EVALUATION AND QUALITY ANALYSIS OF NEW PLANT TYPE (NPT) ADVANCED LINES OF RICE FOR AMAN SEASON

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CERTIFICATE

This is to certify that the thesis entitled, **"EVALUATION AND QUALITY ANALYSIS OF NEW PLANT TYPE (NPT) ADVANCED LINES OF RICE FOR AMAN SEASON"** submitted to the 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 results of a piece of bona fide research work carried out by SAZIA-E-JANNAT , Registration No. 08-3136 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dated: December, 2014
Place: Dhaka, Bangladesh

Prof. Dr. Md. Sarowar Hossain
Supervisor

DEDICATED

TO

MY BELOVED PARENTS AND

TEACHERS

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The Author

EVALUATION AND QUALITY ANALYSIS OF NEW PLANT TYPE (NPT) ADVANCED LINES OF RICE FOR AMAN SEASONAS HIGH YIELDING VARIETIES

BY

SAZIA-E-JANNAT

ABSTRACT

A field experiment was conducted with three advanced lines (AL-29, AL-36, AL-18) and two check varieties (BRRI dhan-39, BRRI dhan-49) of rice *(Oryza sativa* L.) at Sher-e-Bangla Agricultural University experimental farm, to perform varietal characterization and to carry out of yield evaluation based on different morphological characters during the period of June 2014 to December 2014. The experiment was laid out in a randomized complete block design with three replications. In the experiment highest plant height was for BRRI dhan 49 (106.5 cm) and days to 50% flowering for AL-36 which required maximum days (106 days). For days to maturity, BRRI dhan 39 required highest days (142 days) and maximum number of tillers showed AL-36 (22.33). Maximum number of effective tillers showed AL-36 (2.87) and maximum panicle length showed AL-29 (26.68 cm).The highest number of filled grains was for AL-29 (178.30) and the highest number of empty grains was in BRRI dhan 99 (22.00). For 1000-grain weight, AL-36 was the best than others (2.437g). AL-36 showed highest yield per plant (49.19), AL-29 showed highest yield per plot (10.75 g) and yield per hectare (6.32 ton). In correlation analysis a highly significant positive association was found for days to 50% flowering with grain yield/ha. The maximum length (9.667 mm), breadth (1.910 mm)and L/B ratio (5.063 mm) of rough rice was showed for AL-18. The maximum length (6.810 mm) and L/B ratio (4.087 mm) of brown rice was showed for BRRI dhan 39 and maximum breadth (1.793 mm) of brown rice was showed for AL-18. The maximum length (6.547 mm) and breadth (1.670 mm) of milled rice was showed for AL-18.and maximum L/B ratio (4.607 mm) of milled rice was showed for BRRI dhan 39. The maximum length (9.357 mm), breadth (2.437 mm) and L/B ratio (4.147 mm) of cooked rice was showed for BRRI dhan 39. The maximum milling percent (71.97%), head rice recovery percent (67.27%) and alkali spreading value (6.933) were found from BRRI dhan-49. The maximum hulling percent (81.00%) and water absorption percent (269%) were found from AL-36 whereas maximum volume expansion percent (72.33%) was found from AL-29. In correlation coefficient analysis highly significant positive associations were found for length of rough rice with breadth of rough rice and length of brown rice, breadth of rough rice with length of brown rice and L/B ratio of brown rice with L/B ratio of milled rice. Highly significant negative associations were found for breadth of milled rice with L/B ratio of milled rice.

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SOME COMMONLY USED ABBREVIATIONS

ABBREIATION	FULL NAME

AEZ	Agro-Ecological Zone
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
^{0}C	Degree centigrade
g	Gram (s)
MP	Muriate of Potash
TSP	Triple Super Phosphate
no.	Number
RCBD	Randomized Complete Block Design
t/ha	Ton/hectare
%	Percent
df	Degrees of freedom
CV	Co-efficient of Variation
SE	Standard Error
kg	Kilogram
Kg/ha	Kilogram/hectare
ppm	Parts Per Million
pH	Concentration of Hydrogen Ions
CEC	Cation Exchange Capacity
hr	Hour
mm	Millimeter
mMt	Million Matric ton
HI	Harvest Index
LSD	Least Significant Differences
et al.,	and others
BBS	Bangladesh Bureau of Statistics
IRRI	International Rice Research Institute
ANOVA	Analysis of Variance

CHAPTER I
INTRODUCTION

Rice *(Oryza sativa* L.) is the most important crop of tropical world. It is the major sources of food for approximately half of the world population and hence the most important crop on the earth (Goff, 1999). Rice is cultivated in about 152.04 mha and contributes 585.59 million tons of grains. Above 90% of total rice is produced and consumed in Asia-Pacific region. Rice provides 20-80% dietary energy and near about 12-17% of dietary protein for Asians (Azeez, 1986). In China, hybrid rice grows well and produce higher yield than modern cultivar and attracts farmer's attention (Lin and Yuan, 1980). Outside China, India is the first country to develop and commercially exploit the hybrid technology and 17 hybrids have been released (Hossain, 2004).

Rice dominates over all other crops and covers 75% of the total cropped area of Bangladesh. Total rice production in Bangladesh was about 10.97 million tons in 1971 when the country's population was only about 70.88 million whereas the country is now producing about 33.54 million tons rice to feed her 142.3 million people as staple food (BBS, 2010). The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020. But the average yield of rice is poor (4.34 t ha^{-1}) in Bangladesh (BRRI, 2011). Over 90% people depend on rice for their daily diets and it engages over 65% of the total agricultural labor-force. To feed the fast increasing global population, the worlds annual rice production must be increased from 520 million tons of 1994 to 760 million tons by the year 2020 (Kundu and Ladha, 1995).The challenged faced by the rice scientist are to developed technologies to break the genetic yield barrier(s) and make quantum yield increase to meet the required food needs of the country beyond 2000AD. During the last 25 years, an additional 300 mt of rice was produced through the adaptation of hybrid rice on large scale in China. Hybrids rice through its enhanced productivity enabled China to spare around four million hectare rice area annually for the production of other high value crops (Ahmed *et al.*, 2001).

In the commercial production of hybrids optimum plant density ensures the plants to grow properly with their aerial and underground parts by utilizing more solar radiation and soil nutrients (Miah *et al.*, 1990). Hybrid rice the highest yielding inbred check varieties of similar duration. Adoption of hybrids on large scale can contribute to increase production and productivity (Mishra, 2001). F_1rice hybrid produced more grain yield than semi dwarf inbred cultivars (Virmani *et al.*, 1982; Lin and Yuan, 1980).

Development of hybrid rice has brought a great hope and aspiration to meet the challenging demand of food deficits of the 21stcentury. China successfully developed hybrid rice in 1994 and by 1991 had expanded its cultivated area to 17.3 million hectares (Yuan and Fu, 1996).

Yield is the product of yield components i.e. panicle no., grain no., and grain weight in rice (Yoshida, 1981). Yield of rice is a function of genotype and environment. For increasing yield, a good number of varieties with high yield potential have been developed (Hossain *et al.* 1990). However, variation in yield may occur due to inability of choosing appropriate variety for an appropriate environment. Environment includes both climatic and management variables. All the modern varieties of rice do not suit similar climatic variables; thus season-specific recommendations are made for season(s) other than they are recommended for all seasons (Hossain *et al.*, 1987).

In Bangladesh hybrid rice has a good prospect but very little research work has been done for the development of hybrid. Only one rice hybrid variety named BRRI hybrid 1 has been released for commercial cultivation by Bangladesh Rice Research Institute (BRRI).

Since emergence in 1972, the BRRI has earned international standard of agricultural research and heritage status developing over 77 numbers of modern/high yielding (including four hybrids) varieties of rice. The performance of two Boro rice varieties of BRRI dhan 28 and BRRI dhan 29 are highly commendable. These two inbred HYV rice varieties are internationally competitive and considered to be mega varieties. The potential and cultivable commercial yields of BRRI dhan 28 is 6 to 6.5 ton per hectare and BRRI dhan 29 is 7 to 7.5 ton per hectare (Anon, 2004).

The hybrid varieties mostly cultivated in Bangladesh are mostly imported from China by private seed companies and only one hybrid varieties BRRI hybrid 1 has developed by Bangladesh Rice Research Institute and potentiality of this hybrid is 8.5 ton per hectare (Anon, 2004). Hussain *et al.*(2002) reported that two rice hybrids Sonarbangla 1(CNSGC6) and Alok 6201 released in Bangladesh during 1998-1999 are not well accepted by the producer, due to high rate of unfilled grains, grain shedding, crop lodging, though their yield advantage were 23% and 5% higher than that of HYVs, respectively. Greater emphasis is being given for increasing yield of hybrid rice during development or imported from other countries.

In the major rice-consuming countries, grain quality characteristics delicate the market value of the commodity and play an important role in the development and adoption of new varieties. The research will facilitate to develop high yielding Aman rice which would be used in further breeding programs. Again grain quality includes yield contributing traits as physical appearance, cooking and sensory properties, as well as nutritional value also important. Grain quality should be acceptable to farmers. Greater emphasis is being given for improving eating quality of rice during development or imported from other countries.

The population of Bangladesh is increasing day by day and that is why horizontal expansion of rice area is not possible due to high population pressure on land, to ensure the food security for her increasing population. Therefore, it is an urgent need of the time to increase rice production through increasing yield. Proper practices are the most effective means for increasing yield of rice at farmers level using inbred and hybrid varieties (Alauddin, 2004).

Keeping the foregoing problems in view, present investigation has been undertaken with the following objectives:

1. Evaluation of yield performance of different advanced lines of NPT,
2. To study the milling quality and grain appearances of these lines and
3. To determine the cooking and eating quality of these lines.

CHAPTER II

REVIEW OF LITERATURE

The International Rice Research Institute (IRRI) took the initiative in 1979 to explore potential and problems of developing technology for countries outside China. Learning from Chinese experience, nearly 20 countries are currently involved in development and use of this technology and many of them work in collaboration with IRRI. The annual growth rate in global rice production was only 1.8% during the 1985 to 1992 compared to 2.8% during 1975 to 1985 and 3.6% during 1965 to 1975. Over the years, there has been a gradual decline in the annual growth rate of global rice production. This world requires 60% increase in rice production (Khush, 1996).

According to Swaminathan (1998), we need a minimum annual growth rate of 2.5% in rice production to maintain the self-reliance, and to have sufficient rice production to maintain the self-reliance, and to have sufficient rice for both home consumption and export. Of the various short and long term approaches contemplated for raising further the yield threshold of rice, exploiting of hybrid vigor is considered as the most feasible and readily practicable approaches. Hybrids rice through its enhanced productivity enabled China to spare around four million hectare rice area annually for the production of other high value crops (Ahmed *et al.*, 2001).

Yield of rice is a function of genotype and environment. Environment includes both climatic and management variables. Not all the modern varieties of rice suit similar climatic variables; thus, season-specific recommendations are made for season(s) other than they are recommended for all seasons (Hossain *et al.*, 1987).

Yield is the product of yield components i.e. panicle no., grain no., and grain weight in rice (Yoshida, 1981). Response to selection depends on many factors, such as interrelationship of the character. Therefore, knowledge of the relationship between yield and yield components is desirable to know the magnitude and direction of changes expected during selection.

The available literatures under the heads of the objectives of the study were also reviewed in the following paragraphs.

2.1 Plant height (cm)

Zahid *et al.* (2005); studied 14 genotypes of basmati rice and observed high heritability couple with high genetic advance for plant height and 1000 grain weight.

Darkness may be one of the most important physical characters, because it is often accompanied by lodging resistance and there by adapts well to heavy fertilizer application. Plant height is negatively correlated with lodging resistance; positive for plant height in hybrids would not be desirable, particularly with high nitrogen fertilizer (Futsuhara and Kikuchi, 1984).

Haque *et al.* (1991); reported positive association of plant height with yield per plant but negative association with panicle per plant in modern varieties. Marekar and Siddiqui, (1996) stated that positive and significant correlations were observed between yield per plot and plant height, length of panicle, days to maturity, 1000-grain weight, length of grain and L/B ratio.

Qiu*et al.* (1994); suggested that enhancing biological yields by increasing plant height would be effective in improving hybrid rice yields.

Yu *et al.* (1995); concluded that hybrid where it reaches a height of 90 cm and proved resistant to *Magnaporth egrisea* and *Nilaparvatalugens*.

Padmavathi*et al.* (1996); said that high positive direct effects of plant height, number of panicles/plant and panicle length on grain yield. Saravanan and Senthil (1997) reported that high heritability estimates were observed for plant height (99.15%) followed by days to 50% flowering (98.2%) and productive tillers/plant (98.19%).

He *et al.* (1998); studied that plant height is 102.1 cm and it is directly resistant to rice bacterial leaf blight (*Xanthomonasoryzae).* Yang (1998) observed that plant height is 95-

98 cm while 1000- seed weight is 28 g. The rate of seed set was over 90%. Taste andgrain appearance is better than Akihikari.

Sathya*et al.* (1999);reported that productive tillers per plant, plant height and harvestindex are the principal character, which is responsible for grain yield per plant as they had also positive and significant association with yield.

Oka and Saito (1999) reported that among F_1there were relationships between plant height; panicle length and number of grains/panicle were higher in the hybrid MH2005.Pruneddu and Spanu (2001) conducted that plant height ranged from <65 cm in Mirto, Tejo, Gladio, Lamone and Timo, to 80-85 cm. Nine hybrid rice cultivars were resistant to lodging.

Cristo *et al.* (2000); observed 8 morphological traits. The highest correlation was between the final height and panicle length, and full grains per panicle and yield.Wang (2000) reported that plant height was 88-89 cm directly related to yields.

Mrityunjay (2001) concluded that hybrids, in general, gave higher values for plant height at harvest, panicle length and number of filled grains per panicle, performed better compared to the others in terms of yield and yield components.Ganesan (2001) reported that plant height, days to flowering, number of tillers/plant, and productive tillers/plant had both positive and negative indirect effects on yield.

De *et al.* (2002); experimented that plant height ranged from 80.00 to 132.00 cm, whereas panicle length ranged from 22.00 to 29.00 cm. which is responsible for grain yield per plant.

2.2 Days to 50% flowering

Most scientists indicated that days to 50% flowering has direct and indirect effect on yield, grains/panicle and also tillering height.Ganesan (2001) said that days to flowering, plant height, number of tillers/plant, and productive tillers/plant had both positive and negative indirect effects on yield.

Padmavathi*et al.* (1996); suggested that days to 50% flowering had high positive direct effects on number of panicles/plant and panicle length on grain yield. 1000-grain weight, dry matter production, spikelets sterility, days to 50% flowering, number of grains/panicle and plant height had positive direct effects on grain yield.

Vijayakumar*et al.* (1997); found that hybrids out yielded than their parents when their days to 50% flowering were similar or more than their respective restorers.

Sathya*et al.* (1999); studied of eight quantitative traits in rice *(Oryza sativa).* Days to 50% flowering was the principal character responsible for grain yield per plant followed by 1000-grain weight, plant height and harvest index as they had positive and significant association with yield.

Endo *et al.* (2000) said that flowering occurred 88 days after seedling emergence.

Iftekharuddaula*etal.* (2001); reported that days to flowering, days to maturity, plant height and spikelets/panicle had positive and higher indirect effect on grain yield through grains/panicle.

2.3 Number of effective tillers per plant

Ghose and Ghatge (1960) stated that tiller number, panicle length contributed to yield. Effective tillers/plant, number of grains/panicle and grain weight as the major contributing characters for grain yield were reported by Ghosh and Hossain (1988) and grain yield had positive correlations with number of productive tillers/plant (Paramasivam*et al*. 1995; Tahir*et al*, 2002).

Padmavathi*et al.* (1996); and Jiang *et al.,* (2000) observed the importance of number of tillers/plant which influencing yield.

Ganapathy*et al.* (1994); studied that the number of productive tillers per hill, panicle length and grains/panicle had a significant and positive association with grain yield.

Mishra *et al.* (1996); concluded that number of tillers per hill and number of grains per panicle exhibited positively high significant correlation with yield.

Ashvani*et al.* (1997); studied twenty two genotypically diverse strains of hybrid rice were to correlate yield contributing characters. Number of effective tillers/plant showed significant and positive correlation at genotypic and phenotypic levels with, grain yield/panicle, 1000-grain weight and total biological yield/plant.

Saravanan and Senthil (1997) studied that information on heritability. High heritability estimates were observed for productive tillers/plant (98.19%), plant height (99.15%) followed by days to 50% flowering (98.2%).Nehru *et al.,* (1999) suggested that increased yield might be due to increased numbers of tillers and spikelets fertility percentage and test weight.

