T., Hussain, I., Ahmad, N., Nauman, M., Ali, M., Saeed, S., Zia, M. and Ali, F. (2018). Regular article genetic variability, correlation and cluster analysis in elite lines of rice. Journal of Scientific Agriculture, 2, 85-91. https://doi.org/10.25081/jsa.2018v2.900

International Rice Research Institute (IRRI) (2013). Standard Evaluation System (SES) for Rice (5th ed.)

Jain, S. M. (2005). Major mutation-assisted plant breeding programs supported by FAO/IAEA. *Plant Cell, Tissue and Organ Culture*, 82, 113-123.

Kharkwal, M. C., and Shu, Q. Y. (2009). The role of induced mutations in world food security. Induced plant mutations in the genomics era. *Food and Agriculture Organization of the United Nations, Rome*, 33-38.

Konate, A. K., Zongo, A., Kam, H., Sanni, A. and Audebert A. (2016). Genetic variability and correlation analysis of rice (Oryza sativa L.) inbred lines based on agro-morphological traits. *African Journal of Agricultural Research*, 11(35), 3340-3346.

Lestari, A. P., Abdullah, B., Junaedi, A., and Aswidinnoor, H. (2011). Agronomics characteristics and its correlation of new plant type promising rice lines. *Bulletin Plasma Nutfah*, 17(2) 96 – 103.

Oladosu, Y., Rafii, M. Y., Abdullah, N., Abdul Malek, M., Rahim, H. A., Hussin, G., Abdul Latif, M. and Kareem, I. (2014). Genetic variability and selection criteria in rice mutant lines as revealed by quantitative traits. *The Scientific World Journal*, 190531, 1-12.

Pandey, P., John Anurag, P., Tiwari, D. K., Yadav, S. K. and Kumar, B. (2009). Genetic variability diversity and association of quantitative traits with grain yield in rice (*Oryza sativa L.*). *Journal of Bio-Science,* 17(1), 77-82.

Phapumma, A., Monkham, T., Chankaew, S., Kaewpradit, W., Harakotr, P., and Sanitchon, J. (2020). Characterization of indigenous upland rice varieties for high yield potential and grain quality characters under rainfed conditions in Thailand. *Annals of Agricultural Sciences*, 65(2), 179-187.

Ramasamy, S., Ten Berge, H. F. M., and Purushothaman, S. (1997). Yield formation in rice in response to drainage and nitrogen application. *Field Crops Research*, 51(1-2), 65-82.

Roy, S. K., Ali, M. Y., Jahan, M. S., Saha, U. K., Ahmad-Hamdani, M. S., Hasan, M. M., and Alam, M. A. (2014). Evaluation of growth and yield attributing characteristics of indigenous Boro rice varieties. *Life Science Journal*, 11(4), 122-126.

Sadimantara, G. R., Nuraida, W., and Suliartini, N. W. S. (2018). Evaluation of some new plant type of upland rice (Oryza sativa L.) lines derived from cross breeding for the growth and yield characteristics. In IOP Conference Series: Earth and Environmental Science (Vol. 157, No. 1, p. 012048). IOP Publishing.

Sao, R., Sahu, P. K., Patel, R. S., Das, B. K., Jankuloski, L., and Sharma, D. (2022). Genetic improvement in plant architecture, maturity duration and agronomic traits of three traditional rice landraces through gamma ray-based induced mutagenesis. *Plants*, 11(24), 3448. https://doi.org/10.3390/plants//243448

Shrestha, J., Subedi, S., Kushwaha, U. K. S., & Maharjan, B. (2021). Evaluation of growth and yield traits in rice genotypes using multivariate analysis. *Heliyon*, 7(9).

Showemimo, F, A., Gregorio, G., Olowe, V. I. O., Aukwungwu, M. N., Amaji, A. T., Adigbo, S. O., Olaoye, O. J., Akintokun, P. O., Bodunde, J. G., Idowu, O. T. H. and Awe, C. A. (2011). Varietal Release: Release of two dual purpose "Ofada" rice varieties (FUNAABOR- 1 And FUNAABOR-2) by Federal University of Agriculture, Abeokuta (FUNAAB). *Journal of Agricultural Science and Environment,* 11(2), 122-123.

