VARIABILITY AND INTERRELATIONSHIPS IN TRAITS OF F_4 POPULATIONS OF BORO RICE (*Oryza sativa* L.)

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VARIABILITY AND INTERRELATIONSHIPS IN TRAITS OF F_4 POPULATIONS OF BORO RICE (*Oryza sativa* L.)

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*This is to certify that thesis entitled, **"VARIABILITY AND INTERRELATIONSHIPS IN TRAITS OF F_4 POPULATIONS OF BORO RICE (Oryza sativa L.)"** 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 result of a piece of bona fide research work carried out by **KAMRUL ISLAM,** Registration No:**08-02807** 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 duly been acknowledged.

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TO

MY BELOVED PARENTS

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VARIABILITY AND INTERRELATIONSHIPS IN TRAITS OF F_4 POPULATIONS OF BORO RICE (*Oryza sativa* L.)

ABSTRACT

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A field experiment was conducted with 27 genotypes (22 F_4 materials and 5 check varieties) of *Oryza sativa* L. at the experimental field of Sher-e-Bangla Agricultural University, Dhaka to select early high yielding Boro materials during November, 2013 to May, 2014. The experiment was laid out in Randomized Complete Block Design with three replications. Variability, heritability, correlation and path coefficient were analyzed on the basis of fourteen characters. The genotypes were found significantly variable for most of the characters. Phenotypic variances were comparatively higher than the genotypic variances for all the characters studied. Also PCV were higher than the GCV for all the characters studied. High heritability with high genetic advance in percent of mean was observed for total number of tiller per plant, total number of effective tiller per plant, number of primary branches per panicle, total number of spikelet per panicle, number of filled spikelet per panicle, yield per plant, thousand grain weight and yield per hectare .The significant positive correlation with yield per hectare was found in days to maturity, panicle length, number of secondary branches per panicle and thousand grain weight. Path co-efficient analysis revealed that days to maturity, plant height, number of effective tiller per plant, number of filled spikelet per panicle, total number of spikelet per panicle, yield per plant and thousand gain weight had the positive direct effect on yield per hectare. Considering the variability, heritability, correlation and path coefficient analysis, the seven (7) genotypes viz., (BR 21 × BRRI dhan 29, S-6, P-7), (BR 21 × BRRI dhan 28, S-5, P-4), (BR 21 × BRRI dhan 29, S-6, P-6), (BR 21 × BRRI dhan 29, S-6, P-4), (BR 24 × BRRI dhan 29, S-5, P-4), (BR 21 × BRRI dhan 29, S-6, P-5), (BR 21 × BRRI dhan 29, S-6, P-3) were selected as early high yielding Boro lines for future use.

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LIST OF ABBREVIATED TERMS

Abbreviation	Full word
%	Percent
ºC	Degree Celsius
@	At the rate
σ^2 p	Phenotypic variance
σ^2 g	Genotypic variance
σ^2 e	Environmental variance
Adv.	Advance
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
App.	Applied
Ann.	Annals
ANOVA	Analysis of variance
Assoc.	Associtaion
Archiv.	Archives
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BES	Bangladesh Economic Survey
Biol.	Biological
Biot.	Biotechnogy
Bio.	Biology
Bios.	Bioscience
BINA	Bangladesh Institute of Nuclear Agriculture
BR	Bangladesh Rice
Breed.	Breeding
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV%	Percentage of Coefficient of Variation
Curr.	Current
Dev.	Development
Dig.	Digest

(***Continued…***)

Abbreviation	Full word
Df	Degrees of Freedom
DF	Days to flowering
DM	Days to maturity
DMRT	Duncan's Multiple Range Test
E	East
EC	Emulsified Concentrate
Ecol.	Ecology
ECV	Environmental co-efficient of variation
Env.	Environment
et al.	And others
etc.	Etcetera
Ext.	Extension
F_1	The first generation of a cross between two dissimilar homozygous parents
F_4	The fourth generation of a cross between two dissimilar homozygous parents
F_5	The fifth generation of a cross between two dissimilar homozygous parents
FAO	Food and Agricultural Organization
FGP	Filling spikelet percentage
g	Gram
G	Genotype
GA	Genetic Advance
GAPM	Genetic advance as percentage of mean
GCV	Genotypic coefficient of variation
GDP	Gross Domestic Product
Genet.	Genetics
GW	Spikelet weight
h^2 b	Heritability in broad sense
HI	Harvest Index
Hort.	Horticulture
Imorove.	Improvement
Int.	International
IARI	Indian Agricultural Research Institute

(*Continued…*)

Abbreviation	Full word
J.	Journal
K	Potassium
Kg	Kilogram
m	Meter
M_3	Third generation of mutant lines
MS	Mean sum of square
MP	Murate Potash
MOA	Ministry of Agriculture
m^2	Square meter
N	Nitrogen
N	North
n	Number of Chromosome
Nat.	Natural
Newsl.	Newsletter
NET	Number of effective tiller per plant
NFG	Number of filled grain per panicle
Not.	Notable
NPB	Number of primary branches per panicle
NSB	Number of secondary branches per panicle
NTT	Number of total tiller per plant
NUFG	Number of unfilled grain per panicle
P	Phosphorous
Pl.	Plant
PCV	Phenotypic coefficient of variation
PH	Plant Height
pH	Negative logarithm of Hydrogen ion
Physiol.	Physiology
PL	Panicle length
Q.	Quantum
RCBD	Randomized Complete Block Design
Res.	Research
Rsour.	Resources
RIL	Recombinant inbreed lines
S	Sulfur
SAU	Sher-e-Bangla Agricultural University
Sci .	Science

(***Continued…***)

Abbreviation	**Full word**
Soc.	Society
Tech.	Technology
TNSP	Total number of spikelet per panicle
TSP	Triple Super Phosphate
TGW	1000- grain weight
TSW	1000 seed weight
Univ.	University
Y	Yield ton per hectare
YP	Yield per plant

CHAPTER I

INTRODUCTION

Bangladesh is an agro-based country. Rice is the principal food of this country from time immemorial. It occupies 77% of total cropped area. At present rice alone constitutes about 92% of the total food grains produced annually in the country. It provides 75% of the calories and 55% of the proteins in the average daily diet of the people. Rice is rich in carbohydrate. The protein content is about 8.5 percent. The thiamin and riboflavin contents are 0.27 and 0.12 micrograms, respectively (Bhuiyan *et al.*, 2002). The vast majority of the populations (87%) residing in rural areas that depend on rice as a major source of food.

Bangladesh is the fourth position in rice production in the world. Along with many other rice growing countries, Bangladesh is affected by factors that exert tremendous pressure on the country's ability to produce enough rice for its population. These factors include rapid population growth (1.37%), diminishing rice production area and leaving-off rice yields. The contribution of rice to GDP is 13.09%. Total production of grain crops in Bangladesh in 2012 financial year is 372.66 lac metric ton where as Aus, Aman and Boro rice contribute respectively 21.58,128.97, 187.78 lac metric ton. Nearly 47.30% of our employments are engaged in rice sector (BES, 2014). At present, the occupied land of Aus rice is 2602 thousand acre and Aman rice is 13863 thousand acres as well as Boro rice is 12763 thousand acre land in 2013 (BES, 2014).

By 2025, it is estimated to produce about 60% more rice than what is currently produced to meet the food needs of a growing world population (Fageria *et al.*, 2003). The population will increase to over 4.6 billion by 2050 (Honarnejad *et al.*, 2000) which demands more than 50% of rice needs to be produced (Ashikari *et. al.*, 2005; Srividya *et al.*, 2010). But production is not increasing accordingly.

Rice (*Oryza sativa* L.) is the world most important cereal crop after wheat and maize. Rice has 24 species, of which 22 are wild and two viz. *Oryza sativa* and *Oryza glaberrima* are cultivated (Ray, 1985). It is a self pollinated cereal food crop and it belongs to the family Gramineae (Synonym poaceae) having chromosome number 2n = 24 under the order Cyperales and class Monocotyledon (Hooker, 1979). It is perennial, bisexual cereal crop but cultivated as annual crop.

Rice is cultivated from latitude 53°N to 35° S. Indian subcontinent is the ancestral home of *Oryza sativa*. It has three major sub-species- *indica*, *japonica* and *javanica* (Purseglove, 1985). The rice cultivars grown in Bangladesh belong to sub species *indica* (Alim, 1982).

Agro climatic conditions in Bangladesh are favorable for rice cultivation all the year round. Rice is grown as irrigated boro, Transplanted aus, rainfed broadcast aus, rainfed transplanted aman and rainfed broadcast aman in tropical climate. Boro rice has been gaining much importance in Bangladesh. The average per hectare yield of boro rice is higher than that of aus and aman rice (BRRI, 1999). Among the three rice seasons of Bangladesh, it is the longest rice season, producing the highest spikelet yield (Gomosta *et al.*, 2006).

Therefore, cultivation of short duration variety of rice will be promising practice for our farmers and it will suit with crop competition. So, plant breeders are trying to develop early high yielding varieties through several breeding methods. Inter-varietal crosses and evaluation of generations need to be performed to select early high yielding materials for using them in generating boro rice varieties. Moreover evaluation of genetic variability and inheritance is important to know the source of gene for particular trait within the available germplasm (Tomooka *et al.*, 1967)

The present study was undertaken to find out and establish suitable selection criteria higher seed yield through study of genetic heritability, variability, genetic advance and relationship between yield and its components. Hence, information on variability in respect of yield and its contributing traits required to be properly assessed for its improvement.

Considering the above idea the present investigation was conducted with the following objectives:

- To study the variability of genetic parameters in F_4 segregating populations
- To study the interrelationships and path coefficient analysis of yield contributing traits of rice
- To select early high yielding boro lines to utilize them directly in future program.

CHAPTER II

REVIEW LITERATURE

Rice has wide adaptability to different environmental conditions, as it is evident from its worldwide distribution. Yield of rice variety is determined by the morphological parameters such as plant height, number of effective tiller, number of spikelet per panicle, percentage of filled grain and spikelet weight as well as by environmental factors. Many studies on the variability, interrelationship, path co-efficient analysis, heritability and genetic advance have been carried out in many countries of the world. The review of literature concerning the studies presented under the following heads:

2.1 Variability, heritability, genetic advance and selection

2.2 Co-relation among different characters

2.3 Path co-efficient analysis

2.1 Variability, heritability, genetic advance and selection

Genetic variability is a prerequisite for initiating a successful breeding program aiming to develop high yielding varieties. A good number of literatures concerning the variability in the *Oryza species* are available. Some of those are presented here.

Ketan and Sarkar (2014) studied 26 *idigenous aman rice* cultivars and found that high heritability in days to flowering, plant height, 1000 spikelet weight, panicle length. Number of spikelet per panicle recorded the highest genetic advance followed by plant height and number of secondary branches. High heritability in conjunction with high genetic advance was registered for plant height, days to flowering and number of secondary branches. High heritability in conjunction with low genetic advance was observed for panicle length. Spikelet yield per plant was significantly correlated with number of secondary branches per panicle at phenotypic level while number of spikelet per panicle and fertility percentage at genotypic and phenotypic level. Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for flowering, plant height, number of secondary branches, 1000spikelet weight and panicle length.

Dhanwani *et al.* (2013) studied 13 Quantitative and Qualitative traits in rice. High GCV and high PCV was found on spikelet yield per plant (G= 30.52%, P= 31.18%), filled grain per panicle (G=26.05%, P=26.86%) and high heritability coupled with high genetic advance that showed those characters were governed by additive gene action and suitable for direct selection.

Dutta *et al.* (2013) studied sixty eight genotypes for twelve agronomical important characters to estimate variability and genetic parameters. High genotypic and phenotypic coefficient of variations, high heritability (broad sense) and genetic advance as percentage of mean were shown by eight characters viz. tillers per plant, days to flowering, harvest index, spikelet per panicle, spikelet density, panicle per plant and spikelet yield indicating the influence of additive gene action for these traits.

