

CHAPTER ONE

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the genus *Oryza* which belongs to the tribe *Oryzeae* of the family *Poaceae* (Chang, 1976a). Rice is an ancient agricultural crop and is today one of the principal food crops of the world (Chang, 1981).

Chang,(1976a) identified a region including northeastern, northern Bangladesh and a triangle adjoining Burma, Thailand, Laos, Vietnam, and southern China as the probable primary center of domestication of rice. There are two cultivated species of rice; *Oryza sativa* L. (2n=24 AA), the Asian rice, and *O. glaberrima* Steud. (2n=24, A^gA^g) the African rice. *O. sativa* L. constitutes virtually all of the worlds cultivated rice and is the species grown in the United State (Chang, 1976b).

Of the 25 species distributed in parts of Asia, Africa, Australia, Central and South America, the species *O. sativa* comprises numerous ecotypes or geographical races and several genetic groups (Raemaekers, 2001). The ecogeographical race are divided into Indica the tropical rice and japonica the temperate race and a third race denoted as Javanica or bulu, is believed to have developed in Indonesia and is intermediate between Japonica and Indica rice (Chang.,1976b).

Rice is staple food for half of humanity, more than three billion people; most of them in Asia depend on rice as their major source of food. It is cultivated worldwide in 114 of the worlds 193 countries; 30 in Asia, 28 in America 41 in Africa 11 in Europe and four in Oceania (Kang and Priyadarshan., 2007).

Paddy yield vary greatly according to the types of cultivation, growing conditions and varieties. The fluctuate between a few hundred

Kg/ha in traditional cultivation and 9t/ha in irrigated cultivation, while the average yield in Africa is 2 tones/ha (Raemaekers, 2001)

About 90% of the global rice area is in the Asia continent, where more than 90% of the world's rice is produced and consumed. Rice is cultivated in Asia in irrigated (57%), shallow lowland (33.5%), upland (6.4%) and deep-water (2.7%) ecosystem (Kang and Priyadarshan, 2007). Over 50% of the worlds rice (*O. sativa*. L) is rain-fed, but these non irrigated lands produce only a quarter of total rice output (Mclean *et al*, 2002). Upland rice only covers 90% of the rice area or 1.2 million hectare (Raemaekers, 2001).

Rice is grown on a wide range of landforms affected by an equally wide range of hydrologic conditions (Moorman and Breemen, 1978). Heavy clay soils or silt loam soils with hard pan layers about 30 cm below the surface are typical rice producing soils because they minimize water losses from soil percolation (Fehr, 1987).

Breeding experience has shown that recovering desired rice quality characteristics is not always easy, especially when using new introductions or different germplasm base. Every variety is a compromise assaying used by plant breeder, regarding the end product of their labors, a new cultivar. Each breeding program has its own rice improvement objectives and its project objectives that reflect the needs of the production area. Factors that influence production are grain quality and market demands that determine the profitability of rice production and are the major considerations in establishing breeding objectives (Marshall and Wadsworth, 1994).

Many genetic and environmental factors determine yield, and grain yield is one of the main activities in the later stages of screening breeding materials. Materials with high yield or unique quality characteristics are usually poorly adapted or agronomically inferior and

therefore unacceptable. Thus the objectives will vary among programs and growing regions, but some are common to rice improvement programs (Marshall and Wadsworth, 1994) hence the objectives of this research are;

- 1- To study variability among eight rice genotypes for some yield, yield components and morphological characters.
- 2- To estimate phenotypic and genotypic correlation coefficient between different characters that contributed to increase yield potential.
- 3- To determine the superior genotypes in performance under irrigated condition for further breeding by conventional methods.

CHAPTER TWO

LITERATURE REVIEW

2.1. Historical background:

Rice was first domesticated in Southern China and Northeastern India, probably independently about 8,000 years ago (Khush, 1997). The origin of cultivated rice has been a subject of debate. However, as data and evidence have accumulated over the years, it's clear that genus *Oryza* probably originated 130 million years ago and spread as a wild grass in Gondwanaland-the super continent that broke up into present-day Asia, Africa, the America, Australia, and Antarctica during the early cretaceous period. The genus *Oryza* is found on all these continents except Antarctica (Khush and Virk, 2000). The cultivated species originated from a common ancestor with AA genome. The common Asia rice *O. sativa* is grown around the world while the Africa rice *O. glaberrima*, is grown to a limited extent in a few countries (Kang and Priyadarshan, 2007).

The wild progenitor of *O. sativa* is the common Asian wild rice *O. rufipogon* which varies from perennial to annual types. Annual types, called *O. nivara* were domesticated, resulting in *O. sativa*. Based on archeological and historical evidence, the period of domestication of *O. sativa* began 7000 to 10000 years ago. This conclusion appears to be reasonable, given the fact that the oldest remain of Asian rice was found in eastern China and northern India back date to 7000 B.C. and then spread to Himalayas in India to upper Myanmar, northern Thailand, Laos, Vietnam and beyond to southwest or southern China (Chang, 1976a ; Khush, 1997).

Domestication of *O. glaberrima* is believed to have occurred much later than that of *O. sativa* (3.500 year later), probably in the Niger River delta (Porteres, 1956), from annual species *O. breviligulata*, which in turn evolved from perennial *O. longistaminata*. Centers of diversity for *O. glaberrima* are swamp upper Niger basins and some areas around Guinean coastline, (Kang and Priyadarshan, 2007).

2.2. Botanical description:

Rice is a semi-aquatic plant commonly grown in lowland fields where water is available during all stages of growth. Thus the rice plant consumes large amount of irrigation water (Castillo, 2002).

Rice is probably the most diverse of all food crops and grown as far north as Manchuria (50° N) in china and as far south as Uruguay and south Wales (35° S) in Australia (Khush and Virk, 2005). The Altitude at which rice grow successfully is 1600 m in central Africa, Burundi Rwanda and 1800 m in Madagascar (Raemaekers, 2001).

The growth cycle of rice may be divided into three phases, the vegetative phase, reproductive phase and phase of maturation. The vegetative phase stretches from germination to the end of tillering, the reproductive phase cover panicle initiation, rise of the panicle up the stem booting, emergence of the panicle (heading), flowering and fertilization (Raemaekers, 2001).

Rice plant has four principle parts; a fibrous root system, Culm, leaves and panicle (head) (Juliano, 1985).

2.2.1. Culm:

The main Culm is the first plant stem during early vegetative growth and prior to tillering. Culm is composed of a series of nodes and

internodes, and Culm has a genetically predetermined number of leaves that develop during the growing season (Smith and Dildaly, 2003).

2.2.2. Tillers:

Tillers are culms that develop from the main Culm, individual tiller are complex of shoot units, each capable of developing roots, leaf, tiller and panicle. Tiller developing from the main Culm are called primary tillers and those developing from primary Culm are called secondary tillers, subsequently, tertiary or quaternary tillers may developed before, panicle initiation, the plant could have a total of 40 tillers, 9 primary, 21 secondary 10 tertiary (Smith and Dilday, 2003).

