CHARACTERIZATION OF SOME ADVANCED LINES OF AMAN RICE (*Oryza sativa* L.) FOR RELEASE AS VARIETY

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CERTIFICATE

*This is to certify that the thesis entitled "**CHARACTERIZATION OF SOME ADVANCED LINES OF AMAN RICE (Oryza sativa L.) FOR RELEASE AS VARIETY**" submitted to the department of **Genetics and Plant Breeding,** Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Genetics and Plant Breeding embodies the result of a piece of bona fide research work carried out by MD. KANOB HASNAT, Registration No. 12-04775 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by the Author.

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Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED

PARENTS

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CHARACTERIZATION OF SOME ADVANCED LINES OF AMAN RICE (*Oryza sativa* L.) FOR RELEASE AS VARIETY

BY

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ABSTRACT

The investigation was carried out under field conditions to characterize thirteen advanced lines of aman rice during the period of aman season 2017 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka. These thirteen advanced lines of aman rice were characterized for fifteen qualitative and nineteen quantitative traits. All the genotypes were characterized and categorized as Biodiversity international, IRRI and WARDA. 2007. Among the qualitative characteristics no variation was observed for basal leaf sheath color, leaf blade pubescence, ligule shape and all the genotypes were green, pubescent, 2- cleft type respectively. All the genotypes were lodging resistance. Only two types of ligule and auricle color viz. whitish and yellowish green were found. Among thirteen genotypes ten genotypes viz. (G01, G05, G06, G07, G08, G09, G10, G11, G12 and G13) had well exerted type panicle. Only G08, G09 and G12 were partly awned and G11 was fully awned. Among the quantitative characteristics no variation was observed in case of grain length and grain width and all the genotypes had similar type extra-long (9.10mm) and fine (1.76mm) width grain. Average culm length was 110.24 cm and G06, G09 and G10 showed intermediate to long type's culm length. Genotype G11 showed the highest tiller number as well as effective tillers per hill (21.1 culms and 20.53 culms respectively). Long panicle length with higher number of grains per panicle which were the agronomic superiority. The average panicle length was 27.17 cm and mean total grain was 175.15 per panicle which contributed to an average yield of 35.5 g per plant. G05 showed the highest yield but there were no significant difference among the genotypes G01, G05, G08 and G09 and G11 showed short maturity duration.

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LIST OF ABBREVIATED TERMS

Full Name	Abbreviation
Agro Ecological Zone	AEZ
Agriculture	Agric.
Agronomy	Agron
Advanced Line	Al
At the Rate	@
Bangladesh Burea of Statistics	BBS
Biology	Biol.
Biotechnology	Biotech
Breeding	Breed
Bangladesh Rice Research Institute	BRRI
Centemeter	cm
Degree Celcius	^{0}C
Ecology	Eco.
Environment	Env.
And others	*Et. al*
Food and Agricultural Organization	FAO
Genetics	Genet.
Genotype	G
High Yielding Variety	HYV
International	Int.
Journal	J
Meter	m
Milimeter	mm
Murate of Potash	MP
Physiological	Physiol.
Hydrogen Ion Concentration	pH
Randomized Complete Block Design	RCBD
Research	Res.
Science	Sci.
Square Meter	m^2

ABBREVIATED TERMS (CONT'D)

Full Name	Abbreviation
Technology	Tech.
Triple Super Phosphate	TSP
Transplant aman	T. aman
West Africa Rice Development Association	WARDA
Wetable Powder	WP

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is a plant belonging to the family of grasses, Poaceae. It is one of the three major food crops of the world and forms the staple diet of about half of the world's population. The global production of rice has been estimated to be at the level of 650 million tones and the area under rice cultivation is estimated at 156 million hectares (FAO, 2017).

Asia is that the leader in rice production accounting for regarding 90% of the world's population. Over seventy five of the globe offers is consumed by people in Asian countries and therefore rice is of vast important to food security of Asia. The demand for rice anticipated to extend more seeable of expected increase within the population.

According to the BBS report 2016-2017, The total area under aman crop has been estimated 1,37,96,773 acres (55,83,252 hectares). Total aman production of financial year 2016-2017 has been estimated 1,36,56,054 metric tons and average yield rate has been estimated 2.446 metric tons husked rice per hectare, where broadcast aman, local and HYV production was 1.208 metric tons, 1.681 metric tons and 2.742 metric tons per hectares respectively.

Attemps to beat the rice yield limitation by raising yield, resistance to pests and diseases and adaptableness to various growing conditions, have consisted of breeding programs and therefore the development of hybrid rice varieties. Hybrid rice has been developed in China since 1974 and now is planted in almost 40% of Chinese rice fields (Fujimaki and Matsuba, 1997; Sasaki, 1997).

There are thousands of rice varieties, genotypes, land races and wild species which differ with respect to plant and grain characteristics like plant type, height, nature of leaves, grain size, texture, glutinous nature, aroma, cooking and nutritive quality. Selection of the right type of cultivar is most important factor for optimizing rice production. Although morphological traits have a number of limitations including low polymorphism, low heritability, late expression and vulnerability to environmental influences then morphological characterization is the first step in the classification and evaluation of the germplasm (Smith and Smith. 1989; Smith *et al.,* 1991).

Morphological characterization of germplasm accessions is prime so as to supply info for plant breeding program. Morphological characterization provides the mark of identification that distinguishes one genotype from alternative. Techniques, like plant characterization are with success utilized in recent years to assist in distinctive elite people. It is an imperative tool for choosing varieties or lines supported agronomic, morphological, genetic or physiological characters (Ndour, 1998). Assortment and characterization of this germplasm isn't solely necessary for utilizing the acceptable attribute primarily based donors in breeding programs, however is additionally essential within the gift era for shielding the distinctive rice. However, the employment of the genetic resources of the rice crop is generally being employed for higher yields and early maturity (Ogunbayo *et al.,* 2005).

Qualitative characters are necessary for plant description (Kurlovich, 1998) and are influenced by consumer preference, socio-economic and natural selection. Many morphological characters are the key crucial factors of rice grain yield. Genetic diversity most likely is associate degree insurance against crop failure (Subba Rao *et al.,* 2001).

A variety will not be fully accepted only for its high yielding properties until it's combined with good acceptable grain qualities that meet farmers' needs and culinary preferences. Therefore, there is need to understand available genetic resources for better quality traits since inferior grain quality of the currently high yielding varieties in the domestic market is a dominant phenomenon (Somado *et al.,* 2008).

The rice cropping pattern of Bangladesh has changed. As a result the contribution from every season also changed. Aman rice previously contributed a major portion of total rice however boro is now the major contributor to total rice production in the country. Aus, aman and boro rice were recently reported to account for 7%, 38% and 55% respectively of the total rice production in Bangladesh. (Risingbd, 2014). However, if we have to select short duration and high yielding lines of aman rice that's why we can get higher yield from aman lines. We may contribute higher percentage of total production in Bangladesh.

There is limited number of aman rice variety have been released by BRRI. So, we have to develop aman high yielding variety. For the event of high yielding rice varieties the crossing materials between two high yielding rice varieties might play an important role as parent materials as a result of their most adjustive to the environment. Characterization of advanced lines is the prerequisite to develop modern aman rice variety. It'll pave the ways that for further breeding programs of these advanced lines. So the current investigation was undertaken with the following objectives:

1. To characterize advanced aman lines as per descriptors
2. To select short duration lines of aman rice
3. To select high yielding lines
4. To find out the advanced lines which have potential traits for using in further breeding program as parent material

CHAPTER II

REVIEW OF LITERATURE

The literature relevant to the current investigation entitled "Characterization of some advanced lines of aman rice (*Oryza sativa* L.) for release as variety" through morphological characters has been reviewed during this chapter.

The assessment of genetic diversity is associate degree integral a part of any productive breeding program. Typically breeders are using morphological markers for genetic diversity estimation and variety of morphological descriptors in various crops are vogue for characterization purpose (Rana and Bhat, 2004). Morphological characters of seeds like seed coat color, seed shape, seed length, seed width, kernel length, kernel breadth, kernel shape, presence of awn, thousand seed weight etc. and traits of plants like culm length, time of heading, time of maturity, number of primary branches, number of secondary branches, panicle length, number effective tillers per plant, grain per panicle etc. can invariably be utilized in characterization of rice genotypes. Genetic studies have revealed that these characters are simply heritable and highly hereditary and therefore, could be readily used in distinguishing varieties.

Mehla and Kumar (2008), concluded that there exists wide variation among the rice cultivars in respect to morphological characters viz. awn length, panicle length, leaf blade color and leaf sheath color, node base color, awning, distribution of awns, stigma color, anthocyanin coloration of stem nodes and internodes, hence, these characters can be used for identification of rice cultivars.

Rosa *et al*. (2006), characterized eight populations of *O. glumaepatula* Steud. collected in different hydrographic basins.

Mathure *et al*. (2011), characterized 69 genotypes for agronomic traits and found 36 exquisite genotypes out of them that possessed one or more superior traits such as early flowering, dwarf stature, higher number of productive tillers per plant, long panicles, higher number of filled grains per panicle and strong aroma.

Moreover, when Ashfaq *et al*. (2012), associated various morphological traits with yield, there was a strong association revealed between the plant yield and the other yield component traits namely panicle length, number of seeds per panicle, productive tillers per plant and seed weight per panicle. The yield component traits were associated with other traits that also had a great contribution to the improvement of yield. For instance, panicle length was associated with flag leaf area, number of primary branches per panicle, number of spikelets per panicle, number of seeds per panicle and grain weight per panicle were directly or indirectly associated with the plant yield, leading to increased rice yield.

Sarawgi *et al*. (2014), on the basis of frequency distribution for eighteen qualitative traits of 408 rice germplasm accessions reported that majority of genotypes possessed green basal leaf sheath color (87.25 %), green leaf blade color (89.70 %), pubescent leaf (48.03 %), well panicle exertion (57.10 %), white stigma color (65.93 %), straw apiculus color (78.18 %), compact panicle type (55.63 %), awnless (88.48 %), white seed coat (82.84 %), straw hull color (70.34 %), intermediate threshability (47.30 %), erect flag leaf angle (57.59 %), medium leaf senescence (67.15 %) and straw sterile lemma (97.05 %).

Singh *et al.* (2014), evaluated forty eight upland rice germplasm accessions and characterized for fourteen quantitative and fifteen qualitative traits. The accessions PKSLGR-16, PKSLGR-23, PKSLGR-43 and PKSLGR-45 were found to be most promising for yield and two to four of its component traits.

Kumar *et al.* (2016), characterized 64 aromatic rice germplasm for 35 agro morphological and quality traits and all 64 rice germplasm were found to be distinct on the basis of thirty one agro-morphological and quality traits. Accessions having short stem length, very long panicle length, more number of panicle per plant, and extra-long slender grain may be used as potential donor in hybridization programs.

Choudhury *et al.* (1999), studied 64 indigenous rice varieties to know the nature and magnitude of genetic divergence among them. Based on nine agro morphological characters, these genotypes were grouped into five clusters and found that plant height, tiller number, earliness, grain size and grain yield contributed considerably to total divergence.

Sarawgi (2008), characterized thirty two aromatic rice accessions of Badshahbhog group from IGKV. Raipur, Chhattisgar germplasm. These germplasm accessions were evaluated for twenty-two morphological, six agronomical and eight quality characters viz. leaf blade pubescence, leaf blade color stigma color, lemma and palea color, lemma and palea pubescence etc. The specific genotypes B: 1340, B: 2039, B: 2495, B: 2816, B: 16930, B: Z354, B: 1163, B: 2094 were identified for quality and agronomical characteristics. It was concluded that these accessions may be used in hybridization program to achieve desired segregate for good grain quality with higher yield.

Buchanan-Wollaston *et al.* (2003), stated that leaf senescence is a key developmental step in the life of annual plants. During growth, green leaves accumulate nutrients. The main purpose of senescence is the mobilization and recycling of these nutrients to the developing seeds to prepare the next generation. Developmental signals, aging, or stress can induce leaf senescence. The final stage of this process is death, but cell death is actively delayed until nutrients have been removed.

Hortensteiner and Feller (2002), stated that during senescence, cell constituents are dismantled in an ordered progression. Chlorophyll degradation is the first visible symptom of senescence, but by the time yellowing can be seen, some senescence has already occurred. Chlorophyll, protein, and lipid degradation processes have been largely investigated.

Ookawa *et al.* (2010) and Chen *et al.* (2005), stated that morphological characteristics such as culm thickness, leaf size, leaf angle, and plant height at the heading stage have been considered important traits in breeding both super rice and bioenergy crops.

Ma *et al.* (2004), and Khush (2000), stated that cultivars with large culms, therefore, may be ide types for super rice breeding because the characteristics of semi-dwarfism, lodging resistance, and heavy panicles have been considered to be important traits for super rice breeding.

Hirose *et al.* (2006), found that improving lodging resistance, a thick culm may also act as a carbohydrate store for high yield in rice.

Khush and Peng (1996), stated that one important approach is to find a new plant type with ideal morphology, large panicles, high photosynthetic efficiency, and strong lodging resistance.

Chen *et al.* (2005) and Xu *et al.* (2005), found that morphological characteristics, including stem thickness, leaf size, leaf angle, neck stem vascular bundle abundance, and plant height during the heading stage are important indices in super rice breeding.

Duan *et al.* (2004), Ma *et al.* (2004), and Khush (2000), found that characteristics such as semi-dwarfism, strong lodging resistance, and large panicles are considered the most important traits in super rice breeding.

Xu *et al.* (2005), stated that panicle length is strongly negatively correlated with the grain insertion density, grain quality, and seed-setting ability because excessive panicle length is not favorable for erect positioning and thus disadvantageous for photosynthesis.

Akhtar *et al.* (2011), studied the genotypic and phenotypic correlation for yield contributing characters in ten rice genotypes. Paddy yield had strong genetic correlation with number of grains per panicle, days to maturity and 1000 grain weight. Paddy yield had significant positive correlation with number of grains per panicle and 1000 grain weight.

Doebley *et al.* (2006), found that series of morphological and physiological characteristics distinguish the wild and cultivated species, such as seed shattering, stem growth habit, awn length, and hull or seed color.

Hu *et al*. (2011), stated that awns in cultivated rice were partially or completely eliminated by artificial selection for the convenience of agricultural practices. Long awns in closed panicles significantly decrease the out crossing rate. The genetics of awn length and distribution in rice has been studied in intricate detail.

Yoshida (1981), found that improvement of rice grain yield is the main target of breeding program to develop rice varieties. Grain yield is a complex trait, controlled by many genes and highly affected by environment. In addition, grain yield is also related to other characters such as plant type, growth duration, and yield components.

Sadeghi (2011), also observed positive significant association of grain yield with grains per panicle, days to maturity, number of productive tillers and days to flowering.

Pandey and Anurag (2010), studied the genetic variability among forty rice genotypes for yield and yield contributing components. High significant difference was found for all the characters for the presence of substantial genetic variability. The maximum genotypic and phenotypic coefficient of variability was found for harvest index, grain yield per hill, plant height and biological yield per hill. High heritability coupled with high genetic advance was found for plant height and number of spikelet per panicle.

Ghosh *et al.* (2004), reported that the tiller number and grain number per panicle were affected by the environmental and cultivation factors as well.

Sharief *et al.* (2005), observed morphological characters of four rice cultivars. The varieties were identified through their flag leaf area, angle of the flag leaf, plant height, time of heading, lemma and palea pubescence, culm diameter, number of secondary branches per to particle, number of grains per panicle, panicle density, particle weight, presence of awn, number of tillers, filled grain yield. 1000-grains weight, seed width and grain color.

Shahidulla *et al.* (2009), conducted an experiment to assess the genetic divergence of aromatic rice for grain quality and nutrition aspects. Forty genotypes composed of 32 local aromatic, five exotic aromatic and three non-aromatic rice varieties were used. Univariate and multivariate analyses were done. Enormous variations were observed in majority of characters viz. grain length, breadth, kernel weight, milling yield, kernel length, L/B ratio of kernel and volume expansion ratio (VER). In multivariate analysis, genotypes were grouped into six clusters. In the discriminant function analysis (DFA) function 1 alone absorbed 6l.7% of the total variance. The most contributing variables were kernel weight, kernel length and L/B ratio in function 1. The inter-cluster D2 value was maximum (26.53) between I and VI followed by 21.28 (between I and V). Minimum D2 value was found (5.90) between II and III. Majority of the local aromatic rice varieties with smaller kernels were included in the cluster l. The cluster III contains Elai, Sarwati and Sugandha-I with long-slender kernel and ‘very good" appearance. Thus, they concluded that these varieties can be used in breeding program for improvement of germplasms in cluster-I.