Singh *et al.* (2013) observed forty eight genotypes to examine genetic variability. High genotypic and phenotypic coefficient of variation, heritability and genetic advance as percent of mean was recorded for total number of spikelet per panicle, filled grains per panicle, number of effective tillers, leaf width and spikelet yield per plant. Positive and significant association was recorded by days to 50% maturity, leaf length, leaf width, filled grains per panicle and total number of spikelet per panicle. Spikelet yield per plant showed positive and significant correlation at genotypic and phenotypic levels. Days to maturity, plant height, number of filled grains per panicle and test weight exhibited positive direct effect both at genotypic and phenotypic levels.

Tuwar *et al.* (2013) studied twenty nine genotypes of rice from diverse locations to estimate the genetic components of variability. Analysis revealed that plant height had high estimates of GCV and PCV proceeded by number of tillers and grain weight per panicle. Heritability was higher for days to flowering followed by days to maturity, plant height and panicle length which suggested that these traits would respond to selection owing to their high genetic variability and transmissibility. High heritability coupled with high genetic advance as percent of mean was recorded for number of grains per panicle and grain effects in their expression and would respond to selection effectively as they are least influenced by environment.

Chanbeni *et al.* (2012) studied 70 rice genotypes by considering 13 quantitative characters. They showed that high estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were for spikelet yield per hill followed by tillers per hill and harvest index. High heritability with high genetic advance was recorded for spikelet per panicle.

Satesshkuma *et al.* (2012) estimated variability, heritability, genetic advance in fifty three genotypes of rice for fifteen characters. The highest genotypic and phenotypic coefficient of variation was found for number of productive tillers per plant, grain L/B ratio and grain yield per plant. High heritability was observed for the characters, days to first flower, plant height, number of productive tillers per plant, panicle length, filled grains per panicle, total number of grains, spikelet fertility, hundred grain weight and also for yield per plant. High genetic advance as percent of mean was observed for the characters, days to first flower, plant height, number of productive tillers per plant, panicle length, filled grains per panicle, total number of grains, hundred grain weights and grain yield per plant. Hence, the study suggested the selection based on these traits could be more effective in rice.

Seyoum *et al.* (2012) conducted a field experiments using fourteen rice genotypes during the main rainy seasons of 2009 and 2010 at three rainfed upland locations of Southwest Ethiopia to estimate the genetic variability, heritability of grain yield and yield contributing traits in upland rice. Days to 50% flowering, plant height, grains per panicle, spikelet per panicle, thousand grains weight and grain yield showed relatively high GCV and PCV estimates. High heritability was obtained for plant height (92.17%), followed by 50% flowering (90.16%), thousand grains weight (83.17%), days to 85% maturity (82.45%), panicle length (79.25%) and spikelet per panicle (60.25%) which indicates high heritable portion of variation. High to medium estimates of heritability and genetic advance were obtained for plant height, days to 50% flowering, panicles per plant, spikelet per panicle, grains per panicle and thousand grains weight, indicating the roles of additive gene action and a good scope of selection using their phenotypic performance.

Sohrabi *et al.* (2012) evaluated fifty Malyasian upland rice accessions for 12 growth traits, yield and yield components. The higher magnitude of genotypic and phenotypic coefficients of variation was recorded for spikelet fertility and days to flowering. High heritability along with high genetic advance was registered for yield of plant, days to flowering and flag leaf length-width ration suggesting preponderance of additive gene action in the gene expression of these characters. Plant height showed highly significant positive correlation with most of the traits.

Akinwalel *et al.* (2011) estimated the phenotypic and genotypic coefficients of variation, broad sense heritability, genetic gain and correlations in rice (*Oryza sativa* L.). Genotypic coefficients of variation were lower than the corresponding phenotypic coefficients in all the traits studied, indicating considerable influence of the environment on the expression of the traits. High to medium broad sense heritability estimates were observed for days to maturity, plant height, spikelet weight, spikelet yield and number of spikelet per panicle, panicle weight, number of panicles m^2 and panicle length. High to medium heritability and genetic advance were recorded for the number of spikelet per panicle, spikelet yield, panicle weight and the number of panicles per plant. Spikelet yield exhibited significantly positive correlation with the number of tillers per plant (r=0.58**), panicle weight (r=0.60**) and number of spikelet per panicle (r=0.52*).

Hasan *et al.* (2011) studied twenty four rice varieties for genetic variability, correlation and path analysis. The PCV values were greater than GCV revealing little influence of environment in character expression. High values of heritability along with moderate genetic advance were observed for days to flowering and plant height. Spikelet yield showed positive significant association with number of effective tillers/hill, panicle/m^2, spikelet fertility and thousand spikelet weight at both genotypic and phenotypic levels. Same traits had highest significant and positive effect on yield.

Roy *et al*. (2011) observed high heritability with high genetic advance (GA) for yield per hill followed by number of tillers per hill, number of filled grain per panicle, which indicated that these characters were under additive gene control and selection for genetic improvement for these traits might be effective.

Singh *et al.* (2011) evaluated eighty one rice genotypes for thirteen quantitative traits to examine the nature and magnitude of variability, heritability (broad sense) and genetic advance. Among the traits number of spikelet per panicle exhibited high estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) followed by harvest index, spikelet yield per hill, which suggested this trait would responds to selection owing their high genetic variability and transmissibility. Maximum genetic advance as per cent of mean was recorded for number of spikelet per panicle with high value of heritability.

Bisne *et al.* (2009) studied heritability, genetic advance and variability for yield contributing characters in rice. Genetic parameters for yield and its correspondent characters in rice were estimated from a trial with four CMS lines, eight testers and thirty-two hybrids evaluated for thirteen characters related to yield. High genotypic and phenotypic coefficient of variations was expressed by harvest index, total number of filled grains per panicle, 100-grain weight and spikelet fertility percentage. High heritability coupled with high genetic advance was exhibited by harvest index, total number of chaffy spikelet per panicle, grain yield per plant, total number of filled grains per panicle and spikelet fertility percentage and selection may be effective for these characters.

Rita *et al.* (2009) observed high genotypic and phenotypic coefficient of variations with harvest index, total number of filled grain per panicle, 100-spikelet weight and spikelet fertility percentage. High heritability coupled with high genetic advance was exhibited by harvest index, total number of chaffy spikelet per panicle, spikelet yield per plant, total number of filled grain per panicle and spikelet fertility percentage and selection may be effective for these characters.

Kole *et al.* (2008) studied variability for twelve morphological characters of 18 morphologically distinct mutants in M_4 generation along with their two mother genotypes (IET 14142 and IET 14143), which were developed from Tulaipanja, an aromatic non-basmati rice cultivar of West Beng*al.* Genotypic and phenotypic coefficients of variation were high for flag leaf angle and panicle number; moderate for grain number per panicle, straw weight, harvest index and grain yield per plant; and low for days to flower, plant height, panicle length, spikelet number, spikelet fertility (%) and test weight. High heritability accompanied by high to moderate genetic advance for flag leaf angle, panicle number, grain number, straw weight and grain yield indicated the predominance of additive gene action for the expression of these characters.

Padmaja *et al.* (2008) studied genetic variability, genotypic and phenotypic coefficients of variation, heritability and genetic advance for eleven characters in one hundred and fifty genotypes including five check varieties of rice. The analysis of variance revealed that there were highly significant differences for all the characters except leaf width and 1000 seed weight among the genotypes. The estimates of genotypic and phenotypic coefficients of variation (GCV and PCV) were high for all the characters except days to flowering and panicle length. Heritability and genetic advance were high for all the characters except days to flowering and panicle length, which had moderate genetic advance along with high heritability indicating the involvement of additive type of gene action in controlling these characters.

Ashvani *et al.* (2007) studied the genetic parameters of variability and heritability of different characters in 32 genotypes of rice, grown in Ghaziabad, Uttar Pradesh, India, in Kharif 1992. The heritability and high genetic advance as percentage of mean estimates were highest for days to flowering.

Karim *et al.* (2007) studied variability and genetic parameter analysis in 41 aromatic rice genotypes. The phenotypic variance was higher than the corresponding genotypic variance for the characters. These differences were in case of number of panicles per hill, number of primary branches, number of filled grains per panicle, spikelet sterility (%) and grain yield per hill indicating greater influence on environment for expression of these characters.1000-grain weight and days to maturity showed least difference between phenotypic and genotypic variance, which indicated additive gene action for expression of the characters. High genotypic coefficient of variation (GCV) value was observed for 1000-grain weight followed by spikelet sterility (%), grain yield per hill and number of filled grains per panicle, whereas days to maturity showed very low GCV. High heritability with high genetic advance in percent of mean (GAPM) was observed for 1000-grain weight followed by spikelet sterility (%) and number of filled grains per panicle indicated that these characters were under additive gene control and selection for improvement might be effective. Days to maturity showed high heritability but low genetic advance (GA) (%), which indicated that non additive gene effects were involved for phenotypic expression of this character.

Mustafa and Isheikh (2007) evaluated fourteen rice (*Oryza sativa* L.) genotypes at the Gezira Research Station Farm (GRSF), Sudan for correlation coefficient between yield and yield components among phenotypic markers and polygenic trait analysis. Phenotypic correlations between grain yield and number of filled grain panicle^{-1}, number of panicle m^{-2} and 1000 grain weight were 0.52, 0.36 and 0.27, respectively. These results suggested that improvement in yield could be attained by selecting rice plants for higher number of filled grain panicle^{-1}, number of panicle m^{-2}, and 1000 grain weight.

The effects of panicle type and source-sink relation on the variation in spikelet weight (GW) and quality within a panicle were investigated by Wang *et al.* (2007) using four japonica (*Oryza sativa* L.) varieties differing in spikelet density and two source-sink adjusting treatments. There were significantly differences in GW and filling spikelet percentage (FGP) among superior and inferior spikelet for compact- panicle varieties (Xiushui 994 and Xiushui 63), while not for loose-panicle ones (Xiushui 11 and Chunjiang 15).

Singh *et al.* (2006) evaluated the genetic variability, heritability, genetic advance and character association in 37 rice genotypes. Estimation of phenotypic coefficient of variation and genotypic coefficient of variation were in same magnitude for plant height except fertility percentage. Days to flowering exhibited the highest heritability with moderate genetic advance.

Singh *et al.* (2006) conducted an experiment with 32 genotypes of rice and found high heritability and high genetic advance for plant height, indicating the predominance of additive gene action for this trait.

Sankar *et al.* (2006) conducted an experiment with 34 rice genotypes and high heritability as well as genetic advance was obtained for productive tillers plant^{-1}.

Ananthi *et al.* (2006) studied genotypic and phenotypic coefficient of variation, heritability, expected genetic advance (GA) and genetic advance as percent of mean for spikelet yield and its contributing characters. Relatively high PCV and heritability estimates were recorded for 1000- spikelet weight.

Sharma *et al.* (2006) evaluated 39 upland rice genotypes for the estimation of genetic variability. The significant mean sum square indicated strong variability for days to flowering. Though days to flowering had high heritability (92.8%), it had low GCV.

Sanjeev (2005) conducted an experiment with 19 mutant lines (M_3) derived from pusa Basmati and Taraori Basmati and observed higher heritability for days to flowering compared to other characters.

Satyanarayana *et al.* (2005) studied variability, correlation and path coefficient analysis for 66 restorer lines in rice and observed low heritability for panicle length as well as high variability, heritability and genetic advance for plant height.

Sanjeev (2005) studied 19 mutant lines and found that number of panicle bearing tillers plant^{-1} in Taro Basmati had high genetic advance.

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

According to Bihari *et al.* (2004) who conducted an experiment with seventeen aromatic rice genotypes observed the days to flowering and test weight were highly heritable traits.

Sarma and Bhuiyan (2004) studied genetic variation and divergence in 58 aus rice genotypes and observed highest broad- sense heritability for plant height.

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

Patil *et al.* (2003) evaluated 128 traditional aromatic rice genotypes and found high heritability for 100-spikelet weight associated with yield/hectare.

Gomez and Kalamain (2003) reported high heritability coupled with high genetic advance for biological yield plant^{-1}, plant height and no. of panicle, indicating that these characters can be considered during selection for drought tolerance.

Kumari *et al.* (2003) reported that plant height showed high heritability coupled with modern genetic advances.

Patil *et al.* (2003) evaluated 128 traditional aromatic rice genotypes and found high heritability (>70%) in broad sense for all the characters expected panicle length (54.9).

