PHENOTYPIC AND GENOTYPIC VARIABILITY STUDIES ON SOME RICE GENOTYPES IN LOW LAND ECOLOGY OF NIGERSTATE, NIGERIA

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MTech/SAAT/2016/6658

DEPARTMENT OF CROP PRODUCTION

FEDERAL UNIVERSITY OF TECHNOLOGY

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ABSTRACT

Variability has been known as a tool for any crop improvement programme. Yield improvement can be ascertained if there is enough variability existing in a population. Therefore, this study was conducted to asses morpho-agronomic variations in the lowland rice genotypes in an Alpha lattice design with three replications. The experiment was conducted at National Cereals Research Institute Badeggi and Edozhigi in 2017. Parameters such as Days to 50 % flowering, tiller number, panicle number, panicle length, panicle exertion, plant height, panicle weight and grain yield were collected. The result showed that there exists significant variability amongst the genotypes in all the parameters studied, except panicle weight. In all the yield components studied, the phenotypic coefficient was higher than the genotypic coefficient of variation. Days to 50 % flowering had high heritability (83.63). Association study revealed that positive correlation existed among some of the yield components and some of them were significant such as association between panicle number with panicle length (0.295*). Plant height (0.1506) had the highest direct contribution to the yield and the residual effect for the path analysis was a positive value (0.0291). Principal component analysis partitioned the variability into eight principal components, days to 50 % flowering (0.61) contributed highest variability in the first principal component. Five major cluster groups were identified at cophenetic percentage of 0.578. This investigation therefore, recommends that FARO 15, FARO 17, FARO 24 and Waluye which out yielded the standard checks can be used for further rice improvement programmes.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Rice, *Oryza sativa* (2n = 24) belongs to the family *poceae* and sub family *Oryzoidae* and is consumed by more than fifty percent of the world's population especially in developing countries. The third highest cereal produced is rice after wheat and maize (FAO, 2012). India has the largest area under rice cultivation in the world and ranks second in production (Anonymous, 2013). Rice is one of the significant cereal commodities for the world's population. (Lopez and Joseph, 2008).

It has shaped the culture, diets and economy of thousand of millions of peoples. For more than half of the humanity "rice is life". Considering its important position, the United Nation designated year 2004 as the "International Year of rice. More than 430 million metric tonnes of rice consumed worldwide (USDA, 2008). Rice is a nutritional staple food providing 20 % of the calories and 15 % of proteins consumed by the world's population (Muhammad *et al*., 2015). On the other hand, rice is poor in nitrogenous substances with their average composition being only in trace amounts. The fat content or lipids are only negligible and due to this reason it is considered as a complete food for eating.

Local rice production in Nigeria has now reached 15 million metric tones annually (Ahmad, 2017). West Africa remains the hub of rice production in sub-Saharan Africa but the shortfall in rice production has increased significantly as consumption rises at a rate well above that of production growth. In 2006, paddy rice production in sub-Saharan

Africa was estimated at 14.2million tonnes. Rice production in sub-Saharan Africa grew at 3.23% per annum from 1961 to 2005. This growth rate was higher than the yearly population growth rate of 2.90% during the same period (ARC, 2007).

Rice straw is used as cattle feed, it also used for thatching roof and in cottage industry for preparation of hats, mats, ropes, straw board and litter material. Rice husk is used as animal feed, paper making and as fuel source. Rice flour is rich in starch and is used for making various food materials. It is also used by brewers to make alcoholic malt. Likewise, rice straw mixed with other materials is used to produce porcelain, glass and pottery. Rice straw is also used in manufacturing of paper pulp and livestock bedding. The rice bran is also an important source of animal feed in many countries of the world (Muhammad *et al*., 2015). In husked rice, protein content ranges between 7 and 12 %. The use of nitrogen fertilizers increases the percentage content of some amino acids in rice.

Globally, improving quantity and quality of rice grain has been approached to solve several problems among the world population such as decreasing the number of hidden hunger and malnutrition (Burchi *et al*., 2011). However, a wide variation of grain morphological characteristics will be required as source of genetic materials in breeding for some specific traits as it would have effect on consumer's acceptance in the end. According to Couch and Hittalmani (2018) The yields of rice are complex quantitative traits that involve multiple quantitative trait loci (QTLs), so it is not simple to improve them. Also, the crop environment varies depending on the season, year, location, and a specific area within the field. These variations lead to large fluctuations in crop yield. Therefore, breeders need to assess yield stability of crops in different environments to develop and launch a new variety. Recent advances in rice genomics have improved the understanding of individual QTL functions, thereby unraveling genotype-phenotype relationships and facilitating grain yield improvement (Ikeda *et al*., 2013).

1.2 Statement of the Research Problem

The populations in the major rice-consuming countries continue to grow at a rate of more than 1.5 % per year. According to various estimates, world rice production must increase at the rate of 2 million tonnes per year. To meet this challenge, rice varieties with higher yield potential and greater yield stability are needed.

Inadequate information generated from phenotyping these germplasms that can be used as basis to augment diversity in the genebank collections as well as baseline information for utilization in rice breeding programs. One of the most difficult tasks in carrying out a successful breeding programme is the choice of germplasm. In order to develop a variety with a set of desirable characteristics, rice breeders need to be sure that the source of germplasm has desirable genetic variability and to make the right choice of parental material to be used in a breeding programme breeders must clearly know the type of product to be developed.

1.3 Justification of the Study

Rice genotypes with wide genetic variability are essential to generate viable progenies. The major resource of plant breeders is the genetic variability in gene pool that is accessible to the crop of interest (Thottappily *et al*., 2016). Success of rice improvement programmes depends on the amount of genetic variability and the degree to which the desirable traits are heritable (Ravi *et al*., 2003). Hence assessment of genetic variability among genotypes becomes important in establishing relationships among different cultivars for the initiation of appropriate breeding procedures in crop improvement programmes. Hence, it becomes necessary to split over-all variability into its heritable and non heritable components with the help of certain genetic parameters, which may enable the breeders to plan a proper breeding programme. Therefore, the progress of a population mainly depends upon the amount and magnitude of genotypic variability present in the population. Information on genetic variability among growth as well as yield components in rice has been reported by many workers (Sivasubramanian and Madhava, 2010; Latif and Zamin 2010). The characterization of these genetic resources is a necessity not only for posterity, but also for utilization in different improvement programs such as breeding for improved yield and tolerance to various stresses. The study of morpho-agronomic traits is the conventional way of evaluating genetic variability in crops (Bui and Nguyen, 2015).

1.4 Aim and Objectives of the Study

Aim

The aim of this study was to determine the extent of phenotypic and genotypic variability among the rice genotypes.

Objectives

The objectives of this study were to:

i. Determine extent of variability in some lowland rice genotypes.

ii. Evaluate for growth, yield an yield components in lowland rice genotypes.

iii. Determine direct and indirect contribution of each component to yield in lowland genotypes.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Rice

Evidence of the presence of rice in food of the early man has been found around 5000 BC in China and India from archeological excavations (Sharma *et al*., 2012). Chang (2012) presented evidence for early rice cultivation in the Indian Himalayas 2450-3950 BP and in China 5230 BP, proposing multiple, independent, concurrent domestication events across the region stretching from the foothills of the Indian Himalayas to southwestern and southern China. All forms of Asian rice both indicas and japonicas were obtained from a single domestication that occurred between 8200-13500 years ago in China, of the wild rice *Oryza rufipogon* (Molina *et al*., 2011). Domesticated rice spread throughout Asia, the Mediterranean (2,300 BP), Madagascar (1,500 BP), Southern Europe (500 - 600 BP) and more recently as a result of European colonization, to Africa, North and South America respectively (300-500 BP) (Oka, 2012).