Thippeswamy S., Chandramohan Y., Srinivas, R. and Padmaja D. (2016). Selection of Diverse Parallel lines for Hetevotic Hybrid Development in Rice. *SABRAO Journal of Breeding and Genetics*, 48(3), 285-294.

Zeng, D., Tian, Z., Rao, Y., Dong G, Yang Y, Huang L, Leng Y, Xu J, Sun C, Zhang G, Hu J, Zhu L, Gao Z, Hu X, Guo L, Xiong G, Wang Y, Li J, Qian Q (2017). Rational design of high-yield and superior-quality rice. *Nature Plants* 3, 17031.

Table 1: Selected mutant lines and parents at M_6 plant generation for yield and yield traits

Line number	Name of selected mutants	State
1	FUNAABOR 1	Released variety
2	OG13602_100	Mutant line
3	OG13603_100	Mutant line
4	OG13604_150	Mutant line
5	OG13605_200	Mutant line
6	OG13606_250	Mutant line
7	OG13607_250	Mutant line
8	OG13608_300	Mutant line
9	OG13609_300	Mutant line
10	OG13610_300	Mutant line
11	OG13611_350	Mutant line
12	OG13612_350	Mutant line
13	FUNAABOR 2	Released variety
14	OW13614_100	Mutant line
15	OW13615_100	Mutant line
16	OW13616_150	Mutant line
17	OW13617_200	Mutant line
18	OW13618_250	Mutant line
19	OW13619_250	Mutant line
20	OW13620_250	Mutant line
21	OW13621_300	Mutant line
22	OW13622_300	Mutant line
23	OW13623_300	Mutant line
24	OW13624_300	Mutant line
25	OW13625_350	Mutant line

Table 2: Mean squares for panicle characters of M$_6$ selected promising mutants

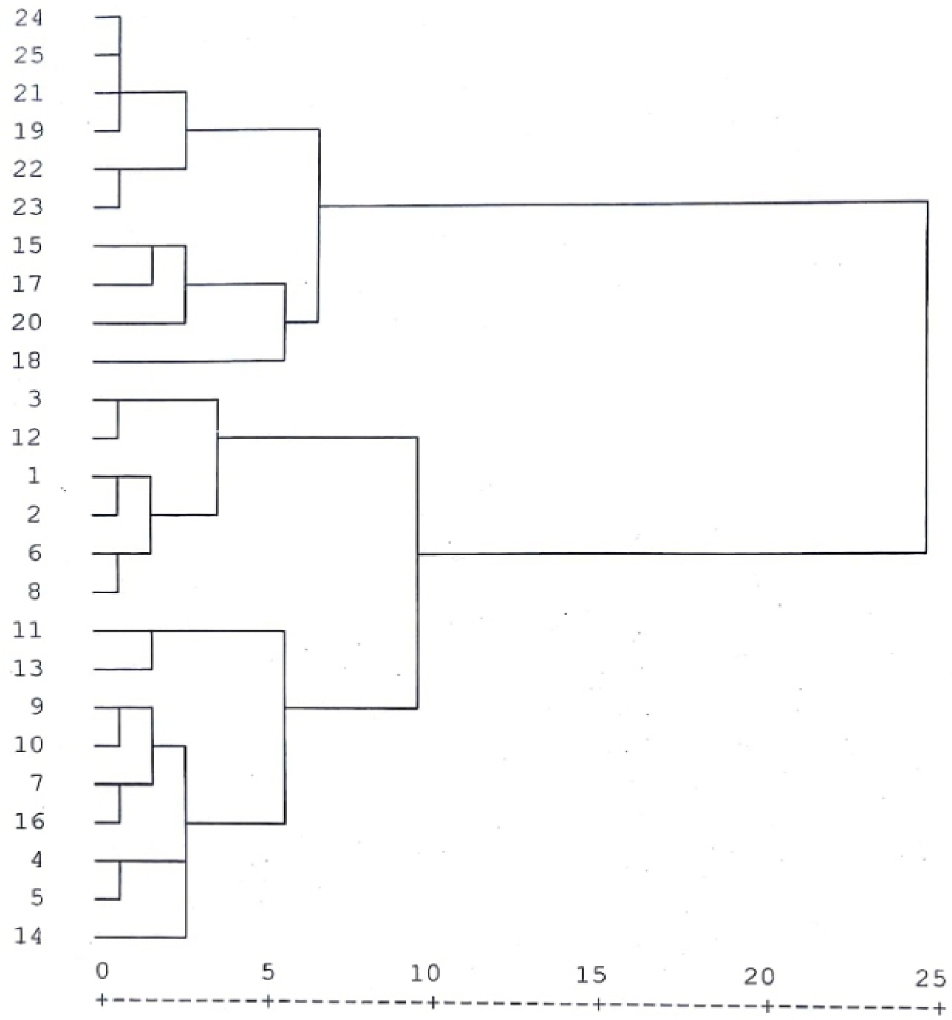
Source of variation	Tiller number	Plant height (cm)	Days to 50% flowering	Maturity	Fertile tiller (%)	Panicle Length (cm)	Hundred Grain weight (g)	Grain weight per panicle (g)	Spikelet number Per panicle	Grain weight per plant (g)
Replicate	3.29	16.05	0.37	1.24	1.21	0.17	0.01	0.61	660.57	249.95
Line	34.64**	114.55**	52.67**	75.58**	28.63**	13.27**	0.16**	11.65**	13137.48**	1661.87**
Error	4.18	26.44	0.47	0.59	2.32	0.99	0.06	0.53	406.24	112.12