Siddique *et al.* (2002) studied some rice varieties included JPS, SWAT-1, SWAT-11, DILROSH-97, PARC-3, IETI- 13711, IRRI-4, GOMAL-6, GHOMAL-7. The data were recorded on number tillers hill^{-1} plant height, number panicles plant^{-1}, 1000-spikelet weight, sterility percentage, straw yield, biological and spikelet yield and harvest index. The analysis of data revealed that statistically significant differences for all the parameters studied except number of tiller plant^{-1} and number panicles plant^{-1}.

Jiang *et al.* (2002) evaluated twenty four genetically diverse elite breeding lines and reported that days to flowering had high heritability coupled with high genetic advance indication additive gene effects.

Yield per hectare is the most important consideration in rice breeding program, but yield is a complex character in inheritance and may involve several related components. Rice yield is a product of number of panicles per unit area, number of spikelets per panicle, percentage of filled grains and weight of 1000 spikelet (Datta and Khanam, 2002). It is therefore important to know the factors or traits that influence spikelet yield directly or indirectly or both, and to determine heritability and genetic predicted. Improving rice (*Oryza sativa* L.) spikelet yield per unit land area is the only way to achieve increased rice production Because of the reduction in area devoted to rice production.

Mishra and Verma (2002) evaluated 16 rice parental cultivars and 72 F_1 progenies and found higher phenotypic co-efficient of variation (PCV) than the genotypic co-efficient of variation (GCV) for spikelet yield/plant. They also found that high heritability coupled with high genetic advance for yield/plant.

Pandey and Awasthi (2002) studied genetic variability in 21 genotypes of aromatic rice for yield contributing traits. Significant genetic variability was observed among the 21 genotypes for the entire yield for contributing traits. They concluded that traits plant height, days to flowering effective tillers per plant, panicle length, number of spikelets per panicle, test weight and spikelet yield per plant play a major role in the enhancement of production of spikelet yield.

Yang *et al.* (2001) studied the spikelet and yield components of two rice cultivars (JND3 and JND13). They observed JND3 exhibited a higher tillering capacity than JND13.

Honarnejad and Tarang (2001) evaluated seven local and alien rice cultivars for yield and yield contributing traits. They observed only 39% low sense heritability for tillers plant^{-1}.

Kumar (2001) carried out an experiment with 42 genotypes derived from seven crosses of rice and reported that phenotypic coefficient of variation was comparatively higher than the corresponding genotypic coefficient of variation for panicle length.

Shanthi and Singh (2001) studied 16 M6 generation of induced along with non-mutant Mashiur for variation in yield and component and found significant variation among the genotypes for all characters studied. Heritability in the broad sense was high (more than 80%) for all characters except spikelet yield per plant (78.99%).

Prasad *et al.* (2001) studied eighty fine rice genotypes to observe genetic variability and selection criteria for some yield contributing characters through correlation and path coefficient analysis.1000 spikelet weight, number of effective tillers/plant, number of fertile spikelet's/panicle and yield/plant showed high genotypic coefficient of variation and high heritability along with high genetic advance as percentage of mean, pointed out their importance for achieving genetic gain through selection.

Bidhan *et al.* (2001) studied the genetic variability, heritability, and genetic advance for yield and yield components in 25 medium duration rice genotypes West Bengal, India, during kharif 1996-97. Observations were recorded for 1000- spikelet weight and 1000- spikelet weight exhibited less environmental effect and high heritability coupled with moderate to high genetic advance.

Awasthi and Pandey (2000) observed significant genetic variability among 21 aromatic low land rice genotypes for days to flowering.

Diaz *et al.* (2000) noted wide variation in panicle length, panicle type, spikelet panicle^{-1}and panicle weight and secondary branches panicle^{-1}.

Tripathi *et al.* (1999) estimated genetic variability, heritability and genetic advance for yield components in 20 deep water rice genotypes. Plant height showed high genotypic and phenotypic variation.

Pattanyak and Gouta (1999) evaluated nine rice genotypes for genetic variability and characters association and found that days to flowering had high genetic heritability and genetic advance in a similar study with 21 aromatic low land rice genotypes.

Chaudhury and Das (1998) estimated genetic variability in 11 deep water rice varieties for yield and yield related characters like effective tillers plant^{-1}. They found a large difference between genotypic and phenotypic co-efficient of variation for effective tillers plant^{-1}.

Thakur *et al.* (1998) observed that the high heritability coupled with high genetic advance for panicle length other characters. They also observed small difference between phenotypic and genotypic coefficient of variation indicating less environmental influences for the expression of this character.

Kamal *et al.* (1998) performed an experiment to assess the yield of nine modern varieties (MV) and six improved varieties (LIV). They observed that modern variety BR11 gave the highest spikelet yield followed by BR10, BR23, Binasail and BR24.

Li and Yuan (1998) reported the parental genotype divergence had a relatively low impact on heterosis for panicle number and 1000 spikelet weight. Plant height, panicle per plant, spikelet per panicle and 1000 spikelet weight increase the yield in modern varieties (Saha *et al.*, 1993).

Genetic variability was determined for 7 quantitative characters in 13 diverse genotypes of upland rice by Paul and Sarmath (1997). Heritability estimates for all characters including spikelet yield were above 90%. Genetic spikelet was low yield per hectare.

A high heritability of 93.1% was observed for plant height in some rice genotypes by Kaw *et al.* (1999). Similar findings were also reported by Ashvani *et al.* (1997).

Debi *et al.* (1997) studied 29 irrigated rice genotypes and found high GCV, h^3 and genetic advance as percentage of mean (GAPM) for number of panicle plant^{-1}.

Twenty- four genotypes of Basmati rice were evaluated by Mani *et al.* (1997) to investigate the extent of genetic variation. A wide range of variation was recorded for all traits studied. A high estimate of heritability coupled with high genetic advance for number of filled grains per panicle suggested the predominance of additive gene action for this character.

BRRI (1997) conducted an experiment with rice and observed that weight of 1000-spikelets of Halio, Tilochachari, Nizershail and Latishail were 26.5, 27.7 and 25.2 respectively.

Narendra and Reddy (1997) studied with 11 rice genotypes and found high levels of variability for all seven yield components recorded. The components spikelets per panicle and 1000-spikelet weight were under the influence of additive genetic effects indicating their role in crop improvement. Selection through panicle length and plant height was found ineffective as they are highly influenced by environmental effects.

Awatshi and Sharma (1996) recorded considerable genetic variability for plant height in 15 of high quality aromatic *Oryza sativa* genotypes.

Singh and Chaudhury (1996) estimated genetic variability, heritability and genetic advance for 12 characters in 100 genotypes of rice. Phenotypic coefficients of variation (PCV) were higher than genotypes coefficient of variation (GCV) for most of the character. But high GCV was observed for spikelet per panicle. High heritability and high genetic advance estimated for spikelet per panicle.

Mishra *et al.* (1996) studied 10 scented rice genotypes and found that genotypic coefficient of variation; heritability and genetic advance were low for effective tillers hill^{-1} in a genetic study on yield and its components of 52 late duration rice genotypes.

Honarnejad (1995) observed low heritability days to flowering 15 F_1 hybrids and from a diallel cross. Low variation, high heritability with moderate genetic advance was reported by Chakraborty and Hazarika (1994) in 36 rice genotypes. But Das *et al.* (1992) evaluated 360 rice genotypes for variability. High heritability coupled with genetic advance in percent of mean found for days to flowering.

In a genetic on yield and its component of 52 late duration rice genotypes, Sawant *et al.* (1994) observed high genotypic and phenotypic coefficient of variation for ear bearings tillers plant^{-1}.

Chowdhury *et al.* (1993) reported that the cultivar BR23 had superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill-1, length of panicle, 1000 spikelet weight, spikelet yield and straw yield. On the other hand, the cultivar Pajam produced significantly taller plant, higher number of total spikelet's panicle^{-1}, spikelet panicle^{-1} and unfilled grain's panicle^{-1}.

Kumar *et al.* (1994) evaluated 9 genotypes of rice for 10 characters and found high genotypic coefficient of variation, high heritability and moderate genetic advance for plant height, indicating the predominance of additive gene effects controlling the character.

Chaubey and Singh (1994) worked with 20 rice varieties and reported high genotypic coefficient of variation, heritability and genetic advance for yield per plant. Thirty rice genotypes were evaluated for variability by Das *et al.* (1992). The highest GCV was found in spikelet per plant. High heritability with high genetic advance in percent of mean was also found in spikelet yield per plant.

Hemareddy *et al.* (1994) studied genetic variability for spikelet yield and its component traits in 81 genotypes of rice and found that phenotypic coefficient of variation (PCV) was higher than the genetic coefficient of variation (GCV) for all traits studied indicating the interaction of traits with the environment. Days to flowering had the highest heritability (98.61%).

Sawant *et al.* (1994) in a genetic study of 6 yield related traits in F_4 generation of rice found that expected genetic advance and heritability were high for spikelet per panicle. A high coefficient of variation and high value of heritability together with high expected genetic advance were also observed by Sawant and Patil (1995).

Chakraborty and Hazarika (1994) reported a very small difference between phenotypic and genotypic coefficient of variation, high heritability along with moderate genetic advance for panicle length.

Chakrabothi and Hazarika (1994) observed least difference indicating non-additive gene action.

Chauhan *et al.* (1993) showed wide of range of variation among the genotypes studied. High estimated genetic advance associated with high heritability estimates was recorded to 1000- spikelet weight, indicating additive gene action and liability to phenotypic selection.

Manual and Prasad (1993) observed little differences between phenotypic and genotypic coefficient of variation indicating less environmental influences. They reported low value of genotypic coefficient of variation, high heritability and low genetic advance for panicle length.

The performances of four rice cultivars/ advanced lines viz., IRATOM24, BR14, BINA13 and BINA19 were evaluated at BINA (1993). It was found that cultivars/ advanced lines differed significantly for the plant height, number of total effective and non-effective tillers hill^{-1}. Panicle length sterile spikelet's panicle^{-1} but spikelet yield did not differ significantly.

Thirty rice genotypes were evaluated for variability by Das *et al.* (1992). Fertile tillers plant^{-1} showed high GCV. Fertile tillers plant^{-1} also showed high heritability with high genetic advance in percent of mean

A study was conducted by Yadav (1992) on 11 plant characters in 16 rice genotypes and revealed that heritability estimate was high for days to flowering and for yield/plant.

Haque *et al.* (1991) reported negative association of 1000 spikelet weight and yield per plant in traditional varieties.

Li *et al.* (1991) worked on 9 rice cultivars and estimated that genetic coefficient of variation was high for yield per plant but they got moderate heritability and moderate genetic advance.

In a study of genetic variability and heritability of 8 yield components in 28 cultivars, Loknathan *et al.* (1991) found expected genetic advance as high as 68.4% for plant height.

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

Kihupi and Doto (1989) reported significant genotypic differences for plant height in selected rice varieties. High estimates of heritability; high expected genetic advance and genotypic and phenotypic coefficient of variation were numerically higher for plant height.

Singh and Gangwer (1989) conducted an experiment with four rice cultivars C-4-8, CR-1009, IET-565 and reported that spikelet number of panicle^{-1}, 1000-spikelet weight and biological yield were higher for C-4-8 than those of the other three cultivars.

Vishwakarme *et al.* (1989) estimates moderate heritability and moderate genetic advance for spikelet yield per plant in 82 population of rice.

Choudhury and Das (1988) worked out estimates of genetic variability, heritability and genetic in 11 deep –water rice varieties for yield and its attributing traits. High genotypic coefficient of variation was observed in spikelet yield. High heritability with high genetic advance was also found for spikelet yield.

Shamsuddin *et al.* (1988) conducted an experiment with nine different rice varieties and observed that plant height differed significantly among the varieties.

Mauray *et al.* (1986) conducted an experiment with a population of 48 upland rice cultivars to obtained information on genetic advance for panicle length, which could be effective for high selection response. Similar observation was reported by Kihupi and Doto (1989).

Singh *et al.* (1986) reported that that phenotypic coefficient of variation was higher than the genetic coefficient for days to flowering and indicated that this character is influenced by environment. They also reported higher value of heritability and genetic advance for days to flowering, indication additive gene affects controlling this trait. In study of 11 plant characters by Talwar *et al.* (1976) estimated heritability for flowering and heritability. They also reported high genotypic and phenotypic coefficient of variation yield per plant.