Mohapatra *et al.* (1993), evaluated 13 agro-morphological characters of 34 mutant lines for the magnitude of genetic divergence using Mahalanobis‘s D^2 statistics. The population was grouped into seven clusters. Plant height (24.6%) and 1000-grains weight (18.3%) contributed considerably, accounting for 43% of total divergence.

Vivekzuradan and Subramanian (l993), evaluated 28 rice genotypes for the magnitude of genetic divergence using Mahalanobis's D^2 statistics. The population was grouped into five clusters. Plant height and grain yield contributed considerably, accounting for 85% of total divergence. The geographic diversity has not been found related to genetic diversity.

Das *et al.* (1992), evaluated 30 rice genotypes for variability analysis and found that plant height, days to 50% flowering, number of filled grains per panicle, panicle length, 1000-grains weight and days to maturity had high genetic coefficient of variation.

Rice tillering is a major determinant for panicle production (Miller *et al.* 1991), and as a consequence affects total yield (Gallagher and Biscoe, 1978). The high tillering capacity is considered as a desirable trait in rice production, since number of tillers per plant is closely related to number of panicles per plant. To some extent, yield potential of a rice variety may be characterized by tillering capacity. On the other hand, it was reported that the plant with more tillers showed a greater inconsistency in mobilizing assimilates and nutrients among tillers. Moreover, grain quality could be also affected by tillering ability due to different grain development characteristics. It has been well documented that either excessive or insufficient tillering is unfavorable for high yield.

Akter *et al.* (2007), evaluated thirty advanced breeding lines of deep-water rice during T. aman season with a view to findings out variability and genetic association for grain yield and its component characters. The highest genetic variability was obtained in filled grains/panicle followed by plant height. Panicles/plant, filled grains/panicle and grain yield had genetic coefficient of variation and heritability in broad sence coupled with high genetic advances in percentage of mean. Panicle length, panicles/plant, plant height, filled grains/panicle and harvest index showed significant positive association with grain yield. Path coefficient analysis also revealed the maximum positive and direct contribution of filled grain yield followed by panicles/plant, 1000- grain weight and flag leaf area. Moreover, plant height had the highest indirect effect on grain yield through filled grains/panicle. Flag leaf area, harvest index and panicle length also had higher positive indirect effect on grain yield through filled grains/panicle.

Shashidhar *et al.* (2005), reported positive association of spikelet yield with plant height, number of production tillers hill-1, dry matter plant-1 and harvest index at fifteen phenotypic and genotypic level.

Yield per hectare is the most important consideration in rice breeding program, but yield is a complex character in inheritance and may involve several related components. Rice yield is a product of number of panicles per unit area, number of spikelets per panicle, percentage of filled grains and weight of 1000 grains (Datta and Khanam, 2002),.

Sarhadi *et al.* (2008), worked with the most important agronomic attributes and aroma of 26 cultivars from Afghanistan, Iran, and Uzbekistan, and controls from Japan, Thailand and India were characterized. Diversity for some traits of agronomic importance, such as plant height was detected among countries, e.g. Afghan cultivars classified as tall, and Iranian and Uzbek intermediate and short, respectively. Differentiations of panicle, grain, leaf, basal internodes, and culm dimension among rice cultivars, indicating the source of rice diversity in Central Asia. According to the results, 6 of 10, 2 of 7, and 0 of 6 of Afghan, Iranian, and Uzbek rice cultivars were scored as aromatic, respectively. Therefore, Afghan cultivars are a good source of aromatic rice germplasm for Central Asia.

An investigation was conducted by Hien *et al.* (2007), to determine the extent of diversity and relationships among 36 aromatic rice cultivars collected from Asia. Characterization for 22 morphological characters with 101 morphometric descriptors was carried out. High and comparative levels of phenotypic variation using phenotypic frequency distribution and Shannon-Weaver diversity index were found between Countries of origin. Most traits were polymorphic except to ligule color, Grain size, grain shape, culm strength; plant height and secondary branching contributed the highest mean diversity indices.

A study was conducted by Hossain *et al.* (2005), in order to investigating the relationship between grain yield with the morphological parameters of five local and three modern aromatic rice varieties. Among the aromatic rice varieties the highest grain yield was obtained from BRRIdhan 34 which identically followed by Kataribhog. The highest plant height was observed in Chinigura which was statistically similar to Kataribhog. The highest number of effective tillers/hill was observed in BRRIdhan 37 and it was identically followed by Radhunipagal. Badshabhog, Chinigura, BRRIdhan 38 and the lowest fertile tillers per hill was obtained from Kalijira which was statistically similar to Kataribhog. The highest number of grains per panicle was found in BRRIdhan 34 and that was the lowest in BRRIdhan 38. Maximum 1000- grains weight was observed in BRRIdhan 38. In respect of yield BRRIdhan 34 and Kataribhog are suitable for Dinajpur region in Bangladesh during T. aman season.

Fifty four elite rice genotypes were evaluated by Madhavilatha *et al.* (2005), for their variability with regards to grain yield, yield components (plant height, number of effective tillers per plant, panicle length. number of grains per panicle, fertility percentage, days to 50% flowering, days to maturity and harvest index) and quality parameters (hulling recovery, kernel length (L), breadth (B), L/B ratio and elongation ratio, volume expansion ratio and 1000-grains weight). Estimation of heritability and genetic advance were also obtained for the above traits.

Kisandu and Mghogho (2004), characterized two hundred and seventy five accessions from all rice growing regions of the Southern Highlands of Tanzania using morphological characters.

Mahto *et al.* (2003), evaluated twenty six early maturing upland rice genotypes for genetic variation, character association and path analysis based on days to 50% flowering. Plant height, number of panicle per plant, panicle length, number of branches per particle. Number of filled grains per panicle, 100.-seed weight and grain yield. The genotypic variance ranged from 5.36 for panicle length to 24.83 for grain yield. The difference between phenotypic and genotypic coefficient of variation was minimum for 1000-grain weight (0.12) and days to 50% flowering (0.13). High values of heritability were observed for 1000-grains weight (98.30%) and days to 50% flowering (97.33%). The number of grains per panicle and panicle length showed a significant difference between phenotypic and genotypic coefficient of variation. The association of high heritability with high genetic advance was observed for 1000-grain weight, days to 50% flowering, grain yield, number of branches per particle and plant height. Grain yield was positively and significantly correlated with days to 50% flowering, number of panicles per plant, number of branches per panicle and number of filled grains per panicle.

Roy *et al.* (2002), evaluated 50 rice cultivars for genetic diversity and responded that plant height, tiller numbers, panicle length. 100-grains weight. 100-kernel weight. Filled grains/panicle and kernel-grain ratio contributed most towards divergence.

Chand *et al.* (2004), studied nineteen genotypes of aman paddy (*Oryza sativa*) emanating from different sources for spikelet yield and their components during kharif. Heritability and genetic advance as percentage of mean were high for 1000 spikelet weight.

Ghosh and Hossain (1988), reported that effective tillers/plant, number of grains/panicle and grain weight as the major contributory characters for grain yield it had positive correlations with number of productive tillers/plant.

Satheesh Kumar *et al.* (2012), estimated correlation in 53 genotypes of rice for fifteen characters. It revealed grain yield per plant exhibited high significant and positive genotypic correlation with number of productive tillers per plant, filled grains per panicle and total number of grains. It is apparent that information of morphological and physiological aspects of crop is also a key feature to plan a creative breeding program. Thus, the genetic reconstruction of plant architecture is required for developing high yielding crop varieties.

Morphological characterization of ninety six landraces rice accessions were assessed by Ogunbayo *et al.* (2007), using 14 agro-botanical traits to study the variations and to select lines that could be used as potential parents. Highest yield was observed for accession 46 (DNN 184) with an average of 12 tillers, plant height of 136 cm and medium maturity date of 136 days. It was observed that number of total tillers per plant was not a functional of yield but rather these traits were significantly associated with plant height and maturity date. It was concluded that these landraces of rice accessions were associated with relatively narrow genetic base; positive heterosis could be promoted if any of the Gagnoa (GGA) accessions is used in a future hybridization program with Danane (DNN) accessions because of genetic distance between members of the two groups.

Naik *et al*. (2006), estimated the nature and magnitude of diversity in fifty aromatic rice accessions including five scented improved varieties. Observations were recorded for 11 morphological and quality characters viz. plant height, panicle length, effective tillers per plant, biological yield per plant, seed length, seed breadth, seed length-breadth ratio, Kernel length, kernel breadth, kernel length-breadth ratio and grain yield per plant. The D^2 analysis indicated the presence of appreciable amount of genetic diversity in the material. The fifty genotypes were grouped into seven clusters. The cluster VI had the highest mean for grain yield per plant and for biological yield per plant. Inter cluster distance was recorded highest between cluster 3 and cluster 4. The least distance was recorded in cluster I and cluster 5. It was concluded that high variability was observed between the genotypes in different clusters for different characters.

Rangare *et al.* (2012), evaluated forty exotic and Indian rice germplasm including one local check for their efficiency with respect to eleven yield and yield contributing characters from kharif, 2009 under normal conditions. Associated studies have indicated that for an improvement in grain yield, the intensive selection should be positive for biological yield per plant, number of fertile tillers per plant, number of spikelet per panicle, test weight, panicle length and days to maturity as these traits showed significantly strong positive association with grain yield, but days to 50% flowering, days to initial flowering, harvest index and plant height through had positively non-significant association with grain yield.

Itani (2002), evaluated the agronomic characteristics of aromatic rice collected from all over Japan, 71 randomly selected cultivars were cultivated along with 21 foreign aromatic cultivars from 7 countries and l8 Japanese non-aromatic cultivars. In addition, 44 Japanese aromatic cultivars and 6 old and I2 new nonaromatic cultivars were examined for their leaf characteristics. The local Japanese aromatic cultivars had a greater height, fewer and larger panicles, greater straw weight, lower yield, less tolerance to lodging and more awns than the new cultivars. Morphologically, the local Japanese aromatic cultivars were divided into eastern and western groups.

Kumar *et al.* (2014), conducted experiment with 40 genotypes of rice. Analysis of variance revealed significant difference among 40 rice genotypes for all characters indicating the existence of variability. High GCV and PCV were observed for grain yield per plant and biological yield per plant. On the other hand, conducted experiment with 19 genotypes of rice, existence of variance in 14 yield contributing character including days to maturity, number of effective tiller per plant, number of field grain of main tiller and yield (ton/ha) were found in analysis of variance. Sadeghi (2011), also observed positive significant association of grain yield with grain per panicle, days to maturity, number of productive tillers and days to flowering.

Singh *et al.* (2016), characterized twenty (ten mega varieties and ten landraces) varieties of rice by using twenty three morphological traits following Distinctiveness, Uniformity and Stability test (DUS). Among the 23 DUS characters utilized in the characterization of twenty rice genotypes, six characters viz., the basal leaf sheath color, color of ligule, shape of ligule, auricles, anthocyanin coloration of auricles and anthocyanin coloration of nodes showed no variation and found distinctive among all the cultivars.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experimental site was conducted at the experimental farm of Sher-e-Bangla Agricultural university, Dhaka-1207, during July 2017 to November 2017. The site was located 23°41’ N latitude and 90°22’ E longitude with an elevation of 8.6 meter from the ocean level.

3.2 Climate and soil

The experimental site was situated in the sub-tropical zone and lies in Agro-ecological region of "Madhupur Tract" (AEZ No. 28). It`s top soil is clay loam in texture and olive gray with fine to medium distinct dark yellowish brown mottles. The range of soil pH is 4.47 to 6.5 and organic carbon content is 0.82%. The experiment area was non-flooded affected having accessible irrigation and drainage system.

3.3 Planting materials

Thirteen rice genotypes were used in the study. The seeds of thirteen genotypes were collected from germplasm center of Sher-e-Bangla Agricultural University. Descriptions of the genotypes are given in Table 1.

3.4 Design and layout

The experiment was set in randomized complete block design (RCBD). The field was divided into 3 blocks; the blocks were sub-divided into thirteen plots (lines) wherever genotypes were randomly allotted. The experimental field size was 26m x 16m wherever 1m boarder was maintained surrounding the field and every block. The experimental field was designed such how wherever row to row distance was 30 cm and plant to plant distance was 25 cm. The thirteen genotypes were distributed each to every plot within every block randomly.

Table 1. List of the genotypes used in the experiment

Genotypes No.	Accession No.
G01	Al-F9 of Richer hybrid
G02	special from 130
G03	special from Al-36(D)
G04	Al-44(i)
G05	Al-36
G06	Al-104
G07	Al-29
G08	Al-36
G09	Al-F9 of Hira hybrid
G10	Al-F9 of Aloron hybrid
G11	special from Al-36 (i)
G12	special from Al-36 (ii)
G13	special from Al-36 (iii)

3.5 Raising of seedling

Seeds of all collected rice genotypes were seeded on 13 July 2017 within the seed bed one by one and correct tags were maintained.

3.6 Preparation of main field

The land was prepared entirely by 3-4 ploughing followed by laddering to attain a good puddle. Weeds and stubbles were removed and thus the land was finally ready by the addition of basal dose of fertilizers recommended by BRRI.

3.7 Application of fertilizers

Adequate soil fertility was ensured by applying of Urea, TSP, MP and Gypsum @ 260-77-79-55 kg/ha, respectively. Total Urea was applied in three installments, at fifteen days after transplanting (DAT), 30 DAT and 45 DAT recommended by BRRI.

3.8 Transplanting of seedling

Healthy seedlings of twenty six days old were transplanted on 7 August 2017 in separate strip of experimental field. Water level was maintained properly after transplanting.

3.9 Intercultural operation and after care

Necessary gap filling was done at intervals seven days of transplantation. The crop was unbroken weed free throughout the growing period. Hand weeding was done at twenty five and forty days once transplantation. Flood irrigation was given to the field when necessary.

3.10 Plant protection measure

Proper management measures were taken against rice stem borer throughout tillering and heading stage of rice. Furadan 5G @ l kg per square metre was applied at active tillering stage and panicle initiation stage of rice for controlling rice yellow stem borer. Cupravit 80WP @ 2.5 g per liter water was applied against bacterial leaf blight of rice.

3.11 Methods of recording of observations

To study the stable diagnostic characteristics knowledge on the morphological characters were collected from 5 at randomly elected hills from every replicated plots. The plants were elected from middle to avoid border impact and portion of the plot. The mean was calculable. Fifteen qualitative and nineteen quantitative traits were recorded using the descriptors developed by BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007. The descriptors are presented in the Table 2 and Table 3.The observations for characterization were recorded at field condition as follows.

3.11.1 Qualitative traits evaluation methods

The experimental plots were visited daily and needed data were collected as per schedule. A data record book was used for keeping records of data associated with identification of the genotypes. Rice Descriptors developed by The BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007. (Table 2 and 3) were used for data collection and recording. The images of specific trait were taken from the experiment field at appropriate lines of different trait to compare the distinctness among the rice genotypes. Images and knowledge associated with distinctness in morphological traits were taken on every of the thirteen rice genotypes. This was done notably to search out the expression of the qualitative traits of the genotypes when grown below constant environment.

3.11.1.1 Basal leaf sheath color

Data was collected at late vegetative Stage on basal leaf sheath color and therefore the rice genotypes were classified into four groups with codes in line with guided descriptors as per follows.

Green-1

Green with purple lines-2

Light purple-3

Purple-4

3.11.1.2 Green color intensity of leaf blade

Observations with respect to green coloration of leaf blade at late vegetative stage the rice genotypes were classified into four groups with codes according to guided descriptors as per follows.

No green-0 (No green color visible due to anthocyanin)

Light green-3

Medium green-5

Dark green-7

3.11.1.3 Leaf blade attitude

Leaf blade attitude refers the position of the tip of the blade relative to its base, scored on the leaf below the flag leaf at late vegetative (prior to heading) stage and the rice genotypes were classified into four groups with codes according to guided descriptors as per follows.

Erect-1

Horizontal-5

Drooping-7

3.11.1.4 Leaf blade pubescence

It was assessed each visually and by touch, rubbing fingers over the leaf surface from the tip to downward at late vegetative stage and also the discovered genotypes were classified into 3 groups as per descriptors by following means.