Thakur *et al.* (1999); studied genetic variability and correlations among grain yield and its attributing traits, in an F_2 population in hybrid rice. Correlation studies suggested that tillers per plant, had a positive association with grain yield, plant height, panicle weight, biological yield and harvest index.

Sathya*et al.* (1999); studied of eight quantitative traits in rice *(Oryza sativa),* productive tillers per plant was the principal character responsible for grain yield per plant followed by 100-grain weight, days to 50% flowering, plant height and harvest index as they had positive and significant association with yield.

Nuruzzaman*et al.* (2000); concluded that tiller number varied widely among the varieties and the number of tillers per plant at the maximum tiller number stage ranged between 14.3, 39.5, and 12.2, 34.6.

Nehru *et al.* (2000); observed that the number of productive tillers directly correlated with yield and thus improved yields.Ganesan (2001) reported that plant height, days to flowering, number of tillers/plant, and productive tillers/plant had both positive and negative indirect effects on yield.

Ma *et al.* (2001); experimented that ADTRH1 is a rice hybrid. It tillers profusely (12-15 productive tillers per hill) under 20 x 10 cm spacing, with each panicle 27.5-cm long, producing 142 grains. In different trials, ADTRH1 showed 26.9 and 24.5% higher yield over CORH1 and ASD18, respectively, with an average yield of 6.6 t/ha.

Laza*et al.* (2001); concluded that the early vigor of hybrid rice (*Oryza sativa*) developed in temperate areas has been mainly attributed to its higher tillering rate. However, the tillering rate of hybrids was significantly lower than or equal to that of conventional varieties.Somnath and Ghosh (2004) reported that the association of yield and yield related traits with the number of effective tillers and had negative association with yield and yield components.

2.4 Panicle length (cm)

Ganapathy*et al.* (1994); reported that panicle length, the number of productive tillers per hill, and grains/panicle had a significant and positive association with grain yield.

Ramalingam*et al.* (1994); observed that varieties with long panicles, a greater number of filled grains and more primary rachis would be suitable for selection because these characters have high positive association with grain yield and are correlated among themselves.

Sawant*et al.* (1995); concluded that panicle length was negatively correlated with flowering time and positively correlated with tiller height.Marekar and Siddiqui (1996) concluded that positive and significant correlations were observed between yield per plot and plant height, length of panicle, days to maturity, 1000-grain weight, length of grain and L/B ratio.

Padmavathi*et al.* (1996); concluded that number of tillers/plant, number of panicles/plant, panicle length and 1000-grain weight was positively associated with grain yield.Oka and Saito (1999) said that there were relationships with parental values for panicle length, grain number/panicle and panicle emergence date. The hybrid MH2005 gave a yield of 6.09 t/ha compared with 4.36 t/ha from cv. Hitomebore.

Nehru *et al.* (2000); showed that values for test weight and yield differed significantly for hybrids (21-24 g) and varieties (19-23 g). No differences in panicle length were noted between the two groups.
Cristo *et al.* (2000); observed that highest correlation was between the final height and panicle length, and full grains per panicle and yield. There were associations between rice hybrids and their parents.Ganesan (2001) conducted that panicle length (0.167) had the

highest significant positive direct effect on yield/plant followed by number of tillers/plant (0.688), panicle exertion (0.172), and plant height (0.149).

Laza*et al.* (2004); study was measured with yield-related traits, panicle size had the most consistent and closest positive correlation with grain yield.

2.5 Filled grain per panicle

Mahajan (1993) indicated that filled grains/panicle, grain yield/plant was positively and significantly correlated with straw yield/plant.Geetha (1993) indicated that number of ear-bearing tillers, filled grain/per panicle, percentage filled grain, and test weight, straw yield and harvest index were all correlated positively with grain yield.

Yang and Song (1994) observed that heterosis was highest for number of effective panicles (59.06%) and high for total filled grain number/main panicle (42.44%). Number of effective grains/ panicles was correlated with 100-grain weight and 10-grain length.

Ganapathy*et al.* (1994); said that the number of filled grains/panicle, productive tillers per hill, panicle length had a significant and positive association with grain yield.Ramalingam*et al.,* (1994) examined the varieties with long panicles, a greater number of filled grains/panicle and more primary rachis would be suitable for selection because these characters have high positive association with grain yield.

Lin (1995) studied the relationship among filled grains/panicle, grain size, yield components and quality of grains. The percentage of filled grains/panicle was the most important factor affecting grain yield.

Padmavathi*et al.* (1996); concluded that number of filled grains/panicle, plant height 1000-grain weight, dry matter production, spikelets sterility, days to 50% flowering had positive direct effects on grain yield.

Mishra *et al.* (1996); concluded that phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) estimates were higher no. of tillers per hill and number of grains per panicle exhibited positively high significant correlation with yield.

Mani *et al.* (1997); investigate the extent of genetic variation and interrelationship among them. A wide range of variation was recorded for all the traits. A high estimate of heritability coupled with high genetic advance for number of filled grains/panicle suggested the predominance of additive gene action for this character.

Liu *et al.* (1997); evaluated 24 *indica* x *japonica* hybrids where, filled grain/panicle (FSP) spikelets/panicle (SP), and 1000-grain weight was positively correlated with GWP. Filled grain/panicle (FSP) had the highest effect on GWP.

Ramana*et al.* (1998) observed that hybrids produced more panicles m^{-2} and filled grains per panicle than conventional cultivars.

Dhananjaya*et al.* (1998); evaluated some 121 elite homozygous rice genotypes. Most variation was observed for filled grain/panicle, number of fertile spikelets and grain yield/plant. Grain yield was positively correlated with number of filled grain/panicle, harvest index, panicle density, 1000-grain weight, number of productive tillers and plant height. Oka and Saito (1999) experimented that among F_1 hybrids from crosses of rice cv. Sasanishiki with other cultivars there were relationships with parental values for grain number/panicle, panicle length, and panicle emergence date.

Cristo *et al.* (2000); observed the highest correlation between full grains per panicle, final height and panicle length and yield.

Mrityunjay (2001) reported that the performance of 4 rice hybrids and 4 high yielding rice cultivars. Hybrids, in general, gave higher values for number of filled grains per panicle, plant height at harvest, panicle length compared to the others.Ganesan (2001) conducted that an experiment of 48 rice hybrids. Filled grains/panicle (0.895) had the highest significant positive direct effect on yield/plant followed by number of tillers/plant (0.688, panicle length (0.167) and plant height (0.149).

Liu and Yuan (2002) studied the relationships between high yielding potential and yielding traits. Filled grains per panicle was positively correlated with biomass, harvest index and grain weight per plant.

Parvez*et al.* (2003); studied the yield advantage for the hybrid rice was mainly due the proportion of filled grains per panicle, heavier grain weight (35%) and increased values than the control (28%).

Chaudhary and Motiramani (2003) filled grain yield per panicle showed significant positive correlation with effective tillers per plant, spikelets density and biological yield per plant.Yuan *et al.*, (2005) the variation in fertile grain percentage/panicle in *indica* was greater than that in *japonica*

2.6 Total grains per panicle

Yang and Song (1994) reported that in a hybrid from crosses heterosis was highest for number of effective panicles (59.06%) and high for total grain /main panicle (42.44%).

Ganapathy*et al.* (1994); concluded that the number of productive tillers per hill, panicle length and grains/panicle had a significant and positive association with grain yield.

Lin (1995) studied the relationship among the grain size, yield components and quality. The percentage of filled grains was the most important factor affecting grain yield.

Mishra *et al.* (1996); concluded that phenotypic coefficient of variation and genotypic coefficient of variation estimates were high for grains per panicle. Number of tillers per hill and total number of grains per panicle exhibited positively high significant correlation with yield.

Wey and Traore (1998) analysed of yield components. The most important components were the number of panicles per plant and the number of grains per panicle.

Dhananjaya*et al.* (1998); most variation was observed for productive tillers/plant, number of fertile spikelets and total grain yield/plant. Grain yield was positively correlated with harvest index, panicle density; number of fertile spikelets, 1000-grain weight, number of grains and plant height.

Oka and Saito (1999) experimented that among F_1hybrids crosses with rice cv. Sasanishiki. Plant height, panicle length and number of grains/panicle were higher in the hybrid than in Sasanishiki, but the 1000-grain weight was lower.

Ma *et al.* (2001); examined under 20 x 10 cm spacing, producing 142 grains/panicle, and with more than 90% spikelet fertility. The hybrid recorded the highest grain yield 11.4 t/ha.

Sarkar*et al.* (2005); studied the number of grains/panicle was negatively associated with number of panicle.

Yuan *et al.* (2005); studied the variation in the yield components of 75 high-quality rice cultivars. Among the yield components, the greatest variation was recorded for number of grains per panicle in *indica* rice, and number of panicles in *japonica* rice.

2.7 Days to maturity

Lin and Yuan (1980) reported that most hybrids had longer growth duration, however, Xu and Wang (1980) observed that days to maturity depended on the restorer.

Yu *et al.* (1995); concluded that hybrid variety was bred from the cross II32A/Hui 92 in the Zhejiang province of China it reaches a height of 90 cm and has a growth period of 122-125 days.

He *et al.* (1998); studied that hybrid the growth period is 136 days. The hybrid combinations Lexiang 202×Minghui-151 showed early maturity and fine grain quality. Duration of jaymati from sowing to seed is 170 days for summer, and 130 days for autumn and winter rice (Ahmed, 1998).

Pruneddu and Spanu (2001) conducted that earliest hybrid rice cultivar Ebro, reaching maturity 114 days after sowing, and Balilla, Tejo and Thaibonnet were the latest, reaching maturity 128 days after sowing.

Yang (1998) examined that Chao Chan-1, a hybrid rice cultivar. The growth period is 145 days. Conversely, Ponnuthurai*et al.*, (1984) reported that hybrid growth duration similar to that of the shorter duration parent.

Wang (2000) experimented that in plot trials in 1998 and 1999, growth period of early hybrid rice cv. Zhe 9516 was 116 and 117 days, respectively.

Ma *et al.* (2001); experimented that ADTRH1 is a rice hybrid. This hybrid is semi dwarf and matures in 115 days. Huang *et al.,* (1999) studied the morphological and physiological characteristics of Yueza 122. The results showed that it was an early maturity hybrid combination with duration of 83 days from sowing to heading in the early cropping season.

Parvez*et al.* (2003); observed that shorter field duration was observed in Sonarbangla-1 than the control. Ma *et al.,* (2001) studied a comparative performance of 8 rice hybrids. All hybrids showed shorter growth duration (97-107 days) than the controls (110-116 days).

Wei *et al.* (2004); concluded that Yueza 122 was bred by crossing GD-IS with Guanghui 122. It shows wide adaptability, high and stable grain yield, moderate growth period, and fine grain quality, high resistance to rice blast and medium resistance to bacterial blight.

2.8 1000-grain weight (g)

Kim and Rutger (1988) observed positive yield predominantly in 1000- grain weight and no. of spikelets per plant. They also observed high correlation between 1000-grain weight and grain yield.

Kumar *et al.* (1994); stated that grain weight was highly correlated to grain size, which is product of grain length and width that are inherited independently and this independent inheritance lead to variation in F_1 grain weights.

Padmavathi*et al.* (1996); concluded that number of tillers/plant, number of panicles/plant, panicle length and 1000-grain weight was positively associated with grain yield.

Marekar and Siddiqui (1996) observed that positive and significant correlations between yield per plot and plant height, length of panicle, days to maturity, 1000-grain weight, length of grain and L/B ratio.

Ashvani*et al.* (1997); stated that 1000 grain weight and total biological yield/plant may be considered for further improvement of rice.

Yang (1998) studied that Chao Chan-l hybrid rice was 1000-seed weight is 28 g. which is directly related with yield.

Sathya*et al.* (1999); reported that 1000-grain weight, days to 50% flowering, plant height and harvest index as they had positive and significant association with yield.

Ma *et al.* (2001); experimented that ADTRH1 is a rice hybrid. 1000-grain weight is 23.8 g. In different trials, ADTRH1 showed 26.9 and 24.5% higher yield over CORH1 and ASD18.

Iftekharuddaula*et al.* (2001); reported that genotypic correlation co-efficient were higher than the corresponding phenotypic correlation coefficient in most of the traits. Days to flowering, days to maturity, grains per panicle, 1000-grain weight and harvest index showed significant positive correlations with grain yield.

Sarkar*et al.* (2005); said that the highest heritability value was registered for 1000-grain weight, followed by brown kernel length and grain length.

2.9 Biological yield (g)

A positive significant correlation between biological yields also been reported by no. of workers in rice (Siddiq and Reddy, 1984; Malik *et al.*,1988Ganesan and Subramaniam, 1990). High yielding hybrids also showed significant heterosis and heterobeltiosis for total dry matter and harvest index (Ponnuthurai*et al.*,1984 Kim, 1985).

Kim and Rutger (1988) noted that hybrids that gave high grain yields also produced high biomass. In addition, biomass yield at different growth stages showed different patterns for hybrid rice and conventional rice. Hybrid rice has more dry matter accumulation in the early and middle growth stages.

Hybrid rice also accumulates more total dry matter than conventional rice (Zhende, 1986). Qiu*et al.*, (1994) experimented that the higher the biological yield, the higher was the economic yield (the regression equation is given). Results suggested that enhancing biological yields by increasing plant height would be effective in improving hybrid yields.

Geetha (1993) indicated that straw yield and harvest index were all correlated positively with grain yield.

Ramesha*et al.* (1998); conducted that the superior yielding ability of the hybrids over the controls resulted from increased total biomass and increased panicle weight, with almost the same level of harvest index.

Peng*et al.* (2000); concluded that the increasing trend in yield of cultivars due to the improvement in harvest index (HI), while an increase in total biomass was associated with yield trends for cultivars-lines.

2.10. Grain yield/plant

Mahajan*et al.* (1993); indicated that grain yield/plant was positively and significantly correlated with straw yield/plant and filled grains/panicle.

Ganapathy*et al.* (1994); concluded that the number of productive tillers per hill, panicle length and grains/panicle had a significant and positive association with grain yield.

Geetha*et al.* (1994); studied those six hybrids for grain characters. ADRH4 was the highest yielding (19.7 g/plant).The increased yield in this hybrid was due to a higher number of grains per plant. Correlation analysis revealed that only grains per plant had a strong positive association with grain yield.

Ashvani*et al.* (1997); observed that grain yield/plant showed significant and positive correlationat genotypic and phenotypic levels with number of effective tillers/plant, grain yield/panicle, 1000 grain weight and total biological yield/plant.

Paul and Kand (1997); said that yield was negatively correlated with false grains/panicle days to maturity, plant height and filled grains/panicle.

Dhananjaya*et al.* (1998); evaluated that grain yield was positively correlated with harvest index, panicle density, number of fertile spikelets, 1000-grain weight, number of productive tillers and plant height.

Thakur *et al.* (1999); stated that high heritability coupled with high genetic advance were estimated for biological yield, panicle-weight, branches per panicle and grains per plant, and indicated the major contribution of additive gene action for expression of these characters.

Pushpa*et al.* (1999); evaluated fifty genotypes of upland rice for 10 quantitative traits. The genotypic coefficient of variation was highest for grain yield/plant and also high for spikelets/panicle and grain yield/panicle.

Chauhan*et al.* (1999); grain yield was positively associated with dry matter at 50% flowering, biological yield and harvest index. Leaf area index, dry matter accumulation of 50% flowering, biological yield and harvest index seemed to be important in improvinggrain yield.

Oka and Saito (1999) experimented that among F_1 hybrids from crosses of rice cv. Sasanishiki. The hybrid MH2005 gave a yield of 6.09 t/ha compared with 4.36 t/ha from cv. Hitomebore. Plant height, panicle length and number of grains/plant were higher in the hybrid than in Hitomebore, but the 1000-grain weight was lower. Ganesan (2001) concluded that grains/plant had the least significant positive direct effect on number of tillers/plant (0.688), panicle exsertion (0.172), panicle length (0.167) and plant height (0.149).

Pruneddu and Spanu (2001) data are tabulated on grains per plant, days from sowing to maturity, grain yield, and plant height, number of fertile stems per m^2, 1000-grain weight and yield percentages. Yields were generally lower mainly due to unfavorably high temperatures.

Chaudhary and Motiramani (2003) reported that grain yield per plant showed significant positive correlation with effective tillers per plant, spikelets density and biological yield per plant. Almost all characters exhibited high heritability coupled with high genetic advance, except harvest index.

2.11 . Yield potential of hybrid

Prior to the breeding of hybrids, yield potential of *indica-japonica* hybrids in Hunan Province, China, and Korea were evaluated with the assumption that the yield potential could be estimated by compensating for yield losses due to hybrid sterility.