**Mean square value significant at 1% probability level

Table 3: Mean values for selected Ofada rice mutants and parents at M$_6$ plant generation

Line	Tiller number	Plant height (cm)	Days to 50% flowering	Maturity	Fertile tiller (counted)	Panicle Length (cm)	Hundred Grain weight(g)	Grain weight per panicle (g)	Spikelet number per panicle	Grain weight per plant (g)
FUNAABOR 1	9.67^{d-g}	130.33^{ab}	79.33^{h}	99.67^{fg}	8.67^{d}	26.37^{h-j}	2.93^{kl}	5.73^{gh}	189.33^{klm}	57.56^{d-g}
OG13602_100	8.33^{efg}	127.33^{abc}	75.33^{klm}	93.67^{i}	6.33^{hij}	27.30^{e-h}	3.33^{de}	4.93^{h}	179.00^{lm}	31.60^{i}
OG13603_100	7.67^{efg}	126.67^{abc}	79.67^{h}	96.67^{g}	6.00^{hij}	25.43^{ij}	3.37^{cde}	6.00^{gh}	201.33^{jkl}	52.77^{e-h}
OG13604_150	15.00^{ab}	118.33^{c-g}	80.00^{h}	96.67^{g}	11.00^{cd}	30.63^{ab}	3.50^{abc}	5.57^{gh}	259.67^{fg}	59.30^{def}
OG13605_200	18.33^{a}	114.67^{efg}	80.00^{h}	100.67^{f}	16.00^{a}	27.37^{e-h}	3.27^{d-g}	4.93^{h}	254.67^{fgh}	76.10^{bcd}
OG13606_250	9.00^{efg}	127.67^{abc}	74.33^{m}	92.33^{j}	6.66^{hij}	28.20^{d-h}	3.17^{f-i}	4.83^{h}	156.33^{m}	30.93^{i}
OG13607_250	10.33^{c-g}	119.33^{c-g}	85.00^{de}	105.33^{bc}	7.67^{f-i}	26.73^{g-j}	3.53^{ab}	7.80^{ef}	257.00^{fgh}	50.57^{e-i}
OG13608_300	8.00^{efg}	112.33^{g}	78.00^{i}	94.00^{i}	6.00^{hij}	26.73^{g-j}	3.40^{bcd}	5.10^{h}	158.67^{m}	31.30^{i}
OG13609_300	6.67^{fg}	118.00^{c-g}	76.33^{jk}	96.67^{h}	5.33^{ij}	29.67^{bcd}	3.40^{bcd}	8.07^{ef}	236.00^{g-j}	29.33^{i}
OG13610_300	11.00^{cde}	123.33^{a-e}	76.33^{jk}	96.33^{h}	8.67^{d-h}	28.27^{d-h}	3.23^{e-h}	8.00^{ef}	247.00^{f-i}	67.63^{cde}
OG13611_350	13.67^{bc}	112.67^{fg}	75.00^{lm}	93.00^{ij}	10.33^{c-e}	29.07^{b-e}	3.23^{e-h}	5.27^{h}	200.33^{jkl}	75.90^{bcd}
OG13612_350	9.00^{efg}	115.00^{efg}	75.67^{jkl}	96.33^{h}	7.00^{g-j}	28.47^{c-g}	3.57^{a}	5.83^{gh}	217.00^{ijk}	40.73^{f-i}
FUNAABOR 2	8.33^{efg}	119.33^{c-g}	87.33^{a}	107.67^{a}	6.00^{hij}	29.47^{b-d}	2.93^{kl}	6.87^{fg}	221.67^{h-k}	53.63^{e-h}
OW13614_100	11.00^{cde}	133.00^{a}	87.00^{ab}	107.67^{a}	10.00^{c-f}	28.27^{d-h}	3.10^{hij}	8.27^{de}	276.67^{ef}	79.50^{bc}