Glabrous-1 (smooth—including ciliated margins)

Intermediate-2

Pubescent-3

3.11.1.5 Ligule shape

Shape of the penultimate leaf ligule was discovered and therefore the genotypes were categorized as following that are shown hypothetically in Figure 1.

Absent-0, Truncate-1

Acute to acuminate-2, 2-cleft-3

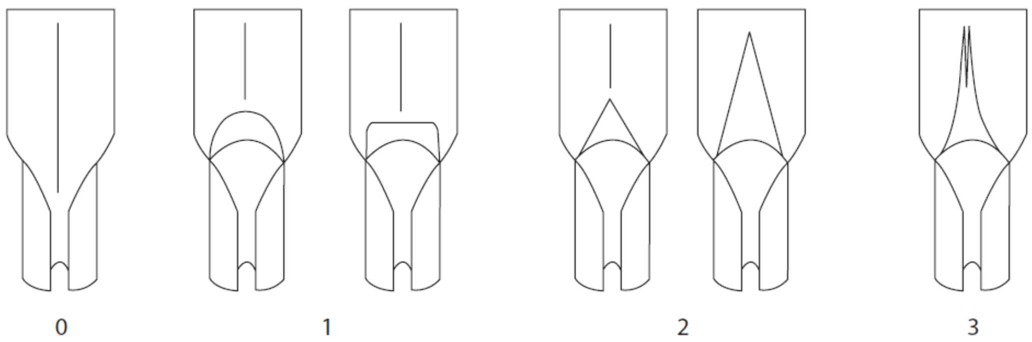


Figure 1. Ligule shape

3.11.1.6 Ligule color

Ligule color was visually observed at late vegetative stage and genotypes were categorized into six groups following the guided descriptors.

Absent (ligule less)-0 Whitish-1

Yellowish green-2 Purple-3

Light purple-4 Purple lines-5

3.11.1.7 Auricle color

Auricle color was visually observed at late vegetative stage and genotypes were categorized into four groups following the guided descriptors.

Absent (no auricles)-0 Whitish-1

Yellowish green-2 Purple-3

3.11.1.8 Flag leaf attitude

Flag leaf attitude was determined by the angle of attachment between the flag leaf and the main panicle axis. It was just observed visually and classified into four groups that are shown hypothetically in Figure 2.

Erect-1,

Semi-erect (intermediate)-3

Horizontal-5,

Descending-7

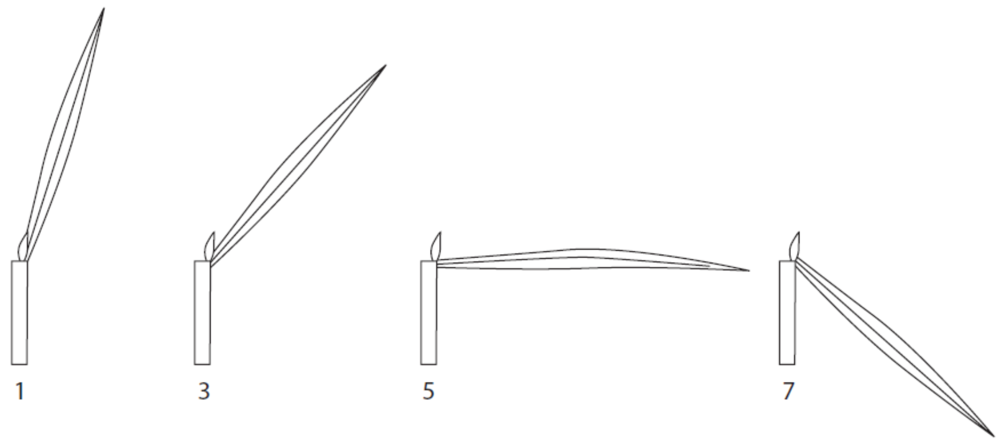


Figure 2. Flag leaf attitude

3.11.1.9 Culm habit

Culm habit was estimated by the average angle of inclination of the base of the main culm from vertical. It was just observed visually and classified into following groups that are shown hypothetically in Figure 3.

Erect (<15°)-1,

Semi-erect (intermediate) (~20°)-3

Open (~40°)-5

Spreading (>60–80°)-7

Procumbent (culm or its lower part rests on ground surface)-9

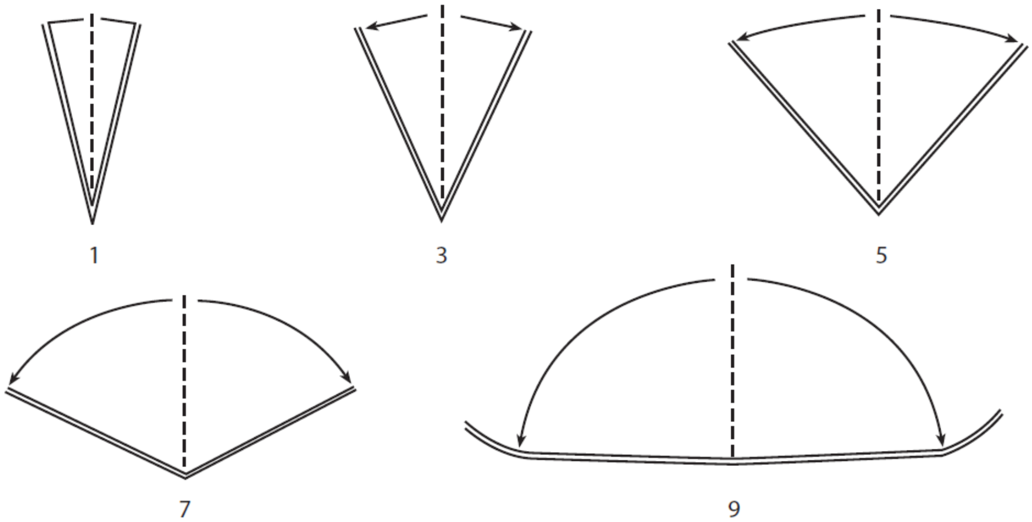


Figure 3. Culm habit

3.11.1.10 Culm: lodging resistance

It was viewed at maturity stage based on the degree of lodging. Genotypes were categorized by the subsequent groups.

Very weak -1 (all plants flat),

Weak-3 (most plants nearly flat)

Intermediate-5 (most plants leaning about 45°)

Strong- 7 (most plants leaning about 20° from vertical)

Very strong-9 (all plants vertical)

3.11.1.11 Panicle: attitude of branches

Attitude of panicle branches was determined by the compactness of the panicle and was classified according to its mode of branching, angle of primary branches and spikelet density by the following groups.

Erect (compact panicle)-1 Semi-erect (semi-compact panicle)-3

Spreading (open panicle)-5 Horizontal-7 Drooping-9

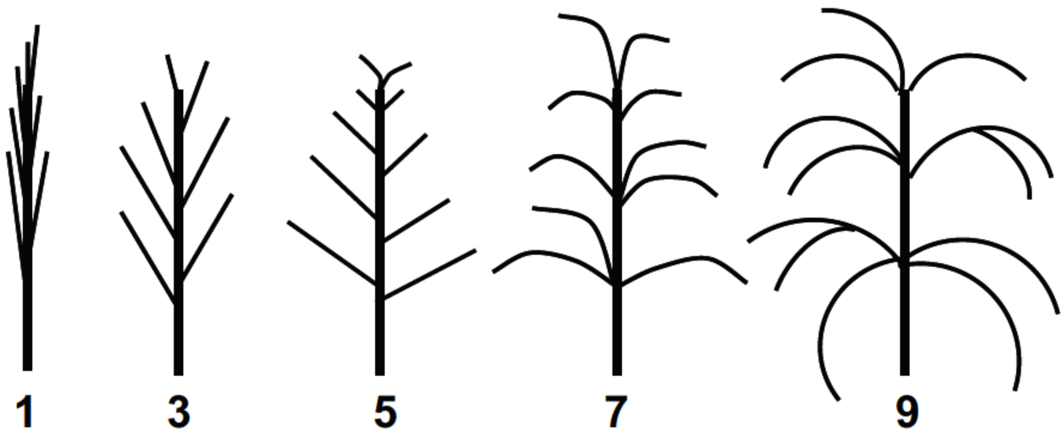


Figure 4. Attitude of panicle branches

3.11.1.12 Panicle exertion

Panicle exertion was observed at near ripening stage and was categorized by the subsequent groups that are shown hypothetically in Figure 5.

Enclosed-1 Partly exserted-3,

Just exserted-5 Moderately well exserted-7,

Well exserted-9

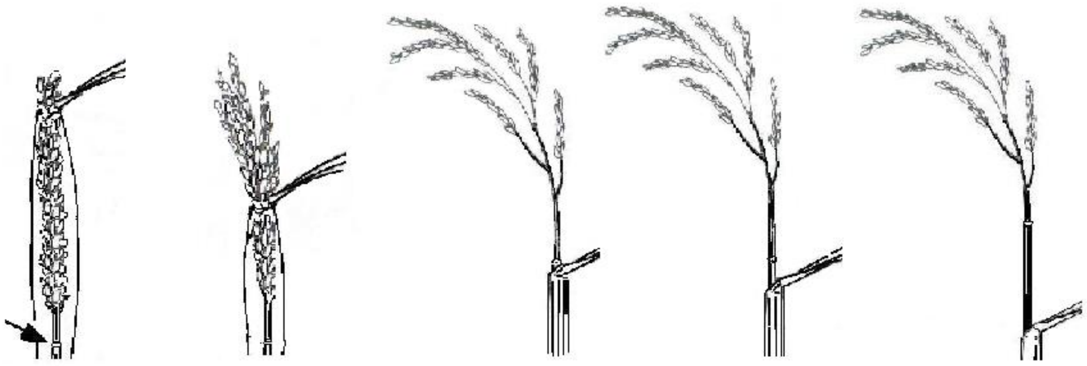


Figure 5. Panicle exertion

3.11.1.13 Grain color (lemma and palea color)

Grain color was observed after harvest in presence of sufficient sun light. It was categorized by subsequent groups.

Straw-1 Golden-2

Purple-4 Black-5

3.11.1.14 Leaf senescence

The leaf senescence was visually recorded at the time of harvest and observed any leaves were retained green color or not. Leaf senescence is categorized into three groups as follows,

Early (all leaves have lost their green color at maturity)

Intermediate (1-2 leaves retain green color at maturity)

Late and slow (2 or more leaves retain green color at maturity)

3.11.1.15 Presence of awns

The observation was recorded after maturity stage. It was normally a character of wild species of rice and grouped as per descriptors.

Absent-0

Partly awned-1

Fully awned-2

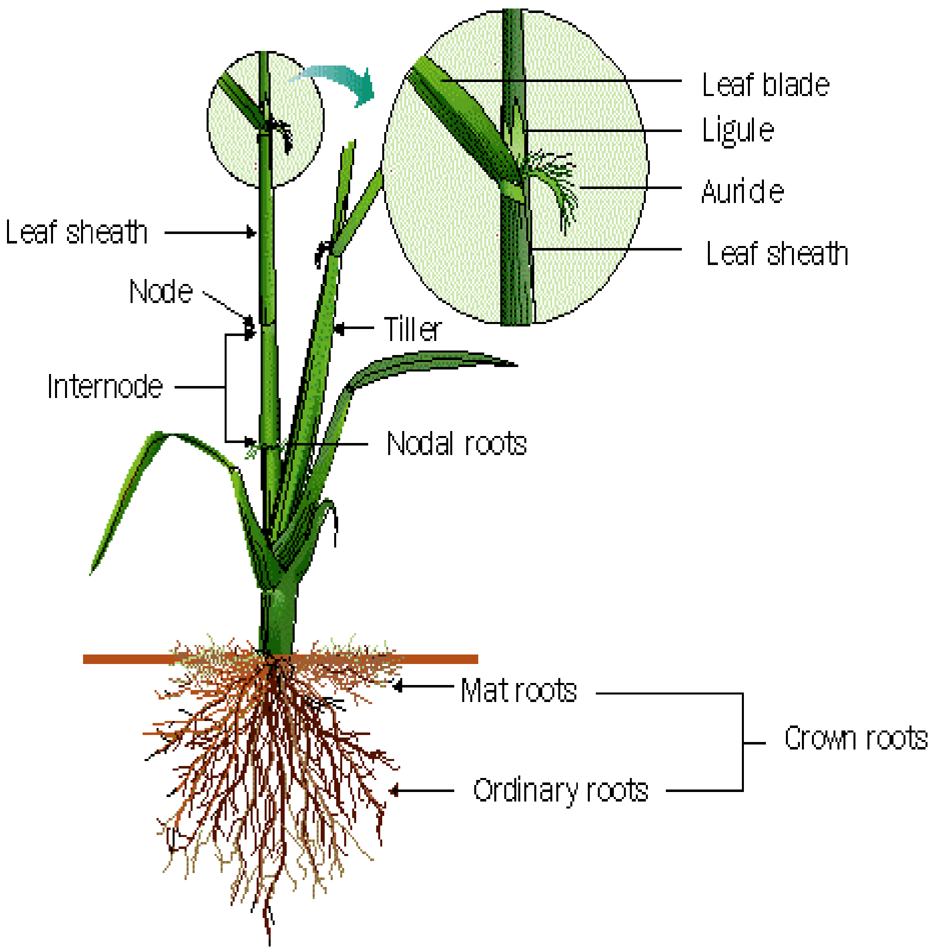


Figure 6. Morphology of a rice plant (vegetative stage)

Table 2. Descriptors with codes for qualitative characteristics

SL.NO.	Characteristics	Descriptors with codes
1	Basal leaf sheath color	Green-1, Green with purple lines-2, Light purple-3, Purple-4
2	Grain color intensity of leaf blade	No green-0, Light green-3, Medium green-5, Dark green-7
3	Leaf blade attitude	Erect-1, Horizontal-5, Drooping-7
4	Leaf blade pubescence	Glabrous-1, Intermediate-2, Pubescent-3
5	Ligule shape	Absent-0, Truncate-1, Acute to acuminate-2, 2-cleft-3
6	Ligule color	Absent (ligule less)-0, Whitish-1, Yellowish green-2, Purple-3, Light purple-4, Purple lines-5
7	Auricle color	Absent (no auricles)-0, Whitish-1, Yellowish green-2, Purple-3
8	Flag leaf attitude	Erect-1, Semi-erect (intermediate)-3, Horizontal-5, Descending-7
9	Culm habit	Erect (<15°)-1, Semi-erect (intermediate) (~20°)-3, Open (~40°)-5 Spreading (>60–80°)- 7, Procumbent (culm or its lower part rests on ground surface)-9
10	Culm: lodging resistance	Very weak -1, Weak-3 , Intermediate- 5, Strong- 7,Very strong-9
11	Panicle: attitude of branches	Erect (compact panicle)-1,Semi-erect (semi compact panicle)-3, Spreading (open panicle)- 5, Horizontal-7 Drooping-9
12	Panicle exertion	Enclosed-1, Partly exserted-3, Just exserted-5, Moderately well exserted-7, Well exserted-9
13	Lemma and palea Color (Grain Color)	Straw-1, Golden-2, Purple-4, Black-5
14	Leaf senescence	1-Late and slow (>2 leaves), 5- Intermediate (1-2 leaves), 9- Early and fast (0 green leaf)
15	Presence of awns	Absent-0,Partly awned-1, Fully awned-2

Source: BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007. Descriptors for wild and cultivated rice (*Oryza spp*.).

3.11.2 Quantitative Traits Evaluation Methods

3.11.2.1 Seedling height (30 DAS)

The average height of the five plants from the plant base to the tip of the leaf was calculated in centimeters at thirty days after sowing (30DAS). In keeping with their length, the observed genotypes were classified into 3 totally different classes as per descriptors.

3 -Short (<30 cm)

5- Intermediate (31-40 cm)

7- Tall (>60 cm)

3.11.2.2 Flag leaf length

After panicle initiation flag leaf length was measured in centimeter scale from the jointing point of flag leaf and panicle to the tip point of flag leaf. It was categorized by the following groups as per descriptors.

1- Very short (<21 cm)

3 -Short (21-30 cm)

5 -Intermediate (31-50 cm)

7 -Long (51-80 cm)

9 -Very long (>80 cm)

3.11.2.3 Flag leaf breadth

After panicle initiation flag leaf breadth was measured in centimeter scale at the middle of flag leaf. It was categorized by the following groups as per descriptors.