The first rice crop was seen in China (Emu Du region) around 5000 BC and in Thailand around 4500 BC. They were later seen in Cambodia, Southern India and Vietnam. Later derived species indica and japonica expanded to other Asian countries such as Indonesia, Myanmar, Pakistan, Philippines, Sri Lanka, Korea and Japan (Molina *et al*., 2011). The Asian rice (*Oryza sativa*) became adapted to farming in the Middle East and Mediterranean Europe around 800 BC. The Moros brought rice to the Spanish European country when they conquered the country around 700 AD (Huang *et al*., 2012). After the mid-15th century, rice cultivation spread throughout Italy and then France, later to other parts of the continents during the great age of the European exploration. The Spanish people took this crop to South America at the beginning of the 18th century (UNCTAD, 2015). Introduction of *O. sativa* to Africa also brought it in contact with the more recently domesticated (3,500 BP), closely related West African domesticated species *O. glaberrima* (Chang, 1976). Rice (*Oryza glaberrima* Steud) is indigenous to Nigeria and has been cultivated for the past 3,500 years (Hardcastle, 2012). The earliest cultivation of improved rice varieties (*O. sativa* L.) started in about 1890 with the introduction of upland varieties to the high forest zone in Western Nigeria (Hardcastle, 2012; Atanda *et al.,* 2012).

Consequently, by 1960 *O. sativa* had taken over from *O. glaberrima*, which is now limited to some deep-flooded plains of the Sokoto-Rima river basin and other isolated pockets of deep swamps all over the country (Atanda *et al.*, 2012, Imolehin, 2012).

2.2 The History of Rice in West Africa

Rice belongs to the poaceae family, the *Oryza* genus (Megan and Mc Couch, 2014). It has been cultivated in West Africa for at least 2000 years. It was cultivated in the Fezzan or modern-day Libya by the Garamantes. There are about 20 different species, of which the cultivated varieties are *Oryza sativa* and *Oryza glaberrima* (Vaughan and Morishima, 2012). African rice (*Oryza glaberrima*) is a distinct species from Asian rice (*Oryza sativa*), which is one of the two domesticated rice species (Linares, 2016). It was first domesticated and grown in West_Africa (Wang *et al*., 2014), and brought to the Americas by enslaved West African rice farmers (Judith, 2004). It is now largely a subsistence crop, rarely sold in markets even in West Africa (Ikhioya, 2013). It has been partly replaced by higher-yielding Asian_rice (Wang *et al*., 2014), and the number of varieties grown is declining, making up an estimated 20 % of rice grown in West Africa (Linares, 2016). In comparison to Asian rice, *O. glaberima* is hardy, pest-resistant, low-labour, suited to a variety of African conditions (Linares, 2016).

African rice was domesticated from wild African rice, *Oryza barthii*, while Asian rice (*Oryza sativa*), was domesticated from wild Asian rice, *Oryza rufipogon*. *Oryza barthii* still grows wild in Africa, in a wide variety of open habitats. The Sahara was formerly_wetter, with massive paleolakes in what is now the Western Sahara. As the paleolasces dried, the wild rice retreated and probably became increasingly domesticated as it relied on humans for irrigation. Thus, the rice growing in deeper, more permanent water became floating_rice.

Asian rice came to West Africa in the late 1800s, and by the late twentieth century had substantially replaced native African rice. However, African rice was still used in specific, often marginal habitats, and preferred for its taste (Ologbon, 2012). Farmers may grow African rice to eat and Asian rice to sell, as African rice is not exported. Rice-growing regions of Africa are generally net rice importers partly due to a lack of good local rice-processing capacity so price increases (Taimiyu, 2010). Among the efforts to increase yield was the adoption of NERICA cultivars, crossbred to specifications from local farmers using African rice varieties provided by local farmers (Linares, 2016). These were bred during the 1990s and released in the early 21st century (Sarla, 2014). Results so far have been mixed; the NERICA varieties are less hardy and more labour-intensive, and effects on real-world yields vary. Subsidies of nerica seeds have also been criticized for encouraging the loss of native varieties and reducing the independence of farmers.

2.3 Rice Improvement in Nigeria

The activities of rice breeding task forces in Nigeria involve research into upland, rain fed lowland and irrigated low land. Through the task forces, lines bred for different ecological problems are composed into nurseries of nominations from Africa Rice and National Programmes. The National Agricultural Research System (NARs) that share similar production constraints in a given ecology evaluate these nurseries and the results from these evaluations are discussed at Africa Rice Centre headquarters at the end of each cropping season after which some varieties from these nurseries are then identified for national use. AfricaRice at full incorporation into the Consultative Group on International Agricultural research system (CGIAR) established a lowland breeding station at the International Institute of Tropical Agriculture (IITA), The national program benefited agricultural research scientists in Nigeria because scientists could enjoy closer collaborations with their African Rice counterpart at the station. (Emodi and Madukwe, 2008).

2.4 Climatic Requirement of Rice

Rice can be grown in different environments depending upon water availability and temperature conditions (IRRI, 2013). Cold stress is a common problem in rice cultivation and affects global production as a crucial factor (Hu *et al*., 2012). Rice is a cold-sensitive plant that originated from tropical or subtropical zones. When low temperature occurs during the reproductive stages, it can cause serious yield and yield components losses

(Lewin *et al*., 2006). The optimum temperature for rice cultivation is between 25°C and 35°C, and in temperate regions, rice growth is impressed by limited period that favors its growth (Garath *et al*., 2003).

Exposure to cold temperature affects all phonological stages of rice and lower grain production and yield, too. Low temperature in vegetative stage can cause slow growth and reduce seedling vigor (Matthews *et al*., 2006). low number of seedlings, reduce tillering (Iwama *et al*., 2002) increase plant mortality (Sato *et al*., 2004) increase the growth period (Alvarado and Hernaiz (2007) and in reproductive stage, it can cause to produc panicle sterility and lower grain production and yield . Critical stages for cold damage include germination, booting, flowering, and filling stages (Satake, 1976).

2.5 Morpho-agronomic characteristics of rice

2.5.1 Panicle number and length panicle is borne on the uppermost internode of the culm which is often mis-termed a peduncle. The architectural design of the panicle covers several aspects such as spikelet density, panicle length and panicle curvature (Sharief *et al*., 2015). The number of panicle with filled grains generally determines the ultimate yield of the crop. This gives an indication that accessions with long panicles will accommodate more grain than short panicles accessions. Efisue *et al*. (2014) reported that accessions with long panicles possess high yielding ability. Kumar *et al*. (2015) by studying traits in rice varieties reported that there are positive and significant correlations between panicle length and grain yield.

2.5.2 Tillers

A rice plants generally consists of main shoot and tillers which initiate at different times and differ in growth and development patterns depending on the time of their initiation and genotype (Krishna and Nidhi, 2014). Tiller number plays a significant role in influencing rice grain yield since it is closely related to number of panicles per unit ground area. Rahman *et al*. (2011) reported that tillers contribute a great portion of grain yield and the extent of contribution varies among genotype and planting density.

Tillering in rice is one of the most important agronomic traits for grain production because tiller number per plant determines panicle number, a key component of grain yield (Liu *et al*., 2011; Zhu *et al*., 2011). Furthermore, tiller number usually serves as a suitable model trait for the study of developmental characteristics, since it changes over time. Hence, the genetic elucidation of tiller number has become a focus in rice genetic and breeding research (Liu *et al*., 2010). Therefore grain yield and its contributing traits vary greatly with tiller type and early initiated tillers produce more grains than late initiated tillers (Peltonen and Jarvinen, 2015). According to Senapati *et al*. (2015) high tillering capacity is regarded as an important trait in rice production since the number of tillers per plant is closely correlated to number of panicles per plant. Wu *et al.* (2015) stated that yield potential of a rice genotype may be considered by its tillering capacity. Therefore variation in grain development and yield between tillers is unpredictable over the genotypes differing in tillering ability. Variation in grain yield among tillers has been regarded the most important factor affecting yield potential for a given rice variety. Lafarge *et al*. (2015) reported that grain quality could be also affected by tillering ability due to different grain development characteristics.