OW13615_100	17.67^{a}	133.00^{a}	86.33^{abc}	106.67^{ab}	14.00^{ab}	25.20^{j}	2.93^{kl}	9.77^{abc}	350.00^{ab}	96.77^{ab}
OW13616_150	10..67^{c-f}	129.67^{ab}	85.67^{cd}	106.67^{ab}	9.67^{c-g}	29.00^{b-f}	3.30^{def}	7.57^{ef}	254.33^{fgh}	93.^{27abi}
OW13617_200	13.33^{bcd}	125.67^{a-d}	86.00^{bcd}	106.67^{ab}	11.67^{bc}	25.43^{ij}	3.07^{ijk}	8.00^{ef}	325.00^{bcd}	93.27^{ab}
OW13618_250	10.67^{c-f}	118.00^{c-g}	83.67^{fg}	104.67^{cd}	8.67^{d-h}	24.83^{j}	2.83^{lm}	10.40^{ab}	382.67^{a}	84.50^{bc}
OW13619_250	7.00^{efg}	122.67^{b-f}	84.00^{ef}	104.67^{cd}	5.00^{ij}	30.27^{bc}	3.13^{ghi}	10.80^{a}	362.00^{ab}	35.77^{hi}
OW13620_250	16.67^{b}	118.67^{c-g}	76.67^{h}	99.67^{fg}	10.33^{c-e}	28.60^{c-g}	2.97^{jkl}	10.87^{a}	312.33^{bc}	104.93^{a}
OW13621_300	6.33^{g}	119.33^{c-g}	79.33^{h}	100.00^{fg}	4.33^{j}	22.57^{k}	2.87^{lm}	8.90^{cde}	339.33^{bc}	38.17^{ghi}
OW13622_300	7.00^{efg}	115.00^{efg}	76.67^{j}	96.33^{h}	4.67^{j}	26.60^{g-j}	3.37^{cde}	8.43^{de}	307.00^{cde}	38.93^{ghi}
OW13623_300	6.33^{g}	119.00^{c-g}	82.67^{g}	102.67^{e}	5.00^{ij}	32.20^{a}	2.77^{m}	8.03^{ef}	296.00^{de}	36.57^{hi}
OW13624_300	7.67^{efg}	121.33^{b-g}	83.67^{fg}	103.67^{de}	4.33^{j}	26.37^{h-j}	2.90^{lm}	9.47^{bcd}	340.00^{bc}	45.77^{f-i}
OW13625_350	7.33^{efg}	116.00^{d-g}	83.33^{fg}	103.67^{de}	5.33^{ij}	27.13^{f-i}	3.13^{ghi}	9.90^{abc}	332.00^{bcd}	48.97^{e-i}

Mean with the same alphabets in the same column are not significantly different at $P \leq 0.05$ using Duncan Multiple Range Test (D MRT)



Intercluster distance

Fig. 1:Dendogram of the 25 M_6 selections using Average Linkage

Table 4: Cluster membership and mean for vegetative and reproductive traits

Trait	Clusters and membership Cluster I	Cluster II	Cluster III
	5,7,8,9,10	1	2,3,4,6
Tillering	8.433	8.111667	**12.58375**
Plant height	120.867	123.2217	121.2088
Days to flowering	82.534	**77.055**	**83**
Days to maturity	102.869	**95.61167**	103.0438
Fertile tiller	7	6.221667	**9.79125**
Panicle length	26.91	27.08333	**28.85125**
Hundred Grain weight(g)	2.997	**3.295**	3.24875
Grain weight per panicle(g)	**9.457**	5.403333	7.135
Spikelet number per panicle	**334.833**	183.61	260.7925
Grain weight per plant(g)	63.801	**36.21**	**64.835**