Araki *et al.* (1988); noted that two experimental *indica/japonica* hybrids, Kanto Kou1 and Ouu Kou1. Ouu Kou1 gave an average yield increase of 22% at six sites, excluding the one affected by cold weather in 1991.

Yuan (1990) reported that an experiment *indica/japonica* hybrid, Erjiuqingindica (TGMS)/DT13 (japonica WC variety) was conducted at the Hunan Hybrid Rice Research Centre in 1989. This hybrid gave a yield increase of 47% against an *indica* hybrid V-You-6.

Khush and Aquino (1994) reported that the yield potential of modern high yielding varieties grown under the best tropical conditions is 9-10 t/ha. Tropical rice hybrids under similar condition have shown about 12 t/ha.

Khush*et al.* (1998); also noted that if these new plant cultivars will be used to produce hybrid rice, which is expected to have a yield potential of 13 t/ha.

Ramana*et al.* (1998); observed the mean grain yield of the best performing rice hybrids was 37.7% higher than the conventional cv. IR-64 during 1993, while in 1995 the maximum yield of rice hybrid MTUHR 2037 was 10.3, 17.4 and 31.1% higher than that of comparison cultivars Chaitanya, BPT 5204 and Tellahamsa, respectively. The mean grain yield of rice hybrids during 1996 was 23.7 and 26.0% higher than BPT 5204 and Tellahamsa, respectively.

Khan *et al.* (1998); hybrids produced a higher grain yield/plant than the respective mid-parents in both F_1 cross-combinations. Average heterosis value for yield was 1.14.

Ma *et al.* (2001); studied a comparative performance of 8 rice hybrids and the control cultivars PS02 and PTT1. The hybrids possessed more leaves (12-15.9) than the local cultivars (15.1-15.3) as well as higher yield. NN49 produced the highest yield (7.142

t/ha) which was 58.78 and 26.52% higher than those of PS02 and PTT1.

Ma *et al.* (2001); experimented that ADTRH1 is a rice hybrid in different trials, ADTRH1 showed 26.9 and 24.5% higher yield over CORH1 and ASD18, respectively, with an average yield of 6.6 t/ha. The hybrid recorded the highest grain yield 11.4 t/ha. The highest yield of the control in these trials was 9.6 t/ha. Parvez*et al.,* (2003)conducted a comparative study to evaluate four imported hybrid rice cultivars with a high yielding variety (BRRI Dhan-29).The Chinese cultivar, Sonarbangla-1, performed best in terms of all the parameters considered. The other three Indian cultivars (Amarsiri-1, Aalok and Loknath) had lower performance than the control. Sonarbangla-1 produced a 20% higher rice yield (7.55 t/ha) than the control (6.26 t/ha). Yield advantage for the hybrid rice was mainly due to heavier grain weight (35%).

CHAPTER III
MATERIALS AND METHODS

The field experiment was conducted at the central research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period fromJune 2014 to December 2014. This chapter deals with a brief description on experimental site, climate, soil, land preparation, planting materials, layout of the experimental design, land preparation, fertilizer application, irrigation and drainage, intercultural operation, data recording and their analysis, plant height, days to 50% flowering, date of maturity, no of tiller, no. of effective tillers per plant, panicle length, no. of filled grain per plant, no. of empty grain per panicle, 1000-grain weight, grain yield per plant, grain yield per plot and total yield.

3.1. Experimental site

The experiment was conducted in the Sher-e-Bangla Agricultural University research farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh.A field view of the experiment plot is presented in plate 1 and plate 2.

3.2. Geographical location

The experimental area was situated at 23°77'N latitude and 90°23'E longitude at an altitude of 8.6 meter above the sea level. The experimental field belongs to the Agro-ecological zone of “The Modhatupur Tract”, AEZ-28. For better understanding about the experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.3. Characteristics of soil

The experiment was carried out in a typical rice growing soil belongs to the Modhupur Tract (UNDP, 1988). Soil was sandy loam in texture. The land was well drained with good irrigation facilities. The nutritional status of the experimental soil of farm area determined in the SRDI, the Soil Testing Laboratory, Khamarbari, Dhaka have been presented in Appendix II and III. The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO(1988). Soil series: Tejgaon, General soil: Non calcareous dark grey.

Plate 1. A field view of the experimental plot

Plate 2.A close view of rice at ripening stage.

3.4. Climatic condition of the experimental site

The experimental area is under the sub-tropical climate that characterized by the three distinct seasons. The monsoon or rainy season extending from May to October, winter or dry season from November to February and the pre-monsoon period or hot season from March to April. Information regarding monthly maximum and minimum temperature, rainfall, relative humidity, soil temperature and sunshine as recorded by Bangladesh Meterological Department,Agargaon, during the period of study.

3.5. Planting materials

Three advance lines and two check varieties collected from Bangladesh Rice Research Institute were used for this experiment.

Varieties are:

- **i.** G_1 = AL-29
- **ii.** G_2 = AL-36
- **iii.** G_3 = AL-18
- **iv.** G_4 = BRRI dhan39 (Check)
- **v.** G_5 = BRRI dhan49(Check)

3.6. Seed sprouting

Healthy seeds were selected following standard method. Seeds were immersed in water for 24 hours. These were then capped in tightly and shady areas. The seeds started sprouting after 48 hours, which were suitable for sowing in 72 hours.

3.7. Raising of seedling

A common procedure was followed in raising of seedlings in the seedbeds. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed.

3.8. Layout of the experimental design

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. There were five treatment combinations. The total no. of unit plots was

15. The size of unit plot is 3m x 2m. The distance between plot to plot and replication were 1m.

3.9. Land preparation

The experimental plot was prepared by three successive ploughing and cross ploughing. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from final ploughing. Individual plots were cleaned and finally leveled.

3.10. Transplantation

Thirty days old, seedlings were transplanted in 3m x 2m plot with spacing of 25 cm x 20 cm between rows and plants, respectively with single seedling per hill.

3.11. Fertilizer management

At the time of final land preparation total P and K were used as basal dose and total N was splitted into three installments. The experimental plot was fertilized with 60:40:40 kg/ha N, P and K, respectively. The first one third of N was applied as basal dose, second installment was at 15 days after first installment and third was applied at 15 days after second installment. Gypsum and Zinc Sulphate were also applied as a source of S and Zn at the rate 60 kg and 10 kg/ha as basal dose.

3.12. Irrigation and drainage

The experimental field was irrigated properly and adequate water was ensured throughout the whole crop growth period. A good drainage facility was also maintained for immediate release of excess rainwater from the field.

3.13. Intercultural operation

3.13.1. Gap filling

After one week of transplanting gap filing was done whenever it was necessary using the seedling from the previous source.

3.13.2. Weeding

First weeding was done at 20 days after seedling planting followed by second weeding at 15 days after first weeding.

3.13.3. Application of irrigation water

Irrigation water was added to each plot according to the needs. All the plots were kept irrigated as per treatment. Before ripening, the field was kept dry for all the treatments. Irrigation was given at a regular interval to maintain 2-3 cm depth up to hard dough stage of rice.

3.13.4. Plant protection measures

Plants were infested with rice stem borer, leafhopper, and rice hispa, rice bug to some extent, which was successfully controlled by application of insecticides such as Diazinon, and Ripcord @ 10 ml/ 10 liter of water for 5 decimal lands. Crop was protected from birds and rats during the grain-filling period. Field trap and phostoxin poisonous bait was used to control the rat. For controlling the birds, watching was done properly, especially during morning and afternoon.

3.13.5. Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. Ten pre selected hills per plot from which different data were collected, separately harvested and bundled properly tagged and then brought to the threshing floor for recording grain and straw yield.Threshing was done using by pedal thresher. The grains were cleaned and sun dried to moisture content of 14%. Straw was also sun dried properly. Finally grain and straw yield per plot were recorded and converted to t/ha.

3.14. Data recording

Data were recorded on physical characters and yield components for all the entries from five randomly selected plants of the middle rows in each replication as follows:

3.14.1. Evaluation of the yield and yield components performance of different advanced lines and check varieties

3.14.1.1. Plant height

Height (cm) of the plant from the ground level to the tip of the main panicle was measured in cm.

3.14.1.2. Days to 50% flowering

No. of days required for 50% of the plants to show panicle emergence, from the date of showing were recorded.

3.14.1.3. Number of tillers per plant

Total no. of tillers in a plant counted at the time of harvesting.

3.14.1.4. Number of effective tillers per plant

Total no. of panicle bearing tillers in a plant counted at the time of harvesting.

3.14.1.5. Days to maturity

No. of days required from sowing to physical maturity was recorded.

3.14.1.6. Panicle length (cm)

The length of the panicle from its base to the tip of the panicles excluding awns was measured in cm.A view of data collecting is presented in Plate 3.

Plate 3. Collection of yield contributing data of advanced lines and check

3.14.1.7. Number of filled grains per panicle

No. of filled grains present on the main panicle was recorded.

3.14.1.8. Number of empty grains per panicle

No. of empty grains present on the main panicle was recorded.

3.14.1.9. 1000-grain weight (g)

1000 grains were counted from a random sample drawn from bulk produce and

3.14.1.10. Grain yield per plant (g)

Grain yield in gm plant^{-1} was taken after harvesting, threshing, cleaning and drying the produce to 14% moisture level.

3.14.1.11. Grain yield/plot (kg)

Grain in gm plant^{-1} ten plants of each replication was taken after harvesting, threshing, cleaning and drying the produce to 14% moisture level and calculated for 3m x 2m = 6m^2 in kg.

3.14.1.12. Grain yield/ha (t)

Grain yield plot^{-1} was converted into grain yield ha^{-1} in ton.

3.14.2. Study of the milling and grain appearance

3.14.2.1. Hulling percent

The samples of 200g well dried paddy from each entry were de hulled in mini "Satake Rice Machine" and the weight of brown rice was recorded. Hulling was worked out as,

$$\text{Hulling } \% = \frac{\text{Weight of brown rice}}{\text{Weight of rough rice}} \times 100$$

3.14.2.2. Milling percent

The brown rice obtained after de hulling was passed through "Satake Rice Whitening and Caking Machine" for 5 minutes to obtain uniformly polished grains and the weight of polished grains was recorded. Milling percent was calculated as,

$$\text{Milling \%} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100$$

3.14.2.3. Head rice recovery

The milled samples were sieved to separate whole kernels from the broken ones. Small proportion of whole kernels which passed alone with broken grains was hand separated. Head rice recovery was calculated in percentage as,

$$\text{HRR \%} = \frac{\text{Weight of whole milled rice}}{\text{Weight of rough rice}} \times 100$$

3.14.2.4. Length of rough rice (mm)

The length of rough rice was recorded.

3.14.2.5. Breadth of rough rice (mm)

The breadth of rough rice was recorded.

3.14.2.6. L/B ratio of rough rice

L/B ratio was computed according to following formula:

$$\text{L/B ratio} = (\text{Grain length})/(\text{Grain breadth})$$

3.14.2.7. Length of brown rice (mm)

The length of brown rice was recorded.

3.14.2.8. Breadth of brown rice (mm)

The breadth of brown rice was recorded.

3.14.2.9. L/B ratio of brown rice

L/B ratio was computed according to following formula:

$$\text{L/B ratio} = (\text{Grain length})/(\text{Grain breadth})$$

3.14.2.10. Length of milled rice (mm)

The length of milled rice was recorded.

3.14.2.11. Breadth of milled rice (mm)

The breadth of milled rice was recorded.

3.14.2.12. L/B ratio of milled rice

L/B ratio was computed according to following formula:

$$\text{L/B ratio} = (\text{Grain length})/(\text{Grain breadth})$$

3.14.2.13. Grain type

Grain types (polished rice) were classified by using the following classification proposed by Ramaiah committee in 1965 for the purpose of trade and commerce, approved by Ministry of Food, Govt. of India, is given below:

On the basis of average length of kernel, milled rice is classified into following categories.

Table 1. Classification of milled rice on the basis of average length

Scale	Size	Length (mm)
1	Extra long	>7.50
2	Long	6.61 to 7.50
3	Medium	5.51 to 6.60
4	Short	5.50 to less

Grain shape is estimated by length/breadth ratio of kernels as:

Table 2. Classification of milled rice on the basis of length/breadth of kernels

Scale	Size	Length (mm)
1	Slender	Over 3.0
2	Medium	2.1 to 3.0
3	Bold	1.1 to 2.0
4	Round	1.0 to less

Ahuja*et al.*, (1995)

Grain types were classified by using the following classification proposed by Ramaiah committee in 1965:

Table 3. Systematic classification of grain types of rice proposed by Ramaiah committee in 1965

Class	Designation	Description	
		Length	Length/Breadth ratio
Long Slender	LS	Length 6 mm and above	Length/Breadth ratio 3 and above
Short Slender	SS	Length less than 6 mm	Length/Breadth ratio 3 and above
MediumSlender	MS	Length less than 6 mm	Length/Breadth ratio 2.5 to 3
Long Bold	LB	Length 6 mm and above	Length/Breadth ratio less than 3
Short Bold	SB	Length less than 6 mm	Length/Breadth ratio less than 2.5

(Source: Shoba Rani, 2003)

3.14.3. Determination of cooking and eating characteristics of the grain

3.14.3.1. Length of cooked rice (mm)

The length of cooked rice was recorded.

3.14.3.2. Breadth of cooked rice (mm)

The breadth of cooked rice was recorded.

3.14.3.3. L/B ratio of cooked rice

L/B ratio was computed according to following formula:

$$L/B \text{ ratio} = (\text{Grain length})/(\text{Grain breadth})$$

3.14.3.4. Water absorption percentage

It is measured as the volume of water needed to cook 1 gm of rice in a definite period of time and temperature. Sample comprising one gram milled rice kernels was used for the study of this character. Weight of the samples was recorded before and after cooking. Water absorption was calculated in percentage as,

$$\text{Water absorption \%} = \frac{W_2 - W_1}{W_1} \times 100$$

Care was taken to remove excess water from the cooked samples with the help of blotting papers before weight. For cooking, the rice samples were taken in long test tube and presoaked in slightly excess but uniform quantity of water (10 ml) for five minutes and were placed over a water bath maintained at boiling temperature (100^0 C) for 6 to 7 minutes. The sample tubes were then taken out and cooled under room temperature for 10 minutes.

3.14.3.5. Volume expansion percentage

The same sample of one gram rice kernels that was used for the study of water absorption was used for this study as well. After recording the weight of uncooked samples, their volume was determined by displacement of water method using a finely graduated narrow cylinder of 5 ml capacity. After cooking, final volume of the above sample was recorded and volume expansion percentage was calculated-

$$\text{Volume expansion \%} = \frac{V_2 - V_1}{V_1} \times 100$$

3.14.3.6. Gelatinization temperature (GT)

A sample of eight whole milled rice kernels from each entry was placed in small petriplates (5 cm wide) containing 10 ml of 1.7% potassium hydroxide (KOH) solution. The petriplates were covered and placed in an incubator maintained at 30 ± 1^0 C for 16 hours as suggested by Zaman (1981). After 16 hours of incubation, the petriplates were gently taken out from the incubator. Alkali spreading values of six grains of each entry were recorded separately and mean was calculated on a 7 point numerical scale proposed by Jennings *et. al.* (1979) .

Table 4. Numerical scale for scoring gelatinization temperature of rice

Score	Spreading	Clearing	Alkali digestion	Gelatinization temperature

1	Kernel not affected	Kernel chalky	Low	High
2	Kernel swollen	Kernel chalky; collar powdery	Low	High
3	Kernel swollen with collar incomplete and narrow	Kernel chalky; collar cottony or cloudy	Low or intermediate	Highor intermediate
4	Kernel swollen with collar complete and wide	Centre cottony; collar cloudy	Intermediate	Intermediate
5	Kernel split or segmented with collar complete and wide	Centre cottony; collar clearing	Intermediate	Intermediate
6	Kernel dispersed merging with collar	Centre cottony; collar clear	High	Low
7	Centre and collar clear	Centre and collar clear	High	Low

According to the alkali spreading score the G.T. types were classified as follows:

Table 5. Classification of GT types according to the alkali spreading score

Alkali spreading value/code	**G.T. Types**
1-3	High
4-5	Intermediate
6-7	Low

3.15. Analysis of variance

Differences between genotypes for the characters studied were tested for significance by the ‘Analysis of Variance’ technique.Analysis of variance was done on the basis of the following model:

Yij = m+gi+rj+eij

Where,
Yij = Phenotypic observation on i^{th} genotype in j^{th} replication

m = general mean

gi = effect of i^{th} genotype

rj = effect of j^{th} replication

eij = random error associated with i^{th} genotype and j^{th} replication

The structure of Analysis of Variance (ANOVA) table was as follows:

Table 6. The structure of analysis of variance (ANOVA)

Source of variation	**Df**	**MSS**	**Expected MSS**	**F-value**
Replication	(r-1)	Mr	$\sigma e^2 + g\sigma r^2$	
Treatment	(g-1)	Mg	$\sigma e^2 + r\sigma g^2$	Mg/Me
Error	(r-1) (g-1)	Me	σe^2	
Total	(rg-1)			

Where,

r = No. of replication

g = No. of genotypes (treatments)

Mr, Mg and Me = Mean sum of squares due to replications, genotypes and error respectively

σe^2 = Error variance = Me

σr^2 = Genotypic variance = (Mg - Me)/r and

σp^2 = Phenotypic variance = $\sigma e^2 + \sigma g^2$

MSS due to genotype were tested against the error variance using 'F' test at p = 0.05 or p = 0.01 with degree of freedom for higher and lower value of variance.