3 -Narrow (<1 cm) 5 –Intermediate (1-1.5cm)

7- Broad (>2 cm)

3.11.2.4 Culm length

It was measured from ground level to the base of the panicle during the maturity stage. It was categorized by the following groups as per descriptors.

1- Very short (<50 cm) 2 -Very short to short (51–70 cm)

3 -Short (71–90 cm)

4 -Short to intermediate (91–105 cm)

5 -Intermediate (106–120 cm)

6 -Intermediate to long (121–140 cm)

7 -Long (141–155 cm)

8 -Long to very long (156–180 cm)

9 -Very long (>180 cm)

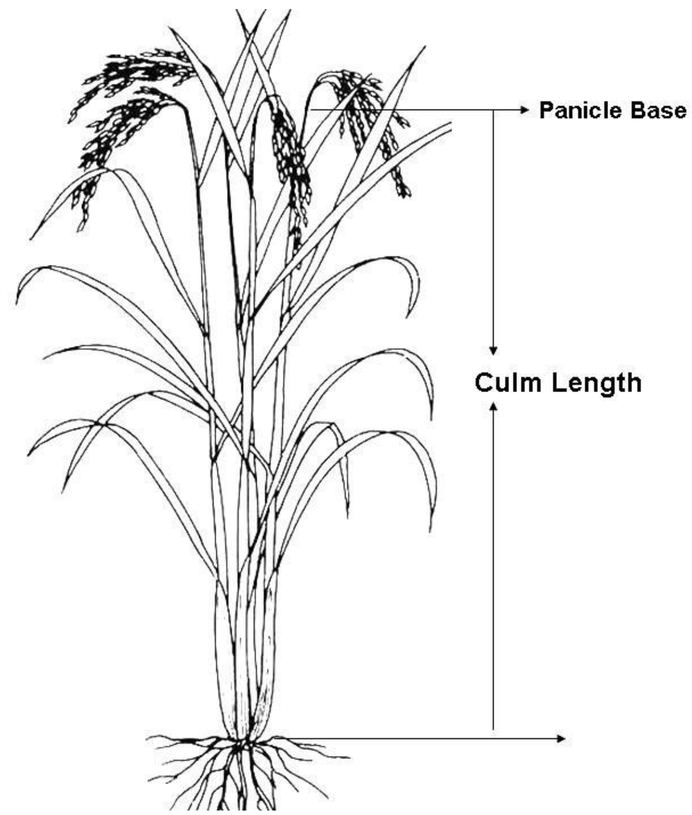


Figure 7. Culm length

3.11.2.5 Culm diameter

It was measured from mother tillers at the lowest internode and observed the genotypes into following groups.

1-Small (<5.0 mm)

3- Medium (5.1-6.0 mm)

5- Large (6.1-7.0 mm)

7- Very large (>7.0 mm)

3.11.2.6 Tillers per hill/plant

The total number of tillers was counted from every of the sample plants and therefore the average was taken. Supported this character, all the genotypes were classified into following groups.

2- Low (<10 culms)

5 -Intermediate (11-15 culms)

7 -High (>20 culms)

3.11.2.7 Effective tillers per plant

Effective tillers are the tillers that bears panicle and therefore the number of effective tillers was counted from every of the sample plants and therefore the average was taken. Based on this character, all the genotypes were sorted into following groups.

3 -Low (<7 culms),

5- Intermediate (8- 12culms),

7- High (>15 culms)

3.11.2.8 Panicle length

The mean length typically at random chosen panicles of main tillers from five hills was measured from neck to the tip of the panicle of main tiller while not awn in centimeters.

According to their length, the observed genotypes were classified into 5 different classes.

1-Very short (<11 cm), 3- Short (12-15 cm),

5- Medium (16-25 cm) 7- Long (26-35 cm),

9- Very long (>35cm)

3.11.2.9 Branching of panicle

Observations with relevance range of total primary branches per particle were recorded at maturity so total range of secondary branches per panicle was conjointly counted. Branching of panicle indicates the ratio of secondary branches to primary branches per panicle. All the genotypes were sorted into 3 groups.

0- Absent

1 - Sparse (~1 secondary branch per primary branch),

3- Dense (~2-3 secondary branches per primary branch),

3 - Clustered (~3-4 secondary branches per primary branch)

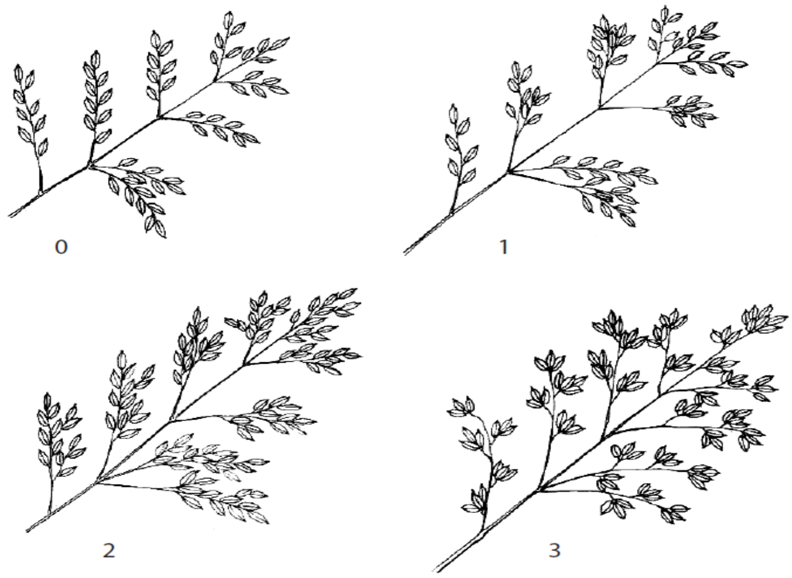


Figure 8. Branching of panicle

3.11.2.10 Number of filled grains per panicle

The number of filled grains of 5 randomly chosen panicles of main tillers from 5 hills was recorded and so averaged. In keeping with this, the observed genotypes were classified into four totally different classes as per descriptors.

1-Few (<150)   3-Medium (151-200),

5-Many (201-300)   7-So Many (>301)

3.11.2.11 Number unfilled grains per panicle

The number of unfilled grains of 5 randomly elect panicles of main tillers from 5 hills was recorded then averaged. In keeping with this, our observed genotypes were classified into 3 completely different classes as per descriptors.

1-Few (<30),

3-Medium (31-50),

5-Many (>51)

3.11.2.12 Total number of grains per panicle

Total number of grain was measured by adding filled and unfilled grains per panicle and also the determined genotypes were classified into 3 totally different classes as per descriptors.

1-Few (<200) 3-Medium (201-300)

5-Many (301-350) 7-So Many (>351)

3.11.2.13 Thousand seed weight (dry)

After threshing and recording the net yield, a random sample of grown a thousand seeds were counted and weighed at 12% moisture content to record the check weight. Per check weight, the genotypes were categorized into four different groups as following.

1-Very low (<15g) 3-Low (16-19g),

5-Medium (20-23g) 7-High (24-27g)

3.11.2.14 Days to main heading (80%)

The number of days from date of sowing till eightieth plants with heading within the plots was recorded on every individual plot and replication and therefore the genotypes were classified into following groups.

1-Early (<80 Days) 3-Medium (81-100 Days),

5-Late (101-125 Days) 7-Very Late (>125 Days)

3.11.2.15 Days to maturity

The number of days from date of sowing till eightieth seeds become matured considering every replication was recorded on every individual plot and also the genotypes were classified into following groups.

1-Early (<95 Days) 3-Medium (96-120 Days)

5-Late (121-140 Days) 7-Very Late (9>4 Days)

3.11.2.16 Grain length (mm)

Grain length was measured in millimeter and a vernier calipers was used for clear visual image. Five grains from each genotypes were measured and therefore the mean was recorded. The genotypes were classified into the following descriptors

1-Short (<5.50 mm) 3-Medium (5.51-6.5 mm)

5-Long (6.51-7.5 mm) 7-Extra Long (>7.51 mm)

3.11.2.17 Grain width (mm)

Grain width was measured in millimeter and a vernier calipers was used for clear visual image. Five grains from each genotypes were measured and therefore the mean value was recorded. The genotypes were classified as per descriptors.

1-Fine (<2.5 mm)

3-Medium (2.51-3 mm)

5-Coarse (>3 mm)

3.11.2.18 Yield per plant

Panicles of randomly elect plants per replication were threshed, seeds were sun dried for 2 days and weighed and so averaged. Seed yield was adjusted at 12% moisture content. The genotypes were classified into 3 totally different groups based on seed yield per plant as-

1-Low (<20g)

3-Medium (20-27g)

5-High (>27)

3.11.2.19 Yield per square meter area

All the plants of one square meter area per replication were threshed, seeds were sun dried for 2 days and weighed and so averaged. Seed yield was adjusted at 12% moisture content. The genotypes were classified into 3 totally different groups based on seed yield per plant as-

1-Low (<450g), 3-Medium (450-650g),

5-High (>650g)

Table 3. Descriptors with codes for quantitative characteristics

SL.NO.	Characteristics	Descriptors with codes
1	Seedling height (30 DAS)	3 -Short (<30 cm), 5- Intermediate (~45 cm), 7- Tall (>60 cm)
2	Flag leaf length	Very short (<21 cm), 3 -Short (~30 cm), 5 - Intermediate (~50 cm), 7 -Long (~70 cm), 9 - Very long (>80 cm)
3	Flag leaf breath	3 -Narrow (<1 cm), 5 –Intermediate, 7- Broad (>2 cm)
4	Culm length	1- Very short (<50 cm), 2 -Very short to short (51–70 cm), 3 -Short (71–90 cm), 4 -Short to intermediate (91–105 cm), 5 -Intermediate (106–120 cm), 6 -Intermediate to long (121– 140 cm), 7 -Long (141–155 cm), 8 -Long to very long (156–180 cm), 9 -Very long (>180 cm)
5	Culm diameter	1-Small (<5.0 mm), 3- Medium (5.1-6.0 mm), 5- Large (6.1-7.0 mm),7- Very large (>7.0 mm)
6	Tillers per hill	3- Low (<10 culms), 5 -Intermediate (~15 culms), 7 -High (>20 culms)
7	Effective Tillers per hill	3 -Low (<7 culms), 5- Intermediate (~ 10culms), 7- High (>15 culms)
8	Panicle length	Very short (<11 cm), 3- Short (~15 cm), 5- Medium (~25 cm), 7- Long (~35 cm), 9- Very long (>40 cm)
9	Branching of panicle	0 Absent, 1 -Sparse (~1 secondary branch per primary branch) 2- Dense (~2-3 secondary branches per primary branch) 3 -Clustered (~3-4 secondary branches per primary branch)
10	No. of filled grains per panicle	1-Few(<150), 3-Medium(151-200), 5- Many (201-300), 7-So Many(>301)
11	No. unfilled grains per panicle	1-Few(<30), 3-Medium(31-50), 5-Many(>50)
12	Total no. of grains per panicle	1-Few(<200), 3-Medium(201-300), 5- Many (301-350) 7-So Many(>351)
13	Thousand seed weight(dry)	1-Very low(<15g), 3-Low(16-19g), 5- Medium(20-23g), 7-High(24-27g)
14	Days to main heading (80%)	1-Early(<80), 3-Medium(81-100), 5-Late (101- 125), 7-Very Late(>125)

Table 3 (Cont'd)

15	Days to maturity	1-Early(<95), 3-Medium(96-120), 5-Late(121- 140), 7-Very Late(>141)
16	Grain length (mm)	1-Short(<5.50), 3-Medium(5.51-6.5), 5- Long(6.51-7.5), 7-Extra Long (>7.51)
17	Grain width (mm)	1-Fine(<2.5), 3-Medium(2.51-3), 5-Coarse(>3)
18	Yield per plant	1-Low(<20g), 3-Medium(20-27g) 5-High(>27)
19	Yield per meter square	1-Low (<450g), 3-Medium (450-600g), 5-High (>600g)

Source: BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007. Descriptors for wild and cultivated rice (*Oryza spp*.).

3.11.3 Statistical application

The qualitative and quantitative data in relation to morphological traits are simply presented in tabular type for easier description per the descriptors developed by BIOVERSITY INTERNATIONAL, IRRI AND WARDA. 2007. The data were organized as per IBPGR-IRRI formulation with the help of Microsoft-XL program and weren't required to applied statistical analysis.

Coding and code analysis

- All the genotypes were characterized by following the descriptors developed by BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007.
- Each character was coded according to IRRI and also the genotypes were classified and grouped by analyzing the codes.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted with a view to characterizing and evaluating thirteen advanced lines of aman rice as per the guided descriptors developed by BIOVERSITY INTERNATIONAL, IRRI and WARDA. 2007. Fifteen qualitative and nineteen quantitative characters were observed. Results have been compiled in tabular form according to descriptors and described by the following ways:

- Qualitative Characteristics
- Quantitative Characteristics

4.1 Qualitative Characteristics

4.1.1 Basal leaf sheath color

On the basis of basal leaf sheath coloration the observed genotypes were categorized as green-1, green with purple lines-2, light purple-3, purple-4 as presented in Table 4. All the genotypes were found green color of basal leaf sheath. So, there was no variation among the observed genotypes (Table 4). Arif (2015) found green and green with purple lines of leaf sheath color working with thirty landraces.

4.1.2 Green color intensity of leaf blade

Based on green color intensity of leaf blade the observed genotypes were categorized in 4 groups like no green- 0, light green-3, medium green-5 and dark green-7. Here 6 genotypes (G04, G05, G08, G11, G12 and G13) were shown medium green color and 7 genotypes (G01, G02, G03, G06, G07, G09, and G10) were shown dark green color of leaf blade. No green and light green color leaf blade were found (Table 5). Arif (2015) also found light green color leaf blade.

Table 4. Categorization and grouping based on basal leaf sheath color

Types	Code	Genotypes
Green	1	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13
Green with purple lines	2	Nil
Light purple	3	Nil
Purpel	4	Nil

Table 5. Categorization and grouping based on green color intensity of leaf blade

Types	Code	Genotypes
No green	0	Nil
Light green	3	Nil
Medium green	5	G04, G05, G08, G11, G12 and G13
Dark green	7	G01, G02, G03, G06, G07, G09, and G10

4.1.3 Leaf blade attitude

On the basis of leaf blade attitude the observed genotypes were classified into 3 groups as erect-1, horizontal-5 and drooping-7 in nature. Here, 7 genotypes (G02, G03, G05, G08, G11, G12 and G13) were erect type. 5 genotypes (G01, G06, G07, G09 and G10) were horizontal type and 1 genotype (G04) was drooping in nature (Table 6). Samia (2016) found erect and horizontal type of leaf blade attitude working with nine genotypes.

4.1.4 Leaf blade pubescence

Based on leaf blade pubescence, rice genotypes were categorized as glabrous-1, intermediate-2 and pubescent-3 (Table 7). But there was no variation among the genotypes observed and all the genotypes were pubescent type (Plate 1). Same result was found by Samia (2016).

4.1.5 Ligule shape

Based on ligule shape, rice genotypes were classified as absent- 0, truncate-1, acute to acuminate-2 and 2-cleft -3 type (Table 8). But there was no variation among the observed genotypes and all the genotypes were pubescent type (Plate 2). Khanam (2018) also found truncate and acute type of ligule shape working with ten genotypes.

4.1.6 Ligule color

Based on ligule color cultivated rice were categorized into 6 groups as absent (ligule less)-0, whitish-1, yellowish green-2, purple-3, light purple-4 and purple lines-5. Only 2 types of ligule color viz. whitish and yellowish green color were found among thirteen genotypes. Eight genotypes (G01, G03, G04, G05, G07, G08, G09 and G10) were whitish type and five genotypes (G02, G06, G11, G12 and G13) were yellowish green type (Table 9). Same types of ligule color were found by Samia (2016) and Arif (2015). Whitish and yellowish green color ligules have been presented in Plate 3 and Plate 4.