2.5.3 Panicle weight The mass of grains of individual plants directly determines the yield of a population, (Verica *et al*., 2013). As a final product of the interaction between a lot of physiological and biochemical processes in the plants, the mass of grains from plant depends on several properties, such as the number of panicles per plant, number of grains per panicle and weight of grain, (Verica *et al*., 2013). Changing any of these properties result in change of the grain yield per plant. The link of this property with other components of yield indirectly contributes to its high variability, (Verica *et al*., 2013).

2.5.4 Days to 50 % flowering Transition of apical bud in-to floral bud demarcates the initiation of reproductive stage of rice in its growth cycle. Number of days taken for this transition determines the heading date or days to flowering of any rice cultivar (Yano *et al*., 2001).

2.5.5 Plant height

Plant height is not only a decisive factor in plant architecture, but also an important agronomic trait that is directly linked to the harvest index and yield potential (Yang and Hwa, 2008). Therefore, morphological characteristics such as plant height have been considered important traits in breeding both super rice and bio-energy crops.

2.6 Rice Cultivation

Rice grows in all the agro ecological zones as diverse as the Sahel of Borno State and the coastal swamps of the southwest and south-south (Longtau, 2003). According to Longtau (2003), six rice growing environments have been identified, they are upland, hydromorphic, rain fed lowland, irrigated lowland, deep inland water and mangrove swamp. According to Damola

(2010), rice growing environment in Nigeria are usually classified into five rice ecosystems: rain-fed lowland which accounts for 47 % of total rice production area, rain-fed upland (30 %), irrigated lowland including large-scale irrigation schemes and small-scale irrigation schemes which account for 16 % of total rice area, deep water (5 %) and mangrove swamp accounting for less than 1% of total rice area.

Imolehin and Wada (2000) show the possible land area for rice production in Nigeria to be 4.6 million and 4.9 million hectares, and the areas include five different ecologies such as; upland, inland or shallow swamp ecology, irrigated rice ecology, deep water or floating rice ecology and tidal (mangrove) swamp ecologies. These ecologies cannot be the same in terms of hydrology and water control. The type of rice plants that are grown are different for each ecology. Rice bred for the irrigated land for instance cannot be grown in the uplands or flood plain and deep water environment (Pingali *et al.,* 1997). In all, rice varieties are bred for a specific zone. Therefore, the modern FARO 44 high yielding variety that outshined the other varieties was developed for the irrigated and the favorable rainfed lowlands.

Rice is grown under various growing environment. Four major environments are generally recognized as follows: irrigated, rainfed lowland, upland, and lastly flood prone.

i. **Upland ecology** - In the upland ecology, crops depend heavily on natural rain for their growth and development. About 55 to 60 percent of the cultivated rice land and 30 to 35 percent of total national rice production come from this ecology (Singh *et al.,* 2011). Some of the upland rice areas are on sloping mountain sides. Also rice is planted under dry conditions just as wheat or maize Naturally well drained soils in bunded or unbunded fields without surface water accumulation (Dingkuhn, 2014). Rice varieties are photoperiod insensitive and have deep roots and some level of drought tolerance. Many of the upland soils have low pH and are deficient in nutrients. Yields thus average about 1.2 tons per hectare. About 16 million hectares of world rice land is classified as upland.

ii. **Irrigated rice-** Approximately, 55% of the world rice area planted to rice, is irrigated and is the most productive rice growing system (Guo *et al.,* 2013). Perhaps 75 % of the world rice production comes from irrigated areas and Asian mega cities are fed from irrigated rice. Irrigation water is provided by human intervention through a variety of works including river diversions, reservoirs and wells. The area of irrigated rice has expanded markedly in the last 3 decades. Modern rice varieties and improved cultivation techniques have had their greatest impact on increasing the productivity of irrigated lands (Sohrabi *et al.,* 2012). Most of the irrigated areas are planted to improved varieties and more fertilizer and other inputs are used than in the other ecologies. Rice yields in irrigated areas have doubled to five tonne per ha in the past 30 years and there is considerable scope for further yield improvement. Irrigated areas are further divided into irrigated wet season when rainfall is supplemented with irrigation water and irrigated dry season when rainfall is very low and irrigation is the primary source of water supply (Farooq , 2011). Yields during the dry season are higher than during the wet season due to higher incoming solar radiation.

iii. **Rainfed lowland rice -** About one fourth of the world rice area is rainfed lowland. Yields average about two tons per hectare (Genet, 2014). Rainfed lowlands have a great diversity of growing conditions that vary by amount of rainfall and duration of rainfall, depth of standing water, duration of standing water, flooding frequency, and time of flooding, soil type and topography. Rainfed lowland fields are bunded and water is impounded, when available, just like irrigated fields. Rainfed lowlands are further subdivided into five categories; Short periods of moisture stress may occur. Improved varieties developed for irrigated conditions are grown in such area and yields average around three tons.

Rainfed shallow drought prone, where rainy period is short and periods of mild to severe drought stress occur during the growing season. Photoperiod insensitive varieties with short duration and degree of drought tolerance are most suitable.

Rainfed shallow submergence prone, where rice crop is submerged during periods of heavy rain falls for up to 10 days. Rainy period is generally long and crop is harvested after the rainy season is over. Photoperiod sensitive varieties are generally grown.

Rain fed medium deep, where water accumulates in the fields in low lying areas and stagnates for 2 to 5 months because of impeded drainage. Photoperiod sensitive varieties with tolerance to stagnant water are grown.

iv. **Flood prone rice -** Flood prone rice is grown in low lying lands in river deltas of South and Southeast Asia. Standing water depth may vary from 5Ocm to more than 5m. However, flooding occurs only during part of the growing season (Khush, 2014). Fields are unbunded. Rice is broadcast sown. Tall varieties with photoperiod sensitivity are grown.

Varieties grown in deeper areas (100 cm) have elongation ability. About 9 million hectares are planted to floodprone rice of which 3 million falls in the category of deepwater rice. Average yields are around 1.6 tonne per hectare.

2.7 Genetic variability studies in rice

Previous studies reported that seed of local rice varieties maintained by farmers are genetically diverse (Dennis, 2016). Diversity analyses may be based on morphological characteristics such as shape, size and pigmentation of plant parts that local farmers use to distinguish different rice varieties (Morishima *et al.*, 2016). Molecular techniques such as AFLP, ISSR and SSR (Saini *et* *al.,* 2016) allow variation to be evaluated between individual plants. An important way of describing a plant is by its qualitative traits (Kurlovich, 1998).

These characters in plant are mostly genetically controlled and thus less influenced by environmental conditions (Sarawgi *et al*., 2013). According to Hien *et al*. (2012), qualitative traits are mainly influenced by natural selection, socio economic scenarios and consumer preference. Systematic study and characterization of high quality rice germplasm is not only important for utilizing the useful donor traits, but also essential for protecting the unique rice varieties. Characterization is a critical step to find genetic relationships among genotypes and to prevent adulteration practices. The study of genetic relationship among different rice cultivars is considered to be an important tool for plant breeders for an efficient selection of the diverse parents for their potential use in a rice breeding program as well as for the improvement of quality traits of rice (Sajib *et* a/., 2012). Moreover, characterization is also essential to prevent adulteration of low priced, non-aromatic rice with high priced aromatic rice and consequently dissemination of information to the consumers.