2.2.3. Leaf:

Leaf blade is the major organ for photosynthesis and transpiration (IBPGR-IRRI, 1980). There is a genetic variation for leaf length and width between cultivars (Jennings *et al.*, 1979), and with position on main Culm for a given cultivar (Tanaka, 1965). Maximum leaf length is reached in the uppermost three to five leaves. The most modern early maturing cultivars develop 12 to 18 leaves on their main stem while the late maturing cultivars can develop up to 23 leaves (Hoshikawa, 1989; Vergara, 1991).

2.3. Rice production systems:

Four major agro-ecosystems are generally recognize (Khush, 1997); (1) Irrigated lowland rice (2) rained-fed lowland rice (3) upland rice (4) flood porn rice. All these production systems are associated with different abiotic stress such as drought, flooding, weeds infestation, soil salinity, acidity and poor nutrients supply. As a result of this, the highest rice yield are recorded in irrigated field while the lowest are found in

upland rice production system where high weed infestation, frequent droughts and poor nutrient supplies greatly limit rice yield.

2.4. Chemical composition:

Rice starch contains amylase and amylopectin whose proportions determine the organoleptic qualities of the rice. Rice grain containing 100% amylopectin is called glutinous or waxy rice. Decorticated rice contains about 12% water, 76% carbohydrate, 1% Fat, 10% protein and 1% minerals. A part from its use as a food; rice is used to produce starch, powder glucose, acetic acid (Raemaekers, 2001).

2.5. International rice improvement and production:

Pre-green revolution varieties of Asian rice in tropics and sub-tropics mature in 160-170 days and many were photoperiod sensitive because of this long duration. IR-8 and subsequent varieties such as IR-20, IR-26 and high yielding varieties (HYVs) were developed in National Agricultural Research Systems (NARS) during the 1970s and 1980. They mature in about 130 days therefore; development of varieties with shorter growth cycle becomes desirable. IR-28, IR-30, IR-36 mature in 110 days whereas IR-50 mature in 105 days. An (NPT) new plant types was conceptualized at IRRI in 1988. Breeding efforts to develop (NPTs) were initiated in 1990 to develop improved germplasm with 15-20% higher yield than the existing HYVs. Donor for the target traits were identified in the mid 1990 is and more than 500 NPTs had been evaluated in observational yield trials (Khush, 1995).

Breeding strategy adopted was to initially exploit the rich variability available in Indica itself and other sub-species of *O. sativa*. NPT developed have 8-10 synchronous tillers, plant high of 100 cm, extremely thick Culm, 150-175 grains per panicle, attest weight of 25 g,

and a slight longer grain filling period (Siddiq and Viraktamath, 2000). Modern semi-dwarf varieties produce a large number of unproductive tillers and excessive leaf area which cause mutual shading thereby reducing canopy photosynthesis and sink size. Further modification of plant architecture with characteristic of low tillering (9-10) tillers no unproductive tillers, 200-250 grains per panicle and erect leaves was proposed (Khush *et al.*, 1998).

At IRRI and in many national programs, breeding efforts to develop accessions possessing multiple resistances have been initiated. IR-26, the first variety improved with multiple resistances for pest and disease was released in 1973. In lowland ecosystem, submergence is as serious constraint as drought. Utilizing FR13A through marker assisted selection, some improved lines with submergence tolerance have been developed at IRRI (Xu *et al.*, 2006).

Successful efforts in inter specific crosses between the two cultivated genotype of rice *O. sativa* and *O. glaberrima* have resulted in the development of a new rice for Africa (NERICA) and are likely to usher in a green revolution (Jones *et al.*, 1997). These rice are weed competitors, drought resistance and tolerant to adverse soil condition, early maturing (75-100days) and high yielding (2.5t/ha). The NERICA rice was first developed in 1999. In 2005 more than 11 varieties were released from Africa rice center (Kang and Priyadarshan, 2007). Genetic engineering techniques hold great promise for development of rice varieties with drought tolerance (Garg *et al.*, 2002). However, demonstration of successful transformation in rice using agrobacterium has been a major breakthrough in genetic engineering (Hei *et al.*, 1994). Engineered rice with better nutritional quality (Vitamin A, golden rice), submergence tolerance, and male sterility are currently undergoing

evaluation before their expected release. However, application of molecular markers will make rice breeding more precise and efficient (Kang and Priyadarshan, 2007).

World production of rice accessed in September 2005 has risen steadily from about 200 million ton of paddy rice in the 1960s to 600 million ton of milled rice in about 68% of paddy rice by weight in a year 2004. The top three reproducers countries were China (26% of the world production), India 20%, and Indonesia 9%.

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2.6. Rice in Sudan:

In the Sudan, rice has been grown since 1905, but on limited acreage and information about methods of reproduction is lacking (Farah, 1981). Rice in Sudan is grown on 7.60 thousand hectares producing 30 thousand tones. However, Sudan produce an average of 3947 kg/ha (AOAD, 2008). Swamp and upland varieties were first tried at the Gezira research farm in 1951. Later, extensive rice trials were carried out at Malakal and several varieties were selected at the Gezira research station. Although rice cultivation in the Sudan was known for sometime, especially in southern Sudan and the White Nile area, large scale production started only in the year 1950 in the upper Nile province (Malakal) and in 1960 in Aweel. But for security reasons production was abandoned. Rice production was started once again along the White Nile at Abu Gassaba (Awok *et al.*, 1996).

Since 1974 up to 1979 rice research at Gezira research station has identified many of the major constraints to high yields in the Gezira. Environment and optimum cultural practices for the crop are now well

established and grain yield of 6.7 tones/ha was obtained. Despite this, the Agricultural policies did not encourage its production (Ghobrial, 1981).

2.7. Variability in rice crop:

Variation within a crop species are mainly hereditary variations that results from heritable causes and transmitted to the progeny. The hereditary variations are essential to the plant breeder, without them there could be no heritable plant improvement. It is difficult to judge what proportion of the observed variability is heritable and what is not heritable i.e., environmental. The process of breeding in such population is primarily conditioned by the magnitude and nature of genotypic and environmental variation (Poehlman, 1987).

Rice breeders set objectives, select parents, hybridize, select and test their materials. The ultimate goal is to recover the desirable features or enhancement of the parent. Curvature or distortion of the kernel as well as variability in size among grains on the panicle are undesirable characteristics (Marshall and Wadsworth, 1994). Anand *et al.*, (1998) studied variability in rice under cold condition and reported that number of filled grains /panicle, seed set percentage and grain yield/plant showed high variability.