Table 6. Categorization and grouping based on leaf blade attitude

Types	Code	Genotypes
Erect	1	G02, G03, G05, G08, G12, G12 and G13
Horizontal	5	G01, G06, G07, G09 and G10
Drooping	7	G04

Table 7. Categorization and grouping based on leaf blade pubescence

Types	Code	Genotypes
Glabrous	1	Nil
Intermediate	2	Nil
Pubescent	3	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13

Table 8. Categorization and grouping based on ligule shape

Types	Code	Genotypes
Absent	0	Nil
Truncate	1	Nil
Acute to acuminate	2	Nil
2-cleft	3	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13

Table 9. Categorization and grouping based on ligule color

Types	Code	Genotypes
Absent (liguleless)	0	Nil
Whitish	1	G01, G03, G04, G05, G07, G08, G09 and G10
Yellowish green	2	G02, G06, G11, G12 and G13
Purple	3	Nil
Light purple	4	Nil
Purple lines	5	Nil

Plate 1. Pubescent type leaf blade

Plate 2. Real view of 2-cleft type ligule

Plate 3. Whitish color ligule

Plate 4. Yellowish green color ligule

4.1.7 Auricle color

Auricle color of rice were categorized into 4 groups as- absent (ligule less)-0, whitish-1, yellowish green-2, and purple-3. Only 2 types of auricle color were found among thirteen genotypes. Eight genotypes (G01, G03, G04, G05, G07, G08, G09 and G10) showed whitish type auricle color and five genotypes (G02, G06, G11, G12 and G13) showed yellowish green type auricle color (Table 10). From Plate-5 and Plate-6 we can see whitish color auricle and yellowish green color ligule respectively. Same types of ligule color were found by Samia (2016) and Arif (2015).

4.1.8 Flag leaf attitude

On the basis of angle of attachment between the flag leaf blade and the main panicle axis the observed genotypes were categorized in 4 groups like erect-1, semi erect (intermediate)-3, horizontal-5 and descending-7 type. In the present study seven genotypes (G03, G06, G08, G10, G11, G12 and G13) were showed erect type flag leaf and six genotypes (G01, G02, G04, G05, G07 and G09) were showed semi-erect type flag leaf (Table 11). Arif (2015) found erect, semi-erect, horizontal and descending types of flag leaf attitude working with thirty landraces.

4.1.9 Culm habit

The estimated average angle of inclination of the base of the main culm from vertical after flowering rice genotypes were classified as erect (<15°)-1, semi-erect (intermediate) (~20°)-3, open (~40°)-5, spreading (60–80°)-7 and procumbent -9 type. Here eleven genotypes (G01, G02, G03, G06, G07, G08, G09, G10, G11, G12 and G13) were erect type, one genotype (G05) was semi-erect and one genotype (G04) was open type in nature (Table 12). Only erect and semi-erect types of culm habit were found by Samia (2016). Plate-7 shows erect type of culm habit.

Table 10. Categorization and grouping based on auricle color

Types	Code	Genotypes
Absent (ligule less)	0	Nil
Whitish	1	G01, G03, G04, G05, G07, G08, G09 and G10
Yellowish green	2	G02, G06, G11, G12 and G13
Purple	3	Nil

Table 11. Categorization and grouping based on flag leaf attitude

Types	Code	Genotypes
Erect	1	G03, G06, G08, G10, G11, G12 and G13
Semi erect (intermediate)	3	G01, G02, G04, G05, G07 and G09
Horizontal	5	Nil
Descending	7	Nil

Table 12. Categorization and grouping based on culm habit

Types	Code	Genotypes
Erect	1	G01, G02, G03, G06, G07, G08, G09, G10, G11, G12 and G13
Semi-erect	3	G05
Open	5	G04
Spreading	7	Nil
Procumbent	9	Nil

Plate 5. Whitish color aurical

Plate 6. Yellowish green color aurical

Plate 7. Erect type culm habit

4.1.10 Culm: lodging resistance

It was scored at maturity based on the observed degree of lodging. It was a very important character. On the basis of culm lodging resistance the observed genotypes were categorized into 5 groups as very weak -1, weak-3, intermediate-5, strong- 7 and very strong-9 type. Here all the genotypes were lodging resistant and grouped under very strong category (Table 13). Arif (2015) found very weak ,weak, intermediate, strong and very strong types of Culm: lodging resistance genotypes.

4.1.11 Panicle: attitude of branches

The compactness of the panicle was classified according to its mode of branching, angle of primary branches, and spikelet density in 5 groups as erect (compact panicle)-1, semi-erect (semi-compact panicle)-3, spreading (open panicle)-5, horizontal-7 and drooping-9. Here one genotype (G05) was spreading type, one genotype (G03) was horizontal type panicle and rest eleven genotypes (G01, G02, G04, G06, G07, G08, G09, G10, G11, G12 and G13) were dropping type panicle (Table 14). Arif (2015) also found erect and semi erect types of panicle. Plate-8 and Plate-9, we can see horizontal and drooping type panicle respectively.

4.1.12 Panicle exertion

On the basis of the degree of exertion it was classified into 5 groups as enclosed-1, partly exerted-3, just exerted-5, moderately exerted-7 and well exerted-9. Here one genotype (G02) was just exerted, two genotypes (G03, G04) were moderately exerted and ten genotypes (G01, G05, G06, G07, G08, G09, G10, G11, G12 and G13) were found well exerted (Table 15). Same result was found by Samia (2016). From Plate 10 and Plate 11 we can see the moderately exerted and well exerted panicle respectively.

Table 13. Categorization and grouping based on lodging resistance

Types	Code	Genotypes
Very weak	1	Nil
Weak	3	Nil
Intermediate	5	Nil
Strong	7	Nil
Very strong	9	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13

Table 14. Categorization and grouping based on panicle attitude of branches

Types	Code	Genotypes
Erect (compact panicle)	1	Nil
Semi-erect (semi-compact panicle)	3	Nil
Spreading (open panicle)	5	G05
Horizontal	7	G03
Drooping	9	G01, G02, G04, G06, G07, G08, G09, G10, G11, G12 and G13

Table 15. Categorization and grouping based on panicle exertion

Types	Code	Genotypes
Enclosed	1	Nil
Partly exerted	3	Nil
Just exerted	5	G02
Moderately exerted	7	G03, G04
Well exerted	9	G01, G05, G06, G07, G08, G09, G10, G11, G12 and G13

Plate 8. Horizontal type panicle

Plate 9. Drooping type panicle


Plate 10. Moderately exerted panicle

Plate 11. Well exerted panicle

4.1.13 Lemma and palea color (grain color)

On the basis of lemma and palea coloration the observed genotypes were categorized as straw-2, golden-3, brown (tawny)-4 and black-11. Lemma and palea combindly indicated the seed coat color actually. Here, six genotypes (G01, G02, G07, G11, G12, G13) were straw type, six genotypes (G03, G05, G06, G08, G09, G10) were golden type and only one genotype G04 was brown (tawny) in color. (Table16). Arif (2015) also found purple and black types grain color working with thirty landraces. Plate-12 showing the brown (tawny) type of grain color. Plate-13 showing the grain color of all thirteen genotypes.

4.1.14 Leaf senescence

For leaf senescence according to descriptor the test lines were categorized in three groups like late and slow-1, intermediate-5 and early and fast-9. All thirteen lines showed late and slow type of leaf senescence (Table 17). Same types of leaf senescence was found by Samia (2016) and Arif (2015).

4.1.15 Presence of awns

This character was observed at maturity stage and based on presence of awns our observed genotypes were categorized into 3 groups as absent-0, partly awned-1 and fully awned-2, where one genotype (G11) was fully awned, three genotypes (G08, G09 and G12) were partially awned and rest nine genotypes (G01, G02, G03, G04, G05, G06, G07, G10, G13) were awnless (Table 18). Same types of awns were found by Samia (2016) and Arif (2015). Plate 14 and Plate 15 showing the partly awned and fully awned genotypes respectively.

Table 16. Categorization and grouping based on grain color

Types	Code	Genotypes
Straw	2	G01, G02, G07, G11, G12, G13
Golden	3	G03, G05, G06, G08, G09, G10
Brown (tawny)	4	G04
Black	11	Nil

Table 17. Categorization and grouping based on leaf senescence

Types	Code	Genotypes
Slow	1	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13
Intermediate	5	Nil
Early and fast	9	Nil

Table 18. Categorization and grouping based on presence of awns

Types	Code	Genotypes
Absent	0	G01, G02, G03, G04, G05, G06, G07, G10, G13
Partly awned	1	G08, G09, G12
Fully awned	2	G11

Plate 12. Brown (tawny) color grain

Plate 13. Seed coat (grain) color observed in thirteen genotypes

Plate 14. Partly awned grain

Plate 15. Fully awned grain

4.2 Quantitative Characteristics

4.2.1 Seedling height (30 DAS)

Seedling height of the observed genotypes ranged from 25.43 cm (G08) to 43.0 cm (G09) with a mean value of 35.70 cm (Appendix-II). On the basis of this character, the genotypes were categorized into three groups as short (<30 cm), intermediate (31-40 cm) and tall (>40 cm). Four genotypes (G08, G11, G12 and G13) was short type, three genotypes (G02, G03 and G07) were intermediate type and rest six genotypes (G01, G04, G05, G06 G09 and G10) were tall type in height (Table 19). Samia (2016) found short type of seedling height among nine genotypes.

4.2.2 Flag leaf length

Flag leaf length of observed genotypes ranged from 29.24 cm to 45.80 cm with a mean value of 33.63 cm (Appendix-II). On the basis of this character, the genotypes were categorized into 5 groups as very short (<21 cm), Short (21-30 cm), intermediate (31-50 cm), long (51-70 cm) and very long (>80 cm) as the guided descriptors where there were no very short type genotypes, four short type (G02, G03, G04 and G05) and nine intermediate types (G01, G06, G07, G08, G09, G10, G11, G12 and G 13), long type genotypes and very long type genotypes were also nil (Table 20). Same types of flag leaf length were found by Samia (2016). From Plate 16 we can see the flag leaf length.

4.2.3 Flag leaf breadth

Flag leaf breadth of observed genotypes ranged from 1.46 cm to 2.3 cm with a mean value of 1.62 cm (Appendix-II). On the basis of this character, the genotypes were categorized into three groups as narrow (<1 cm), intermediate (1-1.5 cm) and broad (>1.5 cm) as the guided descriptors where there were no narrow type genotype, only G (03) was intermediate type genotype and rest twelve broad type genotypes (G01, G02, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13) (Table 21). Arif (2015) also found narrow types of flag leaf breadth. From the Plate-17 we can see a flag leaf breadth.

Table 19. Categorization and grouping based on seedling height (30DAS)

Groups	Scale	Code	Genotypes
Short	<30 cm	3	G08, G11, G12, G13
Intermediate	31-40 cm	5	G02, G03, G07
Tall	>40 cm	7	G01, G04, G05, G06, G09, G10
Range	G(08) 25.43 cm- G(09) 43.0 cm		
Average	35.70 cm		

Table 20. Categorization and grouping based on flag leaf length

Groups	Scale	Code	Genotypes
Very short	<21 cm	1	Nil
Short	21-30 cm	3	G02, G03, G04, G05
Intermediate	31-50 cm	5	G01, G06, G07, G08, G09, G10, G11, G12 and G13
Long	51-70 cm	7	Nil
Very long	>70 cm	9	Nil
Range	G(05) 29.24 cm - G(09) 45.80 cm		
Average	33.63 cm		

Table 21. Categorization and grouping based on flag leaf breadth

Groups	Scale	Code	Genotypes
Narrow	<1 cm	3	Nil
Intermediate	1-1.5 cm	5	G03
Broad	>1.5 cm	7	G01, GO2, G04, G05, G06, G07, G08, G09, G10, G11, G12 and G13
Range	G(03) 1.46- G(01) 2.3		
Average	1.62 cm		

Plate 16. Flag leaf length

Plate 17. Flag leaf breadth

4.2.4 Culm length

Culm lengths of observed genotypes ranged from 159.17 cm to 76.13 cm with a mean value of 38.99 cm (Appendix-II). Based on this character, the genotypes were categorized into 7 groups as very short (<50 cm), very short to short (51– 70 cm), short (71–105 cm), intermediate (106–120 cm), intermediate to long (121–140 cm, Long (141–155 cm) and long to very long (156–180 cm) as the guided descriptors where there were no very short type, very short to short type and short type genotypes. Five short to intermediate type (G02, G03, G07, G08 and G13), five intermediate types (G01, G04, G05, G11 and G12) and three intermediate to long type (G06, G09 and G10) were found (Table 22). Arif (2015) also found long and long to very long types of culm length among thirty genotypes. From the figure-9 we also can distinguish different groups of observed genotypes based on culm length. Plate 18 is showing the culm length measurement at the field.

4.2.5 Culm diameter

From our observed genotypes, it was ranged from 5.38 mm (G10) to 7.04 mm (G11) with a value of 6.11 (Appendix-II). Based on this character, the observed genotypes were classified as small (<5.0 mm), medium (5.1-6.0mm), large (6.1-7.0mm) and very large (>7.0mm) where there were six genotypes (G04, G05, G06, G07, G08 and G10) belongs to medium category, six genotypes (G01, G02, G03, G09, G12, G13) belongs to large category and only one genotypes (G11) belongs to very large category (Table 23). Samia (2016) also found small types of culm diameter among nine genotypes.

4.2.6 Total number of tillers per hill

The number of tillers per plant ranged from 10.2 (G04) to 21.1 (G11) with a mean value of 16.78 (Appendix-II). Based on this character, the observed genotypes were identified as few (<10), medium (11-15) and high (>15) number of tillers per plant as presented in Table 24. Four genotypes (G07, G09, G10 and G13) had intermediate number of tillers per plant and rest nine genotypes (G01, G02, G03, G04, G05, G06, G08, G11 and G12) showed high tillering (Table 24). Same types of result were found by Samia (2016).

Table 22. Categorization and grouping based on culm length

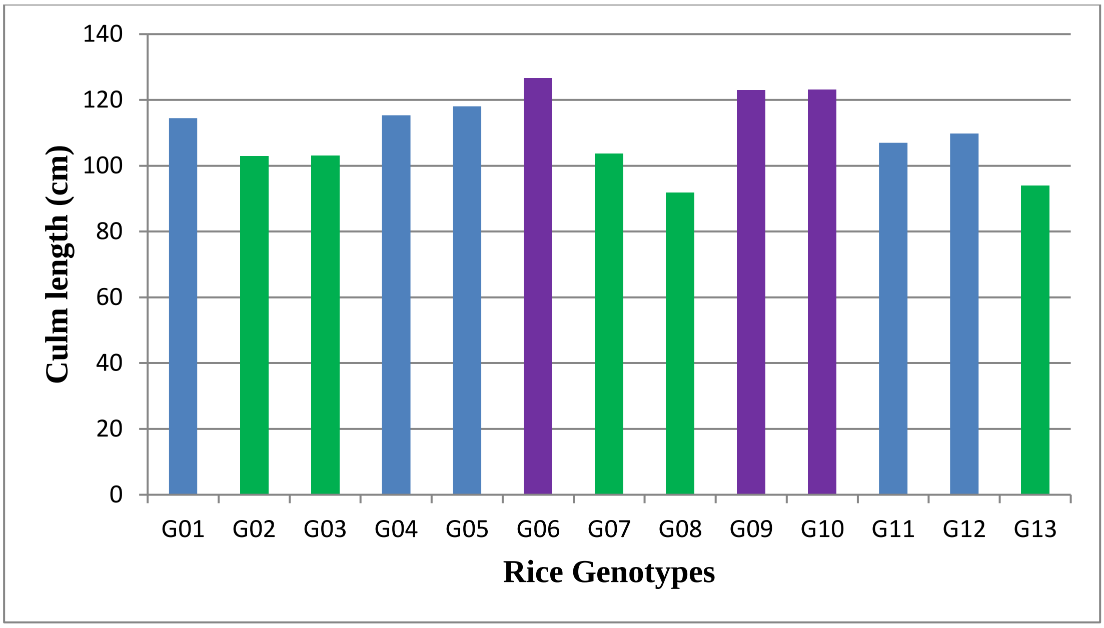
Groups	Scale	Code	Genotypes
Very short	<50 cm	1	Nil
Very short to short	51-70 cm	2	Nil
Short	71-90 cm	3	Nil
Short to intermediate	91-105 cm	4	G02, G03, G07, G08, G13
Intermediate	106- 120 cm	5	G01, G04, G05, G11, G12
Intermediate to long	121-140 cm	6	G06, G09, G10
Long	141-155 cm	7	Nil
Long to very long	156-180 cm	8	Nil
Very long	>180 cm	9	Nil
Range	(G08) 91.87 cm- (G06) 126.6 cm		
Average	110.24 cm		

Table 23. Categorization and grouping based on culm diameter

Groups	Scale	Code	Genotypes
Small	<5.0 mm	1	Nil
Medium	5.1- 6.0 mm	3	G04, G05, G06, G07, G08, G10
Large	6.1-7.0	5	G01, G02, G03, G09, G12, G13
Very large	>7.0	7	G11
Range	(G10) 5.38 mm- (G11) 7.04 mm		
Average	6.11		

Table 24. Categorization and grouping based on total number of tillers per hill

Groups	Scale	Code	Genotypes
Low	<10 culms	3	Nil
Intermediate	11-15 culms	5	G07, G09, G10, G13
High	>15 culms	7	G01, G02, G03, G04, G05, G06, G08, G11, G12
Range	(G04) 10.2 culms- (G11) 21.1 culms		
Average	15.78 culms		



Green color indicates short to intermediate culm length, blue color indicates intermediate and violet color indicates intermediate to long type culm length

Figure 9. Grouping of observed genotypes based on culm length

Plate 18. Culm length measurement at field

4.2.7 Effective tillers per hill

The number of effective tillers per plant of the observed genotypes ranged from 10.13 to 20.53 with a mean value of 14.86 (Appendix-II) and considering this character, the observed genotypes were categorized as low (<7), intermediate (8- 12) and high (>12) effective tillers per plant. Only two genotypes (G09, G10) had intermediate number of effective tillers per plant and rest eleven genotypes (G01, G02, G03, G04, G05, G06, G07, G08, G11, G12, G13) showed high type effective tillering (Table 25). Same types of result were found by Samia (2016).