3.16. Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al*. (1955).

Genotypic variance ($\sigma^2 g$) = GMS-EMS/r

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of square

r = number of replications

Phenotypic variance ($\sigma^2 ph$) = $\sigma^2 g$ + EMS

Where,

$\sigma^2 g$ = Genotypic variance

EMS = Error mean sum of square

3.17. Estimation of genotypic and phenotypic correlation co-efficient

For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1958) and Johnson *et al.* (1955) were adopted.

The genotypic co-variance components between two traits and have the phenotypic co-variance component were derived in the same way as for the corresponding variance components. The co-variance components were used to compute genotypic and phenotypic correlation between the pairs of characters as follows:

Genotypic correlation (r_{gxy}) = (σ_{gxy}) / √ ($\sigma^2_{gx.}$ σ^2_{gy})

Where,

σ_{gxy}= Genotypic co-variance between the traits x and y

σ^2_{gx} = Genotypic variance of the traits x

σ^2_{gy} = Genotypic variance of the traits y

Phenotypic correlation (r_{pxy}) = (σ_{pxy}) / √ ($\sigma^2_{px.}$ σ^2_{py})

Where,

σ_{pxy}= Genotypic co-variance between the traits x and y

σ^2_{px} = Genotypic variance of the traits x

σ^2_{py} = Genotypic variance of the traits y

3.18. Statistical analysis

The data were statistically analyzed quantitative data and the treatment means were compared by Dunkan’s Multiple Range Test (DMRT). The package used for analysis was MSTAT-C version-88, developed by Michigan State University, Agricultural University of Norway.

CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to evaluate the performance of different yield and quality attributes of three advanced lines and two check varieties from Bangladesh.

4.1. Characterization of the genotypes

In the present study, three advanced lines and two check varieties of rice collected from research organization have been evaluated for their performance of yield and yield contributing traits, interrelationships of these traits for commercial cultivation. Generally, a breeder aims at accumulating favorable genes from diverse resources in a particular genotype, which would largely depend upon the availability of genetic variability in the germplasm in respect of any particular character and evaluate that character for better use of human beings.

4.2. 1. Mean performance for yield and yield components

Mean performance of yield and yield components of the lines with check variety have been presented character wise in Table 7.

4.2.1.1. Plant height (cm)

Plant height in different advanced lines of rice varied significantly (Table 7). In the present study plant height ranged from 95.70 cm in AL-36 to 106.5 cm in BRRI dhan 49 with a mean of 101.37 cm. The tallest plant height (106.5 cm) was recorded in BRRI dhan 49 which was statically similar with BRRI dhan 39 (104.7 cm) and AL-29 (102.30 cm), while the shortest plant height (95.70 cm) was recorded in AL-36 which was statically similar with AL-29 (102.30 cm) and AL-18 (97.63 cm).Khush (1999) reported that short stature reduces the susceptibility of rice crop to lodging and leads to higher harvest index. A plant height of 90-100cm is considered ideal for maximum yield. Yu, *et al.*, (1995) concluded that hybrid where it reaches a height of 90 cm and proved resistant to *Magnaporthegrisea* and *Nilaparvatalugens*. Wang (2000) reported that plant height was directly related to yields. Pruneddu andSpanu(2001) reported that plant

Table 7.Mean performance of yield and yield contributing characters of some advanced lines of rice and check

Genotypes	Plant height (cm)	Days to 50% flowering	Days to maturity	No. of tillers per plant	No. of effective tillers per plant	Length of panicle (cm)
AL-29	102.30 abc	103.00 a	130.00 b	21.20 ab	1.200 c	26.68 a
AL-36	95.70 c	106.00 a	133.30 ab	22.33 a	2.870 a	25.85 ab
AL-18	97.63 bc	85.00 b	128.70 b	19.07 bc	2.000 b	26.62 a
BRRI dhan 39	104.7 ab	88.00 b	142.00 a	17.87 c	2.000 b	25.02 b
BRRI dhan 49	106.5 a	104.00 a	137.30 ab	21.53 ab	2.333 b	24.35 b
$LSD_{0.05}$	7.23	11.48	8.38	2.70	0.508	1.46
SE (±)	2.21	3.51	2.57	0.831	0.155	0.448
Range	95.70-106.5	85.00-106.00	128.67-142.00	17.87-22.33	1.20-2.87	24.35-26.68
Mean	101.37	97.20	134.27	20.40	2.08	25.70
CV (%)	3.79	6.27	3.32	7.06	12.96	3.02
Level of significance	*	**	*	*	**	*

* = Significant at 5% level of probability, ** = Significant at 1% level of probability

Table 7 (cont'd).

Genotypes	No. of filled grain/plant	No. of empty grain/plant	1000 grain wt (g)	Grain yield/ plant(g)	Grain yield/plot (kg)	Grain yield (t/ha)
AL-29	178.30 a	19.20 b	2.16 b	44.32 ab	10.75 a	6.320 a
AL-36	165.50 b	15.93 c	2.437 a	49.19 a	9.957 a	5.913 a
AL-18	163.00 bc	17.60 b	2.433 a	38.62 bc	6.157 c	4.000 b
BRRI dhan 39	147.30 d	22.00 a	2.280 ab	30.11 c	8.247 b	4.213 b
BRRI dhan 49	152.80 cd	17.93 b	2.087 b	44.84 ab	10.30 a	5.973 a
$LSD_{0.05}$	11.15	1.58	0.198	8.87	0.969	1.25
SE (±)	3.42	0.485	0.059	2.72	0.297	0.386
Range	147.27-178.33	15.93-22.00	2.09-2.44	30.11-49.19	6.15-10.75	4.00-6.32
Mean	161.37	18.53	2.28	41.42	9.08	5.28
CV (%)	3.67	4.54	4.51	11.38	5.67	12.65
Level of significance	**	**	**	**	**	**

* = Significant at 5% level of probability, ** = Significant at 1% level of probability

height ranged from <65 cm in Mirto, Tejo, Gladio, Lamone and Timo, to 80-85 cm. Nine hybrid rice cultivars were resistant to lodging. Yang (1998) reported that plant height is 95-98 cm. Patnaik*et al.* (1990) found that hybrids with intermediate to tall plant height. Ponnuthurai*et al.* (1984) reported that taller plants might have better plant canopy for photosynthesis. De *et al.*(2002) experimented that plant height ranged from 80.00 to 132.00 cm. Considering all of them that short stature is effective for rice yield.A comparative performance of advanced lines and check variety for plant height is presented in Figure 1.

4.2.1.2. Days to 50% flowering

Days to 50% flowering of different advanced line of rice varied significantly (Table 7). The maximum days for 50% flowering (106 days) was recorded from AL-36 which was statistically similar with BRRI dhan 49 (104 days) and AL-29 (103 days), whereas the minimum days (85 days) was recorded from AL-18 which was statistically similar with BRRI dhan 39 (88 days). Endo *et al.* (2000) said that flowering occurred 88 days after seedling emergence of hybrid. This lines definitely would mature earlier and ultimately reduce crop duration. A comparative performance of advanced lines and check variety for days to 50% flowering and days to maturity is presented in Figure 2.

4.2.1.3. Number of tillers per plant

Maximum number of tillers per plant (22.33) was recorded from AL-36(Table 7) which was statiscally similar with BRRI dhan 49 (21.53) and AL-29 (21.20) whereas the minimum number (17.87) was recorded from BRRI dhan 39 which was statistically similar with AL-18 (19.07).A comparative performance of advanced lines and check variety for number of tillers/plant and number of effective tillers/plant is presented in Figure 3.

4.2.1.4. Number of effective tillers per plant

Number of effective tillers per plant of different advanced line of rice varied significantly. The maximum number of effective tillers per plant (2.87) was recorded from AL-36 whereas the minimum number (1.2) was recorded from AL-29 (Table 7). Earlier manyworkres reported that higher number of productive tillers is responsible for higher yield (Panday*et al.*, 1995; Reddy and Ramachandraiah, 1995; Padmavathi*et al.*, 1996).

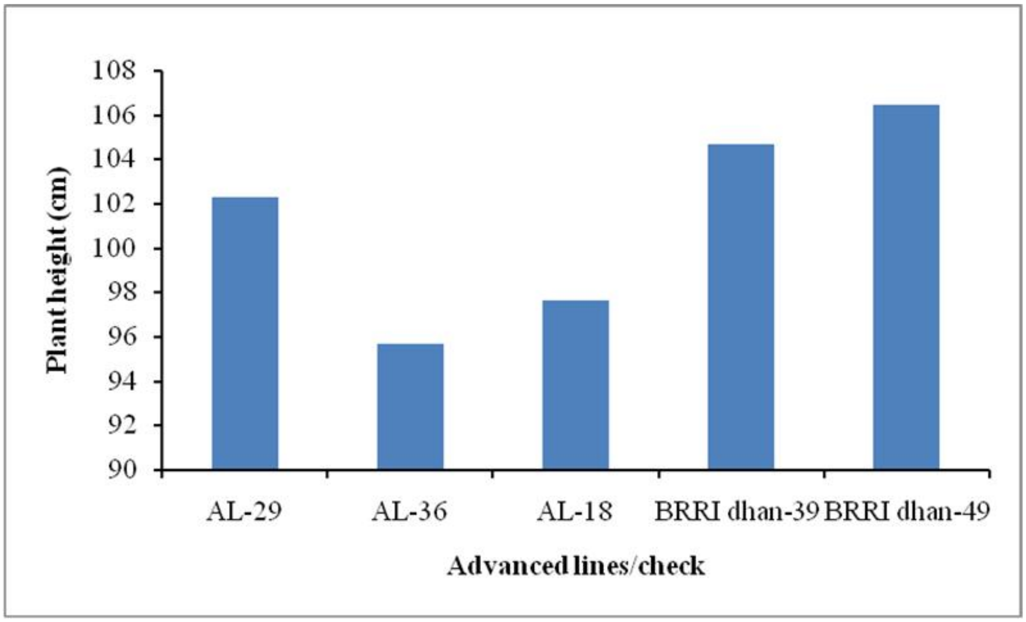

Figure 1. Relative performance of advanced lines and check for plant height

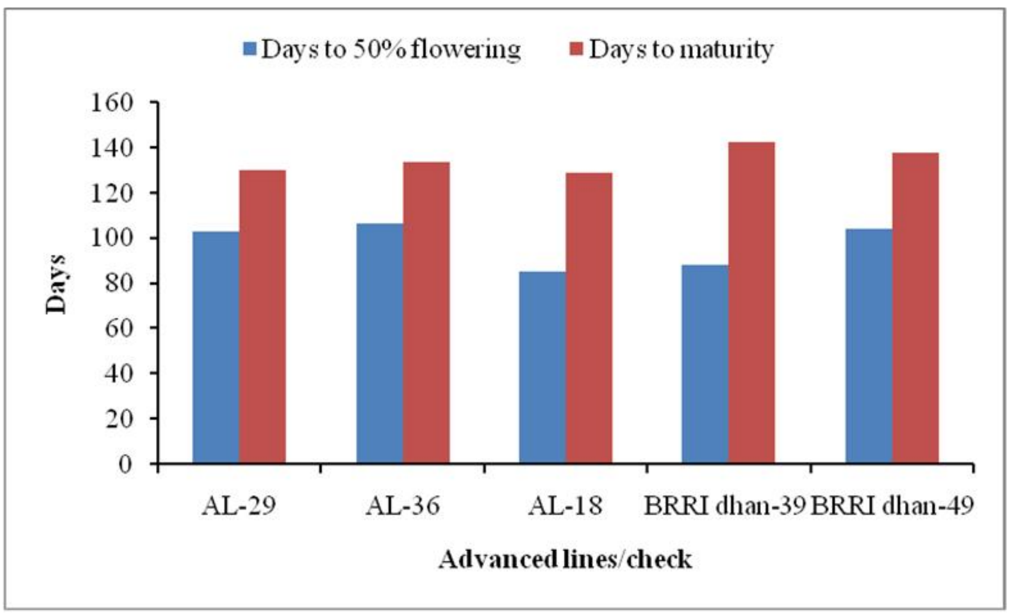

Figure 2. Relative performance of advanced lines and check for days to 50% flowering and days to maturity

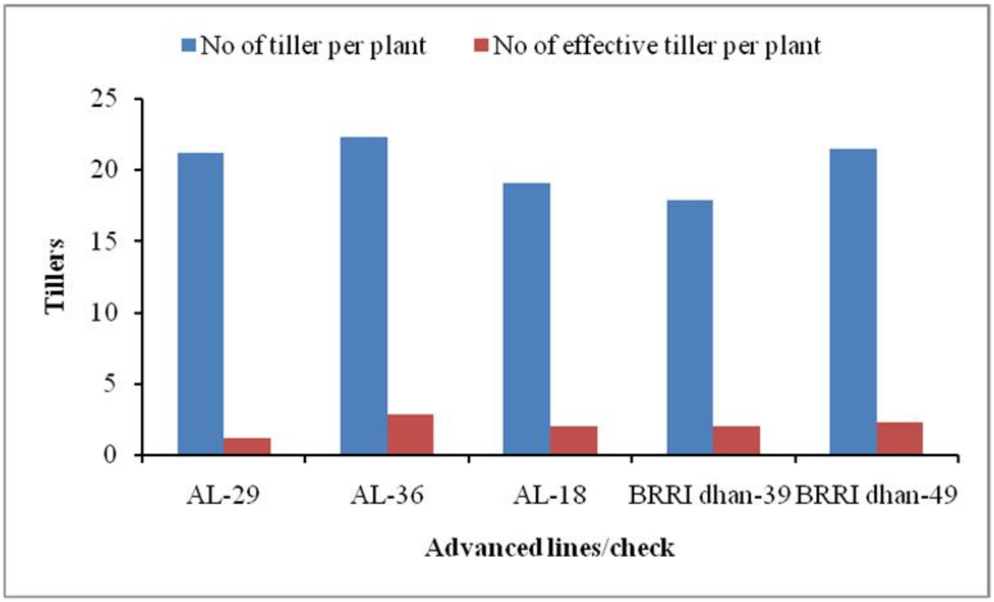

Figure 3. Relative performance of advanced lines and check for no of tillers/plant and number of effective tillers/plant

4.2.1.5. Panicle length (cm)

The maximum panicle length (26.68 cm) was recorded from AL-29 which was statistically similar with AL-18 (26.62 cm) and AL-36 (25.85 cm), whereas the minimum panicle length (24.35 cm) was recorded in BRRI dhan49 (Table 7) which was statically similar with BRRI dhan-39 (25.02 cm) and AL-36 (25.85 cm). Wang *et al.* (1991) reported that the length of panicle varied from 26.30 cm to 27.00 cm among the *indica/japonica* hybrids. A comparative panicle appearance is presented in Plate 4.

4.2.1.6. Number of filled grain/plant

Number of filled grain showed significant positive association with yield. The maximum filled grain (178.30) was recorded from AL-29 whereas minimum (147.30) was recorded from BRRI dhan-39 (Table 7) which was statically similar with BRRI dhan49 (152.80).

Mrityunjay, (2001) studied the performance of 4 rice hybrids and 4 high yielding rice cultivars and reported that hybrids, in general, gave higher values for number of filled grains per panicle. Ramana*et al.,* (1998) observed that hybrids produced more panicles m^{-} and filled grains per panicle than conventional cultivars. Parvez*et al.,* (2003) reported that yield advantage for the hybrid rice is mainly due the proportion of filled grains per panicle, heavier grain weight (35%) and increased values than the control (28%).A comparative performance of advanced lines and check variety for number of filled grain/plant and number of empty grain/plant is presented in Figure 4.

4.2.1.7. Number of empty grain/plant

The maximum empty grain (22.00) was recorded from BRRI dhan39 whereas minimum (15.93) was recorded from AL-36 (Table 7).