Prasad *et al.*, (2001) studied genetic variability in fine rice and reported that (GCV) % ranged from 3.2% to 20.8% whereas (PCV) % ranged from 3.3% to 21.3%. Highest GCV% was obtained for 1000 grains weight followed by number of fertile grains/panicle, number of effective tillers/plant and yield/plant. Among them, 1000 grains weight, number of effective tillers/plant and number of fertile grains/panicle showed more than 15% variation at the phenotypic level (PCV) %.

Borbora and Hazarika, (1998) studied genetic variability for panicle characters in rice for thirty genotypes and reported significant variation among the genotypes for different characters. The difference between genotypic and phenotypic coefficient of variation were relatively low for almost all the characters except grain yield/plant.

Nuruzzaman *et al.*, (2002) studied variability for eight quantitative characters in 14 rice genotypes and found significant means squares indicating strong variability among the genotypes for the studied traits.

Rasheed *et al.*, (2002) studied variability on yield and its components in 15 rice genotypes and found significant difference among genotypes for all traits, indicating genetic diversity and hence selection was effective. Maximum variability was recorded in grain yield/plant, followed by productive tillers/plant and total number of tillers/plant. It was observed that phenotypic coefficient of variation was higher than genotypic coefficient of variation for all traits. Zaman *et al.*, (2005) investigated genetic variability of characters contributing to genetic in 15 genotypes and found that day to 50% flowering and 1000 grains weight made the largest contribution to yield then other traits.

Iftekharaddaula *et al.*, (2002) investigated genetic variability of characters contributing to genetic in irrigation rice genotypes. They found that, harvest index, panicle length, and 1000 grains weight were significantly and positively correlated with grain yield. The highest direct effect on grain yield was exhibited by spikelet/plant followed by plant height, harvest index, 1000 grains weight and panicle length. Hence, these traits were found important in offering good scope for the improvement of irrigated rice through traditional selection. Hassain *et al.*, (2005) studied variability of quantitative characters in five local and

three aromatic rice genotypes. They reported significant differences among varieties for grain yield, fertile tillers/hill, grains/panicle, panicle length and 1000 grain weight.

In India, Sarma *et al.*, (1996) studied variability for different characters in 39 upland rice genotypes, most of them were early maturing cultivars, and found significant mean sum of squares indicating strong variability among the genotypes for the studied traits. Genotypic coefficient of variation (GCV) % was the highest for effective tillers/m² (44.8%) followed by panicle weight (29.1%), secondary branches/panicle (28.8%), grain yield/m² (25.9%) and spikelet/panicle (25.4%).

Vange and Ojo (1997) studied variability on yield and its components in 10 early- duration and 12 medium duration of Nigerian lowland rice varieties. They reported that the phenotypic coefficient of variation PCV% was generally higher than genotypic coefficient of variation GCV% in both early and medium duration genotypes. The differences were low for days to 50% heading and plant height in medium duration rice group, in addition to panicle weight, panicle length and seed weight/panicle in the early-duration group. A moderate amount of variability (10-20%) was observed for days to 50% heading, plant height, panicle/m², panicle weight, number of seeds/panicle, and 1000 seed weight in medium duration category whereas in the early duration category plant height, tillers/m², panicle/m², branches/m², seeds weight/panicle, and 1000 seed weight showed a moderate amount of variability.

In Egypt, El Hissewy *et al.*, (1986) studied the genetic variance of grain yield and its major components in two crosses, Reiho× Ratna

(cross I) and calrose×IR28 (crossII). The yield components studied were number of ear-bearing tillers per plant, panicle length, panicle weight, number of filled grains/panicle and 100 grain weights. Additive genetic components significantly governed all traits except 100 grain weight in cross Reiho×Ratna.

2.8. Interrelationship:

Yield is polygenic controlled character and influenced by the environment. It is complex and is dependent on many component traits. The estimation of character association could identify the relative importance of independent character that may be useful as indicator for one or other characters (Sharaan and Ghallab, 1997). Yield is frequently negatively correlated with quality and the breeder must compromise between those two important objectives. Very high yield lines often exhibit poor grain quality characteristic making them unacceptable for release as cultivars (Marshall and Wadsworth, 1994).

El Kady *et al.*, (1990) studied the genetic variability of yield and its components and some agronomic characters of rice. The results showed positive and significant correlation between grain yield/plant and 1000 grain weight, number of spikelet/panicle and number of reproductive tillers/plant.

Aly (1979) investigated the phenotypic correlation in some short statured rice cultivar and strains. The results showed that there were highly significant and positive correlation between grain yield/plant and number of total tillers/plant, number of ear-bearing tillers/plant, and number of grains/plant.

El-Hity *et al.*, (1992) studied the phenotypic and genotypic variability in some rice genotypes. Significant positive phenotypic

correlation was reported among several characters especially grain yield components. However, heading date and plant height was not significantly correlated with grain yield. A study on correlation coefficient of yield and other agronomic traits revealed a highly significant and positive correlation between grain yield/plant and panicle length as well as 1000 grain weight and panicle as state by Aidy *et al.*, (1992). Padmavathi *et al.*, (1996) studied association of various yield components in rice and reported that number of tillers/plant, number of panicle/plant; panicle length and 1000 grain weight were positively associated with grain yield.

Mehetre *et al.*, (1996) studied variability and correlation in eight upland varieties treated with gamma rays. They reported that grain yield /plant was positively correlated with tillers/plant, but was negatively and significantly correlated with days to 50% flowering (-0.41) and maturity (-0.42), plant height (-0.77), panicle length (-0.30) and percent sterility (-0.77). Negative correlation of characters tiller/plant, panicle length and spikelet/panicle might be due to highest correlation with sterility. Percent sterility was positively and significantly correlated with plant height (0.579) and positively correlated with days to 50% flowering (0.38), maturity (0.37) and plant height (0.68). Both plant height and tiller/plant were significantly and positively correlated with days to 50% flowering (0.416 and 0.376) and maturity (0.425 and 0.361). Days to 50% flowering had highly significant and positive correlation with days to maturity (0.999).

Luzikihupi (1998) studied interrelationship between yield and some selected agronomic characters in rice. He found that grain yield was positively correlated with all characters except percent of unfilled grains and days to 50% flowering which had negative but non significant

correlation with grain yield. The negative association between yield and percent of unfilled grains was accepted since percent of filled grains/panicle had a high significant correlation with grain yield. The highest correlation coefficient with grain yield was record with the number of panicles/plant (0.72) $P= 0.001$ indicating the importance of this component in rice. Number of filled grains/panicle was positively correlated with panicle length (0.598) indicating that plants with large panicle tend to have a high number of fertile grains. Similarly, a positive correlation was observed between number of panicle/plant and panicle length.