4.2.8 Panicle length

The panicle length was measured in cm from panicle base to the tip of the panicle of main tiller without awns. The panicle length of the observed genotypes ranged from 21.35 cm to 31.67 cm with a mean value of 27.17 cm (Appendix-II) and based on this character, the genotypes were classified into five groups as very short (<11 cm), short (12-15 cm), medium (16-25 cm), long (26-35 cm) and very long (>35 cm). Five genotypes (G01, G03, G08, G09 and G13) were medium in panicle length and remaining eight genotypes (G02, G04, G05, G06, G07, G10, G11 and G12) showed long type panicles where others type panicle were not found (Table 26). Same types of result were found by Samia (2016). From the Figure-10 we also can distinguish different groups of observed genotypes based on panicle length where genotypes and panicle length has been presented horizontal and vertical axis respectively.

4.2.9 Branching of panicle

our observed genotypes were classified into four groups (Table 27) where every genotypes showed primary branching and grouping were followed actually by secondary branching as absent (0), sparse (1), dense (2-3), clustered (>3) type. Five genotypes (G03, G05, G06, G07 and G08,) were sparse type and rest eight genotypes (G01, G02, G04, G09, G10, G11, G12 and G13) were dense type where G04 showed highest (2.97) secondary branching and G08 showed lowest (1.32) secondary branching (Appendix-II). Arif (2015) and Samia (2016) found clustered types of panicle length.

Table 25. Categorization and grouping based on effective tillers per hill

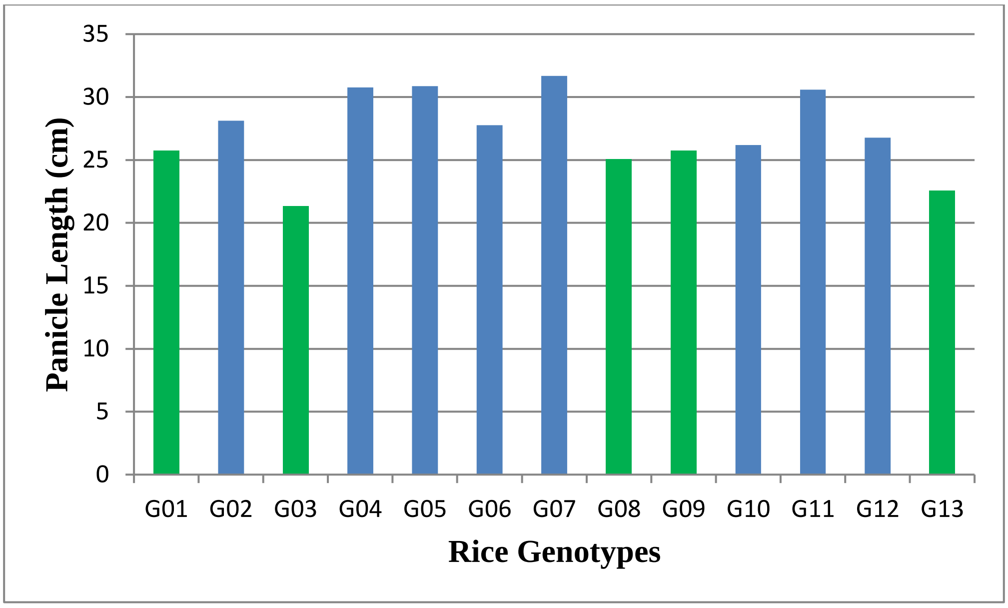
Groups	Scale	Code	Genotypes
Low	<7 culms	3	Nil
Intermediate	8-12 culms	5	G09, G10
High	>12 culms	7	G01, G02, G03, G04, G05, G06, G07, G08, G11, G12, G13
Range	(G04) 10.13- (G11) 20.53 culms		
Average	14.86 culms		

Table 26. Categorization and grouping based on panicle length

Groups	Scale	Code	Genotypes
Very short	<11 cm	1	Nil
Short	12-15 cm	3	Nil
Medium	16-25 cm	5	G01, G03, G08, G09, G13
Long	26-35 cm	7	G02, G04, G05, G06, G07, G10, G11, G12
Very long	>35 cm	9	Nil
Range	(G03) 21.35 cm- (G07) 31.67 cm		
Average	27.17 cm		

Table 27. Categorization and grouping based on branching of panicle

Groups	Scale	Code	Genotypes
Absent	0	0	Nil
Sparse	1	1	G03, G05, G06, G07, G08,
Dense	2-3	2	G01, G02, G04, G09, G10,G11, G12, G13
Clustered	>3	3	Nil
Range	(G08) 1.32- (G04) 2.97		
Average	2.22		



Green color indicates medium panicle length and blue color indicates long panicle length

Figure 10. Grouping of observed genotypes based on panicle length

4.2.10 Number of filled grains per panicle

The number of filled grains per panicle ranged from 102.4 to 192.73 with a mean value of 147.50 (Appendix-II). On the basis of this character, the genotypes were grouped as few (<150), medium (150-200), many (201-300) and so many (>301) number of filled grain per panicle. Six genotypes (G03, G06, G07, G08, G12 and G13) were recorded as few and rest seven genotypes (G01, G02, G04, G05, G09, G10 and G11) were recorded as medium category (Table 28). Samia (2016) was found 'many types' of filled grain per panicle and 'so many types' of filled grains was found by Arif (2015).

4.2.11 Number of unfilled grains per panicle

The number of unfilled grains per panicle ranged from 13.6 to 42.2 with a mean value of 27.62 (Appendix-II). On the basis of this character, the genotypes were grouped as few (<30), medium (31-50) and many (>51) number of unfilled grain per panicle. Eight genotypes (G02, G05, G07, G08, G09, G10, G11 and G13) were recorded as few, while five (G01, G03, G04, G06 and G12) as medium category (Table 29). 'Many types' of unfilled grains were found by Samia (2016) and Arif (2015).

4.2.12 Total number of grains per panicle

The total number of grains per panicle ranged from 116.0 to 231.46 with a mean value of 175.15 (Appendix-II). On the basis of this character, the genotypes were grouped as few (<200), medium (201-300), many (301-350) and so many (>351) number of grains per panicle. Only one genotype (G04) was recorded as medium and rest twelve genotypes (G01, G02, G03, G05, G06, G07, G08, G09, G10, G11, G12 and G13) were under few groups (Table 30). 'Many' and 'so many' types of total number of grains were found by Arif (2016). Figure 11 we can distinguish groups of observed genotypes based on total number of grains per panicle where genotypes and grain numbers has been presented horizontal and vertical axis respectively.

Table 28. Categorization and grouping based on number of filled grains per panicle

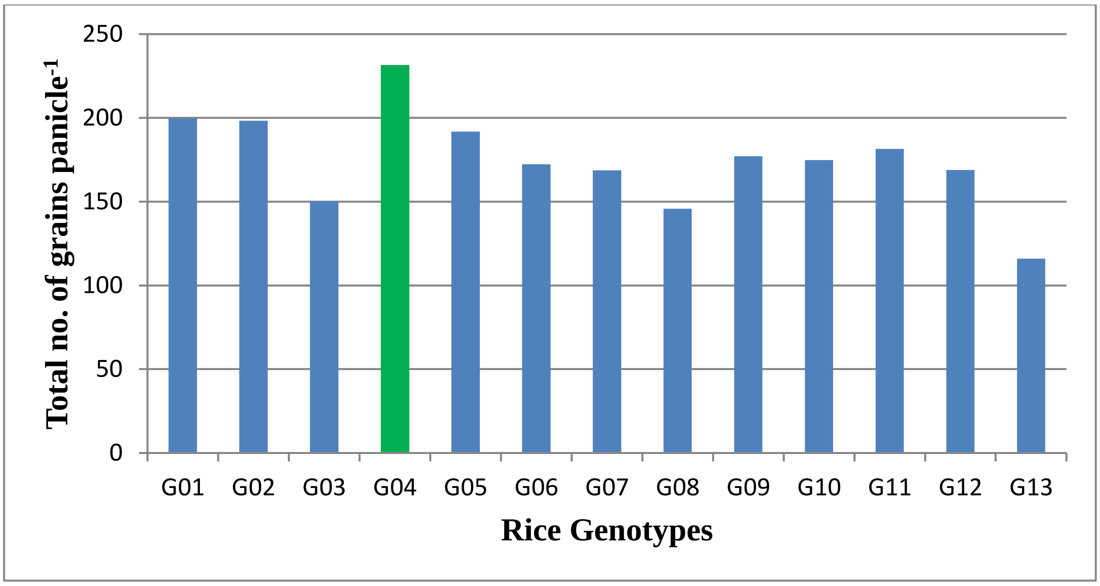
Groups	Scale	Code	Genotypes
Few	<150	1	G03, G06, G07, G08, G12, G13
Medium	151-200	3	G01, G02, G04, G05, G09, G10, G11
Many	201-300	5	Nil
So many	>300	7	Nil
Range	(G13) 102.4- (G04) 192.73		
Average	147.50		

Table 29. Categorization and grouping based on number of unfilled grains per panicle

Groups	Scale	Code	Genotypes
Few	<30	1	G02, G05, G07, G08, G09, G10, G11, G13
Medium	31-50	3	G01, G03, G04, G06, G12
Many	>50	5	Nil
Range	(G13) 13.6 – (G03) 42.2		
Average	27.62		

Table 30. Categorization and grouping based on total number of grains per panicle

Groups	Scale	Code	Genotypes
Few	<200	1	G01, G02, G03, G05, G06, G07, G08, G09, G10, G11, G12, G13
Medium	201-300	3	G04
Many	301-350	5	
So many	>351	7	
Range	(G13) 116.0- (G04) 231.6		
Average	175.15		



Blue color indicates few numbers of grains per panicle and green color indicates medium number of grains per panicle

Figure 11. Grouping of observed genotypes based on total number of grain per panicle

4.2.13 Days to main heading (80%)

Date on which 80% of the plants are heading. It is specified either as the number of days from seed sowing date to main heading date. Time of 80% heading of the observed genotypes ranged from 76 days to 98 days with a mean value of 89 days (Appendix-II). On the basis of time of 80% heading, all genotypes were classified into 4 groups as early (<80 days), medium (81- 100days), late (101-125) and very late (>125). Three genotypes (G11, G12 and G13) showed early and rest ten genotypes (G01, G02, G03, G04, G05, G06, G07, G08, G09 and G10) were recorded as medium in maturity (Table 31). Arif (2015) found late and very late types of days to main heading working with thirty landraces.

4.2.14 Days to maturity

Time of maturity was calculated as days required from sowing to maturity. Time of maturity of the observed genotypes ranged from 111 days to 130 days with a mean value of 120.24 days (Appendix-II) and on the basis of this character, all the genotypes were classified into 4 groups as early (<95 days), medium (96-120 days), late (121-140) and very late (>141 days). Three genotypes (G11, G12 and G13) were recorded as early maturity and rest ten genotypes (G01, G02, G03, G04, G05, G06, G07, G08, G09 and G10) were recorded as medium in maturity (Table 32). Arif (2015) found very late type of maturity among thirty landraces. This grouping based on days to maturity is also shown in bar graph for more easy perception by the following Figure-12 where genotypes have been shown horizontal axis and yield per plant along vertical axis.

4.2.15 Thousand seed weight (Dry)

Thousand grain weights of the observed genotypes ranged from 16.13 g to 25.20 g with a mean value of 20.90 g (Appendix-II). Here, the genotypes were grouped as very low (<l5 g), low (l6-19 g), medium (20-23 g) and high (24-27 g). Only two genotypes (G09, G10) were recorded as high, two genotypes (G07, G13) as low and rest nine genotypes (G01, G02, G03, G04, G05, G06, G08, G11 and G12) were recorded as medium types (Table 33). Samia (2016) found very high types seed weight among nine genotypes.

Table 31. Categorization and grouping based on days to main heading

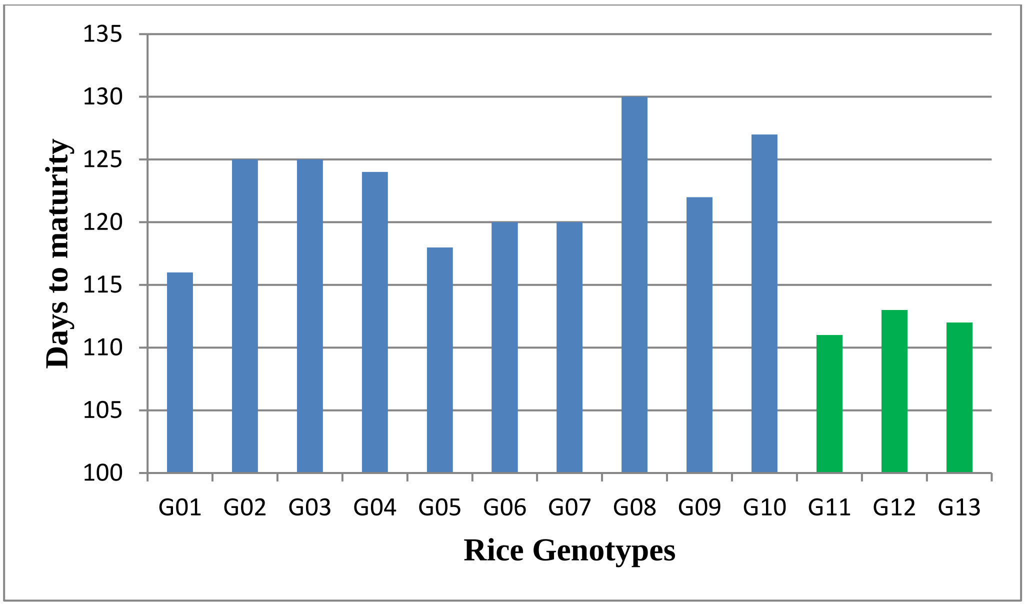
Groups	Scale	Code	Genotypes
Early	<80	1	G11, G12, G13
Medium	81-100	3	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10
Late	101-125	5	Nil
Very late	>125	7	Nil
Range	(G11) 76 days- (G09) 98 days		
Average	89 days		

Table 32. Categorization and grouping based on days to maturity

Groups	Scale	Code	Genotypes
Very late	<100	1	Nil
Early	101-115	3	G11, G12, G13
Medium	116-135	5	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10
Late	136-150	7	Nil
Very late	>150	9	Nil
Range	(G11) 111days- (G08) 130 days		
Average	120.24 days		

Table 33. Categorization and grouping based on thousand seed weight (Dry)

Groups	Scale	Code	Genotypes
Very low	<15 g	1	Nil
Low	16-19 g	3	G07, G13
Medium	20-23 g	5	G01, G02, G03, G04, G05, G06, G08, G11, G12
High	24-27 g	7	G09, G10
Very high	>27 g	9	
Range	(G013) 16.13 g- (G09) 25.20 g		
Average	20.90 g		



Green color indicates early maturity and blue color indicates medium maturity days

Figure 12. Grouping of observed genotypes based on days to maturity

4.2.16 Grain length (mm)

Grain length of thirteen genotypes ranged from 8.14 mm to 11.16 mm with a mean value of 9.10 mm (Appendix-II). On the basis of grain length, the observed genotypes were grouped as short (<5.50 mm), medium (5.51-6.5 mm), long (6.51-7.5 mm) and extra-long (>7.51 mm. Here all genotypes were recorded as extra-long (Table 34). Arif (2015) found long and medium types of grain length working with thirty landraces. From Plate- 19 we can see extra-long rice grain.