Unambiguous, reliable, fast and cost-effective identification of genetic divergence in rice cultivars is essential for the effective utilization and protection of plant genetic resources (Barcaccia, 2009). According to International Union for Protection of New Plant Varieties (UPOV), any new characteristics used in varietal characterization should be clearly defined, accepted and should have standard method of observation, least or not affected by environment, accessible to breeders, associated with reasonable costs and efforts. Different approaches based on morphological, physico-chemical, biochemical and molecular attributes have been used to achieve characterization of genetic divergence among rice cultivars (Chakravarthi and Naravaneni, 2014).

Rice genetic resources are key components to breeding programmes, and farmers have played important roles in contributing to rice diversity by developing and nurturing thousands of rice varieties for several years. This vast wealth of rice germplasm including landraces and traditional varieties is a good source of important alleles to develop new rice varieties. These germplasm serve as the foundation of any rice breeding programme because they are the source of important traits necessary for improving and developing new breeds of rice varieties. Several reports have shown the utilization of rice landraces in developing new varieties.

The achievement of high yield of rice mainly initiate from breeding new genotype with adaptive traits to yield production and improvement of management and grain quality characters which are also reported to play an important role in genetic divergence (Julfiquar, 2006) than yield quality characters, few morphological traits that is plant height, number of panicle per plant, number of effective tillers, 1000-grain weight, panicle length also contribute to the genetic variability (Babu, 2013). Hence, critical assessment of nature and magnitude of genetic variability is one of the important prerequisites in formulating effective breeding methods. The knowledge of direct and indirect effects of yield components is necessary to reveal which effect is important (Isong *et al*., 2013).

Correlation coefficient is known to determine the relationship between components necessary for selection, however when more characters are involved, the indirect association between characters become more complex. Path coefficient analysis is found to be useful in revealing the relationship among traits whereby suitable for effective selection of complex traits in rice (Liaqat *et al*., 2015, Iqbal *et al*., 2006). combination of heritability with genetic advance over mean is more effective and reliable in predicting the resultant effect of selection (Ramanjinappa *et al*., 2011). Genetic Advance according to Hamdi *et al*. (2017) will ostensibly show the magnitude of the expected genetic gain from one cycle of selection. Therefore, the study of direct and indirect association will help in understanding the yield components and form the basis for selection to improve yield. In genetic diversity studies using morphological traits, the most important variables describing phenotypic variation are defined by principal component (PC) analysis. Diversity studies using principal component analysis have been carried out in rice by several authors to understand and prioritize the most essential traits which explain much of the variability among the studied genotypes (Guei *et al*., 2015).

Correlation analysis is a measure of the strength of association between two characters (traits). Morphological and physiological traits analysis in plant through correlation can be used as tool for indirect selection. Correlation studies assist plant breeders at the time of selection and provide valuable information about yield and yield related traits. Selection in plant breeding holds major importance in the development of any crop and knowledge about the criteria used for selection of any crop is an asset. Breeders must always have a target in mind before proceeding towards improvement of any crop through selection.

Genetic advance as per cent of mean provides more reliable information regarding the effectiveness of selection in improving the traits. Genetic advance denotes the improvement in the genotypic value of the new population over the original population (Ghosh and Sharma, 2012).

2.8 Economic importance of rice

Rice is no longer a luxurious food but as a cereal, it has become a major source of energy, for urban people just as rural ones (Ojo *et al*., 2009). Rice is an important source of energy, iron, calcium, vitamins, and protein (IRRI, 2016). In 2000, global production of milled rice was about 415 million tons (CIRAD, 2008). From the year 2000 to 2003, this production gradually declined and it increased in 2004 from 390 million tonnes in 2008.

The quality desired in rice varies from one geographical region to another and consumers demand certain varieties and favors specific quality traits of milled rice for home cooking (Juliano *et al.*, 2013; Azeez and Shafi, 2013). Due to the widely varied preferences of consumers, the world rice market is not homogenous.

In 2005, statistics from the European Association of Agricultural Economics (EAAE) shows that Nigeria is the largest rice importer in West Africa, with an average yearly import of 1.6 million metric tonnes since the year 2000 (USAID, 2010). Total consumption stands at 4.4 million tons of milled rice while annual consumption per capital stands at 29kg and this has continued to rise at 11% per annum; induced by income growth. Nigeria produces only about 2.8 million metric tons with a deficit of 1.6 million metric tons excluding the large quantity being smuggled through the porous borders (USAID, 2010).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Location

The experiment was carried out at National Cereals Research Institute experimental field Badeggi (Latitude 9°45'N, Longitude 6°07'E and altitude 70.5 m above sea level (masl) and Edozhigi Latitude 9°45'N and Longitude 6°17'E altitude 50.57 metres above sea level (masl) respectively, all in southern Guinea Savanna agro-ecological zone of Nigeria.

3.2 Experimental Materials

The local rice varieties used for this experiment were collected from farmers in Niger State rice growing villages and the improved varieties were collected from National Cereals Research Institute, Badeggi (NCRI), rice breeding unit.

3.3 Experimental Design and Layout

The experiment was laid out in Alpha lattice design in 3 replications. The experiment comprises of 10 plots and 5 blocks, in each block of a size 5x1m^2. In gross experimental plot which measured 27m x 57m^2.

Table 3.1: List of Varieties Used for the Experiment

S/NO	NAME	TYPE	S/NO	NAME	TYPE
1	Dangote	Local	26	FARO 50	improved
2	Goro	Local	27	FARO 51	improved
3	Guzan	Local	28	FARO 52	improved
4	FARO 15	Improved	29	FARO 56	improved
5	FARO 16	Improved	30	FARO 57	improved
6	FARO 17	Improved	31	FARO 60	improved
7	FARO 19	Improved	32	FARO 61	improved
8	FARO 20	Improved	33	FARO 62	improved
9	FARO 21	Improved	34	FARO 63	improved
10	FARO 22	Improved	35	FARO 64	improved
11	FARO 24	Improved	36	FARO 65	improved
12	FARO 26	Improved	37	FARO 4	improved
13	FARO 27	Improved	38	Ndayikako	Local
14	FARO 30	Improved	39	Ebangichi	Local
15	FARO 31	Improved	40	Waluye	Local
16	FARO 32	Improved	41	Jarisilimi	Local
17	FARO 33	Improved	42	Biruwa	Local
18	FARO 34	Improved	43	Hajiya Fatima	Local
19	FARO 37	Improved	44	Upland	Local
20	FARO 41	Improved	45	Salama	Local
21	FARO 44	Improved	46	Suleiman	Local
22	FARO 45	Improved	47	Jamila	Local
23	FARO 47	Improved	48	Yar Yamidi	Local
24	FARO 48	Improved	49	Bisalai	Local
25	FARO 49	Improved	50	Kududogichi	Local

3.4 Cultural practices Standard agronomic practices such as seed bed preparations, site preparation, seed sowing and thinning-out, fertilizer application, weed control and harvesting were adhered to;

3.4.1 Tillage operation

Ploughing, harrowing and levelling were carried out manually with cutlass and hoe.

3.4.2 Nursery Practices

Seedling was raised on nursery bed measuring 1.5 m wide, 10 m long and 4 to 6 cm above the ground surface. It was done by drilling method. Mulching was done with grass to avoid depicking by rodent and maintain soil moisture. The mulch was removed 7 days after seedling emergence.

3.4.3 Transplanting

Transplanting was done 21 days after seedling emergence at spacing of 20 by 20 cm inter and intra row spacing.

3.4.4 Weeding

Manual weeding was carried out regularly at 21 and 42 days after transplanting.

3.4.5 Fertilizer application

The equivalent of 40 kg each of N, P_2O_5 and K_2O per hectare was applied at transplanting as basal application. Top dressing of 46 % N fertilizer, was applied in 2 split application by 1^{st} top dressing at 21 days after transplanting, 2^{nd} top dressing at panicle initiation.