4.2.1.8. Days to maturity

The maximum days for maturity (142 days) were recorded in BRRI dhan 39 which was statistically similar with BRRI dhan 49 (137.3 days) and AL-36 (133.3 days) whereas the minimum days (128.7 days) recorded from AL-18 which was statistiscallysimilar with AL-

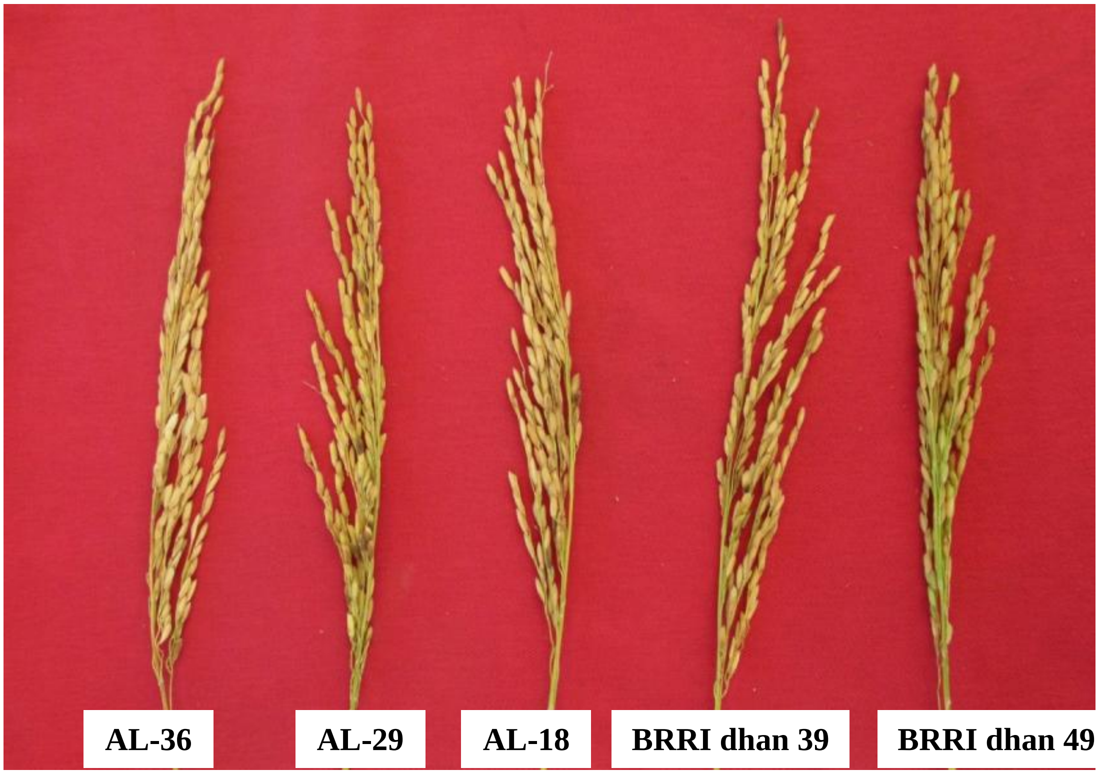

Plate 4. Comparison of panicle appearance of advanced lines and check

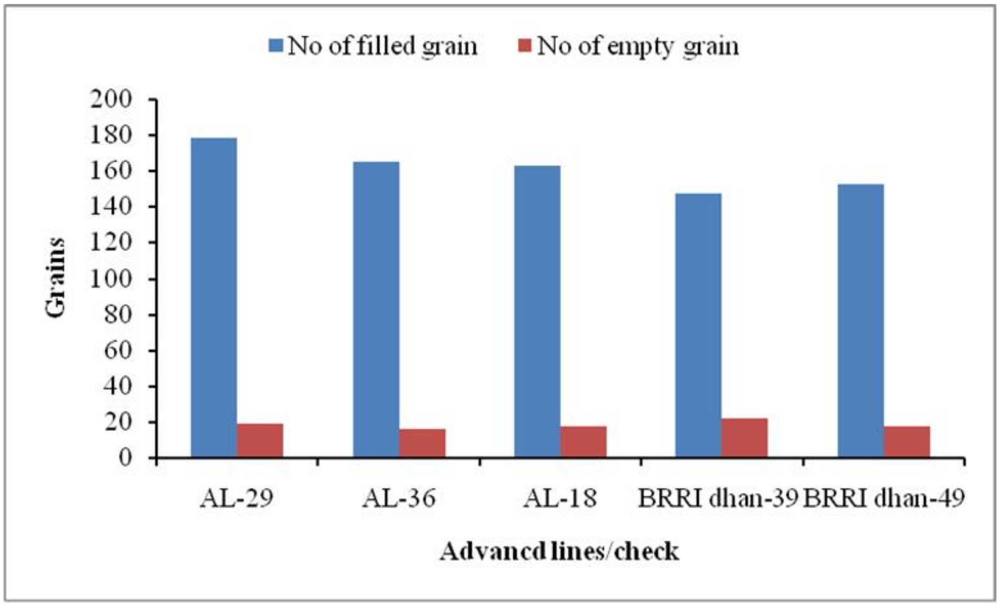

Figure 4. Relative performance of advanced lines and check for number of filled grain/plant and number of empty grain/plant

36 (133.3 days) and AL-29 (130 days). Yang (1998) examined that Chao Chan-1 a hybrid had growth period of 145 days.Parvez*et al.*, (2003) observed that shorter field duration was observed in Sonarbangla-1 than the control. Ma *et al.*, (2001) studied 8 rice hybrids and reported that all hybrids had shorter growth duration (97-107 days) than the controls (110-116 days). Ma *et al.*, (2001) experimented with ADTRH1 is a rice hybrid that matured in 115 days. Huang *et al.*, (1999) studied the morphological and physiological characteristics of Yueza 122. They reported that it was an early maturity hybrid combination with duration of 83 days from sowing to heading in the early cropping season. Conversely, Ponnuthurai*et al.*, (1984) reported that hybrid had growth duration similar to that of the shorter duration parent (Table 7).

4.2.1.9. Weight of 1000 seeds (g)

The maximum weight of 1000 seed grain (2.437 g) was recorded from AL-36 (Table 7), which was statistically similar with AL-18 (2.433 g) and BRRI dhan39 (2.28 g) whereas minimum weight (2.087 g) was recorded from BRRI dhan49 which was statically similar with AL-29 (2.16 g) and BRRI dhan39 (2.28 g). Yang (1998) studied Chao Chan1 hybrid rice which had 1000-seed weight of 28 g. Ma *et al.*, (2001) experimented ADTRH1 a rice hybrid, had 1000-grain weight of23.8 g. In different trials, ADTRH1 showed 26.9 and 24.5% higher yield over CORH1 and ASD18. A comparative performance of advanced lines and check variety for 1000 grain weight (g) is presented in Figure 5.

4.2.1.10. Grain yield per plant (g)

The maximum yield per plant (49.19 g) was recorded from AL-36 which was statistically similar with BRRI dhan49 (44.84 g) and AL-29 (44.32 g) whereas the minimum (30.11 g) was recorded from BRRI dhan39 which was statistically similar with AL-18 (38.62 g).Varietal differences of grain yield were reported by Biswas*et al.*, (1998). This variation in the grain yield might be due to the environment (Mahapatra, 1993) or the correlation of grain yield per plant with various yield contributing characteristics like number of grains per panicle, grain weight and correlation with these traits (Table 7).

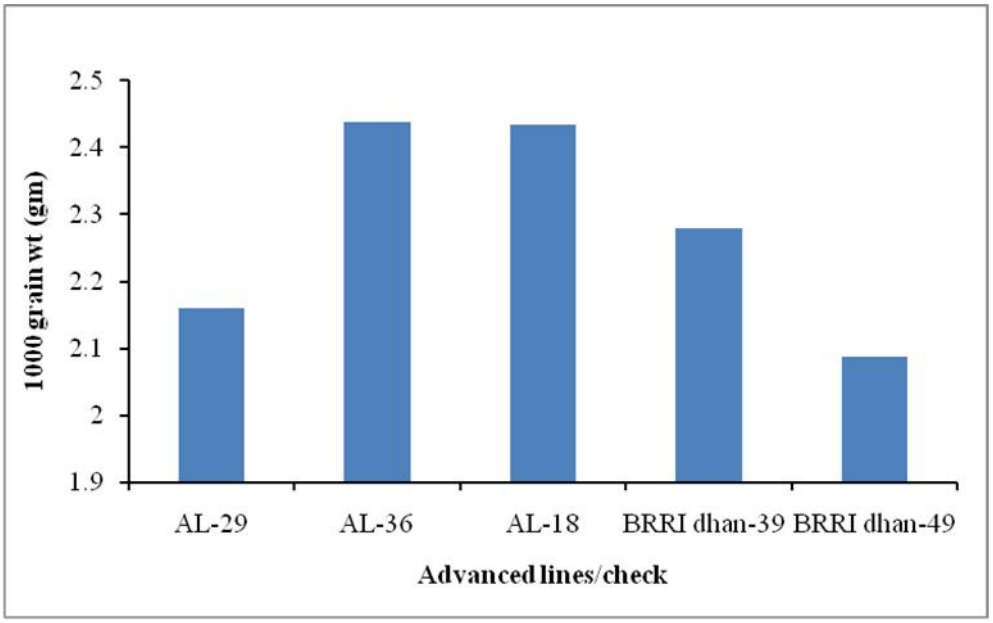

Figure 5. Relative performance of advanced lines and check for 1000 grain weight (g)

4.2.1.11. Grain yield (kg/plot)

The maximum yield per plot (10.75 kg) was recorded from AL-29 which was statistically similar with BRRI dhan49 (10.30 kg) and AL-36 (9.957 kg), whereas the minimum (6.157 kg) was recorded from AL-18 (Table 7).

4.2.1.12. Grain yield (t/ha)

The maximum yield per hectare (6.32 ton) was recorded from AL-29 (Table 7), which was statically similar with BRRI dhan49 (5.973 ton) and AL-36 (5.913 ton) whereas the minimum (4.00 ton) was recorded from AL-18 which was statically similar with BRRI dhan39 (4.213 ton). Kim and Rutger (1988) noted that hybrids that gave high grain yields also produced high biomass. Qiu, *et al.,* (1994) reported that the higher the biological yield, the higher is the economic yield.A comparative performance of advanced lines and check variety for grain yield (t/ha) is presented in Figure 6.

4.2.2. Analysis of correlation of co-efficient of yield and yield components

Yield is a complex product being influenced by several interdependent quantitative characters. Selection for yield may not be effective unless the direct or indirect influences of other yield components are taken into consideration. Higher genotypic correlations than phenotypic one might be due to modifying or masking effect of environment in the expression of the character under study. Character association analysis among yield and yield contributing traits revealed that all the genotypic correlation (Chaudhury and Das, 1973). This indicates that suppressing effect of the environment which modified the phenotypic expression of these characters by reducing phenotypic coefficient values.

Correlation was done to measure the mutual relationship between ten different yield and yield contributing characters and to determine the component characters on which selection could be based for improvement in yield of rice genotypes (Table 8).

Table 8. Coefficients of phenotypic and genotypic correlation among different yield components

Characters		Days to 50% flowering	Days to maturity	No. of tillers/plant	No. of effective tillers/plant	Panicle length (cm)	No. of filled grain/plant	No. of empty grain/plant	1000 grain wt (g)	Grain yield (t/ha)
Plant height(cm)	r_p	0.028	0.635	-0.233	-0.359	-0.672	-0.471	0.661	-0.882*	0.107
	r_g	-0.129	0.465	-0.425	-0.294	-0.893*	-0.534	0.670	-0.946*	0.129
Days to 50% flowering	r_p		-0.069	0.937*	0.220	-0.179	0.391	-0.488	-0.400	0.970**
	r_g		-0.233	0.858	0.298	-0.329	0.368	-0.528	-0.524	0.975**
Days to maturity	r_p			-0.341	0.272	-0.850	-0.838	0.602	-0.314	-0.167
	r_g			-0.546	0.375	-0.979*	-0.911*	0.604	-0.445	-0.119
No. of tillers/ plant	r_p				0.314	0.005	0.506	-0.755	-0.184	0.895*
	r_g				0.374	-0.094	0.488	-0.815	-0.260	0.946*
No. of effective tillers/ plant	r_p					-0.448	-0.440	-0.545	0.437	-0.020
	r_g					-0.381	-0.452	-0.530	0.507	-0.044
Panicle length (cm)	r_p						0.817	-0.233	0.481	-0.063
	r_g						0.794	-0.283	0.398	-0.030
No. of filled grain/ plant	r_p							-0.410	0.068	0.520
	r_g							-0.441	0.038	0.550
No. of empty grain/ plant	r_p								-0.360	-0.393
	r_g								-0.357	-0.390
1000 grain wt (g)	r_p									0.944*
	r_g									0.957*

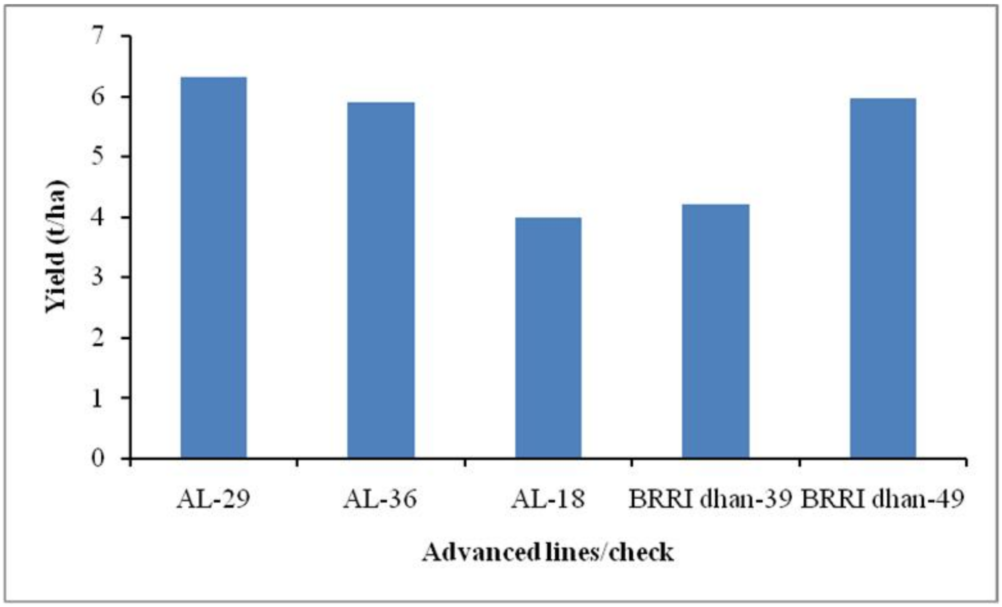

Figure 6. Relative performance of advanced lines and check for grain yield (t/ha)

4.2.2. 1. Plant height (cm)

Plant height showed insignificant and positive relationship with days to 50% flowering, days to maturity, number of empty grain per plant and grain yield. Plant height showed significant negative relationship with 1000 grain weight and insignificant negative relationship with number of tillers per plant, number of effective tillers per plant, panicle length and number of filled grain per plant. Tahir*et al*., (1988) and Prasad *et al*., (2001) found that plant height was negatively correlated with number of tillers per plant and grain yield. But, Gomathinayagam*et al*., (1988) and Rasheed*et al*., (2002) obtained positive and significant correlation of grain yield with plant height which is not in line with present finding, which might be due to the differences of the genetic constitution of the material used.

4.2.2. 2. Days to 50% flowering

Days to 50% flowering showed significant positive relationship with number of tiller per plant and grain yield and insignificant positive relationship with number of effective tiller per plant and number of filled grain per plant. Days to 50% flowering also showed insignificant negative relationship with days to maturity, panicle length, number of empty grain per plant and 1000 grain weight.

4.2.2. 3. Number of tillers/ plant

Number of tillers per plant showed significant positive correlation with grain yield and insignificant positive correlation with number of effective tillers per plant, panicle length and number of filled grain per plant. Number of tillers per plant also showed insignificant negative correlation with number of empty grain per plant and 1000 grain weight.

4.2.2. 4. Number of effective tillers/ plant

Number of effective tillers per plant showed insignificant positive correlation with 1000 grain weight and insignificant negative correlation with panicle length, number of filled grain per plant, number of empty grain per plant and grain yield. Reddy and Kumar (1996) reported that productive tillers/plant showed significant positive correlation with grain yield. On the other hand, the correlation of this character with panicle length and number of unfilled spikelet/plant is negative insignificant.

4.2.2. 5. Panicle length (cm)

Panicle length showed insignificant positive correlation with number of filled grain per plant and 1000 grain weight. Panicle length also showed insignificant negative correlation with number of empty grain per plant and grain yield. Saini and Gagneja (1975) reported that panicle length is negatively correlated with grian yield.