CHAPTER THREE

MATERIALS AND METHODS

3.1. The experimental site:

The study was conducted at the experimental farm, college of Agricultural Studies, Sudan University of Science and Technology (Shambat) during the period in 10 August 2009 to February 2010. Shambat is located at longitude 32°-35° E, latitude 15°- 40° N, and altitude 280m above sea level. The climate of the locality is semi arid, with low relative humidity. The temperature varies between 45°C maximum and 21°C in summer and 15°C in winter (Adam, 2002).

The soil of the experimental site is described as loam clay. It is characterized by a deep cracking, moderately alkaline with low permeability, low nitrogen content and pH of 7.5-8 and a high exchangeable sodium percentage (ESP) in subsoil (Abdelhafiz, 2001).

3.2. Methods:

The plant materials used in the study is consisted of eight genotypes of Rice (*Oryza sativa* L.) (Table: 3-1). They were obtained from Agricultural Research Corporation (ARC) at White Nile State (kosti).

Land was deep ploughed with disc plough followed by disc harrow and then leveling. Ridging at spacing 0.7 m between rows. After that, land was divided into plots with ridges 3.5m long. The area of each plot was 4×4 meter. Treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. The experiment comprised 24 plots.

Seeds were planted by direct method on 10/8/2009 at seed rate of 120 kg/hectare. Seeds were sown at lateral site of the rows near the top

of the ridge. All plots were irrigated at sowing date, and then each plot was irrigated twice per week and continued until harvest. The total amount of rainfall received during the raining season 2009 is presented in Appendix (I).

Weeds were eradicated frequently by hand weeding. Nitrogen fertilizer was applied to the experiment at a rate of (N 150 Kg/ha) in tow doses, one dose after one month from sowing date, and the second doses after month of adding the first dose. Generally the experiment was well established with no incidence of pest or disease except termites *Microtermes thoracalis*. They were controlled chemically by dourouspand EC 48% in two doses during the vegetative stage. Bird scarring was done on selected plants for yield attribute to protect the plants from bird damage.

3.3. Data collection:

Parameters measured were.

3.3.1. Plant height (cm):

Plant height was measured from the surface of the ground up to the top of the panicle on five randomly selected plants in each plot.

3.3.2. Stem diameter (mm):

Measured as the average thickness of the main Culm, using vernier caliper on main stem of five randomly selected plants.

3.3.3. Number of leaves per plant:

The total number of leaves per plant, including leaves of tillers and main Culm leaves, was counted from five randomly selected plants per plot. Then average number of leaves per plant was obtained.

3.3.4. Leaf area (cm²):

Measured on the three leaves on the main Culm down the flag leaf, length of each leaf was measured from basic of leaf up to apex, also

width of three leaves in middle was measured, and then the leaf area was calculated according to Stickler *et al* method (1961).

$$\text{Leaf area (cm}^2\text{)} = \text{length of leaf} \times \text{maximum width} \times 0.75$$

3.3.5. Days to 50% flowering (days):

Recorded as days from sowing date to time when 50% of the plants in each plot had reached flowering.

3.3.6. Days to 50% maturity (days):

Recorded as days from sowing date to time when seeds of the plant had reached physiological maturity.

3.3.7. Number of tillers per plant:

Number of tillers was counted from five plants selected randomly in each plot and then average number of tillers per plant was calculated.

3.3.8. Panicle length (cm):

It was measured from panicle base up to panicle tip of five randomly selected plants.

3.3.9. Grain length (mm):

Measured as the average from 20 randomly selected grains.

3.3.10. Number of grains per panicle:

The total number of filled grains and unfilled grains per panicle was counted from 20 panicles selected randomly from each plot. Then the average number of grains per panicle was calculated.

3.3.11. Number of filled grains per panicle:

Filled grains from 20 panicles selected randomly were counted and recorded as an average number.

3.3.12. Percentage of unfilled grains per panicle (%):

Average number of unfilled grains per panicle was counted from 20 different panicles in each plot. Then percentage of unfilled grain was computed according to the following formula.

$$\text{Percent of unfilled grain/panicle} = \frac{\text{number of unfilled grains/panicle} \times 100}{\text{total number of grains/panicle}}$$

3.3.13. Weight of 100 grain (g):

Hundred seeds were taken randomly from total seeds of each plot, then weighed and recorded as average weight for 100 grains.

3.3.14. Grain yield (Kg/ ha):

The total seed of plants in one linear meter along row in each plot was weight and recorded. Then yield kg/hectare was calculated according to the following formula;

$$\text{Grain yield kg/hectare} = \frac{\text{area in hectare (10000 m}^2\text{)} \times \text{seeds weight (kg)}}{\text{Unit area (0.7 m}^2\text{)}}$$

3.3.15. Harvest index (%):

Plants in one linear meter of row were harvested and dried, weight then the seeds was separated and weight. Harvest index was calculated according to the following formula

$$\text{Harvest index} = \frac{\text{yield weight}}{\text{total biomass of plant weight}} \times 100$$

3.4. Statistical analyses:

The collected data were subjected to individual statistical analysis as follows.

3.4.1. Analysis of variance (ANOVA):

The recorded data were subjected to individual analysis of variance to determine the extent of variation among the genotypes. Individual analysis of variance was carried out using program of analysis SAS Institute. Inc. 1997 for a randomized complete block design.

3.4.2. Coefficient of variation (C.V):

It was determined for each character studied.

$$\text{C.V} = \frac{\sqrt{\text{Mean Square of Error}}}{\text{Grand mean}} \times 100$$

3.4.3. Standard error (S.E) = $\sqrt{\text{Mean Square of Error}}$

3.4.4. Phenotypic (σ_{ph}^2) and genotypic (σ_g^2) variance:

They were estimated from individual analysis of variance (ANOVA) Table as follows;

$$\text{Phenotypic variance (} \sigma_{ph}^2 \text{)} = \sigma_g^2 + \sigma_e^2$$

$$\text{Genotypic variance (} \sigma_g^2 \text{)} = \frac{M_2 - M_1}{r}$$

Where:

r = number of replications

σ_e^2 = Error or environmental variance

M_2 = mean squares of genotypes

M_1 = mean squares of error

3.4.5. Phenotypic and genotypic coefficients of variation:

They were computed according to the formula suggested by Burton and De Van (1953) as follows:

$$\text{Phenotypic coefficients of variation (PCV \%)} = \frac{\sqrt{\sigma_{ph}^2}}{\text{Grand mean}} \times 100$$

$$\text{Genotypic coefficients of variation (GCV \%)} = \frac{\sqrt{\sigma_g^2}}{\text{Grand mean}} \times 100$$

3.4.6. Covariance analysis:

It was used to estimate genotypic and phenotypic covariance components between two traits (A and B). They were used further for the computation of genotypic and phenotypic correlation coefficient between different characters, using the formula suggested by Miller *et al.*, 1958.