3.4.6 Harvesting

The crop was harvested when the grains are hard and are turning yellow/ brownish at 30 - 45 days after flowering or a month after 50 % flowering.

3.4.7 Threshing

Threshing was carried out on tarpaulin by beating the rice against a stick.

3.4.8 Winnowing

Winnowing was done to separate the chaff and empty grains from well-filled matured grains.

3.5 Data Collection

i Plant height

Plant height (cm) was measured from soil surface to tip of the plant at reproductive stage using the metre rule.

ii Panicle number per plant (PNPP)

The total number of panicles was counted and recorded at the maturity stage before harvest.

iii Tiller number

This was obtained by counting the number of tillers per plant randomly per plot manually with hand and averaged across replications for each genotypes during the maturity stage.

iv Panicle exertion

The extent to which the panicle is exerted above the flag leaf sheath and it was score using the scale of 1-9 as described by IRRI (2013). 1-Enclosed (panicle is partly or completely enclosed within the leaf sheath of the flag leaf blade), 3-Partly exerted (panicle base is seen slightly beneath the collar of the flag leaf blade), 5-Just exerted (panicle base coincides with the collar of the flag leaf blade), 7-Moderately well exerted (panicle base is seen above the collar of the flag leaf blade) and 9-Well exerted (panicle base is seen well above the collar of the flag leaf blade).

v Panicle length

The panicle length was measured from the base of the panicle to the tip. A total of five panicle were measured from each entry.

vi Panicle weight

Panicles were obtained from harvested samples of genotypes and weighed on a balanced scale to determine the weight in grams.

vii Days to 50% flowering

Days to 50% flowering were recorded when half of the plant population started flowering.

x. Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using MSTAT package 1.3 versions and correlation was done as described by Muhammad *et al.* (2015). Estimates of variance component were determined according to Shivanna (2008). Cluster and Principal Component analysis was used to group the genotype according to their response patterns.

CHAPTER FOUR

4.0 RESULTS

4.1: Mean Square for Eight Agronomic Traits of Fifty Lowland Rice Evaluated

Result of the mean square analysis of variance for the agronomic traits studied is presented in Table 4.1. There were highly significant differences amongst the entries at Badeggi for plant height, tiller number, panicle number, panicle exertion, days to 50 % flowering and grain yield showed significant differernce. Panicle length was significant at <0.05 probability level. Panicle weight showed no significant difference. Similarly, there was highly significant differences for panicle number, panicle exertion and days to 50 % flowering in Edozhigi. Panicle length and grain yield were significantly different at <0.05 probability level with plant height, tiller number and panicle weight not significantly different.

Combined location result showed there were highly significant differences amongst the entries in their mean squares. Plant height, tiller number, panicle length, panicle number, panicle exertion and days to 50 % flowering were significantly different at < 1 percent level of probability. Grain yield was significantly different at <0.05 probability level. Panicle weight showed no significant difference. genotypes at 2 locations. Highly significant genotypes effects were observed for all the traits. The genotype by locations were significantly different at < 1 percent level of probability for 50 % flowering. But, significantly different at <0.05 probability level for panicle exertion and panicle weight. Environmental effect was highly significant on days to 50 % flowering, tiller number, plant height and panicle number. Grain yield and panicle exertion were significant at <0.05 % probability level.

4.1: Mean Square for Eight Agronomic Traits of Fifty Lowland Rice Evaluated

Traits	Mean Square				
	Genotypes (G) Location 1	Genotypes (G) Location 2	Genotypes (G) Combined	Locations(L) Effects	G x L Interaction
Plant height (cm)	298.57**	78.05^{ns}	251.98**	15.32^{ns}	245.08**
Number of Tillers	7342.77**	3610.42^{ns}	6546.75**	982.83^{ns}	6844.99**
Panicle Length (cm)	6.79*	10.14*	11.56**	9.92^{ns}	7.62^{ns}
Number of Panicles	3279.08**	2277.72**	3712.11**	15336.75^{ns}	4770.13**
Panicle exertion	6.36**	4.68**	8.53**	72.03*	2.84*
Panicle Weight (g)	39.00^{ns}	39.59^{ns}	37.87^{ns}	1188.03*	36.02^{ns}
Days to Flowering	284.98**	321.69**	182.01**	462587.65**	155.47**
Grain Yield (Kg/ha)	1189178.16**	1518375.36*	1399465.05*	786432.00^{ns}	1462908.48*

*Significant at 5 %

**Significant at 1 %

4.2: Mean values for Plant Height (PH), Number of Tillers (TN)and Panicle Length (PL) among Fifty Lowland Rice Cultivars from combined analysis of variance

Significant differences existed amongst entries for plant height at maturity with FARO 15 (104.07 cm) recorded the tallest plants while FARO 44 (73. 80cm) had the shortest plant height. Number of tiller counted per meter square (m^2) were significantly different at ($p<0.05$) among the genotypes such that FARO 30 (357.17) produced the highest number of tillers compared to FARO 61 (190.17) which produced the lowest tillers among all the entries. Panicle length observed in this study was significantly different in all the entries with FARO 60 (27.36 cm) recorded the highest compared to genotype Bisalai (19.79 cm) which had the lowest.

4.3: The mean values from combined analysis of variance (ANOVA) for panicle number, panicle exertion and panicle weight

There was significant difference in the entries for panicle number such that FARO 60 (278.00) had the highest panicle number among the entries studied. Whereas FARO 20 (143.17) recorded the least panicle number. Panicle exertion were significantly ($p<0.05$) different among the genotypes with the following FARO 20, FARO 41, FARO 64 and Guzan recorded the highest score (6) compared to FARO 50 and FARO 32 which recorded the lowest score (1). Panicle weight was not statistically different among all the genotypes. But, the highest panicle weight was recorded in FARO 47 (38.17) compared to Goro (25.83g) that recorded lowest among all the genotypes (Table 4.3).

Table 4.2: Mean values for Plant Height (PH), Number of Tillers (TN)and Panicle Length (PL) among Fifty Lowland Rice Cultivars

S/N	Genotypes	PH	TN	PL
1	Biruwa	96.55	284.83	25.09
2	Bisalai	95.34	246.17	19.79
3	Dangote	91.10	213.67	23.57
4	Ebangichi	88.96	275.83	22.54
5	FARO 15	104.07	222.67	25.37
6	FARO 16	81.77	249.00	23.68
7	FARO 17	82.05	277.17	22.50
8	FARO 19	94.36	261.17	23.53
9	FARO 20	83.17	260.50	21.99
10	FARO 21	88.08	242.67	22.54
11	FARO 22	97.54	241.50	22.01
12	FARO 24	93.83	293.33	23.23
13	FARO 26	85.27	274.50	23.64
14	FARO 27	77.09	308.83	23.03
15	FARO 30	84.78	357.17	24.38
16	FARO 31	93.53	218.50	22.80
17	FARO 32	84.25	280.67	25.73
18	FARO 33	85.03	289.33	24.25
19	FARO 34	90.73	243.83	22.61
20	FARO 37	82.53	229.33	22.75
21	FARO 40	89.91	268.00	22.78
22	FARO 41	87.20	250.00	22.77
23	FARO 44	73.80	252.17	22.43
24	FARO 45	83.17	282.33	22.83
25	FARO 47	81.47	246.00	25.41
26	FARO 48	87.73	273.00	24.98
27	FARO 49	90.80	339.17	24.01
28	FARO 50	92.11	286.67	23.22
29	FARO 51	92.07	255.17	24.34
30	FARO 52	98.74	280.00	24.26
31	FARO 56	92.17	257.00	23.22
32	FARO 57	80.67	242.67	24.30
33	FARO 60	91.87	268.67	27.36
34	FARO 61	95.62	190.17	25.72
35	FARO 62	98.17	281.17	23.18
36	FARO 63	91.85	254.17	24.04
37	FARO 64	97.18	257.00	24.99
38	FARO 65	91.70	258.67	26.02
39	Goro	95.52	263.33	23.59
40	Guzan	97.70	216.17	23.79
41	Hajiya Fatima	95.61	236.83	26.28
42	Jamila	95.05	229.00	24.76
43	Jarisilimi	96.21	297.50	26.34
44	Kududogichi	98.17	202.00	25.61
45	Ndayikako	88.48	286.50	24.49
46	Salama	100.85	230.17	22.62
47	Suleiman	86.89	194.67	25.10
48	Upland	87.89	220.33	24.64
49	Waluye	98.27	239.17	23.77
50	YarYamidi	90.13	237.83	24.16
	Minimum	42.00	190.17	19.79
	Maximum	120.00	486.00	32.66
	Mean	90.54	257.32	23.92
	SE-Mean	0.69	3.51	0.16
	LSD	14.18	75.09	3.27