Singh *et al.* (1986) studied genetic variability and extent of heritability in 98 upland cultivars and showed a wide range of phenotypic variation and high heritability along with high estimated genetic advance for 1000-spikelet weight. 1000-spikelet weight has been reported as high heritable character by Majumder *et al.* (1971).

Jangale *et al.* (1985) studied variability, heritability and genetic advance for some quantitative characters in upland rice and reported that plant height had high heritability. They also found that spikelet yield had maximum genetic advance by plant height.

Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984).

Ghosh *et al.* (1981) estimated low heritability (19.05%) for panicle length in rice. But high heritability for panicle length was reported by Singh *et al.* (1986). They also observed a wide range of phenotypic variation for panicle length among the genotypes.

Improvement of rice spikelet yield is the main target of breeding program to develop rice varieties for diverse ecosystems. However, spikelet yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al.*1979). Expected genetic advance for plant height was found to be highest in a study carried out by Ghosh *et al.* (1981) of 34 indigenous rice varieties.

In an analysis of genetic variability of 40 rice genotypes, Sinha and Bhattacharyya (1980) observed that broad sense heritability of plant height was nearly 90%.

Sinha and Bhattacharyya (1980) reported high heritability along with high genetic advance for per plant.

Mehetre *et al.* (1964) observed high genotypic coefficient of variation (GCV), high heritability and high genetic advance for plant height.

Yield in cereals is a complex character and determined by some yield component. Grafius (1964) suggested that these yield components express their genetic and environmental effects finally through spikelet yield.

Ghose and Ghatge (1960) stated that tiller number, panicle length contributed to yield.

2.2 Correlation among different characters

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

Satheeshkumar *et al.* (2012) estimated correlation in fifty three genotypes of rice for fifteen characters. It revealed grain yield per plant exhibited high significant and positive genotypic correlation with number of productive tillers per plant, filled grains per panicle and total number of grains.

Akinwale *et al.* (2011) evaluated twenty rice genotypes in the International Institute of Tropical Agriculture, Ibadan, Nigeria during 2008/2009 cropping season. They reported that grain yield had significantly positive correlation with the number of tillers per plant (r = 0.58**), panicle weight (r =0.60*) and number of grains per panicle (r= 0.52*). Therefore, the results suggest that these traits can be used for grain yield selection.

Sadeghi (2011) used 49 rice varieties (*Oryza sativa* L.) in an experiment to determine variability, heritability and correlation between yield and yield components for 2 years. Grain yield was found to be positively and significantly correlated with grains per panicle, days to maturity, panicle weight, number of productive tillers, days to flowering, plant height, panicle length indicating the importance of these characters for yield improvement in this population.

Ghosal *et al.* (2010) evaluated eighteen advanced breeding lines for yield and yield contributing characters to observe their variability, associations and direct and indirect effect on yield during boro season, 2009. Path coefficient analysis revealed that effective tillers/m^2, thousand grain weight (g) and growth duration (days) had higher direct effects on yield (t/ha).

Nandeshwar *et al.* (2010) evaluated twenty five F_2 progenies derived from the crosses involving HYV and quality rice during kharif 2005. Grain yield plant $^{-1}$ possessed significant positive correlation with panicle number plant $^{-1}$, panicle weight and grain number panicle $^{-1}$ while it had significant negative correlation with plant height.

Wattoo *et al.* (2010) conducted an experiment in order to determine the associations among yield components and their direct and indirect influence on grain yield of rice. For this purpose, 30 genotypes collected from different sources were tested. The phenotypic correlations among the yield traits were estimated. Grain yield was significantly correlated with its component characters, number of productive tillers per plant, number of grains per panicle and flag leaf area.

Vange (2009) conducted a field experiments in 2005 in the Experimental Farm Station of the University of Agriculture, Makurdi, Nigeria to evaluate the performance and genetic diversity of some upland rice accessions. Genotypic correlation analysis of yield with other traits revealed that yield had a significantly positive correlation with flag leaf area, number of tillers, number of panicles, panicle weight, panicle length, number of branches/panicle, number of seeds/panicle and seed weigh/panicle, grain length and 1000 seed weight.

Agahi *et al.* (2007) conducted an experiment to investigate correlation coefficient of grain yield and sixteen yield-related traits among 25 lines. The results showed that grain yield was significantly correlated with days to heading, total tillers, number of productive tillers, days to maturity, number of grain per panicle, flag leaf length, flag leaf width and plant height.

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

grain weight and flag leaf area. Moreover, plant height had the highest indirect effect on grain yield through filled grains/panicle. Flag leaf area, harvest index and panicle length also had higher positive indirect effect on grain yield through filled grains/panicle.

Sankar *et al.* (2006) studied on correlation on single plant yield and its components in 34 rice genotypes. They concluded that single plant yield was positively and significantly correlated with days to 50 per cent flowering, productive tillers/plant, panicle length and grains/panicle and hence can be taken as indices for improving yield in rice.

Singh *et al.* (2006) conducted an experiment with 37 rice genotypes and reported that there were highly significant differences among the genotypes for plant height and the estimates of phenotypic coefficient of variation and genotypic coefficient of variation were of the same magnitude for the character but high heritability was recorded for the character.

Habib *et al.* (2005) evaluated 10 local biroin rice varieties with a view to find out variability and genetic association for spikelet yield and its component characters. The highest genetic variability was obtained in flag leaf area and filled grain/panicle. High heritability associated high genetic advance was observed in filled grains/panicle, 1000 spikelet weight, harvest index and spikelet yield. Genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients in most of cases. Plant height, day to maturity and filled grain/panicle showed significant positive correlation with spikelet yield.

Patil and Sarawgi (2005) evaluated 128 aromatic rice accessions and estimate genetic variation and correlation for 7 traits and found that number of ear-bearing tiller hill^{-1} had high genotypic and phenotypic coefficient of variation. High heritability coupled with high genetic advance was also estimated for this character.

Satyanarayana *et al.* (2005) studied variability, correlation and path coefficient analysis for 66 restorer lines in rice and observed low heritability in number of effective tillers plant^{-1}.

Zahid *et al.* (2005) studied 14 genotypes of basmati rice and observe high heritability couple with high genetic advance for plant height and 1000- spikelet weight. They also reported that plant height has negative correlation with yield. In addition he observed the positive relationship of plant high with spikelet quality.

Shrama and Haloi (2004) studied genetic variation and divergence in 58 aus rice and found the highest genotypic as well as phenotypic coefficient of variation for number of effective tillers plant^{-1}.

Mahto *et al.* (2003) evaluated twenty six early maturing rice genotypes and found that the difference between phenotypic and genotypic coefficient of variation was minimum for days to flowering (2.13) high values for heritability (97.33) and high genetic advance.

Iftekharuddaula *et al.* (2001) studied twenty-four modern rice varieties of irrigated ecosystem with a view to finding out variability and genetic association for grain yield and its component characters. All the characters tested were showed significant variation among the varieties. The highest genetic variability was obtained in spikelets/panicle and grains/panicle. High heritability together with high genetic advance in percentage of mean was observed in plant height, 1000-grain weight, grains/panicle and spikelet/panicle.

Prasad *et al.* (2001) studied eighty fine rice genotypes to observe genetic variability and selection criteria for some yield contributing characters through correlation and path coefficient analysis. Correlation coefficient study revealed high positive correelation of spikelet yield with effective tillers/plant, fertile spikelets/panicle and 1000 spikelet weight. A significant negative correlation was obtained between spikelet yield and plant height. Path coefficient analysis revealed maximum contribution of fertile spikelets/panicle to spikelet yield.

Guimara (2002) indicate that the plants with comperatively large panicles tend to have high number of filled grains. However, in most of the cases positive correlation was observed between number of panicle/ plant and panicle length.

The correlation between heterosis over better parent and inbreeding depression showed that yield can be improved by direct selection for days to flowering and number of productive tillers per plant (Verma *et al.*, 2002).

Shanthi and Singh (2001) observed that plant height exhibited low variation between phenotypic and genotypic coefficient of variation. High heritability coupled with high genetic advance was observed in plant height, which governed largely through the additive effect of genes.

Prasad *et al.* (2001) conducted an experiment where eight fine rice genotypes were studied. Correlation coefficient study revealed high positive correlation of grain yield with effective tillers/plant, fertile grains/panicle and 1000-grain weight. A significant negative correlation was obtained between grain yield and plant height.

Satyavathi *et al.* (2001) evaluated 15 rice varieties and found moderate to high co-efficient of variation for plant height.

Kumer *et al.* (2001) carried out an experiment with 42 genotypes derived from seven crosses of rice and reported that phenotypic coefficient of variation was comparatively higher than the corresponding genotypic coefficient of variation form number of panicle plant^{-1}.

Shanthi and Singh (2001) found significant variation among the genotypes for all characters studied. Panicle length exhibited low variation between phenotypic and genotypic coefficient of variations.

Atwal and Singh (2001) studied genetic variability and observed that genetic coefficient of variation (GCV) was higher than the phenotypic coefficient of variation (PCV) for days to flowering. They also found high heritability and genetic advance for this character.

Sangeeta-Mahitkar *et al.* (2000) conducted an experiment during the kharif season of 1998 in Akola, Maharashtra, India to investigate the correlation between the growth and yield contributing characters, and crop yield of upland rice. A positive and significant correlation was observed by Singh and Chaudhury (1996) estimated genetic variability, heritability and genetic advance for 12 characters in 100 genotypes of rice. 1000 spikelet weight showed high value of genotypic coefficient of variation (GCV) than phenotypic coefficients of variation (PCV), while low heritability for 1000 spikelet weight was reported by Honarnejad (1995).

Chen-Liang *et al.* (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains per plant, number of spikes per plant and spikelet weight per plant, but heterosis for spike fertility was low. Xiao *et al.* (1996) indicated that heterosis in F_1 hybrids for spikelet/panicle showed a positive and significant correlation with genetic distance in *indic*a x *indica* but not in *indica* x *japonica* crosses.

Tomar *et al.* (2000) found that the correlation estimates were highest between harvest index and 1000-grain (48.71) followed by yield/plant and number of grains/panicle (44.71), flag leaf length and plant height (43.15), and number of grains/panicle and panicle length (41.72). A negative correlation was found between biological yield and harvest index (−39.41), 1000-grain weight and number of grains/panicles (−33.31), 50% flowering and panicle length (−2.74) and 50% flowering and number of primary branches/panicle (−2.94). The yield/plant had positive association with plant height, number of effective tillers, panicle length, primary branches/panicle, number of grains/panicle and 1000-grain weight, harvest index, biological yield, flag leaf length and its width and days to 50% flowering.

Jiang *et al.* (2000) observed the importance of number of tillers/plant influencing yield. Productive tillers/hill showed significant positive correlations with correlations with spikelet yield (Reddy and Kumar, 1996).

Sawant and Patil (1995) evaluated 75 genotypes of rice and found high coefficient of variation for spikelet yield per plant. High value of heritability coupled with high expected genetic advance was observed for spikelet yield per plant.

Chaubey and Richharia (1993) studied simple correlation on eight quantitative characters in 80 *Indica* rice varieties, including HYV and indigenous high quality rice in two environments each at two locations during rainy season. Grain yield per plant showed significant positive correlation with plant height, panicle length, spikelet per panicle, panicle weight, and test weight.

Bai *et al.* (1992) reported that spikelet yield per plant positively correlated with numbers of positively tillers and number of spikelet per/plant.

Palaniswamy and Kutty (1990) showed that panicle was negatively correlated with flowering duration and positively with tiller height.

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

Associations of various yield components in rice (Padmavathi *et al.*, 1986) indicated that the plants with large panicles tend to have a high number of fertile spikelet. Similarly, a positive correlation was observed between number of panicle/plant and panicle length.

Kaul and Kumar (1982) reported high genotypic coefficient of variation and high heritability of plant height. Plant height is considered as an important plant character related to yield in rice. Plant height was found to vary from variety to variety in rice.