$$\text{Phenotypic correlation (r}_{ph}\text{)} = \frac{\sigma_{ph}^{AB}}{\sqrt{(\sigma_{ph}^2 A) \times (\sigma_{ph}^2 B)}}$$

$$\text{Genotypic correlation (r}_g\text{)} = \frac{\sigma_g^{AB}}{\sqrt{(\sigma_g^2 A) \times (\sigma_g^2 B)}}$$

Where:

σ_g^{AB} = Genotypic covariance between two traits (A and B)

σ_{ph}^{AB} = Phenotypic covariance between two traits (A and B)

σ_g^A = Genotypic variance for trait A

σ_g^B = Genotypic variance for trait B

σ_{ph}^A = Phenotypic variance for trait A

$\sigma_{ph}^2 B$ = Phenotypic variance for trait B

3.4.7. Comparison between genotypes:

The means were separated using the least significant difference (LSD) at 5% level of significance according to the formula:

$$LSD = \sqrt{\frac{2 \times Error\ Mean\ Square}{r}} \times t$$

Where:

r : number of replications

**Table (3-1): List of seeds of eight genotypes of rice (*Oryza sativa* L.)
used in the study:**

Genotype	Source
WITA4	ARC
IR3240	ARC
WITA5	ARC
NERICA	ARC
ITA252	ARC
WITA7	ARC
TOX3081	ARC
IR2042	ARC

A.R.C. refers to Agricultural Research Corporation

Table (3-2): Analysis of variance (ANOVA) for a randomized complete block design for the characters studied at Shambat (2009/2010).

Source of variation	Degrees of freedom	Mean squares	F.calculate d
Replication	$(r-1) = 2$	M_3	M_3/M_1
Genotype	$(t-1) = 7$	M_2	M_2/M_1
Error	$(r-1)(t-1) = 14$	M_1	
Total	$(rt-1) = 23$		

M_3, M_2, M_1 mean square for replication, treatment and error, respectively

r = replication

t = treatment

CHAPTER FOUR

RESULTS

4.1. Phenotypic variability:

Statistical analysis of variance revealed a highly significant difference ($P \leq 0.01$) in plant height, stem diameter, number of leaves per plant, Leaf area, days to 50% flowering, days to 50% maturity, number of tillers per plant, grain length, number of grains per panicle, number of filled grains per panicle, weight of 100 grain, grain yield kg/ha, and harvest index. Significant differences ($p \geq 0.05$) for panicle length were observed and non significant differences for percentage of unfilled grains per panicle were found (Table 4-1).

4.1.1. Plant height (cm):

The results showed that the highest values (60.07, 69.70 and 75.87cm) were obtained by the genotypes WITA4, ITA252 and NERICA, respectively, while the lowest values (47.73, 51.83cm) were scored for the genotypes IR3240 and WITA5 respectively. The grand mean was 59.2 and the coefficient of variation was 9.28 (Table: 4-2).

4.1.2. Stem diameter:

Table (4-2) demonstrates that genotype ITA252 exhibited the highest value (9.90mm), whereas the lowest value (5.6mm) was scored by the genotype NERICA. The grand mean was 8.6 and the coefficient of variation was 7.53.

4.1.3. Number of leaves per plant:

The genotypes IR2042 and IR3240 obtained the highest number of leaves (88.4 and 93.4), whereas the genotypes NERICA attained the smallest number of leaves (29.60). The grand mean was 74.1 and the coefficient of variation was 15.85 (Table: 4-2).

4.1.4. Leaf area (cm²):

ITA252 and NERICA achieved the highest values (36.78 and 41.04 cm²), while the lowest values (26.32 and 26.61cm²) were recorded for the genotypes IR3240 and TOX3081 respectively. The grand mean was 30.3 and the coefficient of variation was 7.91 (Table: 4-2).

4.1.5. Days to 50% flowering:

The earliest genotypes were NERICA and WITA7, WITA4 that reached 50% flowering in 67 and 103 days respectively. The latest genotypes were WITA5 and IR3240 that reached 50% flowering after 135-138 days respectively. The grand mean was 116.6 and the coefficient of variation was 4.52 (Table: 4-2).

4.1.6. Days to 50% maturity:

The earliest genotypes were NERICA and WITA7, which reached 50% maturity in 97 and 133days respectively, while the latest one was genotype WITA5, which reached in 170 days to 50% maturity. The grand mean was 147.8, and the coefficient of variation was 3.29 (Table: 4-2).

4.1.7. Number of tillers per plant:

The highest values for number of tillers per plant (15.2, 15.27 and 15.33) were exhibited by the genotypes WITA5, WITA4 and IR3240 respectively while the lowest value (5.47) were attained by the genotype NERICA. The grand mean was 12.3 and the coefficient of variation was 16.4 (Table: 4-2).

4.1.8. Panicle length (cm):

The longest panicles (20.4, 20.6 and 21.4 cm) were attained by the genotypes ITA252, TOX3081, and NERICA respectively, whereas the shortest Panicles 17.2 and 17.6 cm were recorded for the genotypes WITA5 and IR3240 respectively. The grand mean was 19.3 and the coefficient of variation was 8.07 (Table: 4-2).

Table (4-1): Mean squares from individual analysis of variance
For growth and yield traits and it's components of eight
genotypes of rice (*Oryza sativa* L.) grown at Shambat in
Season 2009/2010.

Characters	Mean squares of blocks	Mean squares of genotypes	Mean squares of Error
Plant height (cm)	26.293 ^{ns}	258.956**	30.178
Stem diameter(mm)	1.803*	4.757**	0.647
No. of leaves/plant	468.662 ^{ns}	1150.582**	137.940
Leaf area(cm ²)	0.396 ^{ns}	91.063**	5.741
Days to 50% flowering	54.047 ^{ns}	1751.881**	27.756
Days to 50% maturity	32.792 ^{ns}	1842.952**	23.649
No. of tillers/plant	4.525 ^{ns}	33.705**	4.110
Panicle length (cm)	2.389 ^{ns}	6.602*	2.434
Grain length(mm)	0.177 ^{ns}	1.475**	0.158
No. of grains/panicle	525.343 ^{ns}	1050.283**	200.434
No. of filled grains/panicle	253.062 ^{ns}	526.780**	70.522
Percentage of unfilled grains/panicle (%)	360.474 ^{ns}	285.985 ^{ns}	136.360
Weight of 100 grains(g)	0.004 ^{ns}	0.327**	0.007
Grain yield kg/ha	54444.863 ^{ns}	1234271.575**	122380.922
Harvest index (%)	0.001 ^{ns}	0.016**	0.002

*, **= significant differences at p= 0.05 and p=0.01, respectively.

Ns= no significant difference.