4.2.2. 6. Number of filled grain/ plant

Number of filled grain per plant showed insignificant positive correlation with 1000 grain weight and grain yield. Number of filled grain per plant also showed insignificant negative correlation with number of empty grain per plant. Silitonga (1989) and Bai*et al*., (1992) reported that filled grain/plant has positive correlation with grain yield.

4.2.2. 7. Number of empty grain/ plant

Number of empty grain per plant showed insignificant negative correlation with 1000 grain weight and grain yield.

4.2.2. 8. Days to maturity

Days to maturity showed insignificant positive correlation with number of effective tillers per plant and number of empty grain per plant. Days to maturity also showed insignificant negative correlation with number of tillers per plant, panicle length, number of filled grain per plant, 1000 grain weight and grain yield.

4.2.2. 9. 1000 grain wt (g)

1000 grain weight showed significant positive correlation with grain yield. Yolanda and Das (1995), Prasad *et al*., (2001) and Iftikharuddaula*et al*., (2002) also found the similar result. Kenedy and Rangasamy (1988) reported highly significant correlation between 1000 grain weights at the phenotypic level.

4.3. Study of milling and grain appearance

When rice is threshed, the hull (lemma and palea) remains intact- this is known as ‘rough rice’. The hull is removed (about 20% of the kernel weight) to produce brown rice. Further milling removes the burn (the seed coat, embryo and some endosperm) to produce milled rice. The quality of rice is determined by grain appearance, cooking quality and nutritional value. The grain is important for farmers as it determines the market price and to consumers as it determines their acceptability. Quality in rice is a combination of several physic-chemical characters of the grain. The physical properties of the rice grain are determined by grain color, shape, and size, grain weight, hardness of the endosperm, appearances of the milled kernels, hulling and milling recovery. Starch, protein, minerals and vitamins constitute the chemical components of the rice grain. The market quality depends on physical attributes, while consumer’s preference (cooking, eating and nutritive value) depends on chemical traits. Interestingly, both are inter-dependent.

4.3.1. Mean performance of qualitative characters (before cooking)

The results on mean performance of various quality characters (before cooking) of the advanced lines and check varieties have been presented character wise in Table 9. The discussion is as follow:

4.3.1.1. Hulling percent

The maximum hulling percent (81.00%) was recorded from AL-36 (Table 9), whereas the minimum (76.67%) was recorded from AL-18 which was statistically similar with AL-29 (77.00%), BRRI dhan 49 (78.00%) and BRRI dhan39 (78.33%). Sandeep (2003) found 71.67 to 84.56 hulling percent during characterization of 20 new plant type genotypes in rice.

4.3.1.2. Milling percent

The maximum milling percent (71.97%) was recorded from BRRI dhan49, whereas the minimum (71.10%) was recorded from AL-18 (Table 9). Ahuja*et al*., (1995) reported a range of 67 to 71 milling percent in Basmati varieties.

Table 9. Mean performance of qualitative characters before cooking in different advanced lines and check

Genotypes	Hulling (%)	Milling (%)	HRR (%)	Rough rice			Brown rice			Milled rice		
				Length (mm)	Breadth (mm)	L/B ratio	Length (mm)	Breadth (mm)	L/B ratio	Length (mm)	Breadth (mm)	L/B ratio
AL-29	77.00 b	71.52	65.67 ab	8.943 b	1.820 ab	4.880	6.440 ab	1.630 b	3.953 ab	6.427 a	1.560 abc	4.317 a
AL-36	81.00 a	71.49	63.17 b	9.320 ab	1.860 a	5.017	6.697 a	1.687 b	3.970 ab	6.333 a	1.490 bc	4.407 a
AL-18	76.67 b	71.10	65.67 ab	9.667 a	1.910 a	5.063	6.783 a	1.793 a	3.783 bc	6.547 a	1.670 a	3.873 b
BRRI dhan 39	78.33 b	72.23	66.17 a	9.343 ab	1.867 a	5.013	6.810 a	1.667 b	4.087 a	6.387 a	1.467 c	4.607 a
BRRI dhan49	78.00 b	71.97	67.27 a	8.303 c	1.690 b	4.933	6.057 b	1.643 b	3.683 c	5.893 b	1.640 ab	3.817 b
$LSD_{0.05}$	2.52	2.86	2.48	0.476	0.133	0.331	0.403	0.842	0.245	0.352	0.145	0.309
SE (±)	0.774	0.879	0.762	0.146	0.041	0.101	0.123	0.027	0.074	0.108	0.043	0.095
Range	76.67-1.00	71.10-2.23	63.17-7.27	8.30-9.67	1.69-1.91	4.88-.06	6.06-6.81	1.63-1.79	3.68-.09	5.89-6.55	1.47-1.67	3.82-.61
Mean	78.20	71.66	65.59	9.12	1.83	4.98	6.56	1.68	3.90	6.32	1.57	4.20
CV (%)	1.72	2.13	2.01	2.77	3.86	3.52	3.25	2.79	3.32	2.96	4.85	3.90
Level of significance	*	NS	*	**	*	NS	*	*	*	*	*	**

* Significant at 5% level of probability, **Significant at 1% level of probability

4.3.1.3. Head rice recovery percent

The maximum head rice recovery percent (67.27%) was recorded from BRRI dhan49 (Table 9) which was statically similar with BRRI dhan39 (66.17%), AL-29 and AL-18 (65.67%) whereas the minimum (63.17%) was recorded from AL-36 which was statically similar with AL-29 and AL-18 (65.67%).A comparative view of rough rice and milled rice is presented in Plate 5.

4.3.1.4. Grain dimension

The milling and marketable qualities depend on largely upon the size and shape of the grain. Grain dimension is expressed as length, breadth and thickness, where as shape is generally expressed as ratio between the length and breadth. With respect to grain dimension, variation is found in materials studied, as we can see from performance of each genotype (Table 9).Grain length is an important physical property, which attracts consumer's attention. The people of Bangladesh like long, slender, shiny grain. Length breadth ratio of the grains indicates the fineness of the grain.

The appearance of milled rice is important to the consumer, which in turn assumes important to the producer and miller. Therefore, grain size and shape of milled rice are the foremost characteristics of rice quality that breeders consider in developing new varieties for release commercial production. Preference for grain size and shape vary from one group of consumers to another. Some ethnic groups prefer short bold grains, while medium and long slender grains are preferred by others. While grain size and shape of milled rice can be visually classified, more precise measurement are needed for classification and for critical comparison of genotypes/lines. In present study, the grain shape and size are characterized following Ramaiah Committee classification (1965). The lines or genotypes are classified into long slender (LS), short slender (SS), medium slender (MS), long bold (LB) and short bold (SB). In the present study, all lines have been grouped into class long slender and the checks are in the short slender group (Table 10).

Table 10. Classification of grain types of advanced lines and check varieties on the basis of systematic classification of rice proposed by Ramaiah Committee (1965)

Classification group				
Long Slender	**Short Slender**	**Medium**	**Long Bold (LB)**	**Short Bold**

(LS) (Length 6 mm & above, L/B ratio 3 and above)	**(SS) (Length less than 6 mm, L/B ratio 3 and above)**	**Slender (MS) (Length 6 mm & above, L/B ratio 2.5 to 3)**	**(Length 6 mm & above, L/B ratio less than 3)**	**(SB) (Length less than 6 mm, L/B ratio less than 2.5)**
AL-29	BRRI dhan-39	-	-	-
AL-36	BRRI dhan-49	-	-	-
AL-18	-	-	-	-

Plate 5. A comparative view of rough rice and milled rice of different advanced lines and check

4.3.1.5. Length, breadth and L/B ratio of rough rice

The maximum length of rough rice (9.667 mm) was recorded from AL-18 whereas minimum (8.303 mm) was recorded from BRRI dhan49 (Table 9). The maximum breadth of rough rice (1.910 mm) was recorded from AL-18 whereas minimum (1.690 mm) was recorded from BRRI dhan49. The maximum ratio of length and breadth of rough rice (5.063 mm) was recorded from AL-18 whereas minimum (4.88 mm) was recorded from AL-29. Viraktamath (1987) observed that kernel breadth enhanced the milling output and head rice recovery strongly associated with milling percentage.

4.3.1.6. Length, breadth and L/B ratio of brown rice

The maximum length of brown rice (6.810 mm) was recorded from BRRI dhan39 whereas the minimum (6.057 mm) was recorded from BRRI dhan49 (Table 9). The maximum breadth of brown rice (1.793 mm) was recorded from AL-18 whereas the minimum (1.630 mm) was recorded from AL-29. The maximum ratio of length and breadth of brown rice (4.087 mm) was recorded from BRRI dhan39 whereas the minimum (3.683 mm) was recorded from BRRI dhan49.

4.3.1.7. Length, breadth and L/B ratio of milled rice

The maximum length of milled rice (6.547 mm) was recorded from AL-18 whereas the minimum (5.893 mm) was recorded from BRRI dhan49 (Table 9). The maximum breadth of milled rice (1.670 mm) was recorded from AL-18 whereas the minimum (1.467 mm) was recorded from BRRI dhan39. The maximum ratio of length and breadth of milled rice (4.607 mm) was recorded from BRRI dhan39 whereas the minimum (3.817 mm) was recorded from BRRI dhan49.

4.3.1.8. Endosperm translucency and chalkiness

Among the three advanced lines, all showed clear-cut translucent endosperm appearance (Table 11). The check varieties also showed translucent grain. The endosperm appearance of all lines was good. Grain appearance was largely determined by endosperm opacity, the amount of chalkiness.

Table 11. Endosperm appearances in advanced lines and check varieties

Lines/check	Endosperm appearances
AL-29	Translucent
AL-36	Translucent
AL-18	Translucent
BRRI dhan-39	Translucent
BRRI dhan-49	Translucent

4.3.2. Mean performance of qualitative characters (after cooking)

The results on mean performance of various quality characters (after cooking) of the advanced lines and check varieties have been presented character wise in Table 12. The discussion is as follow:

4.3.2.1. Length, breadth and L/B ratio of cooked rice

The maximum length of cooked rice (9.357mm) was recorded from BRRI dhan39 whereas the minimum (8.307 mm) was recorded from BRRI dhan49 (Table12). The maximum breadth of cooked rice (2.437 mm) was recorded from BRRI dhan39 whereas the minimum (2.103 mm) was recorded from AL-36. The maximum ratio of length and breadth of cooked rice (4.147 mm) was recorded from BRRI dhan-39 whereas the minimum (3.683 mm) was recorded from BRRI dhan49 (Fig. 7). Shoba Rani (2003) reported that kernel length after cooking of nine released hybrids of India ranging from 10.2 to 12.4 mm. Soroush*et al*., (1995) showed cooked kernel length 10.62 to 12.32 mm. Sandeep (2003) found kernel length/breadth ratio after cooking of 20 new plant type genotypes which was ranged from 2.04 to 3.95. Soroush*et al*., (1995) showed L/B ratio of cooked kernel 3.69 to 4.30.

4.3.2.2. Water absorption percent

The maximum water absorption percent (269.00%) was recorded from AL-36 which was statically similar with AL-29 (261.3%) and BRRI dhan49 (255.7%) whereas the minimum (220.00%) was recorded from BRRI dhan-39 (Table 12) which was statically similar with AL-18 (228.3%). Hogan and Planck (1958) observed that short and medium grain varieties of the USA have high water absorption as compared to long grain types. Zaman (1981) reported that the good cooking rice varieties have water absorption value ranging between 174 to 275%, whereas majority of those showing pasty appearance have value as high as from 300 to 570%.

Table 12. Mean performance of qualitative characters after cooking in different advanced lines and check

Genotypes	Cooked rice			Water absorption percentage	Volume expansion percentage	Alkali spreading value
	Length(mm)	Breadth(mm)	L/B ratio			
AL-29	9.117 a	2.377 ab	3.960 b	261.3 a	72.33 a	4.067 c
AL-36	8.497 b	2.103 b	4.040 ab	269.0 a	48.20 b	5.300 b
AL-18	8.510 b	2.223 ab	4.007 ab	228.3 b	45.62 b	4.067 c
BRRI dhan-39	9.357 a	2.437 a	4.147 a	220.0 b	53.10 b	3.850 c
BRRI dhan-49	8.307 b	2.277 ab	3.683 c	255.7 a	46.28 b	6.933 a
$LSD_{0.05}$	0.558	0.303	0.157	18.63	11.38	0.429
SE (±)	0.171	0.093	0.047	5.72	3.48	0.132
Range	8.31-9.36	2.10-2.44	3.68-4.15	220.00-269.00	45.62-72.33	3.85-6.93
Mean	8.76	2.28	3.97	246.87	53.11	4.84
CV (%)	3.39	7.07	2.07	4.02	11.38	4.73
Level of significance	*	NS	**	**	**	**

*Significant at 5% level of probability, **Significant at 1% level of probability

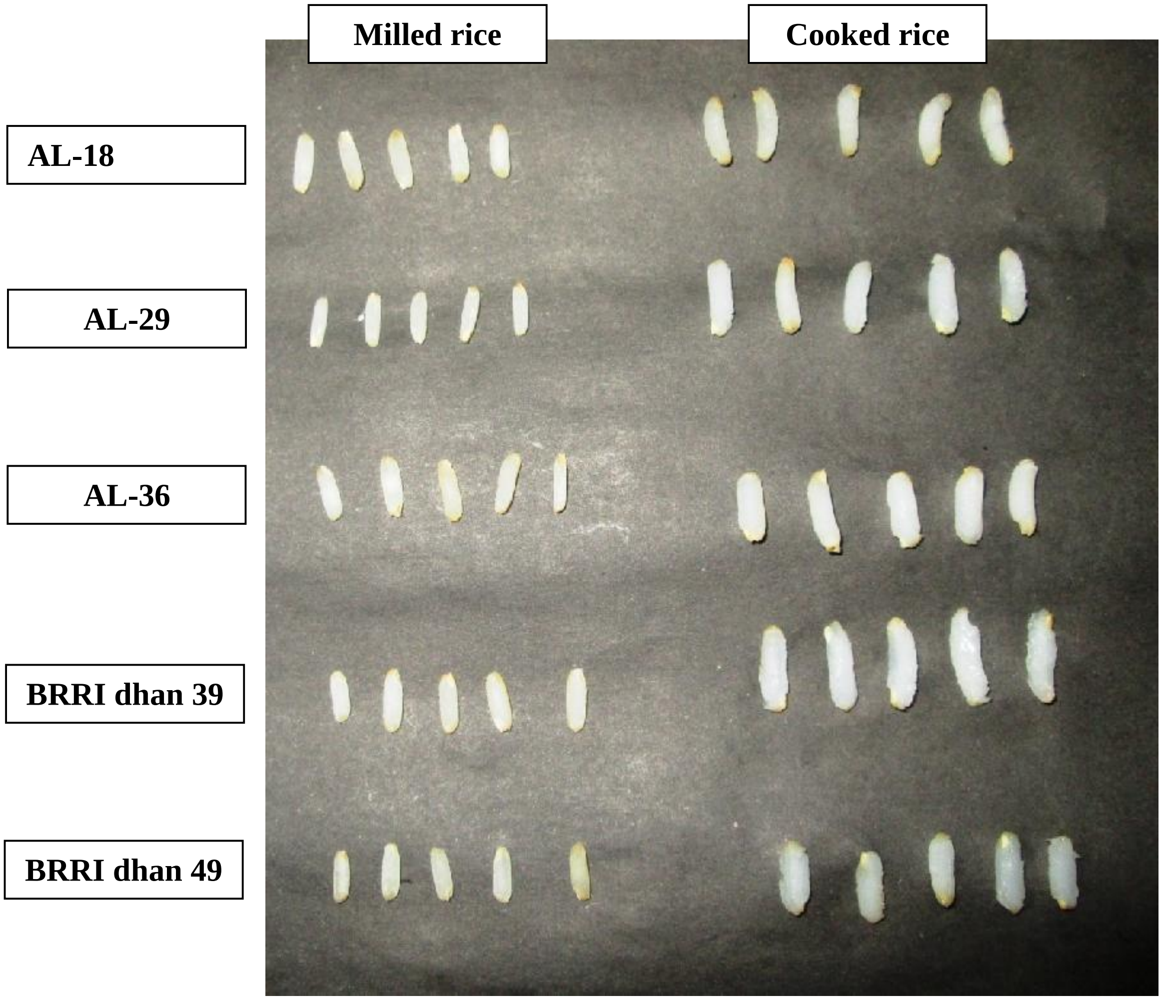

Plate 6. A comparative view of milled rice and cooked rice of different advanced lines and check