2.3 Path co-efficient analysis

When more characters are involved in correlation study it becomes difficult to ascertain the traits which really contribute towards the yield. The path analysis under such situation helps to determine the direct and indirect contribution of these traits towards the yield.

Seyoum *et al.* (2012) conducted field experiments using fourteen rice genotypes during the main rainy season of 2009 and 2010 at three rain fed upland locations of Southwest Ethiopia to estimate the path coefficient of grain yield and yield contributing traits in upland rice. They showed grains per panicle had maximum positive direct effect.

Abarshahr *et al.* (2011) studied 30 varieties of rice in order to estimate genetic variability and relationship among some agronomic traits of rice under two irrigation regimes. Path analysis for paddy yield indicated that the number of spikelet per panicle and flag leaf length had positive direct effects and days to complete maturity and plant height had negative direct effects on paddy yield under optimum irrigation condition, while flag leaf width and number of filled grains per panicle had positive direct effects and days to flowering had negative direct effect on paddy yield under stress condition.

Ghosal *et al.* (2010) studied eighteen advances breeding lines for yield and yield contributing characters to observe their variability, associations and direct and indirect effect on yield during Boro season, 2009. They found that effective tillers/m^2, thousand grain weight (g) and growth duration (days) had higher direct effects on yield (t/ha). All together with the genetic variability, correlation and path analysis revealed that Effective tiller/m^2, panicle length (cm), thousand grain weight (g) and growth duration (days) are the most important yield components in rice.

Nandeshwar *et al.* (2010) evaluated twenty five F_2 progenies derived from the crosses involving HYV and quality rice during kharif, 2005. Panicle number per plant imparted maximum direct effect on grain yield followed by grain number per panicle, 100-grain weight and panicle length in this regard.

Yadav *et al.* (2010) carried out a field experiment to establish the extent of association between yield and yield components and others characters in rice. They found that harvest index, biological yield, number of tillers per hill, panicle length, number of spikelet per panicle, plant height and test weight had direct positive effect on seed yield per hill, indicating these are the main contributors to yield.

Karad *et al.* (2008) observed a wide range of variability in yield and yield contributing characters. Path coefficient analysis revealed that length of panicle had the highest positive direct effect followed by number of panicles, number of tillers plant^{-1} and number of mature panicles whereas the characters plant height, number of immature panicles and 1000-grain weight had the negative direct effect via indirect effect on grain yield plot^{-1}.

Rokonuzzaman *et al.* (2008) evaluated twenty modern Boro rice varieties with a view to find variability and genetic association for grain yield and yield components character. The experiment was conducted at BRRI farm during the Boro season of 2004. Path coefficient showed that number of effective tiller per plant and plant height are the characters that contribute largely to grain yield.

Ashvani *et al.* (2007) carried out Path analysis in 22 genotypes of rice, grown in Hardwar, Uttaranchal, India, during kharif, 1990-91. They found that days to flowering had the highest positive direct effect on spikelet yield. Thus greater emphasis should be given for selection of these characters.

Kishore *et al.* (2007) conducted an experiment during kharif, 2004 in Hyderabad Andhra Pradesh, India with 70 rice genotypes, including aromatic and non-aromatic lines. Path coefficient analysis revealed that days to flowering showed positive direct effects on spikelet yield.

Habib *et al.* (2005) reported that the plant height, days to maturity, 1000 spikelet weight and chlorophyll content had positive and highest direct effect on spikelet yield.

Moreover, panicle length had highest indirect effect on spikelet yield through plant height and filled grains/panicle had positive and higher indirect effect on spikelet yield through days to maturity, panicle per hill and panicle length.

Guo *et al.* (2002) studied the genetic relationships between rice yield and its components using correlation and path analyses involving a set of 241recombinant inbreed lines (RIL) population of Shanyou 63, Data were recorded for 1000- spikelet weight (TGW) and it showed tremendous transgressive variation.

Iftekharuddaual *et al.* (2001) reported that high number of grins/panicle, bold grains, more panicles/m^2 and higher harvest index had positive and higher direct effect on grain yield. Moreover, days to maturity, days to flowering, plant height and spikelet/panicle had positive and higher indirect effect on grain yield through grains/panicle.

Nayak *et al.* (2001) studied the genotypic and phenotypic correlations and path analysis in 10 quantitative traits of 200 scented rice genotypes, including 1 scented rice control. Path coefficient analysis revealed that 1000-spikelet weight contributed positive direct effect on the spikelet yield of the plant.

CHAPTER III

MATERIALS AND METHODS

The details of different materials used and methodology followed during the experimental period are described in this chapter as follows:

Experimental treatments and sources of plant materials:

3.1 Experimental site:

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka – 1207 during November 2013 to May 2014. The location of the experimental site was situated at 23° 74" N latitude and 90°35" E longitudes with an elevation of 8.6 meter from the sea level. Experimental site was showed in (Appendix I) (Plate 1).

3.2 Soil and climate:

The experimental site was situated in the subtropical zone. The soil of the experimental site belongs to Agro ecological region of "Madhupur Tract" (AEZ No. 28). The soil was clay loam in texture and olive gray with common fine to medium distinct dark yellowish brown mottles. The pH was 5.47 to 5.63 and organic carbon content is 0.82% (Appendix II). The records of air temperature, humidity and rainfall during the period of experiment were noted from the Bangladesh Meteorological Department, Agargaon, Dhaka (Appendix III).

3.3 Planting materials:

Twenty seven (27) genotypes were selected for experiment. Among them, twenty two were F_4 materials and 5 check varieties (Table 1).

3.4 Design:

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total experimental area was divided into 3 blocks.

3.5 Collection of Seed:

The experimental seeds (F_4) were collected from germplasm of Sher-e-Bangla Agricultural University and Bangladesh Rice Research Institute.

Table 1. List of genotypes, their serial number and their sources of collection

Serial No.	Designation	Source
G_1	BR 21	BRRI
G_2	BR 24	BRRI
G_3	BRRI dhan 28	BRRI
G_4	BRRI dhan 29	BRRI
G_5	BRRI dhan 36	BRRI
G_6	BR 21 X BRRI dhan 28, S-5, P-1	SAU
G_7	BR 21 X BRRI dhan 28, S-5, P-2,	SAU
G_8	BR 21 X BRRI dhan 28,S-5, P-3	SAU
G_9	BR 21 X BRRI dhan 28,S-5, P-4	SAU
G_{10}	BR 21 X BRRI dhan 28, S-5, P-6	SAU
G_{11}	BR 21 X BRRI dhan 29, S-6, P-1	SAU
G_{12}	BR 21 X BRRI dhan 29, S-6, P-2	SAU
G_{13}	BR 21 X BRRI dhan 29, S-6, P-3	SAU
G_{14}	BR 21 X BRRI dhan 29, S-6, P-4	SAU
G_{15}	BR 21 X BRRI dhan 29, S-6, P-5	SAU
G_{16}	BR 21 X BRRI dhan 29, S-6, P-6	SAU
G_{17}	BR 21 X BRRI dhan 29, S-6, P-7	SAU
G_{18}	BR 21 X BRRI dhan 36, S-1, P-1	SAU
G_{19}	BR 21 X BRRI dhan 36, S-1, P-2	SAU
G_{20}	BR 21 X BRRI dhan 36, S-1, P-3	SAU
G_{21}	BR 21 X BRRI dhan 36, S-1, P-4	SAU
G_{22}	BR 21 X BRRI dhan 36, S-1, P-5	SAU
G_{23}	BR 24 X BRRI dhan 28, S-10, P-2	SAU
G_{24}	BR 24 X BRRI dhan 28, S-10, P-5	SAU
G_{25}	BR 24 X BRRI dhan 29, S-5, P-1	SAU
G_{26}	BR 24 X BRRI dhan 29, S-5, P-3	SAU
G_{27}	BR 24 X BRRI dhan 29, S-5, P-4	SAU

Plate 1. An overview of field

3.6 Seedling raising:

The seed bed was prepared well by puddling the wetland with repeated ploghing followed by laddering. The seeds were soaked for 24 hours and then these were kept in a gunny bag in dark condition. After sproughting, the seedlings were sown in the previously wet seed bed on 5 December, 2013. Proper care was taken so that there was no infestation of pest and diseases and no damage by birds.

3.7 Methods:

The following precise methods were followed to carry out the experiment:

3.7.1 Land preparation for tranplanting:

The experimental field was first opened by a tractor on November and two ploughing were performed. After a few days the land was further ploughed and cross ploughed with power tiller followed by laddering to get a good tilth condition. Weeds and stubble were removed from the field prior to tranplanting of seedlings. The boundaries around the individual plot were made firm enough to control water and fertilizer movement between plots.

3.7.2 Fertilizers and manure application:

The fertilizers N, P, K, S and B in the form of urea, TSP, MP, Gypsum and Borax respectively were applied. The entire amount of TSP, MP, Gypsum, Zinc Sulphate and Borax were applied during final preparation of field. Urea was applied in two equal installments t before sowing and flowering. The dose and method of application of fertilizer are son in (Appendix IV).

3.7.3 Transplanting:

Then experimental genotypes were tranplanted randomly to the three block. Thirty five days old seedlings were transplanted to the main field. Each entry was grown as single seedling per hill in the rows on January 05, 2014 with a spacing of 20 cm between rows and 20 cm between plants.

3.7.4 After care:

After establishment of seedlings, various intercultural operations were accomplished for better gowth and development of the rice seedlings.

3.7.5 Irrigation and drainage:

Flood irrigation was given to maintain a constant level of standing water upto 3 cm in the early stages to enhance tillering, proper growth and development of the seedlings and 6-8 cm in the later stage to discourge late tillering. The field was finally dried out 15 days before harvesting.

3.7.6 Gap filling:

First gap filling was done for all of the plots at 10 days after transplanting (DAT).

3.7.7 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.7.8 Top dressing:

After application of basal dose, the remaining doses of urea were top-dressed in 2 equal installments. The fertilizers were applied on both sides of seedlings rows with the soil.

3.7.9 Plant protection

Diazinon 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.7.10 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately. Properly tagged and brought to threshing floor. Enough care was taken for threshing and cleaning of rice seed. Fresh weight of spikelet was recorded. The spikelets were cleaned and finally the weight was adjusted to a moisture content of 14%.

3.7.11 Data recording

Criteria used in recording data were as follows:

I. Days to flowering:

Difference between the dates of transplanting to the date of flowering of a plot was counted and was recorded when 50% plant of a plot were at the flowering stage.

II. Days to maturity

Maturity of the crops of different combination were recorded considering the symptom such as moisture content of rice, color changing of the plant from greenish to straw colored appearance.

III. Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time of harvesting. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot after harvest. The height was measured from the ground level to the tip of the panicle.

IV. Total number of tillers per plant

The total number of tillers per plant was counted as the number of tiller/ plant.

V. Total number effective tillers per hill

The total number of effective tillers per hill was counted as the number of panicle bearing hill per plant. Data on the effective tiller per hill were counted from 10 selected hills and average value was recorded

VI. Panicle length (cm)

The length of panicle was measured with a meter scale from 10 selected plants and the average value was recorded as per plant.

VII. Number of primary branches per panicle

The total number of primary branches arisen from the panicle of a plant was counted as the number of primary branches per plant.

VIII. Number of secondary branches per panicle

The total number of secondary branches arisen from the primary branches of panicle of a plant was counted as the number of secondary branches per plant.

IX. Total number of spikelet's/ panicle

The total number of spikelet was collected randomly from 10 selected of a plot and then average number of filled grain per panicle was recorded.

X. Number of filled grains of per panicle

The total number of filled grains (spikelets) was collected randomly from 10 selected of a plot and then average number of filled grain per panicle was recorded.

XI. Number of unfilled grains of per panicle

The total number of unfilled grains (spikelet's) was collected randomly from selected 10 plants of a plot on the basis of not spikelet in the spikelet and then average number of unfilled grain's per panicle was recorded.

XII. Yield/ plant (g)

Weight of spikelet of 10 randomly selected plants were measured and averaged at dry condition after sun dried.

XIII. 1000 seed weight (g)

One thousand seeds were counted randomly from the total cleaned harvested seeds and then weighted in grams and recorded.