Table 4.3: Mean values for Number of Panicles (PN), Panicle exertion (PX) and Panicle Weight (PW) among Fifty Lowland Rice Cultivars

S/N	Genotypes	PN	PX	PW
1	Biruwa	244.50	4.83	27.33
2	Bisalai	190.83	5.00	28.67
3	Dangote	229.83	4.33	31.33
4	Ebangichi	165.17	4.67	26.67
5	FARO 15	177.17	2.00	28.00
6	FARO 16	224.00	3.83	26.33
7	FARO 17	181.50	3.67	30.17
8	FARO 19	182.17	3.17	30.50
9	FARO 20	143.17	6.00	30.00
10	FARO 21	179.00	3.67	28.17
11	FARO 22	204.50	3.67	28.67
12	FARO 24	189.83	4.33	26.67
13	FARO 26	189.67	5.33	27.17
14	FARO 27	213.00	2.67	29.17
15	FARO 30	219.67	5.00	23.17
16	FARO 31	231.00	5.17	30.00
17	FARO 32	216.33	1.33	31.17
18	FARO 33	199.83	3.83	27.67
19	FARO 34	219.67	2.67	28.67
20	FARO 37	228.00	5.00	31.33
21	FARO 40	182.50	4.83	33.67
22	FARO 41	229.00	6.33	29.00
23	FARO 44	219.83	3.50	30.50
24	FARO 45	217.83	5.50	28.17
25	FARO 47	215.67	3.83	38.17
26	FARO 48	192.50	4.50	29.83
27	FARO 49	230.17	3.83	28.50
28	FARO 50	193.17	1.00	28.17
29	FARO 51	186.83	3.17	29.33
30	FARO 52	195.83	3.67	27.17
31	FARO 56	233.00	3.00	28.17
32	FARO 57	206.00	4.00	27.00
33	FARO 60	278.00	3.50	30.67
34	FARO 61	240.33	3.67	25.83
35	FARO 62	243.67	3.83	26.33
36	FARO 63	209.67	2.83	27.17
]37	FARO 64	196.17	6.33	32.17
38	FARO 65	202.83	5.00	28.00
39	Goro	239.00	5.00	25.83
40	Guzan	211.83	6.17	31.33
41	Hajiya Fatima	248.00	4.00	31.50
42	Jamila	203.33	5.67	34.33
43	Jarisilimi	192.33	5.17	30.17
44	Kududogichi	189.00	5.67	29.83
45	Ndayikako	224.17	3.17	26.67
46	Salama	246.17	3.33	30.83
47	Suleiman	217.17	3.67	27.67
48	Upland	223.67	4.83	29.67
49	Waluye	183.00	5.17	32.00
50	YarYamidi	203.00	4.17	27.67
	Minimum	95.00	1.00	20.00
	Maximum	386.00	11.00	46.00
	Mean	209.65	4.17	29.12
	SE-Mean	2.83	0.11	0.35
	LSD	58.11	2.24	NS

4.4: Mean Values for Days to Fifty Percent Flowering (DF), Grain Yield (GY) and Percentage Grain Yield

Days to 50% flowering were significantly ($p<0.05$) different for all the entries such that FARO 41 (76.30) and FARO 37 (76.10) recorded the longest days to flowering compared to FARO 49 (52.13) which was the shortest duration to 50 % flowering amongst the entries. The individual performance in terms of grain yield of some rice genotypes are significantly ($p<0.05$) different over checks in this study. Twenty one (21) genotypes out of fifty (50) genotypes evaluated recorded high mean value than the population mean. With the exception of FARO 15 with (3455 kg/ha), FARO 17 with (3164 kg/ha), FARO 24 with (3149 kg/ha) and Waluye with (4796 kg/ha) which recorded significantly ($p<0.05$) different over the check. All other genotypes were not statistically significant over the check. Whereas FARO 22 and FARO 52 and Jamila has yield greater or equal to that of the check but there were no significant difference statistically (Table 4.4).

Table 4.4: Mean Values for Days to Fifty Percent Flowering (DF), Grain Yield (GY) and Percentage Grain Yield Advantage (% YA) over a Known Check (FARO 44) for -Fifty Lowland Rice Cultivars

S/N	Genotypes	DF	GY	% YA
1	Biruwa	61.73	2194.00	
2	Bisalai	64.93	2683.00	
3	Dangote	62.10	1953.00	
4	Ebangichi	62.83	2290.00	
5	FARO 15	63.73	3455.00	17.24*
6	FARO 16	59.10	1791.00	
7	FARO 17	55.67	3164.00	7.36*
8	FARO 19	58.03	2402.00	
9	FARO 20	64.00	2709.00	
10	FARO 21	53.27	2907.00	
11	FARO 22	63.07	2949.00	0.07
12	FARO 24	59.93	3149.00	6.85*
13	FARO 26	64.77	2570.00	
14	FARO 27	67.53	2272.00	
15	FARO 30	61.37	2629.00	
16	FARO 31	48.33	1878.00	
17	FARO 32	65.20	2807.00	
18	FARO 33	61.90	2596.00	
19	FARO 34	65.63	2723.00	
20	FARO 37	76.10	2907.00	
21	FARO 40	70.40	2114.00	
22	FARO 41	76.30	2408.00	
23	FARO 44	67.97	2947.00	
24	FARO 45	63.90	2909.00	
25	FARO 47	55.33	1964.00	
26	FARO 48	69.17	2358.00	
27	FARO 49	52.13	2454.00	
28	FARO 50	56.80	2390.00	
29	FARO 51	65.63	2203.00	
30	FARO 52	65.53	3044.00	3.29
31	FARO 56	62.13	2332.00	
32	FARO 57	61.60	2557.00	
33	FARO 60	71.17	2631.00	
34	FARO 61	68.93	2739.00	
35	FARO 62	63.67	2459.00	
36	FARO 63	71.32	2113.00	
37	FARO 64	61.17	2383.00	
38	FARO 65	66.50	2721.00	
39	Goro	67.68	2274.00	
40	Guzan	56.20	2279.00	
41	Hajiya Fatima	55.13	2877.00	
42	Jamila	60.03	3086.00	4.72
43	Jarisilimi	64.10	2164.00	
44	Kududogichi	60.30	2836.00	
45	Ndayikako	61.50	2880.00	
46	Salama	63.20	2645.00	
47	Suleiman	65.33	2532.00	
48	Upland	56.60	2560.00	
49	Waluye	61.73	4796.00	62.74*
50	YarYamidi	56.33	2861.00	
	Minimum	48.33	660.00	
	Maximum	130.00	4796.00	
	Mean	62.70	2610.88	
	SE_Mean	1.93	62.47	
	LSD	4.15	144.30	

4.5 Genetic Paramaters of Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated at Badeggi and Edozhigi 2017 growing season.