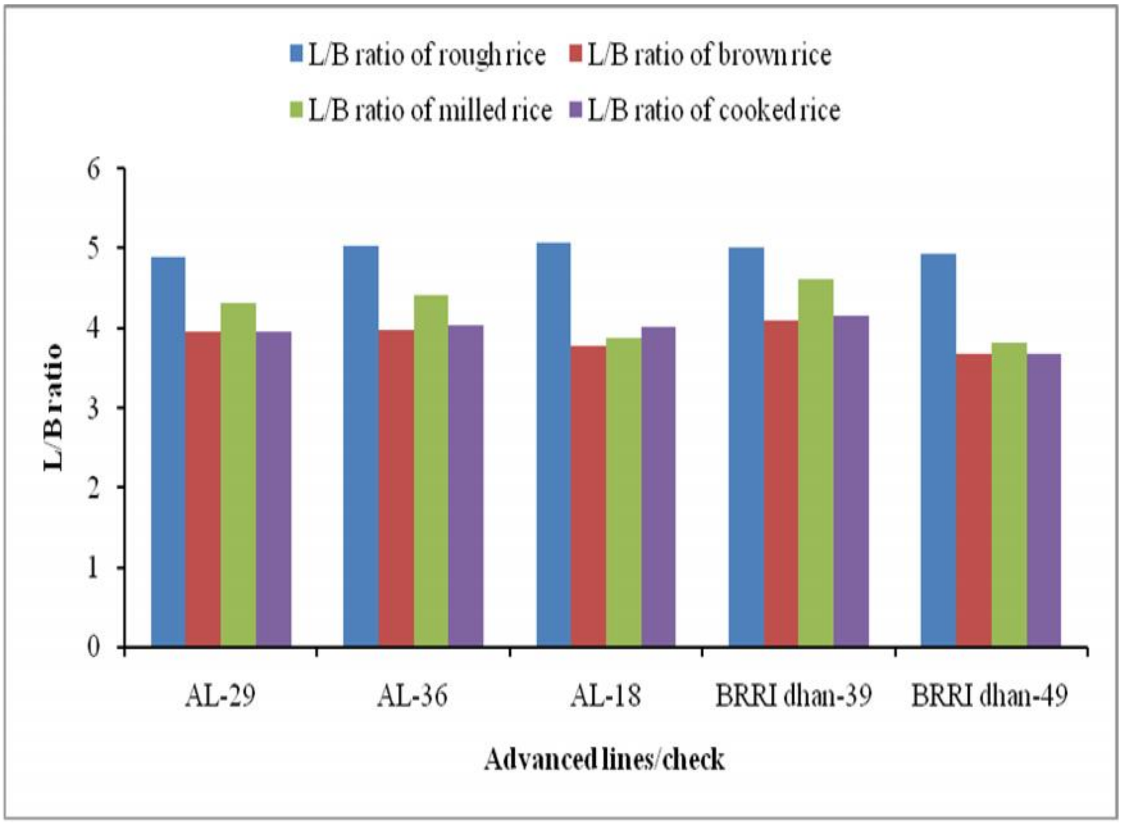

Figure 7. Relative performance of advanced lines and check for L/B ratio of rough rice, brown rice, milled and cooked rice

4.3.2.3. Volume expansion percent

The maximum volume expansion percent (72.33%) was recorded from AL-29 whereas the minimum (45.62%) was recorded from AL-18 (Table 12) which was statically similar with BRRI dhan49 (46.28%), AL-36 (48.20%) and BRRI dhan39 (53.10%). Zaman (1981) reported that the varieties which tend to show high volume expansion are sticky and give a pasty appearance on cooking (Plate7).

4.3.2.4. Alkali spreading value (ASV)

The gelatinization temperature (GT) is considered to be yet another major index of cooking quality of rice. The maximum alkali spreading value (6.933) was recorded from BRRI dhan49 whereas the minimum (3.850) was recorded from BRRI dhan-39 which was statistically similar with AL-29 and AL-18 (4.067) (Table 12).

The time required for cooking is determined by the gelatinization temperature. Alkali spreading value is inversely related to gelatinization temperature. It is the range of temperature within which granules begin to swell irreversibly in hot water. The GT of rice varieties ranging from 55^{0}C to 79^{0}C are grouped into low (55- 69^{0}C), intermediate (70- 74^{0}C) and high (74- 79^{0}C). Rice varieties having intermediate GT produces good quality cooked rice (Table 13).

Study of world collection of rice at IRRI reveals that traditional tropical rice variety, in general of intermediate GT with the exception of Bulk and Waxy rice that are characterized with low GT. A comparative view of alkali spreading value of advanced lines and check was presented in Plate 8.

AL-36

AL-29

AL-18

BRRI dhan 39

BRRI dhan 49

Plate 7. Showing volume expansion percent of advanced lines and check varieties

Table 13. Classification of advanced lines and check varieties on the basis of alkali spreading value and GT types

Lines/check	Alkali spreading value	Alkali digestion	GT types

AL-29	4.067	Intermediate	Intermediate
AL-36	5.300	High	Low
AL-18	4.067	Intermediate	Intermediate
BRRI dhan-39	3.850	Intermediate	Intermediate
BRRI dhan-49	6.933	High	Low

GT= Gelatinization temperature

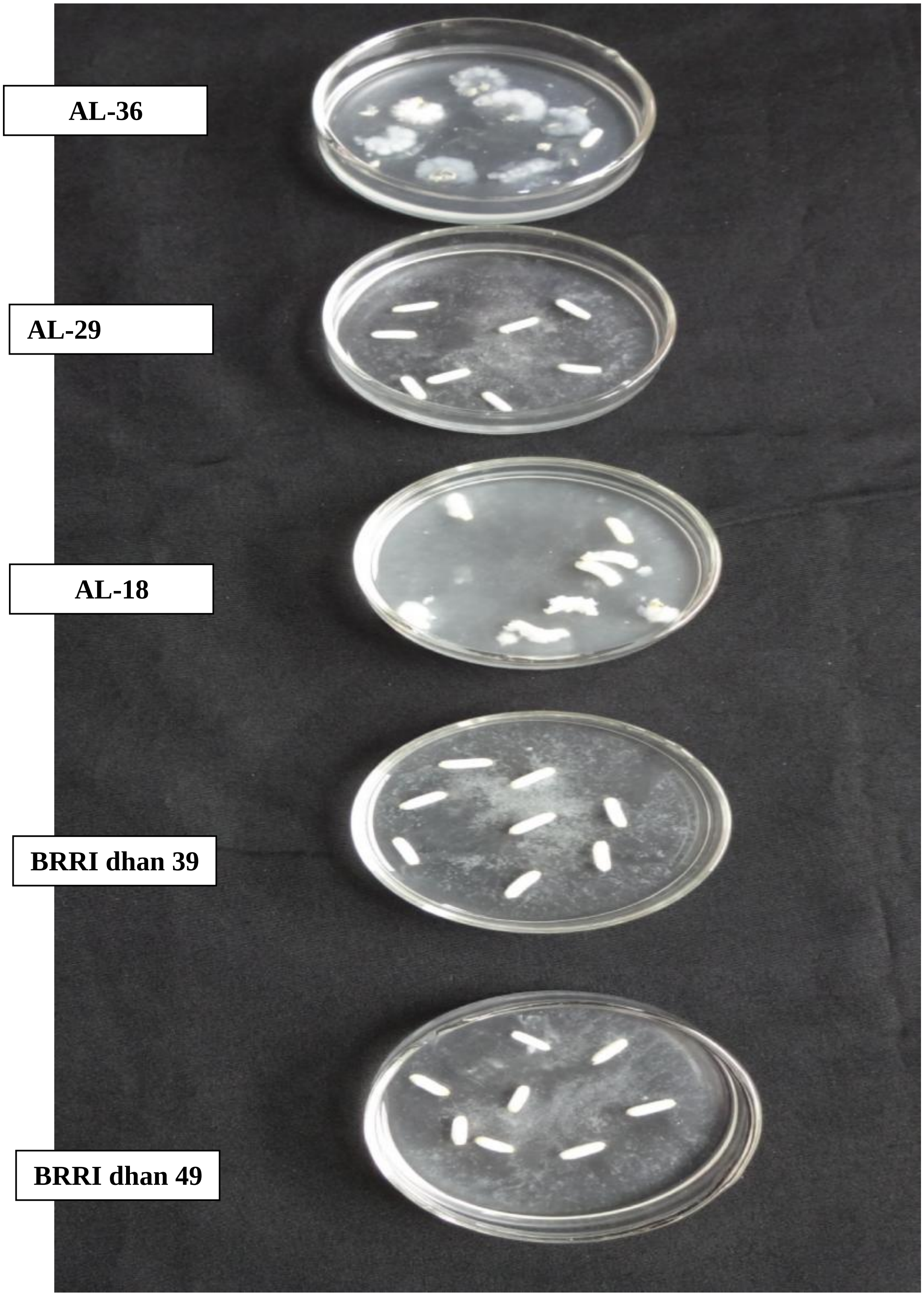

Plate 8. Showing alkali spreading value (GT) of advanced lines and check varieties

4.3.3. Analysis of correlation of co-efficient of quality characters

Quality in rice is a complex trait. For improvement of complex traits of this kind a precise knowledge on nature and strength of relationship between different component indices is important. Such information would help not only to understand the genetic basis of such relationship but also to enable breeders to adopt appropriate breeding and selection strategies. On the point of view, an attempt has been made in the course of the present investigation to study the nature and extent of association between various character pairs relating to quality (milling recovery, grain dimension and cooking) attributes through a simple correlation analysis (Table 14& 15).

4.3.3.1. Length of rough rice

Length of rough rice showed significant positive relationship with breadth of rough rice, length of brown rice and length of milled rice and insignificant positive relationship with L/B ratio of rough rice, breadth of brown rice, L/B ratio of brown rice, L/B ratio of milled rice, length of cooked rice, L/B ratio of cooked rice and hulling percent (Table 14& 15). On the other hand, length of rough rice showed insignificant negative relationship with breadth of milled rice, breadth of cooked rice, milling percent, head rice recovery percent, water absorption percent, volume expansion percent and alkali spreading value.

4.3.3.2. Breadth of rough rice

Breadth of rough rice showed significant positive relationship with length of brown rice, length of milled rice and L/B ratio of cooked rice and insignificant positive relationship with L/B ratio of rough rice, breadth of brown rice, L/B ratio of brown rice, L/B ratio of milled rice, length of cooked rice, hulling percent and volume expansion percent. On the other hand, breadth of rough rice showed insignificant negative relationship with breadth of milled rice, breadth of cooked rice, milling percent, head rice recovery percent, water absorption percent, and alkali spreading value (Table 14& 15).

Table 14. Coefficient of phenotypic correlation among different yield components

Characters		Breadth of rough rice	L/B ratio of rough rice	Length of brown rice	Breadth of brown rice	L/B ratio of brown rice	Length of milled rice	Breadth of milled rice	L/B ratio of milled rice	Length of cooked rice	Breadth of cooked rice	L/B ratio of cooked rice	Milling percent	Hulling percent	Head rice recovery	Water absorption percentage	Volume expansion percentage	Alkali spreading value
Length of rough rice	r_p	0.996**	0.762	0.968**	0.724	0.477	0.905*	-0.215	0.343	0.266	-0.168	0.857	-0.474	0.036	-0.542	-0.479	-0.125	-0.783
Breadth of rough rice	r_p		0.682	0.972**	0.651	0.547	0.953*	-0.267	0.411	0.356	-0.107	0.891*	-0.474	0.011	-0.559	-0.443	0.004	-0.849
L/B ratio of rough rice	r_p			0.730	0.832	0.085	0.425	-0.013	0.003	-0.189	-0.411	0.514	-0.262	0.218	-0.340	-0.556	-0.740	-0.266
Length of brown rice	r_p				0.569	0.656	0.860	-0.431	0.543	0.424	-0.047	0.948*	-0.255	0.147	-0.540	-0.517	-0.087	-0.802
Breadth of brown rice	r_p					-0.237	0.537	0.439	-0.364	-0.330	-0.417	0.292	-0.654	-0.198	-0.203	-0.467	-0.543	-0.320
L/B ratio of brown rice	r_p						0.531	-0.913*	0.988**	0.825	0.351	0.856	0.303	0.345	-0.448	-0.177	0.425	-0.668
Length of milled rice	r_p							-0.183	0.384	0.467	0.054	0.823	-0.535	-0.201	-0.456	-0.369	0.288	-0.932*
Breadth of milled rice	r_p								-0.966**	-0.624	-0.193	-0.651	-0.494	-0.642	0.481	-0.049	-0.257	0.307
L/B ratio of milled rice	r_p									0.778	0.325	0.767	0.403	0.454	-0.448	-0.067	0.410	-0.529
Length of cooked rice	r_p										0.806	0.650	0.420	-0.199	0.084	-0.413	0.650	-0.740
Breadth of cooked rice	r_p											0.148	0.594	-0.564	0.658	-0.509	0.546	-0.404
L/B ratio of cooked rice	r_p												-0.059	0.196	-0.526	-0.440	0.148	-0.847
Milling percent	r_p													0.184	0.454	-0.216	0.010	0.233
Hulling percent	r_p														-0.707	0.462	-0.315	0.321
Head rice recovery	r_p															-0.423	0.020	0.219
Water absorption percentage	r_p																0.260	0.523
Volume expansion percentage	r_p																	-0.442

Table 1. Coefficient of genotypic correlation among different yield components

Characters		Breadth of rough rice	L/B ratio of rough rice	Length of brown rice	Breadth of brown rice	L/B ratio of brown rice	Length of milled rice	Breadth of milled rice	L/B ratio of milled rice	Length of cooked rice	Breadth of cooked rice	L/B ratio of cooked rice	Milling percent	Hulling percent	Head rice recovery	Water absorption percentage	Volume expansion percentage	Alkali spreading value

Length of rough rice	r_g	0.998**	0.926*	0.966**	0.695	0.464	0.899*	-0.228	0.361	0.324	-0.104	0.872	-0.625	-0.010	-0.646	-0.514	-0.171	-0.796
Breadth of rough rice	r_g		0.758	0.496	0.720	0.653	0.475	-0.152	0.443	0.506	0.105	0.962**	-0.326	0.060	-0.524	-0.410	0.001	-0.896*
L/B ratio of rough rice	r_g			0.518	0.613	-0.783	0.579	-0.459	0.031	-0.187	-0.948*	0.477	-0.782	-0.460	-0.965**	-0.822	-0.879*	-0.456
Length of brown rice	r_g				0.440	0.511	0.925*	-0.473	0.558	0.515	-0.183	0.906*	-0.822	0.026	-0.743	-0.632	-0.142	-0.830
Breadth of brown rice	r_g					-0.442	0.591	0.478	-0.396	-0.266	-0.542	0.220	-0.880*	-0.370	-0.389	-0.591	-0.652	-0.334
L/B ratio of brown rice	r_g						0.601	-0.905*	0.905*	0.951*	0.225	0.800	-0.488	0.198	-0.699	-0.309	0.388	-0.702
Length of milled rice	r_g							-0.213	0.473	0.406	0.194	0.879*	-0.399	-0.209	-0.515	-0.368	0.325	-0.941*
Breadth of milled rice	r_g								-0.808	-0.724	-0.426	-0.709	-0.445	-0.646	0.411	-0.070	-0.218	0.317
L/B ratio of milled rice	r_g									0.851	0.292	0.806	0.272	0.492	-0.441	-0.086	0.372	-0.527
Length of cooked rice	r_g										0.905*	0.701	0.670	-0.174	0.123	-0.400	0.731	-0.745
Breadth of cooked rice	r_g											0.135	0.337	-0.620	0.637	-0.648	0.664	-0.450
L/B ratio of cooked rice	r_g												-0.393	0.119	-0.662	-0.500	0.141	-0.871
Milling percent	r_g													-0.516	-0.325	-0.614	-0.333	0.191
Hulling percent	r_g														-0.952	0.379	-0.419	0.325
Head rice recovery	r_g															-0.564	-0.016	0.215
Water absorption percentage	r_g																0.215	0.530
Volume expansion percentage	r_g																	-0.441

4.3.3.3. L/B ratio of rough rice

L/B ratio of rough rice showed insignificant positive relationship with length of brown rice, breadth of brown rice, L/B ratio of brown rice, length of milled rice, L/B ratio of milled rice, L/B ratio of cooked rice and hulling percent. On the other hand, L/B ratio of rough rice showed insignificant negative relationship with breadth of milled rice, length of cooked rice, breadth of cooked rice, milling percent, head rice recovery percent, water absorption percent, volume expansion percent and alkali spreading value (Table 14 & 15).