XIV. Yield (ton/ hectare)

Spikelets obtained from each unit plot were sun dried and weighted carefully and converted to t $h^{-1.}$

3.7.12 Statistical analysis

The data were analyzed for different components. Phenotypic and genotypic variance was estimated by the formula used by Johnson *et al.* (1955). Heritability and genetic advance were measured using the formula given by Singh and Chaudhary (1985) and Allard (1960). Genotypic and phenotypic co-efficient of variation were calculated by the formula of Burton (1952). Simple correlation coefficient was obtained using the formula suggested by Clarke (1973); Singh and Chaudhary (1985) and path co-efficient analysis was done following the method outlined by Dewey and Lu (1959).

i) Estimation of genotypic and phenotypic variances:

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

a. **Genotypic variance,** $\delta^2 g = \frac{MSG - MSE}{r}$

Where, MSG = Mean sum of square for genotypes

MSE = Mean sum of square for error, and

r = Number of replication

b. **Phenotypic variance,** $\delta^2 p = \delta^2 g + \delta^2 e$

Where, $\delta^2 g$ = Genotypic variance,

$\delta^2 e$ = Environmental variance = Mean square of error

ii) Estimation of genotypic and phenotypic co-efficient of variation:

Genotypic and phenotypic co-efficient of variation were calculated by the following formula (Burton, 1952).

$$GCV = \frac{\delta_g \times 100}{\bar{x}}$$

$$PCV = \frac{\delta_p \times 100}{\bar{x}}$$

Where, GCV = Genotypic co-efficient of variation

PCV = Phenotypic co-efficient of variation

δ_g = Genotypic standard deviation

δ_p = Phenotypic standard deviation

$\bar{x}$ = Population mean

iii) Estimation of heritability:

Broad sense heritability was estimated by the formula suggested by Singh and Chaudhary (1985).

$$h^2(\%) = \frac{\delta^2_g}{\delta^2_p} \times 100$$

Where, h^2 = Heritability in broad sense.

δ^2_g = Genotypic variance

δ^2_p = Phenotypic variance

iv) Estimation of genetic advance: The following formula was used to estimate the expected genetic advance for different characters under selection as suggested by Allard (1960).

$$GA = \frac{\delta^2_g}{\delta^2_p} . K. \delta_p$$

Where, GA = Genetic advance

δ^2_g = Genotypic variance

δ^2_p = Phenotypic variance

δ_p = Phenotypic standard deviation

K = Selection differential which is equal to 2.06 at 5% selection intensity

v) Estimation of genetic advance as percentage of mean: Genetic advance as percentage of mean was calculated by the following formula given by Comstock and Robinson (1952).

$$\text{Genetic Advance as percentage of mean} = \frac{\text{Genetic advance}}{\bar{x}} \times 100$$

vi) Estimation of simple correlation co-efficient: Simple correlation co-efficient (r) was estimated with the following formula (Clarke, 1973; Singh and Chaudhary, 1985).

$$r = \frac{\sum xy - \frac{\sum x . \sum y}{N}}{[\{\sum x2 - \frac{(\sum x)2}{N}\}\{\sum y2 - \frac{(\sum y)2}{N}\}]}$$

Where, $\sum$ = Summation

x and y are the two variables correlated

N = Number of observations

vii) Path co-efficient analysis:

Path co-efficient analysis was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985) and Dabholkar (1992), using simple correlation values. In path analysis, correlation co-efficient is partitioned into direct and indirect independent variables on the dependent variable.

In order to estimate direct & indirect effect of the correlated characters, say x1, x2 and x3 yield y, a set of simultaneous equations (three equations in this example) is required to be formulated as shown below:

$$r_{yxl} = P_{yxl} + P_{yx2}r_{xlx2} + P_{yx3}r_{xlx3}$$

$$r_{yx2} = P_{yxl}\, r_{xlx2} + P_{yx2} + P_{yx3}r_{x2x3}$$

$$r_{yx3} = P_{yxl}r_{xlx3} + P_{yx2}r_{x2x3} + P_{yx3}$$

Where, r's denotes simple correlation co-efficient and P's denote path co-efficient (Unknown). P's in the above equations may be conveniently solved by arranging them in matrix from.

Total correlation, say between x_1 and y is thus partitioned as follows:

P_{yx1} = The direct effect of x_1 on y.

$P_{yx2}r_{x1x2}$ = The indirect effect of x_1 via x_2 on y

$P_{yx3}r_{x1x3}$ = The indirect effect of $x_1$via x_3 on y

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula given below (Singh and Chaudhary, 1985):

$$P^2_{RY} = 1 - \sum P_{iy} .riy$$

Where, $P^2RY = (R^2)$; and hence residual effect, $R = (P^2_{RY})$ ½

P_{iy} = Direct effect of the character on yield

riy = Correlation of the character with yield.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to determine the variability among 27 genotypes of rice (*Oryza sativa L.*) and also to study the correlation and path co-efficient for seed yield and different yield contributing characters. The data were recorded on different characters such as days to flowering, days to maturity, plant height (cm), number of total tillers per plant, number of effective tillers per plant, panicle length (cm), number of primary branches per panicle, number of secondary branches per panicle, number of filled grains per panicle, number of unfilled grains per panicle, total number of spikelet per panicle, yield per plant (g), 1000 seed weight (g), yield (ton/ ha). The data were statistically analyzed and thus obtained results are described below under the following heads:

- Variation and performance of the 27 genotypes
- Genetic parameters
- Heritability and Genetic Advance
- Correlations
- Path coefficient analysis
- Selection of individual plant

4.1 Variation and performance of the 27 genotypes

The analysis of variance of 27 genotypes (22 F_4 populations and 5 check varieties) of rice for yield related different characters are shown in Table 2. The analysis of variance for the characters indicated the existence of significant differences among the genotypes studied revealing that sufficient variability is present and selection would be effective to develop the varieties. Mean performance of those characters of individual genotypes with Duncan's Multiple Range Test (DMRT) are presented in Table 3.

Table 2. Analysis of variance (ANOVA) for yield and its related characters of 27 genotypes in *Oryza sativa L.*

Sl. No.	Characters	Mean sum of squares (MSS)		
		Replication	Genotypes	Error
	df	2	26	52
1	Days to flowering	581.123	37.844**	2.803
2	Days to maturity	561.123	66.594**	1.675
3	Plant Height (cm)	891.590	355.106**	7.039
4	Total no. of tiller/ plant	84.303	7.431**	0.480
5	No. of effective tiller/ plant	75.250	7.415**	0.411
6	Panicle length (cm)	114.779	8.516**	0.844
7	No. of primary branches/panicle	40.920	1.628*	0.223
8	No. of secondary branches/ panicle	424.515	48.760**	3.755
9	No. of filled grain /panicle	11171.155	1256.086**	34.253
10	No. of unfilled grain of main/panicle	10263.601	1130.072**	35.308
11	Total no. of spikelet/ panicle	32.772	100.390**	18.890
12	Yield/ plant (g)	556.075	48.936**	1.346
13	1000 seed weight (g)	124.790	11.853**	1.111
14	Yield (ton/ hectare)	45.644	1.442*	0.284

** = Significant at 1% level of probabilities,*=Significant at 5% level of probabilities, df=Degrees of freedom

Table 3. Mean performance of yield and yield contributing characters of 27 genotypes of rice

Genotypes	DF	DM	PH	NTT	NET	PL
G_1	122.7	151.9	106.2	14.17	13.53	24.59
G_2	121.3	141.3	117.9	12.83	11.75	24.83
G_3	125.7	148.8	92.20	15.72	15.18	22.34
G_4	136.3	161.6	100.3	15.99	15.02	25.63
G_5	121.3	147.0	115.3	14.73	14.31	24.49
G_6	117.7	141.5	132.2	12.18	10.97	27.04
G_7	121.3	141.0	121.4	11.53	11.21	25.40
G_8	119.7	141.1	127.4	13.49	13.21	27.02
G_9	122.0	142.3	113.2	12.35	12.20	25.23
G_{10}	120.0	141.7	124.9	10.95	10.33	25.48
G_{11}	120.3	142.4	102.7	12.81	12.47	22.56
G_{12}	118.0	143.1	106.9	13.61	13.38	21.82
G_{13}	118.0	139.5	109.3	11.48	11.25	22.74
G_{14}	119.3	141.1	108.8	11.66	11.07	23.04
G_{15}	119.0	146.1	103.4	12.63	12.12	22.42
G_{16}	119.3	139.7	111.1	11.19	10.87	24.04
G_{17}	119.0	143.1	111.3	10.36	9.936	23.60
G_{18}	121.0	140.3	108.5	12.60	12.40	21.79
G_{19}	120.0	143.4	105.7	14.85	14.26	22.37
G_{20}	122.7	145.9	95.90	17.07	16.53	21.41
G_{21}	121.3	143.0	91.69	16.23	15.05	21.36
G_{22}	120.0	141.0	97.21	14.65	13.96	21.39
G_{23}	120.3	146.0	133.9	12.24	11.64	25.62
G_{24}	123.0	142.9	115.4	13.87	12.91	23.40
G_{25}	118.0	141.1	119.8	13.08	12.85	25.27
G_{26}	119.0	142.8	116.4	13.26	12.76	23.96
G_{27}	121.0	145.0	116.3	13.70	13.33	24.21
Maximum	136.3	161.6	133.9	17.07	16.53	27.04
Minimum	117.7	139.5	91.69	10.36	9.936	21.36
Mean	121.025	143.877	111.305	13.304	12.759	23.816
CV (%)	1.38	0.79	12.38%	5.21%	5.03%	3.86%

DF = Days to flowering, DM = Days to maturity, PH= Plant height, NTT = Number of total tiller per plant, NET=Number of effective tiller per plant, PL= Panicle length, CV (%) = Coefficient of Variation

Table 3 (cont'd). Mean performance of yield and yield contributing characters of some advanced lines of rice

Genotypes	NPB	NSB	TNSP	NFG	NUFG
G_1	9.921	33.55	196.8	178.6	18.23
G_2	10.18	34.36	198.7	171.1	27.60
G_3	9.186	23.68	134.9	111.3	23.53
G_4	11.21	35.74	182.6	153.1	29.50
G_5	10.24	31.59	167.1	151.1	16.00
G_6	12.26	36.83	207.9	178.0	29.83
G_7	11.01	37.86	184.0	164.2	19.73
G_8	11.72	34.81	201.0	178.4	22.60
G_9	10.70	32.82	165.8	146.2	19.53
G_{10}	10.93	34.14	184.9	156.7	28.17
G_{11}	10.78	39.74	190.9	170.6	20.27
G_{12}	10.23	34.96	176.3	142.7	33.60
G_{13}	10.20	35.69	181.0	164.1	16.90
G_{14}	9.844	29.71	162.6	143.0	19.63
G_{15}	11.00	32.11	164.4	151.8	12.60
G_{16}	12.24	38.58	203.8	189.6	14.17
G_{17}	10.34	39.85	200.5	185.0	15.50
G_{18}	10.67	26.90	154.9	142.1	12.77
G_{19}	10.00	29.31	134.3	117.4	16.90
G_{20}	11.29	35.01	178.0	161.5	16.57
G_{21}	10.68	28.69	155.5	134.4	21.10
G_{22}	10.03	29.04	145.8	133.4	12.37
G_{23}	10.21	33.17	176.7	155.1	21.63
G_{24}	10.63	30.31	151.7	138.2	13.47
G_{25}	10.97	34.29	180.3	163.8	16.57
G_{26}	11.50	34.45	175.9	161.1	14.77
G_{27}	10.97	36.10	161.4	141.9	19.50
Maximum	12.26	39.85	207.9	189.6	33.60
Minimum	9.186	23.68	134.3	111.3	12.37
Mean	10.701	33.454	174.731	154.989	19.742
CV (%)	4.41%	6.79%	4.35%	3.83%	22.02%

NPB= Number of primary branches per panicle, NSB= Number of Secondary branches per panicle, NFG = Number of filled grain per panicle, NUFG= Number of unfilled grain per panicle, TNSP= Number of total spikelet per panicle, CV (%) = Coefficient of Variation

Table 3 (cont'd). Mean performance of yield and yield contributing characters of some advanced lines of rice

Genotypes	YP	TSW	Y (t/ha)
G_1	38.03	19.46	8.300
G_2	29.16	21.63	7.239
G_3	33.27	20.75	8.175
G_4	41.91	17.74	9.380
G_5	36.58	20.96	9.012
G_6	40.66	24.09	7.302
G_7	38.20	26.29	8.476
G_8	47.87	24.50	8.665
G_9	35.14	21.88	9.131
G_{10}	35.52	25.13	8.388
G_{11}	35.64	21.42	8.557
G_{12}	28.19	19.38	7.678
G_{13}	34.65	21.71	8.461
G_{14}	31.52	18.88	8.786
G_{15}	32.96	20.59	8.416
G_{16}	32.28	20.21	8.989
G_{17}	39.60	21.21	10.26
G_{18}	33.57	23.34	8.060
G_{19}	29.02	20.80	7.711
G_{20}	36.24	19.46	8.513
G_{21}	34.68	18.96	8.589
G_{22}	37.48	21.13	7.531
G_{23}	32.99	22.09	7.281
G_{24}	33.83	20.42	8.716
G_{25}	33.82	21.05	8.408
G_{26}	33.26	18.25	8.823
G_{27}	34.58	19.34	7.373
Maximum	47.87	26.29	10.26
Minimum	28.19	17.74	7.239
Mean	35.208	21.136	8.378
CV (%)	4.30%	4.99%	6.36%

YP= Yield per plant (gram), TSW= Weight of thousand seed (gram), Y (t/ha) = Yield (ton per hectare), CV (%) = Coefficient of Variation.