Table (4-2): Means of different traits of eight rice genotypes grown at Shambat, 2009/2010.

genotype	Plant high (cm)	Stem diameter (mm)	No of leaves/ plant	Leaf area (cm ²)	Days to 50% flowering	Days to 50% maturity	No of tillers/ plant	Panicle length (cm)	Grain length (mm)	No of grains/ panicle	No of filled grains/p anicle	Percent of unfilled grain/pa nicle	Weight of 100 grains (g)	Grain yield kg/ha	Harvest index
WITA4	60.1	9.0	81.1	27.4	103.0	135.0	15.3	19.4	8.1	94.6	33.8	62.9	1.7	880.9	0.10
IR3240	47.7	9.0	93.4	26.3	135.7	167.3	15.3	17.6	7.5	76.6	24.3	68.1	1.8	954.1	0.11
WITA5	51.8	8.9	71.9	28.6	138.3	170.0	15.2	17.2	8.6	74.1	23.8	66.7	1.9	904.8	0.11
NERICA	75.9	5.6	29.6	41.0	67.7	97.7	5.5	21.4	9.4	58.9	17.5	70.5	2.7	741.7	0.15
ITA252	69.7	9.9	81.8	36.9	133.7	165.3	11.8	20.4	8.3	116.2	50.4	56.4	1.7	1639.7	0.15
WITA7	56.2	9.0	75.9	28.6	103.0	133.0	10.3	19.6	8.1	89.4	51.7	41.2	1.9	2611.5	0.29
TOX3081	56.0	8.8	70.8	26.6	120.7	152.3	11.8	20.6	8.6	94.8	43.1	52.4	2.0	1590.0	0.21
IR2042	55.9	8.6	88.4	26.9	130.3	162.0	13.4	18.5	7.2	64.6	24.3	63.4	1.6	848	0.08
Grand means	59.2	8.6	74.1	30.3	116.6	147.8	12.3	19.3	1.9	83.7	33.6	60.2	1.9	1271.4	0.15
C.V	9.28	7.53	15.85	7.91	4.52	3.29	16.4	8.07	4.84	16.92	24.99	19.40	4.47	27.52	28.49
SE±	2.04	0.28	4.45	1.14	4.81	4.91	0.74	0.39	0.15	4.51	3.06	2.89	0.07	137.67	0.02
LSD	9.62	1.23	20.57	4.20	9.23	8.52	3.55	2.72	0.70	24.82	14.71	22.45	0.15	675.33	0.08

4.1.9. Grain length (mm):

The longest grains (8.6 and 9.43mm) were attained by the genotypes WITA5 and NERICA respectively. The shortest grains (7.17 and 7.47mm) were recorded for the genotypes IR2042 and IR3240 respectively. The grand mean was 1.9 and the coefficient of variation was 4.84 (Table: 4-2).

4.1.10. Number of grains per panicle:

The highest values (89.4, 94.6, 94.8 and 116.2) were scored by the genotypes WITA7, WITA4, TOX3081 and ITA252 respectively. The lowest values (58.9, 64.6 and 74.1) were obtained by the genotypes NERICA, IR2042 and WITA5 respectively. The grand mean was 83.7 and the coefficient of variation was 16.92 (Table: 4-2).

4.1.11. Number of filled grains per panicle:

The highest values for number of filled grains per panicle (43.1, 50.4 and 51.7) were exhibited by the genotypes TOX3081, ITA252 and WITA7 respectively. While the lowest value (17.53) was attained by the genotype NERICA. The grand mean was 33.6 and the coefficient of variation was 24.99 (Table: 4-2).

4.1.12. Percentage of unfilled grains per panicle:

The highest Percentage of unfilled grains per panicle (68.07 and 70.5%) were Exhibited by the genotypes IR3240 and NERICA respectively. Whereas the lowest Percentage of unfilled grains (41.23%) was recorded by genotypes WITA7. The grand mean was 60.2 and the coefficient of variation was 19.40 (Table: 4-2).

4.1.13. Weight of 100 grain (g):

Table (4-2) shows that the highest values of 100 grains (1.9, 2.0 and 2.7) were obtained by the genotypes WITA7, TOX3081 and NERICA respectively. The lowest values (1.6 and 1.7) were achieved by

genotypes IR2042 and WITA4. The grand mean was 1.9, and the coefficient of variation was 4.47 (Table: 4-2).

4.1.14. Grain yield (kg/ha):

The highest values of grain yield kg/ha (1590, 1639.7 and 2611.5 kg/ha) were observed on the genotypes TOX3081, ITA252 and WITA7, respectively. These genotypes were superior in their performance, while the lowest values of grain yield (741.7 and 848.5 kg/ha) were attained by the genotypes NERICA and IR2042. The grand mean was 1271.4 while the coefficient of variation was 28.49 (Table: 4-2).

4.1.15. Harvest index (%):

The highest value (0.294) was attained by the genotype WITA7, while the lowest value (0.077) was recorded by the genotype IR2040. The grand mean was 0.15 and the coefficient of variation was 28.49 (Table: 4-2).

4.2. Phenotypic variance (σ_{ph}^2) and genotypic variance (σ_g^2):

Phenotypic variance had higher values than the genotypic variance. The highest values of phenotypic variance (475.48, 483.75, 602.46, 630.08 and 493011.4) were scored by the number of leaves per plant, number of grains per panicle, days to 50% flowering, days to 50% maturity and grain yield kg/ha respectively. The lowest values (0.01, 0.11, 0.597, 1.86, 3.82 and 9.87) were obtained by harvest index, weight of 100 grain, grain length, stem diameter, panicle length and number of tillers per plant respectively (Table: 4-3). For genotypic variance, the number of grains per panicle, number of leaves per plant, days to 50% flowering, days to 50% maturity and grain yield kg/ha scored the highest values (283.28, 337.55, 574.71, 606.43, 370630.2) respectively, whereas the lowest values (0.01, 0.12, 0.44, 1.39, 1.45) were scored by harvest

Table (4-3): Phenotypic (PCV) % and genotypic coefficients of variation (GCV) %, phenotypic and genotypic variance, for the different characters studied on eight genotypes of rice evaluated at Shambat in Season 2009/2010.

Traits	Phenotypic variance	Genotypic variance	Phenotypic coefficients of variation PCV%	Genotypic coefficients of variation GCV%
Plant height (cm)	106.35	76.26	17.44	14.56
Stem diameter (mm)	1.86	1.45	15.90	14.56
No. of leaves /plant	475.48	337.55	29.42	24.79
Leaf area (cm ²)	34.18	28.44	19.31	17.61
Days to 50% flowering	602.46	574.71	21.05	20.56
Days to 50% maturity	630.08	606.43	16.98	16.66
No. of tillers/plant	13.98	9.89	30.32	25.48
Panicle length(cm)	3.82	1.39	10.11	6.10
Grain length (mm)	0.597	0.44	9.40	8.06
No. of grains/panicle	475.48	283.28	26.29	20.12
No. of filled grains/panicle	222.6	152.09	44.40	36.70
Percentage of unfilled grains/panicle	185.57	49.21	22.63	11.66
Weight of 100 grain (g)	0.11	0.12	17.84	17.27
Grain yield kg/ha	49311.4	370630.2	55.23	47.88
Harvest index (%)	0.01	0.01	0.53	0.45

Index, weight of 100grains, grain length, panicle length and stem diameter, respectively (Table: 4-3).