4.2.17 Grain width (mm)

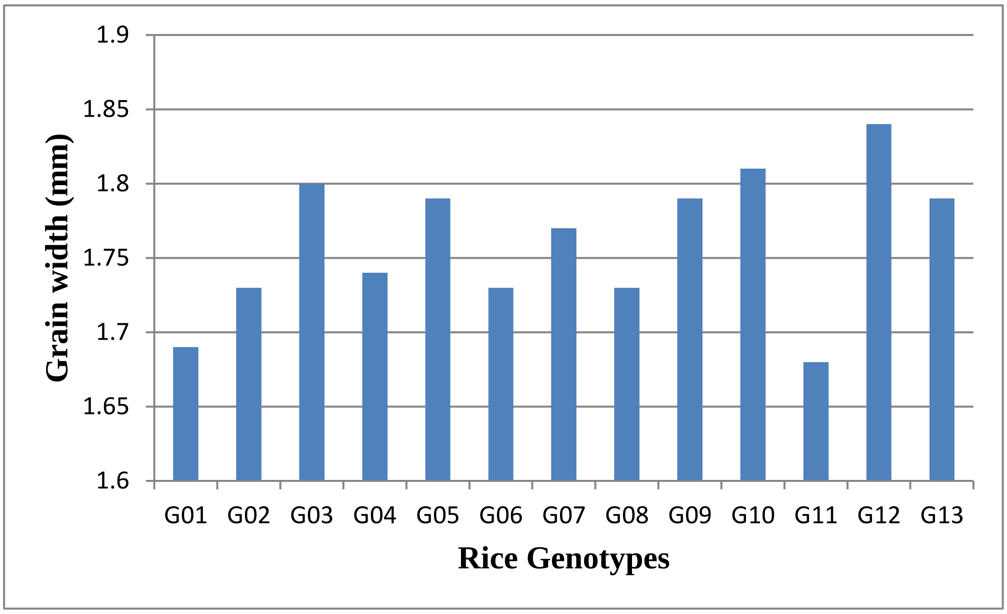
Grain width of thirteen genotypes ranged from 1.68 mm to 1.84 mm with a mean value of 1.76 mm (Appendix-II). On the basis of grain width our observed genotypes were categorized as fine (<2.5 mm), medium (2.51-3 mm) and coarse (>3 mm). Here all genotypes were recorded as fine grain (Table 35). Arif (2015) also found coarse types of grain width among thirty landraces. From Plate- 20 we can see fine rice grain. This grouping based on grain width is also shown in bar graph for more easy perception by the following Figure-13 where genotypes has been shown horizontal axis and grain width along vertical axis.

Table 34. Categorization and grouping based on grain length

Groups	Scale	Code	Genotypes
Short	<5.5 mm	1	Nil
Medium	5.51-6.5 mm	3	Nil
Long	6.51-7.5 mm	5	Nil
Extra long	>7.5 mm	7	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12, G13
Range	(G07) 8.14mm- (G04) 11.16mm		
Average	9.10mm		

Table 35. Categorization and grouping based on grain width

Groups	Scale	Code	Genotypes
Fine	<2.5 mm	3	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12, G13
Medium	2.51- 3 mm	5	Nil
Coarse	>3 mm	7	Nil
Range	(G11) 1.68mm- (G12) 1.84mm		
Average	1.76mm		



Blue color indicates fine grain width

Figure 13. Grouping of observed genotypes based on grain width

Plate 19. Extra-long rice grain

Plate 20. Fine rice grain

4.2.18 Yield per plant

Yield per plant ranged from 22.4gm to 49.47gm with a mean value of 35.76gm (Appendix-II). On the basis of seed yield per plant the observed genotypes were grouped as low (<20gm), medium (20-27gm) and high (>27gm) seed yielder. Only one genotype (G13) was recorded as medium yielder and rest twelve genotypes (G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11 and G12) as high yielder (Table 36). Arif (2015) also found low yield per plant among thirty landraces.

4.2.19 Yield per square meter area

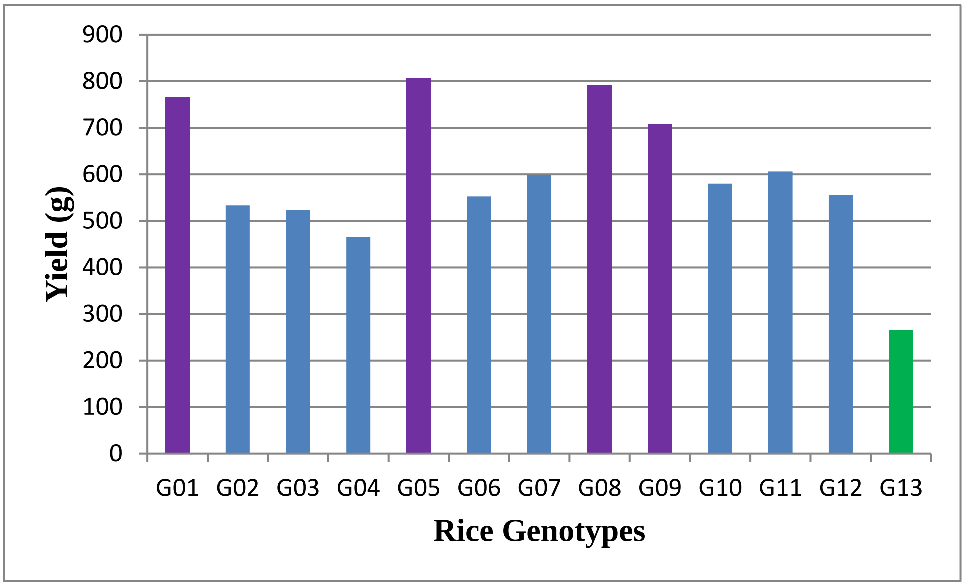
Yield per square meter ranged from 265.0gm to 807.67gm with a mean value of 596.62gm (Appendix-II). On the basis of seed yield per square meter the observed genotypes were grouped as low (<450gm), medium (450-650gm) and high (>650gm) seed yielder. Here only one genotype (G13) was recorded as low yielder. Eight genotypes (G02, G03, G04, G06, G07, G10, G11 and G12) were recorded as medium yielder and rest four genotypes (G01, G05, G08 and G09) as high yielder (Table 37). Samia (2016) found medium and high yielder genotypes per square meter area working with nine advanced lines. This grouping based on yield per square meter is also shown in bar graph for more easy understanding by the following Figure-14 where genotypes have been shown horizontal axis and yield per square meter area along vertical axis.

Table 36. Categorization and grouping based on yield per plant

Groups	Scale	Code	Genotypes
Low	<20 g	1	Nil
Medium	20-27 g	3	G13
High	>27 g	5	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12
Range	(G13) 22.4 g- (G05) 49.47 g		
Average	35.76 g		

Table 37. Categorization and grouping based on yield per square meter area

Groups	Scale	Code	Genotypes
Low	<450g	1	G13
Medium	450-650g	3	G02, G03, G04, G06, G07, G10, G11, G12
High	>650g	5	G01, G05, G08, G09
Range	(G13) 265 g-(G05) 807. 67 g		
Average	596.62 g		



The green color indicates low yielding genotypes, blue color indicates medium yielding and violet color indicates high yielding genotypes.

Figure 14. Grouping of observed genotypes based on yield per square meter area

4.3 Coding and coding analysis

Every character was coded according to IRRI and the genotypes were categorized and grouped by analyzing the codes. On the basis of these characters like green color intensity of leaf blade, leaf blade pubescence, ligule shape, culm lodging resistance, panicle attitude of branches, panicle exertion, flag leaf length, culm length, culm diameter, total number of tiller per hill, effective tillers, panicle length, branching of panicle**,** number of filled grain per panicle, total number of grain per panicle, thousand seed weight, grain length, yield per plant and yield per square meter area all codes were analyzed which has been presented in Table 38.

Here, higher value of the characters indicated the superiority of the genotypes. Here, the genotype (G01 and G11) showed the highest value of 102 and (G13) showed the lowest value of 87 respectively which indicated that (G01 and G11) was the most superior genotype and G13 was the most inferior genotype in respect of these characters.

On the basis of these characters like basal leaf sheath color, leaf blade attitude, flag leaf attitude, culm habit, leaf senescence, presence of awns, number of unfilled grain, days to main heading, days to maturity and grain width all codes were analyzed which has been presented in Table 39.

Here, lower value of the characters indicated the superiority of the genotypes. Here, the genotype (G13) showed the lowest value of 10 and (G01) showed the highest value of 25 respectively which indicated that (G13) was the most superior genotype and (G01) was the most inferior genotype in respect of these characters.

Table 38. Code analysis of the characters where higher value indicates superiority

Geno types	GC ILB	LBP	LS	CLR	PAB	PE	FLL	CL	CD M	TNT	ET	PL	BP	NF G	TN G	1000 SW	GL	YP P	YPS MA	Total
G01	7	3	3	9	9	9	5	5	5	7	7	5	2	3	1	5	7	5	5	102
G02	7	3	3	9	9	5	3	4	5	7	7	7	2	3	1	5	7	5	3	95
G03	7	3	3	9	7	7	3	4	5	7	7	5	1	1	1	5	7	5	3	90
G04	5	3	3	9	9	7	3	5	3	7	7	7	2	3	3	5	7	5	3	96
G05	5	3	3	9	5	9	3	5	3	7	7	7	1	3	1	5	7	5	5	93
G06	7	3	3	9	9	9	5	6	3	7	7	7	1	1	1	5	7	5	3	98
G07	7	3	3	9	9	9	5	4	3	5	7	7	1	1	1	3	7	5	3	92
G08	5	3	3	9	9	9	5	4	3	7	7	5	1	1	1	5	7	5	5	94
G09	7	3	3	9	9	9	5	6	5	5	5	5	2	3	1	7	7	5	5	101
G10	7	3	3	9	9	9	5	6	3	5	5	7	2	3	1	7	7	5	3	99
G11	5	3	3	9	9	9	5	5	7	7	7	7	2	3	1	5	7	5	3	102
G12	5	3	3	9	9	9	5	5	5	7	7	7	2	1	1	5	7	5	3	98
G13	5	3	3	9	9	9	5	4	5	5	7	5	2	1	1	3	7	3	1	87

GCILB: Green color intensity of leaf blade, LBP: Leaf blade pubescence, LS: Ligule shape, CLR: Culm lodging resistance, PAB: Panicle attitude of branches, PE: Panicle exertion, FLL: Flag leaf length, CL: Culm length, CDM: Culm diameter, TNT: Total no. of tiller per hill, ET: Effective tillers, PL: Panicle length, BP: Branching of panicle, NFG: No. of filled grain per panicle, TNG: Total no. of grain per panicle, 1000SW: Thousand seed weight, GL: Grain length, YPP: Yield per plant, YPSMA: Yield per square meter area.

Table 39. Code analysis of the characters where lower value indicates superiority

Geno Types	BLSC	LBA	FLA	CH	LS	PAN	NUG	DMH	DM	GW	Total
G01	1	5	3	1	1	0	3	3	5	3	25
G02	1	1	3	1	1	0	1	3	5	3	19
G03	1	1	1	1	1	0	3	3	5	3	19
G04	1	7	3	5	1	0	3	3	5	3	31
G05	1	1	3	3	1	0	1	3	5	3	21
G06	1	5	1	1	1	0	3	3	5	3	23
G07	1	5	3	1	1	0	1	3	5	3	23
G08	1	1	1	1	1	1	1	3	5	3	18
G09	1	5	3	1	1	1	1	3	5	3	24
G10	1	5	1	1	1	0	1	3	5	3	21
G11	1	1	1	1	1	2	1	1	3	3	15
G12	1	1	1	1	1	1	3	1	3	3	16
G13	1	1	1	1	1	0	1	1	3	3	10

BLSC: Basal leaf sheath color, LBA: Leaf blade attitude, FLA: Flag leaf attitude, CH: Culm habit, LS: Leaf senescence, PAN: Presence of awns, NUG: No. of unfilled grain, DMH: Days to main heading, DM: Days to maturity, GW: Grain width.

Plate 21. Field visit of my honorable supervisor

CHAPTER V

SUMMARY AND CONCLUSION

Rice is that the staple food for quite half the world's population and occupies nearly twenty percent of the total area covered by this cereal. Aman is that the second largest rice crops within the country in relevancy the amount of production whereas boro tops the production. It's notable that the area coverage of aman is that the largest as one crop and boro remains the second. Along with the higher production of aman rice, now a day's the quality of grain and duration of season is that the main concern to release a variety for aman season. Considering these above points, an investigation entitled "Characterization of some advanced lines of aman rice (*Oryza sativa* L.) for release as varieties" was conducted with some advanced lines of aman rice genotypes through a field experiment during the period of aman season 2017 at Sher-e-Bangla Agricultural University, Dhaka 1207.

Thirteen genotypes were evaluated for fifteen qualitative and nineteen quantitative traits of morphological characters to identify the best genotypes. Specific scales were coded for both qualitative and quantitative characters. For some characters higher value of those code indicated superiority such as very strong culm habit (coded as 9) of lodging resistance was showed the superiority. On the other hand, some characters had lower value of those codes indicated superiority such erect culm habit (coded as 1) was showed the superiority.

Higher value of some qualitative characters like green color intensity of leaf blade, leaf blade pubescence, ligule shape, lodging resistance, panicle attitude of branches, panicle exertion indicated the best agronomic performance. Here, in experiment all our thirteen genotypes showed the 2- cleft ligule and very strong lodging resistance which were the most agronomic characters. In case of panicle exertion well exerted panicle was most desirable for easy threshing and G01, G05, G06, G07, G08, G09, G10, G11, G12 and G13 showed the well exerted panicle character.

Lower value of some qualitative characters like basal leaf sheath color, leaf blade attitude, flag leaf attitude, culm habit, leaf senescence, presence of awns indicates the best agronomic characters. All our thirteen genotypes showed the green basal leaf sheath color, erect culm habit and slow leaf senescence which were the most agronomic characters. Here, G08, G09, G11 and G12 showed the presence of awn through it was not suitable for cultivated species. This character was partly observed in G08, G09 and G12 and fully observed in G11.

The higher value of the code of some quantitative characters like flag leaf length, culm length, culm diameter, total number of tillers per hill, effective tillers per hill, panicle length, branching of panicle, number of filled grains per panicle, total number of grains per panicle, days to maturity, thousand seed weight, grain length, yield per plant, yield per square meter area indicated the best agronomic characters. Average culm length was 110.24 cm with a wide range of 91.87 cm- 126.6 cm. Three genotypes (G06, G09 and G10) were intermediate to long type. Culm diameter was very large in only one genotype i.e. (G11). G11 showed the highest tiller number as well as effective tillers per hill (21.1 culms and 20.53 culms respectively).G04 showed the number of filled grains per panicle and total number of grains per panicle respectively. Average thousand seed weight was 20.90 g. G09 and G10 showed the very high types of thousand seed weight.

All our thirteen genotypes showed extra-long grain length with average 9.10 mm. Here, G04 showed the highest 11.16 mm grain length. All the genotypes except G13 showed high yield per plant with average 35.76 g. Here, G05 showed the highest 49.47 g grain per plant and G01, G05, G08 and G09 showed the highest yield on per square meter area about average 596.62 g and G05 showed the highest 807.67 g.

The lower value of the code of some qualitative characters like no. of unfilled grains per panicle, days to main heading, days to maturity, grain width indicated the superiority. Average maturity days were 120.24 days with a wide range of 111.0 days-130.0 days. Only three genotypes (G11, G12 and G13) showed the earliest maturity days. All the genotypes showed fine category of grain width with average 1.76 mm. Here, G11 showed the finest grain width i.e. 1.68 mm. Therefore, in this characterization G01, G09, G11 and G13 lines showed better performance but G05 showed higher yield and G11 showed short maturity duration. Considering all aspect it can be said that these lines need to further study to release as aman variety(s).