4.1.1 Days to flowering

In this study out of 22 genotypes of F_4 generations, the maximum period (122.7 days) for days to flowering was seen in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3). On the other hand, check variety BR 21 took 122.7 days and BRRI dhan 29 took 136.3 days to flowering. The minimum days of flowering (117.7 days) was recorded in G_6 (BR 21 × BRRI dhan 28, S-5, P-1). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 required (122.7 days), (121.3 days), (125.7 days), (136.3 days) and (121.3 days) respectively to flower. So, days to flowering of G_6 (BR 21 × BRRI dhan 28, S-5, P-1) was least of all other check variety. Therefore, G_6 (BR 21 × BRRI dhan 28, S-5, P-1) was suitable for selection as early lines. The second minimum days of flowering (118.0) was observed in G_{12} (BR 21 × BRRI dhan 29, S-6, P-2), G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) and in G_{25} (BR 24 × BRRI dhan 29, S-5, P-1). So, $G_{12,}$ G_{13}, G_{25} were also suitable for selection as early lines aspect of early days to flowering. The rest of the genotypes showed different flowering time (Table 3).

4.1.2 Days to maturity

In this study out of 22 genotypes of F_4 generations, the highest number of days to maturity (146.1days) was recorded in G_{15} (BR 21 × BRRI dhan 29, S-6, P-5). On the other hand, check variety BR 21 took 151.9 days for maturity and BRRI dhan 36 took 147.0 days for maturity. G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) took minimum days (139.5 days) for maturity. Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 matured at (151.9 days), (141.3 days), (148.8 days), (161.6 days) and (147.0 days) respectively. So, days to maturity of G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) was least of all other check variety. Therefore, G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) was suitable for selection as early Boro lines. The second minimum days of maturity (139.7) was recorded in G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) which was also lesser than the check varieties. So, G_{16} was also suitable for selection as early lines aspect of early days to maturity. The rest of the genotypes showed different maturity times in (Table 3). Variation of days to maturity in 22 genotypes of F_4 populations is presented in Figure 1.

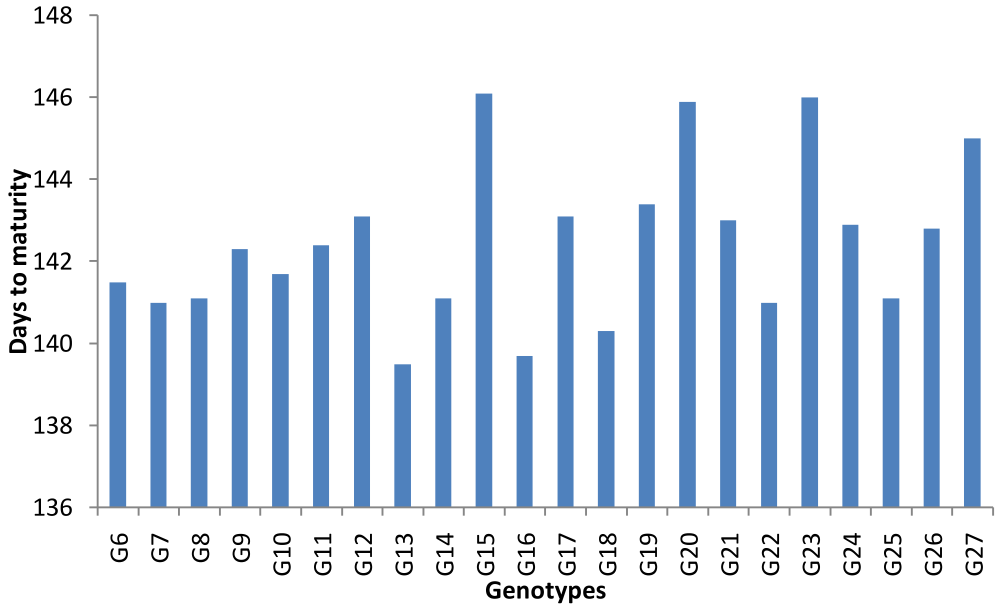


Figure 1. Variations in days to maturity of 22 genotype of F_4 generations

4.1.3 Plant height (cm)

In this study out of 22 genotypes of F_4 generations, the highest plant height (133.9cm) was recorded in G_{23} (BR 24 × BRRI dhan 28, S-10, P-2) and the minimum plant height (91.69cm) was recorded in G_{21} (BR 21 × BRRI dhan 36, S-1, P-4). Whereas, plant height of the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 were (106.2 cm), (117.9 cm), (92.20 cm), (100.3 cm) and (115.3 cm) respectively. So, plant height (cm) of G_{21} (BR 21 × BRRI dhan 36, S-1, P-4) was least of all other check variety. Therefore, G_{21} (BR 21 × BRRI dhan 36, S-1, P-4) was suitable for selection as short plant height because its similarity in tallness to BRRI dhan 28. The second minimum height (95.90 cm) was found with G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) which was also lesser than the check varieties of BR 21, BR 24, BRRI dhan 29 and BRRI dhan 36. So, G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) was also suitable for selection as short plant height. The rest of the genotypes showed differential plant height (Table 3).

4.1.4 Number of total tillers per plant

Out of 22 genotypes of F_4 generations, the highest number of tillers per plant (17.07) was recorded in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) and the minimum number of tillers per plant (10.36) was recorded in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had the value of number of total tiller per plant of (14.17), (12.83), (15.72), (15.99) and (14.73) respectively. So, the number of total tillers per plant of G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) was the highest of all other the check varieties. So, G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) was suitable for selection in aspect of this trait. The second maximum number of tillers per plant (16.23) was observed with G_{21} (BR 21 × BRRI dhan 36, S-1, P-4) which was also higher than the check varieties. So, G_{21} was also suitable for selection in this aspect. The rest of the genotypes showed differential number of tillers per plant (Table 3).

4.1.5 Number of effective tillers per plant

In this study out of 22 genotypes of F_4 generations, the highest number of effective tillers per plant (16.53) was recorded in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) and the minimum number of effective tillers per plant (9.936) was recorded in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had effective tillers per plant (13.53), (11.75), (15.18), (15.02) and (14.31) respectively. So, the number of effective tillers per plant of G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) was the highest of all other the check varieties. Therefore, G_{20} (BR 21 × BRRI dhan 36, S-1, P-3) was suitable for selection in aspect of this trait. The rest of the genotypes showed different number of effective tillers per plant (Table 3). Variation of number of effective tillers per plant in 22 genotypes of F_4 populations is presented in Figure 2.

4.1.6 Panicle length (cm)

In this study, out of 22 genotypes of F_4 generations, the highest number of panicle length (27.04 cm) was recorded in G_6 (BR 21 × BRRI dhan 28, S-5, P-1) which was closely followed by G_8 (BR 21 × BRRI dhan 28, S-5, P-3) (27.02) and the minimum panicle length (21.36 cm) was recorded in G_{21} (BR 21 × BRRI dhan 36, S-1, P-4). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had panicle length (24.59 cm), (24.83 cm), (22.34 cm), (25.63 cm) and (24.49 cm) respectively. So, panicle length of G_6 (BR 21 × BRRI dhan 28, S-5, P-1) and G_8 (BR 21 × BRRI dhan 28, S-5, P-3) was the highest number of all other the check varieties. Therefore, G_6 and G_8 were suitable for selection as they showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential panicle length (Table 3).

4.1.7 Number of primary branches per panicle

In this study, out of 22 genotypes of F_4 generations, the highest number of primary branches per panicle (12.26) was recorded in G_6 (BR 21 × BRRI dhan 28, S-5, P-1) which was closely followed by G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) (12.24) and the minimum number of primary branches per panicle (9.844) was recorded in G_{14} (BR 21 × BRRI dhan 29, S-6, P-4). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had primary branches per panicle (9.921), (10.18), (9.186), (11.21) and (10.24) respectively. So, number of primary branches per panicle of G_6 (BR 21 × BRRI dhan 28, S-5, P-1) and G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) was the highest number of all other the check varieties. Therefore, G_6 and G_{16} were suitable for selection as it showed the better performance than the check

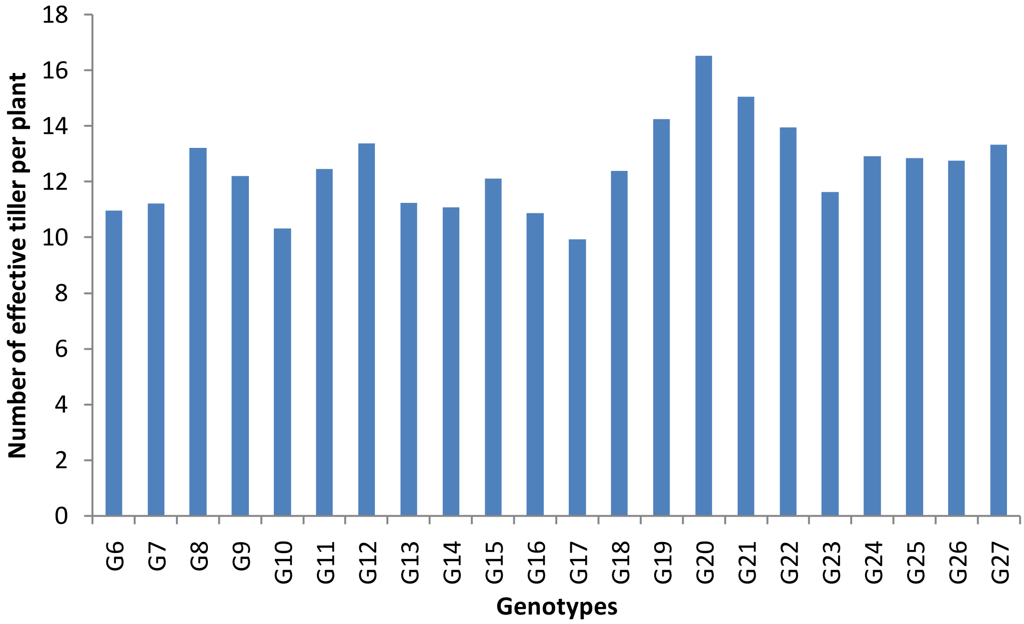


Figure 2. Variations of number of effective tiller per plant in 22 genotypes of F_4 generations

varieties in aspect of this trait. The rest of the genotypes showed differential number of primary branches per panicle (Table 3).

4.1.8 Number of secondary branches per panicle

In this study, out of 22 genotypes of F_4 generations, the highest number of secondary branches per panicle (39.85) was recorded in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) and the minimum number of secondary branches per panicle (26.90) was recorded in G_{18} (BR 21 × BRRI dhan 36, S-1, P-1). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had secondary branches per panicle (33.55), (34.36), (23.68), (35.74) and (31.59) respectively. So, the number of secondary branches per panicle of G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) was the highest number of all other the check varieties. Therefore, The G_{17} was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential number of secondary branches per panicle (Table 3).