4.3. Phenotypic (PCV %) and genotypic (GCV %) coefficients of Variation:

Table (4-3) displays estimation of phenotypic coefficients of variation (PCV %) and genotypic coefficients of variation (GCV %) among the studied characters of eight rice genotypes. Phenotypic coefficients of variation had higher values than the genotypic coefficients of variation for all studied traits. Number of leaves per plant, number of tillers per plant followed by number of filled grain per panicle and grain yield kg/ha, exhibited the highest values of phenotypic coefficients of variation (29.4, 30.3, 44.4 and 55.2%) respectively. The lowest values (0.53, 9.4, 10.1 and 15.9%) were scored by harvest index, grain length, panicle length and stem diameter respectively (Table: 4-3). The highest values of genotypic coefficients of variation (24.8, 25.5, 36.7 and 47.9%) were obtained by number of leaves per plant, number of tillers per plant, number of filled grains per panicle and grain yield kg/ha respectively while the lowest values of genotypic coefficients of variation (0.45%, 6.10%, 8.06%, 11.66%) were scored by harvest index, panicle length, grain length, and percent of unfilled grains per panicle respectively (Table: 4-3).

4.4. Interrelationships between characters:

Simple linear phenotypic and genotypic correlation coefficients between 15 traits studied at Shambat are presented in (Table: 4-4). The genotypic correlation coefficients for most of the traits were higher than the corresponding phenotypic correlation coefficients.

4.4.1. Correlation between growth, yield and its components:

4.4.1.1. Phenotypic correlation:

Grain yield was positively and highly significantly correlated with number of filled grains per panicle and harvest index (0.81, 0.83) respectively (Table: 4-4). Grain yield showed a positive and non significant different correlation with panicle length, number of leaves per

plant, number of grains per panicle, days to 50% maturity and stem diameter (0.26, 0.16, 0.46, 0.04 and 0.32) respectively (Table :4-4). The association between grain yield and plant height, grain length, leaf area, number of tiller per plant, percentage of unfilled grains per panicle, days to 50% flowering and weight of 100 grain were negative and non significant (-0.01, -0.02, -0.25, -0.15, -0.66, -0.02 and -0.10) respectively (Table :4-4).

4.4.1.2. Genotypic correlation:

Grain yield was highly significantly and positive correlated with number of filled grains per panicle and harvest index (0.93 and 0.94) (Table: 4-4). Grain yield was positive and non significantly related with panicle length, leaf area, number of leaves per plant, number of grains per panicle, days to 50% maturity, days to 50% flowering and stem diameter (0.27, 0.01, 0.15, 0.61, 0.07, 0.02 and 0.43) respectively (Table:4-4). Grain yield was negative and highly significantly linked with percentage of unfilled grains per panicle (-1.29). Plant height, number of tillers per plant, grain length and weight of 100 grain obtained a negative and non significant correlation with grain yield (-0.1, -0.23, -0.01 and -0.16) respectively (Table: 4-4).

Table: (4-4): Estimation of genotypic correlation (above the diagonal) and phenotypic correlation (bellow the diagonal) of eight rice genotypes.

traits	Plant height	Stem diameter	No. of leaf /plant	Leaf area	Days to 50% flower	Days to 50% mature	No. of tiller/plant	Panicle length	Grain length	No. of grains / panicle	No. of filled grains	Per. of unfilled grains	Weight of 100 grains	Grain yield kg/ha	Harvest index
Plant height	-	-0.66	-0.72*	-0.99**	-0.67*	-0.69*	-0.95**	0.93**	0.77**	0.10	0.06	0.12	0.70*	-0.10	0.20
Stem diameter	-0.44	-	0.99**	-0.66	0.85**	0.88**	0.80**	-0.63	-0.66	0.80*	0.71*	-0.74*	-0.96**	0.43	0.07
No. of leaves/plant	0.69*	0.71*	-	-0.81**	0.87**	0.81**	0.91**	-0.91**	-0.99**	0.40	0.33	-0.34	-1.05**	0.15	-0.12
Leaf area	0.83**	-0.45	0.60	-	-0.58	-0.57	-0.87**	0.61	0.81**	-0.03	-0.11	0.33	0.75*	0.01	0.22
Days to 50%flowering	-0.65	0.75*	0.67*	-0.55	-	0.99**	0.87**	-1.05**	-0.67*	0.34	0.17	-0.06	-0.76*	0.02	-0.33
days to 50% maturity	-0.62	0.71*	0.68*	-0.57	0.96**	-	0.83**	-0.76*	-0.55	0.47	0.24	-0.73*	-0.72*	0.07	-0.26
No. tillers/plant	-0.52	0.64	0.74*	-0.64	0.67*	0.68*	-	-1.15**	-0.68*	0.32	-0.08	0.27	-0.90**	-0.23	-0.56
Panicle length	0.76*	-0.27	0.38	0.57	-0.58	-0.51	-0.60	-	0.79**	0.30	0.56	-0.70*	0.75*	0.27	0.99**
Grain length	0.49	-0.51	-0.74*	0.64	-0.56	-0.46	-0.66	0.44	-	-0.07	-0.04	0.07	0.96**	-0.01	0.32
No.of grains/panicle	0.06	0.62	0.39	0.07	0.28	0.31	0.11	0.12	0.01	-	1.01**	-1.11**	-0.46	0.61	0.40
filled grain/panicle	0.01	0.47	0.27	-0.06	0.12	-0.21	0.03	0.12	-0.06	0.67*	-	-1.04**	-0.38	0.93**	0.70*
Unfilled grain/panicle	0.10	-0.20	-0.13	0.15	0.01	-0.96**	-0.01	-0.01	0.10	-0.16	-0.83**	-	0.45	-1.29**	-1.01**
100 grain weight	0.52	-0.78**	-0.83**	0.64	-0.73*	-0.66	-0.75*	0.42	0.77**	-0.38	-0.26	0.11	-	-0.16	0.27
Grain yield kg/ha	-0.01	0.32	0.16	0.10	-0.02	0.04	-0.15	0.26	-0.02	0.46	0.81**	-0.66	-0.10	-	0.94**
Harvest index	-0.08	-0.01	-0.37	0.18	0.31	-0.18	-0.39	-0.07	0.29	0.19	0.67*	0.32	0.26	0.83**	-

*, ** Significant difference at $p \geq 0.05$, $p \geq 0.01$ respectively

Ns: no significant difference.