Table 4.5. Presents, estimate of genotypic and phenotypic variances, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), broad sense heritability and genetic advance expressed as percentage of means over two environmental locations. phenotypic variances were higher than the genotypic variances in all the characters studied due to environmental effect. Plant height of (42.84), tiller number of (40.12), panicle number of (38.14) and panicle exertion of (53.49) have moderate heritability. Panicle length of (22.61), panicle weight of (6.62) and grain yield of (12.15) have low heritability. While, days to 50 % flowering of (83.63) has high heritability value. Genotypic coefficient of variance showed panicle exertion (35.60) to have the highest value followed by tiller number (14.84) and grain yield (14.17). Panicle weight recorded the lowest. Phenotypic coefficient of variance was highest for panicle exertion with (48.68), followed by grain yield of (40.64) and tiller number of (23.42). genetic advance over mean was high for panicle exertion with (53.64), days to 50 % flowering of (22.67). while, low percentage was recorded for panicle length and panicle weight.

Table 4.5: Genetic Parameters for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated

Traits	σ^2g	σ^2p	GCV	PCV	(H^2)	GAM
Plant Height (cm)	58.14	135.70	8.42	12.87	42.84	11.36
Number of Tillers	1457.38	3631.99	14.84	23.42	40.13	19.36
Panicle Length (cm)	1.80	7.96	5.61	11.79	22.61	5.49
Number of Panicles	803.14	2105.84	13.52	21.89	38.14	17.20
Panicle Exertion	2.20	4.12	35.60	48.68	53.49	53.64
Panicle Weight	2.21	33.44	5.11	19.86	6.62	2.71
Days to 50 % Flowering	56.95	68.10	12.04	13.16	83.63	22.67
Grain Yield (kg/ha)	136799.20	1125866.65	14.17	40.64	12.15	10.17

σ^2g = Genotypic Variance, σ^2p = Phenotypic Variance, GCV = Genetic Coefficient of Variance, PCV = Phenotypic Coefficient of Variance H^2 = Heritability, GAM = Genetic advance over mean.

4.6: Principal Components for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated at Badeggi and Edozhigi 2017 Rice growing season

Principal component analysis grouped the quantitative traits into 8 components. In which PC1 explained 19 % of the total variation (Table 4.6). Based on the contribution of the eigen vectors to variation, traits such as days to 50 % flowering, panicle weight, panicle exertion and panicle number were the major characters associated with the first principal component. While, plant height, panicle length and tiller number were associated with the second principal component, which accounted for 16 % of the total variation. The third principal component which explained 15 % of the total variation and was dominated by grain yield, tiller number, panicle exertion and panicle number. While, panicle number is the major contributing factor in the forth principal component, which accounted for 13 % of the total variation.

4.7 : Genotypic Correlation Coefficients for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated at Badeggi and Edozhigi 2017 Rice growing season

The result of correlation analysis for yield parameters of some rice genotypes evaluated are shown in Table 4.7. Positive correlation existed between panicle length (0.183), panicle number (0.04) and panicle exertion (0.070) with plant height. while, tiller number has a negative significant correlation with plant height. panicle number has positive significant association with panicle length (0.296*), panicle weight has a positive

Table 4. 6: Principal Components for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Plant height	-0.03	0.70	-0.17	0.11	-0.15	-0.06	-0.60	0.29
Tiller number	-0.10	-0.42	-0.57	-0.13	0.07	-0.59	-0.33	-0.05
Panicle length	0.29	0.47	0.07	-0.52	-0.01	-0.49	0.33	-0.29
Panicle number	0.34	-0.22	0.33	-0.55	0.37	0.18	-0.45	0.23
Panicle exertion	-0.43	0.15	0.36	0.22	0.60	-0.21	-0.20	-0.42
Panicle weight	0.48	-0.02	0.13	0.51	0.32	-0.41	0.18	0.44
Days to 50 % flowering	-0.61	0.04	0.10	-0.30	0.10	-0.17	0.29	0.64
Grain yield	0.07	0.22	-0.61	-0.07	0.61	0.38	0.24	0.02
Standard deviation	1.24	1.14	1.08	1.01	0.96	0.88	0.83	0.76
Proportion of Variance	0.19	0.16	0.15	0.13	0.11	0.10	0.09	0.07
Cumulative Proportion	0.19	0.35	0.50	0.63	0.74	0.84	0.93	1.00
EigenValues	1.54	1.30	1.16	1.03	0.92	0.78	0.69	0.58

Table 4.**7: Genotypic Correlation Coefficients for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated**

	PH	TN	PL	PN	PX	PW	DTF
PH	1.000						
TN	-0.254*	1.000					
PL	0.183	-0.043	1.000				
PN	0.044	-0.063	0.295*	1.000			
PX	0.070	-0.122	-0.078	-0.114	1.000		
PW	-0.023	-0.305*	0.109	-0.061	0.143	1.000	
DF	-0.122	-0.007	0.000	0.111	0.031	-0.102	1.000
GYLD	0.185	-0.086	-0.014	-0.240	-0.011	0.013	0.020

DTF Days to 50 % flowering**, PH** Plant height**, TN** Tiller number**, PN** Panicle number**, PX** Panicle exertion**, PW** Panicle weight**, GYLD** Grain yield**.**

4.8: Genotypic Path Coefficients for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated at Badeggi and Edozhigi 2017 rice growing season

The path coefficient analysis studied showed the direct and indirect contributions of yield attribute to yield with a positive residual value of 0.0291. The analysis revealed that plant height had the highest direct contribution to yield with 0.1906 followed by days to 50 % flowering (0.0751). While, panicle weight recorded the least direct contribution to yield (-0.0041) as shown in Table 4.8. The indirect contributions of the parameters evaluated to yield showed that plant height contributed highest via panicle length (0.0350), followed by panicle number through panicle exertion (0.0315).

4.9: Cluster analysis of morphological traits for grain yield

The cluster groups were five with random distribution of the genotypes. The cophenetic correlation coefficient was 0.578. Cluster one was the largest group with 37 cluster members. Cluster two and cluster four had one cluster member each. While, Cluster three and Cluster five had seven and four cluster members respectively. Cluster group two had the highest group average of tiller number (357.17), Members of cluster three recorded the highest group average number of panicle number (240.90), genotypes in cluster five have the highest average of plant height (98.89) and the highest yielding group with average group seed yield of (3543.25**1**).

Table 4.8. Genotypic Path Coefficients for Eight Agronomic Traits of Fifty Lowland Rice Cultivars Evaluated

	PH	TN	PL	PN	PX	PW	DF
PH	**0.1906**	-0.0483	0.0350	0.0084	0.0133	-0.0043	-0.0233
TN	0.0157	**-0.0620**	0.0027	0.0039	0.0076	0.0189	0.0004
PL	0.0046	-0.0011	**0.0254**	0.0075	-0.0020	0.0028	0.0000
PN	-0.0121	0.0173	-0.0812	**-0.2757**	0.0315	0.0169	-0.0306
PX	-0.0044	0.0077	0.0050	0.0072	**-0.0633**	-0.0090	-0.0020
PW	0.0001	0.0013	-0.0004	0.0003	-0.0006	**-0.0041**	0.0004
DF	-0.0092	-0.0005	0.0000	0.0083	0.0023	-0.0076	**0.0751**

Residual effect = 0.0291, **DF** Days to 50 % flowering**, PH** Plant height**, TN** Tiller number**, PN** Panicle number**, PX** Panicle exertion**, PW** Panicle weight.