RECOMMENDATION

1. From the coding analysis G01 and G11 are superiority for higher value and G13 also showed superiority for lower value.
2. G11 showed short maturity duration among thirteen genotypes
3. G05 showed highest yield among these genotypes
4. Further characterization can be needed for variety release program
5. Multi-regional yield trial is required to observed the performance of yield conducive characters

CHAPTER VI

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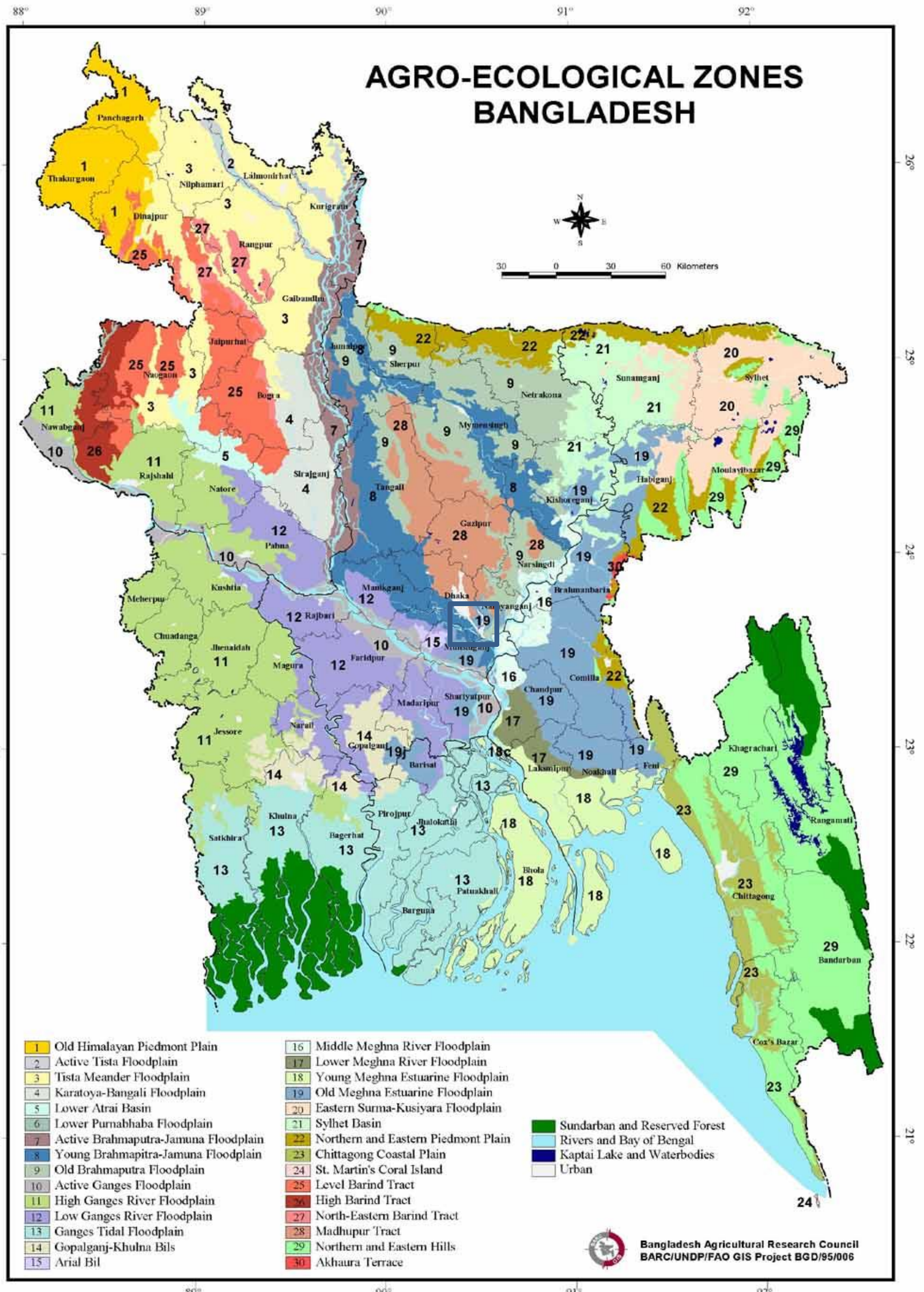
CHAPTER VII

APPENDICES

Appendix I. Map showing the experimental site under the study



→The experimental site of the study

Appendix II. Mean performance of quantitative characters of thirteen genotypes

Genotype	SDLH (cm)	FLL (cm)	FLB (cm)	CL (cm)	CDM (mm)	TNT	ETN	PL (cm)	BCP	NFG
G01	42.13	36.46	2.30	114.44	6.47	16.35	16.40	25.75	2.34	166.40
G02	36.17	28.48	1.56	103.01	6.10	16.87	16.13	28.12	2.61	174.40
G03	35.13	30.48	1.46	103.12	6.28	17.4	15.47	21.35	1.38	107.90
G04	41.87	29.32	1.82	115.36	6.05	10.20	10.13	30.77	2.97	192.73
G05	42.13	29.24	1.58	118.05	5.44	16.90	15.50	30.88	1.94	174.20
G06	41.47	36.50	1.54	126.60	6.01	17.06	15.87	27.76	1.99	137.0
G07	35.13	34.48	1.54	103.68	5.81	17.0	16.06	31.67	1.85	149.93
G08	25.43	32.42	1.76	91.87	5.63	15.70	14.60	25.06	1.32	121.0
G09	43.0	45.80	2.0	123.0	6.18	11.93	11.80	25.75	2.47	154.67
G10	42.83	37.36	1.78	123.13	5.38	11.80	11.47	26.20	2.61	145.27
G11	26.37	31.46	1.76	107.0	7.04	21.10	20.53	30.60	2.60	156.40
G12	26.20	32.94	1.76	109.79	6.81	18.0	16.06	26.77	2.32	131.13
G13	26.27	32.23	1.72	94.06	6.27	14.80	13.20	22.58	2.40	102.40
Mean	35.70	33.63	1.62	110.24	6.11	15.78	14.86	27.17	2.22	147.50
Minimum	25.43	29.24	1.46	91.87	5.38	10.22	10.13	21.35	1.32	102.4
Maximum	43.0	45.80	2.3	126.6	7.04	16.35	20.53	31.67	2.97	192.73

SDLH: Seedling height (30 DAS), FLL: Flag leaf length, FLW: Flag leaf width, CL: Culm length, CDM: Culm diameter, TNT: Total No. of tiller per hill, ETN: Effective tiller No. per hill, PL: Panicle length, BCP: Branching of panicle, NFG: No. of filled grain per panicle, NUG: No. of unfilled grain per panicle.

Appendix II (cont'd). Mean performance of quantitative characters of thirteen genotypes

Genotype	NUG	TNG	DMH	DM	GL (mm)	GW (mm)	1000SW (g)	YPP (g)	YPSMA (g)
G01	33.4	199.8	88	116	9.25	1.69	20.0	45.07	766.33
G02	20.0	198.4	94	125	8.35	1.73	20.0	35.5	533.33
G03	42.2	150.1	94	125	8.80	1.80	22.0	33.93	523.0
G04	38.73	231.46	89	124	11.16	1.74	22.95	34.47	465.67
G05	17.7	191.9	91	118	8.89	1.79	20.53	49.47	807.67
G06	35.27	172.27	93	120	8.70	1.73	21.0	32.53	552.33
G07	18.87	168.8	94	120	8.14	1.77	18.0	33.67	598.67
G08	24.80	145.8	97	130	9.23	1.73	20.0	31.17	792.67
G09	22.47	177.13	98	122	9.71	1.79	20.0	37.27	709.0
G10	29.60	174.87	86	127	8.43	1.81	24.58	28.80	580.33
G11	25.13	181.53	76	111	9.77	1.68	22.0	42.87	606.0
G12	37.47	168.90	77	113	9.05	1.84	20.0	38.0	556.0
G13	13.16	116.0	79	112	8.87	1.79	16.13	22.4	265.0
Mean	27.62	175.15	89	120.24	9.10	1.76	20.90	35.76	596.62
Minimum	13.6	116.0	76	111	8.14	1.68	16.13	22.4	265
Maximum	42.2	231.46	98	130	11.16	1.84	25.20	49.47	807.67

TNG: Total no. of grain per panicle, DMH: Days to main heading, DM: Days to maturity, GL: Grain length, GW: Grain width, 1000SW: Weight of 1000 seed, YPP: Yield per plant, YPSMA: Yield per square meter area.

Appendix III. Mean performance of qualitative characters of thirteen genotypes

Geno type	BL SC	GCI LB	LB A	LB P	LS	LC	A C	FL A	C H	CL R	PA B	PE	G C	LS	PA N
G01	1	7	5	3	3	1	1	3	1	9	9	9	2	1	0
G02	1	7	1	3	3	2	2	3	1	9	9	5	2	1	0
G03	1	7	1	3	3	1	1	1	1	9	7	7	3	1	0
G04	1	5	7	3	3	1	1	3	5	9	9	7	4	1	0
G05	1	5	1	3	3	1	1	3	3	9	5	9	3	1	0
G06	1	7	5	3	3	2	2	1	1	9	9	9	3	1	0
G07	1	7	5	3	3	1	1	3	1	9	9	9	2	1	0
G08	1	5	1	3	3	1	1	1	1	9	9	9	3	1	1
G09	1	7	5	3	3	1	1	3	1	9	9	9	3	1	1
G10	1	7	5	3	3	1	1	1	1	9	9	9	3	1	2
G11	1	5	1	3	3	2	2	1	1	9	9	9	2	1	0
G12	1	5	1	3	3	2	2	1	1	9	9	9	2	1	1
G13	1	5	1	3	3	2	2	1	1	9	9	9	2	1	0

BLSC: Basal Leaf Sheath Color, GILB: Green Color Intensity of Leaf Blade, LBA: Leaf Blade Attitude, LBP: Leaf blade pubescence, LS: Ligule shape, LC: Ligule color, AR: Auricle color, FLA: Flag leaf Attitude, CH: Culm habit, CLR: Culm lodging resistance, PAB: Panicle attitude of branches, PE: Panicle exertion, GC: Grain color, LS: Leaf senescence, PAN: Presence of awns.

Appendix IV. Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Morphological characteristics of the experiment field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General soil type	Deep red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical composition of the soil

Soil separates	%	Methods employed
Soil	36.90	Hydrometer method (Day, 1915)
Silt	26.40	Do
Clay	36.66	Do
Texture class	Clay loam	Do

Source: Central Library, Sher-e-Bangla Agricultural University

C. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.82	Walkley and Black, 1947
2	Total N (kg/ha)	1790.00	Bremner and Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lanester, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner, 1965
6	Available P (kg/ha)	69.00	Olsen and Dean, 1965
7	Exchangeable K (kg/ha)	89.50	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	pH (1:2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Source: Central Library, Sher-e-Bangla Agricultural University

Appendix V. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from July to November 2017

Month	Air temperature (°c)		Relative Humidity (%)	Rainfall
	Maximum	Minimum		
July 2017	36	25	84	72.71
August, 2017	35	23	82	77.83
September, 2017	36	24	83	86.32
October, 2017	35	19	80	72.33
November, 2017	34	15	74	5.25

Source: https:// www.timeanddate.com and https:// www.worldweatheronline.com

Appendix VI. Qualitative and Quantitative characters for various advanced aman lines

Characterization data of G01

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Horizontal	5
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate	5
20	Culm diameter	Large	5
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Medium	5
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Medium	3
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	High	5

Appendix VI (cont'd)

Characterization data of G02

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Yellowish green	2
7	Auricle color	Yellowish green	2
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Just exerted	5
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Intermediate	5
17	Flag leaf length	Short	3
18	Flag leaf breadth	Broad	7
19	Culm length	Short to intermediate	4
20	Culm diameter	Large	5
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G03

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Horizontal	7
12	Panicle exertion	Moderately exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Intermediate	5
17	Flag leaf length	Short	3
18	Flag leaf breadth	Intermediate	5
19	Culm length	Short to intermediate	4
20	Culm diameter	Large	5
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Medium	5
24	Branching of panicle	Sparse	1
25	Number of filled grains per panicle	Few	1
26	Number of unfilled grains per panicle	Medium	3
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G04

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Drooping	7
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Open	5
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Moderately exerted	9
13	Grain color	Brown (tawny)	4
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Short	3
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate	5
20	Culm diameter	Medium	3
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Medium	3
27	Total number of grains per panicle	Medium	3
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G05

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Semi-erect	3
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Spreading (open panicle)	5
12	Panicle exertion	Well exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Short	3
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate	5
20	Culm diameter	Medium	3
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Sparse	1
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	High	5

Appendix VI (cont'd)

Characterization data of G06

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Horizontal	5
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Yellowish green	2
7	Auricle color	Yellowish green	2
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate to long	6
20	Culm diameter	Medium	3
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Few	1
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Medium	3
28	Days to main heading	Medium	5
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G07

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Horizontal	5
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Intermediate	5
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Short to intermediate	4
20	Culm diameter	Medium	3
21	Total number of tillers per hill	Intermediate	5
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Sparse	1
25	Number of filled grains per panicle	Few	1
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Low	3
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont’d)

Characterization data of G08

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	Partly awned	1
16	Seedling height (30DAS)	Short	3
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Short to intermediate	4
20	Culm diameter	Medium	3
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Medium	5
24	Branching of panicle	Sparse	1
25	Number of filled grains per panicle	Few	1
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	High	5

Appendix VI (cont'd)

Characterization data of G09

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Horizontal	5
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Semi erect	3
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	Partly awned	1
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate to long	6
20	Culm diameter	Large	5
21	Total number of tillers per hill	Intermediate	5
22	Effective tillers per hill	Intermediate	5
23	Panicle length	Medium	5
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	High	7
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	High	5

Appendix VI (cont'd)

Characterization data of G10

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Dark green	7
3	Leaf blade attitude	Horizontal	5
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Whitish	1
7	Auricle color	Whitish	1
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	Golden	3
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Tall	7
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate to long	6
20	Culm diameter	Medium	3
21	Total number of tillers per hill	Intermediate	5
22	Effective tillers per hill	Intermediate	5
23	Panicle length	Long	7
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Medium	3
29	Days to maturity	Medium	5
30	Thousand seed weight	High	7
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G11

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Yellowish green	2
7	Auricle color	Yellowish green	2
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	Fully awned	2
16	Seedling height (30DAS)	Short	3
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate	5
20	Culm diameter	Very large	7
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Medium	3
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Early	1
29	Days to maturity	Early	3
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G12

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Yellowish green	2
7	Auricle color	Yellowish green	2
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	Partly awned	1
16	Seedling height (30DAS)	Short	3
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Intermediate	5
20	Culm diameter	Large	5
21	Total number of tillers per hill	High	7
22	Effective tillers per hill	High	7
23	Panicle length	Long	7
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Few	1
26	Number of unfilled grains per panicle	Medium	3
27	Total number of grains per panicle	Few	1
28	Days to main heading	Early	1
29	Days to maturity	Early	3
30	Thousand seed weight	Medium	5
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	High	5
34	Yield per square meter area	Medium	3

Appendix VI (cont'd)

Characterization data of G13

SL. No.	Characteristics	status	code
1	Basal leaf sheath color	Green	1
2	Green color intensity of leaf blade	Medium green	5
3	Leaf blade attitude	Erect	1
4	Leaf blade pubescence	Pubescent	3
5	Ligule shape	2-cleft	3
6	Ligule color	Yellowish green	2
7	Auricle color	Yellowish green	2
8	Flag leaf attitude	Erect	1
9	Culm habit	Erect	1
10	Lodging resistance	Very strong	9
11	Panicle attitude of branches	Drooping	9
12	Panicle exertion	Well exerted	9
13	Grain color	straw	2
14	Leaf senescence	Slow	1
15	Presence of awns	absent	0
16	Seedling height (30DAS)	Short	3
17	Flag leaf length	Intermediate	5
18	Flag leaf breadth	Broad	7
19	Culm length	Short to intermediate	4
20	Culm diameter	Large	5
21	Total number of tillers per hill	Intermediate	5
22	Effective tillers per hill	High	7
23	Panicle length	Medium	5
24	Branching of panicle	Dense	2
25	Number of filled grains per panicle	Few	1
26	Number of unfilled grains per panicle	Few	1
27	Total number of grains per panicle	Few	1
28	Days to main heading	Early	1
29	Days to maturity	Early	3
30	Thousand seed weight	Low	3
31	Grain length	Extra long	7
32	Grain width	Fine	3
33	Yield per plant	Medium	3
34	Yield per square meter area	Low	1