4.3.3.4. Length of brown rice

Length of brown rice showed significant positive relationship with L/B ratio of cooked rice and insignificant positive relationship with breadth of brown rice, L/B ratio of brown rice, length of milled rice, L/B ratio of milled rice, length of cooked rice, and hulling percent. On the other hand, length of brown rice showed insignificant negative relationship with breadth of milled rice, breadth of cooked rice, milling percent, head rice recovery percent, water absorption percent, volume expansion percent and alkali spreading value (Table 14 & 15).

4.3.3.5. Breadth of brown rice

Breadth of brown rice showed insignificant positive relationship with length of milled rice, breadth of milled rice, L/B ratio of cooked rice. On the other hand, breadth of brown rice showed insignificant negative relationship with L/B ratio of brown rice, L/B ratio of milled rice, length of cooked rice, breadth of cooked rice, milling percent, hulling percent, head rice recovery percent, water absorption percent, volume expansion percent and alkali spreading value (Table 14 & 15).

4.3.3.6. L/B ratio of brown rice

L/B ratio of brown rice showed significant positive relationship with L/B ratio of milled rice and insignificant positive relationship with length of milled rice, length of cooked rice, breadth of cooked rice, L/B ratio of cooked rice, milling percent, hulling percent and volume expansion percent. On the other hand, L/B ratio of brown rice showed significant negative relationship with breadth of milled rice and insignificant negative relationship with head rice recovery percent, water absorption percent, and alkali spreading value.

4.3.3.7. Length of milled rice

Length of milled rice showed insignificant positive relationship with L/B ratio of milled rice length of cooked rice, breadth of cooked rice, L/B ratio of cooked rice and volume expansion percent. On the other hand, length of milled rice showed significant negative relationship with alkali spreading value and insignificant negative relationship with breadth of milled rice, milling percent, hulling percent, head rice recovery percent and water absorption percent (Table 14 & 15).

4.3.3.8. Breadth of milled rice

Breadth of milled rice showed insignificant positive relationship with head rice recovery percent and alkali spreading value. On the other hand, breadth of milled rice showed significant negative relationship with L/B ratio of milled rice and insignificant negative relationship with length of cooked rice, breadth of cooked rice, L/B ratio of cooked rice, milling percent, hulling percent, water absorption percent, volume expansion percent.

4.3.3.9. L/B ratio of milled rice

L/B ratio of milled rice showed insignificant positive relationship with length of cooked rice, breadth of cooked rice, L/B ratio of cooked rice, milling percent, hulling percent and volume expansion percent. On the other hand, L/B ratio of milled rice showed significant negative relationship with head rice recovery percent, water absorption percent, and alkali spreading value.

4.3.3.10. Length of cooked rice

Length of cooked rice showed insignificant positive relationship with breadth of cooked rice, L/B ratio of cooked rice, milling percent, head rice recovery percent and volume expansion percent. On the other hand, length of cooked rice showed insignificant negative relationship with hulling percent and water absorption percent and alkali spreading value.

4.3.3.11. Breadth of cooked rice

Breadth of cooked rice showed insignificant positive relationship with L/B ratio of cooked rice, milling percent, head rice recovery percent and volume expansion percent. On the other hand, breadth of cooked rice showed insignificant negative relationship with hulling percent and water absorption percent and alkali spreading value.

4.3.3.12. L/B ratio of cooked rice

L/B ratio of cooked rice showed insignificant positive relationship with hulling percent and volume expansion percent. On the other hand, L/B ratio of cooked rice showed insignificant negative relationship with milling percent, head rice recovery percent and, water absorption percent and alkali spreading value.

4.3.3.13. Milling percent

Milling percent showed insignificant positive relationship with hulling percent, head rice recovery percent, volume expansion percent and alkali spreading value. On the other hand, milling percent showed insignificant negative relationship with water absorption percent.

4.3.3.14. Hulling percent

Hulling percent showed insignificant positive relationship with water absorption percent and alkali spreading value. On the other hand, hulling percent showed insignificant negative relationship with head rice recovery percent and volume expansion percent.

4.3.3.15. Head rice recovery percent

Head rice recovery percent showed insignificant positive relationship with volume expansion percent and alkali spreading value. On the other hand, head rice recovery percent showed insignificant negative relationship with water absorption percent.

4.3.3.16. Water absorption percentage

Water absorption percent showed insignificant positive relationship with volumeexpansion percent and alkali spreading value.

4.3.3.17. Volume expansion percentage

Volume expansion percent showed insignificant negative relationship with alkali spreading value.

Viraktamath (1987) found that highly significant positive correlation of HRR percent with breadth of milled rice and insignificant positive relationship with breadth of rough rice, L/B ratio of brown rice, length of milled rice, breadth of cooked rice and alkali spreading value and insignificant negative relationship with other characters. Yadav and Singh (1989) found that hulling and milling percentage was independent of grain shape whereas HRR was negatively associated of L/B ratio of rough rice. Sood and Siddiq (1986) reported that water uptake shows positive and significant influence on volume expansion.

CHAPTER V
SUMMARY AND CONCLUSION

Bangladesh has made significant improvement in agriculture sector but the chronic food deficiency has persisted unabated for many years. The growth of population in our country is much faster than rice production. Hence yield, the grain quality of rice is the most important factor for deciding the profitability of the farmers as the grain quality decides the price in the market. The breeders and nutritionists seek rice grain with higher content of protein, vitamins and minerals.

Three advance line and two check varieties collected from Bangladesh Rice Research Institute (BRRI) were used for this experiment. Advanced lines were AL-29, AL-36, AL-18 and two checks were BRRI dhan-39 and BRRI dhan-49. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The genotypes were randomly assigned to each plot within each replication. The outcome of the investigations is summarized as under:

In the experiment highest plant height for BRRI dhan-49 was 106.5 cm and lowest for AL-36 (90.70 cm). For days to 50% flowering AL-36 required maximum days (106 days) and AL-18 required lowest days (85 days). For days to maturity BRRI dhan-39 required maximum days (142 days) and AL-18 required minimum days (128.7 days). For number of tillers AL-36 showed maximum performence (22.33) and BRRI dhan-39 showed lowest performance (17.87). For number of effective tillers, AL-36 showed maximum performance (2.87) and AL-29 showed lowest performance (1.2). In panicle length status, AL-29 showed maximum performance (26.68 cm) and for BRRI dhan-49 was the lowest (24.35 cm). Number of filled grains was the highest for AL-29 (178.30) whereas, BRRI dhan-39 only 147.30. Number of empty grains was highest in BRRI dhan-39 (22.00) and for AL-36 it was only 15.93. On the other hand, for 1000-grain weight AL-36 showed best performance (2.437 g) whereas minimum performance was for BRRI dhan-49 (2.087 g). In grain yield per plant (g), AL-36 showed highest yield (49.19 g) and BRRI dhan-39 showed lowest yield (18 g). In case of, grain yield/plot, AL-29 was the best (10.75 kg) than others. For grain yield/ha, AL-29 was the best (6.32 ton) than others.

In correlation coefficient analysis significant positive associations were found for days to 50% flowering with number of tillers per plant and grain yield, number of tillers per plant with grain yield and 1000 grain weight with grain yield. In correlation analysis significant negative associations were found for plant height with1000 grain weight.

In the experiment AL-18 showed maximum length (9.667 mm), breadth (1.91 mm) and L/B ratio (5.063 mm) of rough rice. For brown rice maximum length (6.810 mm), breadth (1.793 mm) and L/B ratio (4.087 mm) showed by BRRI dhan-39, AL-18 and BRRI dhan-39 respectively. For milled rice maximum length (6.547 mm) and breadth (1.67 mm) showed by AL-18 and L/B ratio (4.607 mm) showed by BRRI dhan-39. For cooked rice BRRI dhan-39 showed maximum length (9.357 mm), breadth (2.437 mm) and L/B ratio (4.147 mm). The maximum milling percent (71.97%), head rice recovery percent (67.27%) and alkali spreading value (6.933) were found from BRRI dhan-49. The maximum hulling percent (81.00%) and water absorption percent (269%) were found from AL-36 whereas maximum volume expansion percent (72.33%) was found from AL-29.

In correlation coefficient analysis significant positive associations were found for length of rough rice with breadth of rough rice, length of brown rice and length of milled rice, Breadth of rough rice with length of brown rice, length of milled rice and L/B ratio of cooked rice, length of brown rice with L/B ratio of cooked rice and L/B ratio of brown rice with L/B ratio of milled rice. In correlation analysis significant negative associations were found for L/B ratio of brown rice with breadth of milled rice, length of milled rice with alkali spreading value and breadth of milled rice with L/B ratio of milled rice.

Analysis of variance revealed highly significant variation present among the advanced lines and checks for all the characters studied. Existing of significant level of variation present in the materials indicate the possibility of improving the yield potential. Wide range of mean values for different characters showed presence of wide variability in the experiment. Among the advanced lines AL-29 and among the check varieties BRRI dhan-49 exhibited best performance.

The study revealed existence of variability in respect of quality traits in the material. This offers a scope for exploitation of quality traits in improvement of quality of advanced lines.

Future suggestions:

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Promising lines with high level and good grain quality may further be evaluated in multilocation trial for regional adaptability.
2. The lines should be further evaluated to determine amylase content, protein content etc.
3. Keeping in view the market acceptability of the lines should be further improved for high yield with acceptable quality through breeding.

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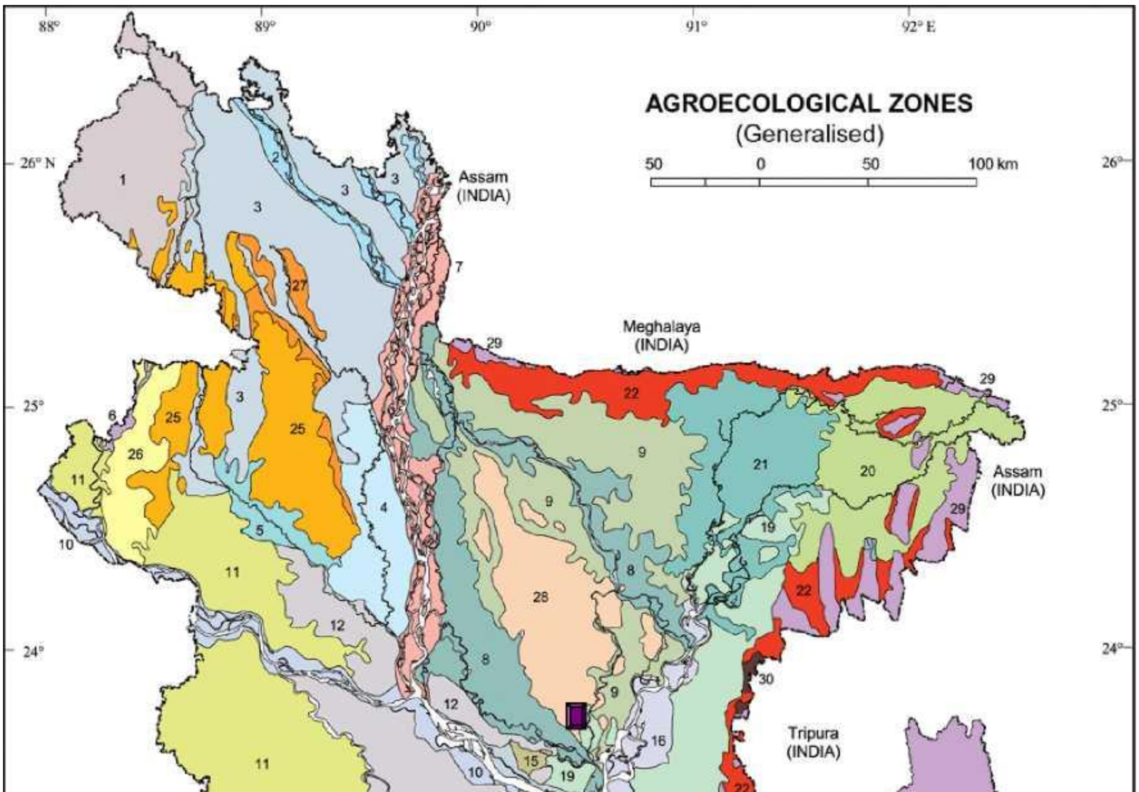
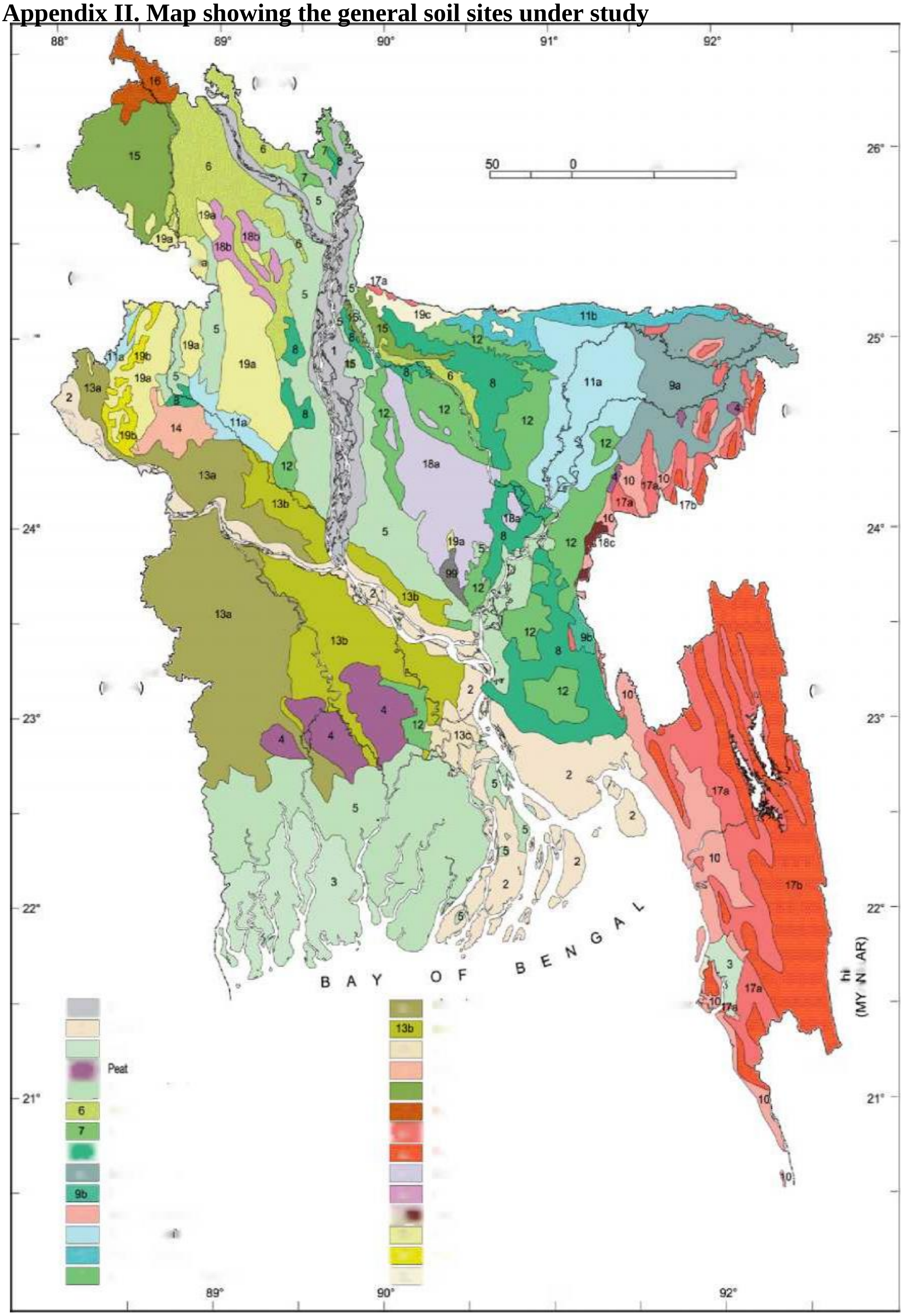
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Map showing the general soil sites under study



Appendix III. Morphological, physical and chemical characteristics of initial soil (0-15 cm depth)

Physical composition of the soil

Soli separates	Percent (%)	Methods employed
Sand	26.90	Hydrometer method (Day, 1915)
Silt	45.40	Do
Clay	29.66	Do
Textural class	Silty-clay	Do

Chemical composition of the soil

Sl.No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.87	Walkley and Black, 1947
2	Total N (kg/ha)	1792	Bremner and Mulvancy, 1965
3	Total S (ppm)	225.80	Bradsley and Lanester, 1965
4	Total P (ppm)	840	Olsen and Sommers, 1982
5	Available N (kg/ha)	53	Bremner, 1965
6	Available P (kg/ha)	69	Olsen and Dean, 1965
7	Exchangeable K (kg/ha)	90.50	Pratt, 1965
8	Available S (ppm)	16.59	Hunter, 1984
9	pH (1:2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.80	Chapman,1965