Table 11: Membership Performance Summary of Fifty Lowland Rice Cultivars in Five Cluster Groups

Parameters		Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Plant Height (cm)	Min	73.80	84.78	86.20	81.47	95.05
	Max	98.74	84.78	100.85	81.47	104.07
	Mean	89.28	84.78	94.29	81.47	98.89
Number of Tillers	Min	194.67	357.17	190.17	246.00	202.00
	Max	339.17	357.17	268.67	246.00	239.17
	Mean	262.73	357.17	235.57	246.00	223.21
Panicle Length (cm)	Min	19.79	24.38	22.62	25.41	23.77
	Max	26.34	24.38	27.36	25.41	25.61
	Mean	23.65	24.38	24.54	25.41	24.88
Number of Panicles	Min	143.17	219.67	211.83	215.67	177.17
	Max	244.50	219.67	278.00	215.67	203.33
	Mean	205.63	219.67	240.90	215.67	188.12
Panicle Exertion	Min	1.00	5.00	3.00	3.83	2.00
	Max	6.33	5.00	6.33	3.83	5.67
	Mean	4.09	5.00	4.29	3.83	4.63
Panicle Weight	Min	25.83	23.17	25.83	38.17	28.00
	Max	33.67	23.17	31.50	38.17	34.33
	Mean	28.74	23.17	29.62	38.17	31.04
Days to 50 % Flowering	Min	48.33	61.37	55.13	55.33	60.03
	Max	76.10	61.37	76.30	55.33	63.73
	Mean	62.74	61.37	64.72	55.33	61.45
Grain Yield (kg/ha)	Min	1791.00	2629.00	2279.00	1964.00	2836.00
	Max	3164.00	2629.00	2877.00	1964.00	4796.00
	Mean	2536.95	2629.00	2558.71	1964.00	3543.25
Number of Members		37	1	7	1	4
Cluster Members		G1 G10 G11 G12 G13 G15 G16 G17 G18 G19 G2 G21 G22 G24 G25 G26 G27 G28 G30 G33 G34 G35 G36 G37 G38 G39 G41 G42 G44 G46 G48 G49 G5 G6 G7 G8 G9	G14	G20 G29 G3 G31 G32 G43 G45	G23	G4 G40 G47 G50

Cophenetic Correlation Coefficient = 0.578

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The major objective of any breeding programme is to produce quality and high yielding varieties for release to farmers. The requirement to achieving this goal is the presence of sufficient amount of genetic variability within genotypes in which desirable lines would be selected for further genetic manipulation that leads to the achievement of targeted objectives. With the desire to have sufficient amount of variability within genotypes. The result of analysis of variance showed that plant height, tiller number, panicle length, panicle number, panicle exertion, days to flowering and grain yield were significant in the two trials.

The highly significant genetic variation ($P < 0.01$) among the genotypes for days to 50 % flowering in this study is similar to those previously reported by Weiya *et al*. (2008), they observed variation in days to flowering of several genotypes and identified a regulatory gene responsible for variation in this physiological trait among rice genotypes. Variation among genotypes for this quantitative trait might be due to the genetic makeup of the genotype or interaction with the environment. The availability of early flowering and maturing genotypes are important for the avoidance of drought condition. The highly significant differences ($P<0.01$) among the accessions for tiller number in this finding is supported by that of Rahman *et al*. (2011).

So also, highly significant ($P < 0.01$) Variability among the accessions for this quantitative trait based on the data analysis was in agreement with earlier findings of Zahid *et al*. (2005), they studied twelve (12) genotypes of coarse rice and reported highly significant variation for various morphological traits including number of panicles per plant. Similar findings were also made by Hassan *et al*. (2003); they concluded that genetic variation was responsible for the significant differences.

Analysis of variance for plant height that was found to be highly significant ($P < 0.001$) among the various accessions studied is in conformity with those of Kole and Hasib (2008). Hussain *et al*. (2005) found out that planting and sowing methods, transplanting date and soil condition affect plant height in rice. Abbasi *et al*. (1995) reported that 100 grain weight is another important yield attributing trait in rice. No significant ($P < 0.01$) variation was observed within the accessions studied for this trait. Result obtained from this study regarding 100 grain weight are similar to those of Ali *et al*. (2000), they found out that, difference in 100 grain weight among the accessions studied was due to grain size and shape. Highly significant difference observed among the genotypes for panicle exertion was in conformity with that of Sarawagi *et al*. (2013) who reported similar variation in rice genotypes for panicle exertion. Panicles enclosed in leaf sheath consume time in harvesting or processing as the panicles have to be removed from the sheath.

The Principal component analysis in this study reveals the total contribution of characters to the variation. The first four components accounted for 63.0 % of the total variation taking into account all the 8 quantitative traits studied. In the present study, it can be deduced that days to 50 % flowering, panicle weight, panicle number, tiller number, plant height, grain yield, were the most important traits which accounted for much of the variability among the rice genotypes. These findings agree with Caldo *et al.* (1996). Correlation analyses revealed that, out of the eight (8) morphological characters; plant height, panicle weight, days to 50 % flowering showed positive association with grain yield. This result corroborates with the findings of Rasheed *et al*. (2002) and Girish *et al*. (2006) also reported the positive association of yield per with plant height at genotypic level. This implies that increase in plant height may increase grain yield (Hallauer and Miranda, 1988).

Cluster analysis is very useful in revealing complex relationships among populations of diverse origins in a more simplified manner. It is also effective in indicating accessions with useful traits belonging to different clusters for hybridization. The 50 genotypes in this study were classified into five main clusters at cophenetic percentage of 0.578 % based on morphological traits, which is an indication of genetic variation among the accessions. The variation observed among the genotypes suggests that morphological traits can reveal diversity existing among rice accessions. This is in agreement with earlier findings of Efisue *et al.* (2014), they reported that morphological traits can discriminate between rice genotypes.

Broad sense heritability estimates were high for days to flowering. This indicates that contribution of environmental conditions was relatively low for these traits. Low broad sense heritability estimate was observed for panicle length, grain yield per plant and panicle weight This shows that the environmental factors strongly influence this characters. Similar results were earlier reported by Mulugeta *et al*., (2012) and Rafii *et al*., (2014) who also reported low heritability for grain yield in his findings and the findings by Sathya and Jebaraj, (2013) who reported low heritability for 100 grain weight.

5.2 Conclusion

In most breeding programmes, morphological traits are always indicators for breeding objectives. The result of this study showed that members of cluster five in the dendograme ; Ebangichi, Guzan, Suleiman and YarYamidi showed the highest yield average, this revealed the relationship that could be used as bases for parental selection during breeding program. The positive correlation that existed between grain yield and plant height, grain yield and panicle weight, grain yield and days to 50 % flowering should be used as basis for improvement of the rice varieties cultivated in the lowland environment. Twenty one (21) genotypes out of fifty (50) genotypes evaluated recorded high mean value than the population mean. With the exception of FARO 15, FARO 17, FARO 24 and Waluye that recorded significantly ($p<0.05$) different over the check. All other genotypes were not statistically significant over the check. Whereas FARO 22 and FARO 52 has yield greater or equal to that of the check but there were no significant difference statistically. This variation that exist within some of the population studied provides opportunity for improvement.

5.3 Recommendations

Based on the results of the study, it is recommended that;

1. FARO 15, FARO17, FARO 24 and Waluye which out yielded the standard check could be subjected to further trial to ascertain their level of performance.
2. Accessions like FARO 22, FARO 52 and Jamila which showed desirable quantitative and qualitative traits in this study should be used for further rice improvement programmes by breeders.
3. Breeders should also pay more attention on traits that showed significant positive association with grain yield such as plant height, panicle weight and days to 50 % flowering.
4. Continuous evaluation of these genotypes should be done to broaden the genetic base of the species.

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