CHAPTER FIVE

DISCUSSION

5.1. Phenotypic variability:

Individual analysis of variance of different traits revealed highly significant differences for all of traits among the studied eight rice genotypes (*Oryza sativa* L.). High variation among rice genotypes could be due to a wide diversity in plants genetic materials, hence knowledge of existing genetic variation assumes important and will offer good scope for improvement of irrigated rice through traditional selection. These results are similar to finding reported by many workers (Anand *et al.*, 1998. Borbora and Hazarika, 1998. Natarajan *et al.*, 2005. Hassain *et al.*, 2005).

In this study (Table: 4-2) and for plant height the result generally revealed that the shortest genotypes scored the highest yield per kg/ha. Similar results were reported by Prasad *et al.*, (2001) who stated that dwarf plant is an important trait in selection for high yield in rice. Also the genotypes scored the highest values of panicle length; number of filled grains per panicle attained the highest grain yield. Similar findings were stated by Ramlingam *et al.*, (1993) who reported that, for high yield in rice, plants should have long panicle and large number of filled grains per panicle. The percentage of unfilled grains per panicle seemed to be higher in this study and affected yield negatively. This may be due to environmental stress or genetic factors. Luzikihup (1998) reported that in order to increase yield in rice, it is important to reduce spikelet sterility or increase spikelet fertility. Also number of tillers per plant affected negatively grain yield. Genotypes with large number of tillers per plant attained low yield and genotypes with less number of tillers

obtained high yield. This may be due to the effect of decreasing or increasing number of effective tillers (bear tillers) per plant. Samonte *et al.*, (1998) state that higher number of effective tillers per plant is important trait which should be considered in selection for high yield rice. The genotypes obtained the large or low number of grains per panicle has various effects on grain yield. Similar results were observed by Kato (1997) who stated that increasing number of spikelets per panicle does not always result in higher grain yield, but with increased filled grains percentage it increases yield.

5.2. Phenotypic variance (σ^2_{ph}) and genotypic variance (σ^2_g):

In this study the phenotypic variance of all traits showed highest values than the genotypic variances. Similar findings were reported by (Rasheed *et al.*, 2002. Reddy and De, 1996. Luzikihupi, 1998). Most values of phenotypic variance among the study traits were higher which indicates that's the responses of genotypes to environmental stress were more pronounced in rice growth stages within genotype or among genotypes are various. Also most of genotypic variances values among the studied traits of the genotypes were higher. This indicates that the greater genetic variability among genotypes could be due to differences in material used.

5.3. Genotypic coefficients of variation (GCV) %:

The genotypic coefficients of variation GCV% indicates the range of genetic variability present in the population and help to compare genetic variability present in various characters. In this study all traits showed low value of genotypic coefficients of variation (GCV) % than the corresponding phenotypic coefficients of variation, these finding agreed with (Adam, 2007).

5.4. Interrelationship between characters:

Correlation coefficients of variation among characters studied in eight genotypes of rice were used to identify characters in positive linkage with grain yield traits with relevant significant increase in yield. In this study positive significant phenotypic correlation coefficients of variation were found between grain yield and the number of filled grains per panicle, harvest index, panicle length, number of leaves, number of grains per panicle, days to 50% maturity and stem diameter.

Genotypic correlation coefficients for grain yield with number of filled grains per panicle, harvest index, panicle length, leaf area, number of leaves, number of grains per panicle, days to 50% flowering, days to 50% maturity, stem diameter and weight of 100 grains gave positive correlation. These correlations could be attributed the effect of genes rather than the effect of the environment (Falconer, 1980). Such, associations have to be attributed to pleiotropy or linkage (Yassin, 1973) or may be due to developmentally induced relationship between these components that are indirectly the consequence of gene action (Adam, 1967). This indicates that selection of such positive associated characters could improve and increase rice yield.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

6.1. Summary:

Rice (*Oryza sativa* L.) with its essential traits has become an important research in the Sudan. Selection or production of new varieties with high yield, early maturity and adapted to Sudan environment are the main challenges facing rice production in the Sudan.

Based on previous findings. Highly significant differences were observed for all characters studied on genotypes except percentage of unfilled grains per panicle give non significant differences.

Phenotypic coefficients of variation and phenotypic variances for all of studied traits among rice genotypes recorded high values than the genotypic coefficients of variation and genotypic variance. On the other hand, genotypic correlation coefficients gave absolutely high associated values than phenotypic correlation for most traits in the studied genotypes, Positive genotypic correlation were found between grain yield with number of filled grains per panicle, harvest index, panicle length, leaf area, number of leaves per plant, number of grains per panicle, days to 50% flowering, days to 50% maturity, stem diameter. Positive phenotypic correlation were observed between grain yield with the number of filled grains per panicle, harvest index, panicle length, number of leaves per plant, number of grains per panicle, days to 50% maturity and stem diameter.

6.2. Conclusions:

1- The wide range of variability existed between the studied genotypes for most of the characters could be of a great benefit in any rice breeding program.

2- The positive correlation genotypic and phenotypic observed between yield and panicle length, number of filled grains per panicle, harvest index, number of leaves per plant, days to 50%flowering, stem diameter, number of grains per panicle and days to 50% maturity, could be promising and illustrate that these characters can be used as indicators in selection for high yielding rice genotypes.

3- The genotypes TOX3081-36-2-2-3-1, ITA252 and WITA7 Identified in possessing potential of superior performance in growth and high yield. These genotypes are proposed to be grown at location under Irrigated condition. These high yielding genotypes can be used as parental lines for any rice breeding program.

4- Rice grain yield is a product of number of filled grains per panicle, panicle length and number of effective tillers per plant.

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APPENDIX

Appendix (I): Mean of maximum and minimum temperature, relative humidity and rains fall season 2009/2010.

Month	Maximum temperature	Minimum temperatur e	Relative humidity%	Rain Fall (mm)
July	38.8	26.2	43	11.1
August	38.8	26.5	46	3.0
September	40.9	27.2	39	1.2
October	39.5	23.8	30	0.2
November	35.3	20.5	28	Nil
December	31.3	15.2	29	Nil
January /2010	32.7	16.3	32	Tr
February	34.2	17.1	28	Nil

Source: Shambat Agro meteorological observation.

Appendix (II): Chemical and physical properties of the field soil

pH phaste	8.2
ECe (Ms / M ²)	1.05
CEC (Meg / 100 g)	43.78
Sar	5.59
O.M(%)	0.46
Available P(PPM)	2.58
CaCO ₃ (%)	4.00
Ca (Meg / L)	2.00
Mg (Meg / L)	1.50
Na (Meg / L)	7.39
K (Meg / L)	0.0213
CO ₃ (Meg / L)	NA
HCO ₃ (Meg / L)	5.80
Cl (Meg / L)	7.50
Fe (Mg / L)	4.742
Zn (Mg / L)	0.085
Cu (Mg / L)	0.305
Sand (%)	32.7
Silt (%)	32.7
Clay (%)	42.8

Source: Abdel hafez (2001).