4.1.9 Number of filled grains per panicle

In this study, out of 22 genotypes of F_4 generations, the highest number filled grains per panicle (189.60) was recorded in G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) and the minimum number of filled grains per panicle (133.4) was recorded in G_{22} (BR 21 × BRRI dhan 36, S-1, P-5). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had filled grains per panicle (178.6), (171.1), (111.3), (153.1) and (151.1) respectively So, the number filled grains per panicle of G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) was the highest number of all other the check varieties. Therefore, G_{16} was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential number of filled grains per panicle (Table 3).

4.1.10 Number of unfilled grains per panicle

In this study, out of 22 genotypes of F_4 generations, the highest number unfilled grains of per panicle (33.60) was recorded in G_{12} (BR 21 × BRRI dhan 29, S-6, P-2) and the minimum number of unfilled grains per panicle (12.37) was recorded in G_{22} (BR 21 × BRRI dhan 36, S-1, P-5) which was closely followed by G_{18} (BR 21 × BRRI dhan 36, S-1, P-1) (12.77). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had unfilled grains per panicle (18.23), (27.60), (23.53), (29.50) and (16.00) respectively. So, the number unfilled grains per panicle of G_{22} and G_{18} was the least number of all other the check varieties. Therefore, G_{22} and G_{18} were suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential number of unfilled grains per panicle (Table 3).

4.1.11 Total number of spikelet per panicle

In this study out of 22 genotypes of F_4 generations, the highest number of spikelet per panicle (207.9) was recorded in G_6 (BR 21 × BRRI dhan 28, S-5, P-1) and the minimum number of spikelet per panicle (134.3) was recorded in G_{19} (BR 21 × BRRI dhan 36, S-1, P-2). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had total number of spikelet per panicle (196.8), (198.7), (134.9), (182.6) and (167.1) respectively. So, the number of spikelet per panicle of G_6 (BR 21 × BRRI dhan 28, S-5, P-1) was the highest number of all other the check varieties. Therefore, G_6 was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential number of spikelet per panicle (Table 3). Variation of total number of spikelet per panicle in 22 genotypes of F_4 populations is presented in Figure 3.

4.1.12 Yield per plant (g)

In this study, out of 22 genotypes of F_4 generations, the highest yield per plant (47.87 g) was recorded in G_8 (BR 21 × BRRI dhan 28, S-5, P-3) and the minimum number of yield per plant (28.19 g) was recorded in G_{12} (BR 21 × BRRI dhan 29, S-6, P-2). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had yielded (38.03 g), (29.16 g), (33.27 g), (41.91 g) and (36.58 g) respectively per plant. So, the yield per plant (g) of G_8 (BR 21 × BRRI dhan 28, S-5, P-3) was the highest of all other the check varieties. Therefore, G_8 was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed different number of yield per plant (Table 3). Variation of yield per plant in 22 genotypes of F_4 populations is presented in Figure 4.

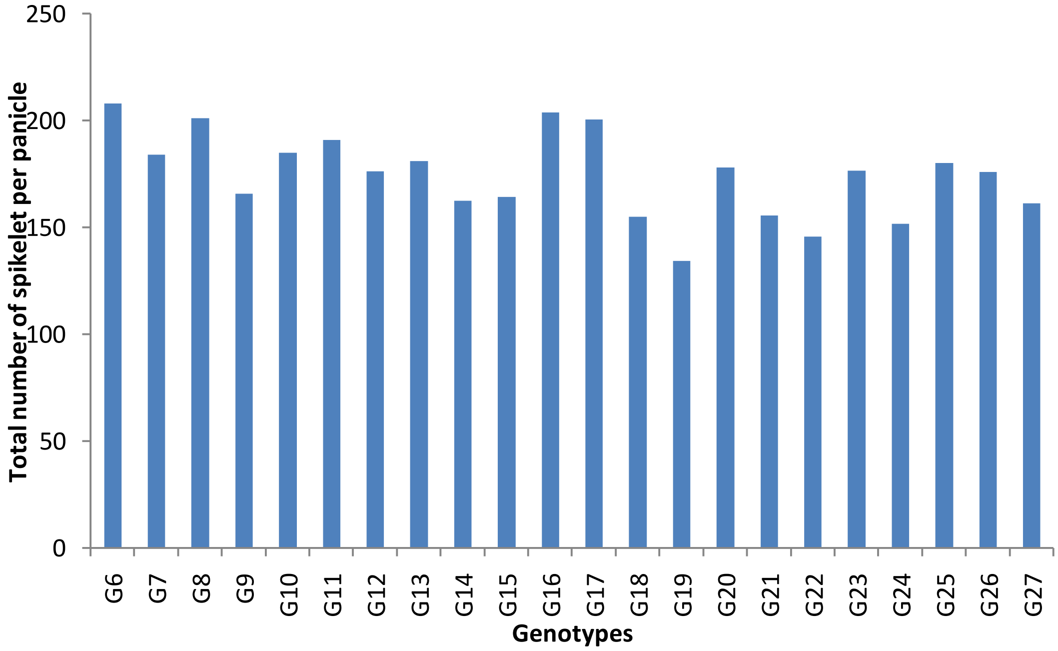


Figure 3. Variations in total number of spikelet/panicle of 22 genotypes of F_4 generations

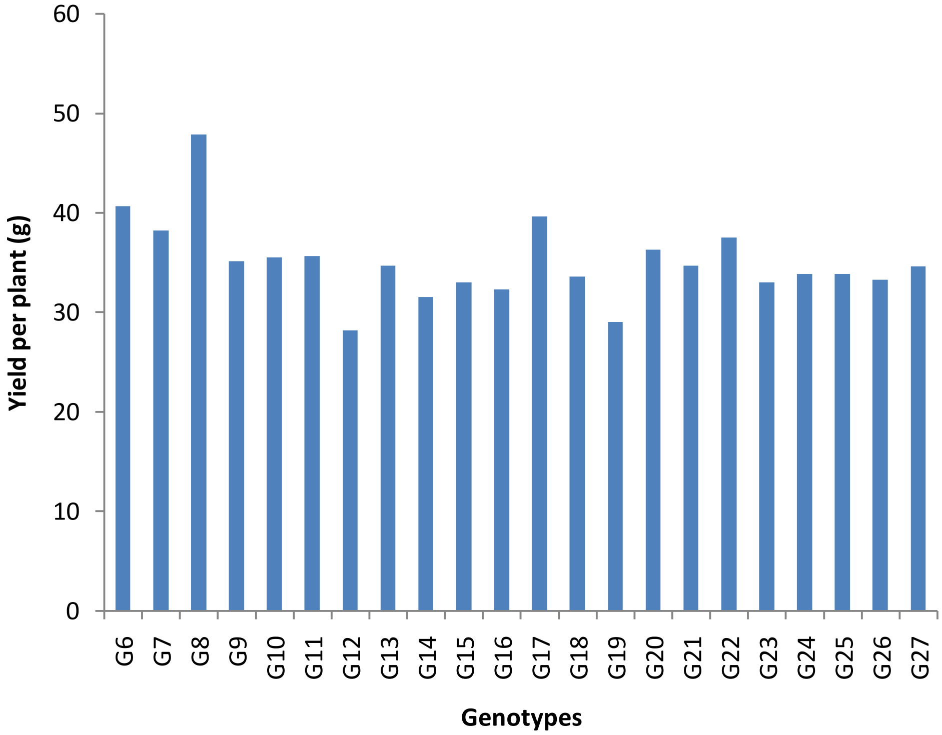


Figure 4. Variations in yield per plant of 22 genotypes of F_4 generations

4.1.13 1000 seed weight (g)

In this study, out of 22 genotypes of F_4 generations, the highest 1000 seed weight (26.29 g) was recorded in G_7 (BR 21 × BRRI dhan 28, S-5, P-2) and the minimum 1000 seed weight (18.25 g) was recorded in G_{26} (BR 24 × BRRI dhan 29, S-5, P-3) which was closely followed by G_{14} (BR 21 × BRRI dhan 29, S-6, P-4) (18.88 g). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had 1000 seed weight of (19.46 g), (21.63 g), (20.75 g), (17.74 g) and (20.96 g) respectively. So, the 1000 seed weight of G_7 (BR 21 × BRRI dhan 28, S-5, P-2) was the highest of all other the check varieties. Therefore, G_7 was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. The rest of the genotypes showed differential 1000 seed weight in (Table 3). Variation of thousand seed weight in 22 genotypes of F_4 populations is presented in Figure 5.

4.1.14 Yield (ton/ ha)

In this study, out of 22 genotypes of F_4 generations, the highest yield (10.26 ton/ha) was recorded in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) and the minimum number of yield (7.281 ton/ha) was recorded in G_{23} (BR 24 × BRRI dhan 28, S-10, P-2). The second maximum yield per hectare (9.131) was recorded in G_9 (BR 21 × BRRI dhan 28, S-5, P-4). Whereas, the check variety BR 21, BR 24, BRRI dhan 28, BRRI dhan 29 and BRRI dhan 36 had yielded (8.300 ton/ha), (7.239 ton/ha), (8.175 ton/ha), (9.380 ton/ha) and (9.012 ton/ha) respectively. So, the yield (ton/ha) of G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) was the highest of all other the check varieties. Therefore, G_7 was suitable for selection as it showed the better performance than the check varieties in aspect of this trait. Again, the yield (ton/ha) of G_9 (9.131) was also close to BRRI dhan 29 and BRRI dhan 36. So, G_9 was also suitable for selection. The rest of the genotypes showed different yield (ton/ha) (Table 3). Variation of yield per hectare in 22 genotypes of F_4 populations is presented in Figure 6.

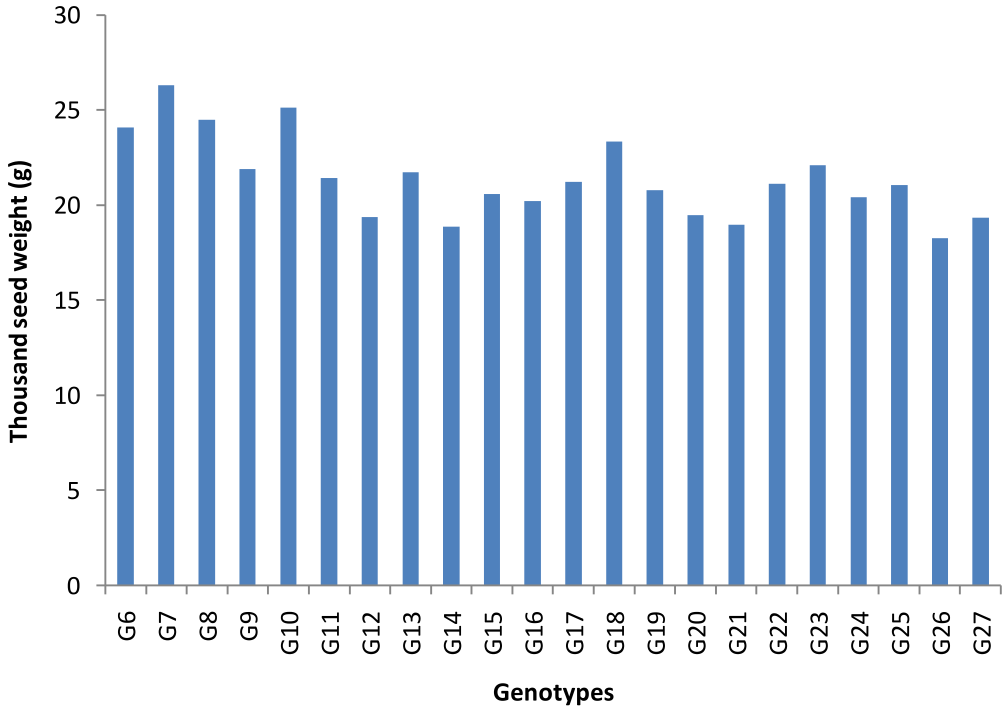


Figure 5. Variations in thousand seed weight of 22 genotypes of F_4 generations

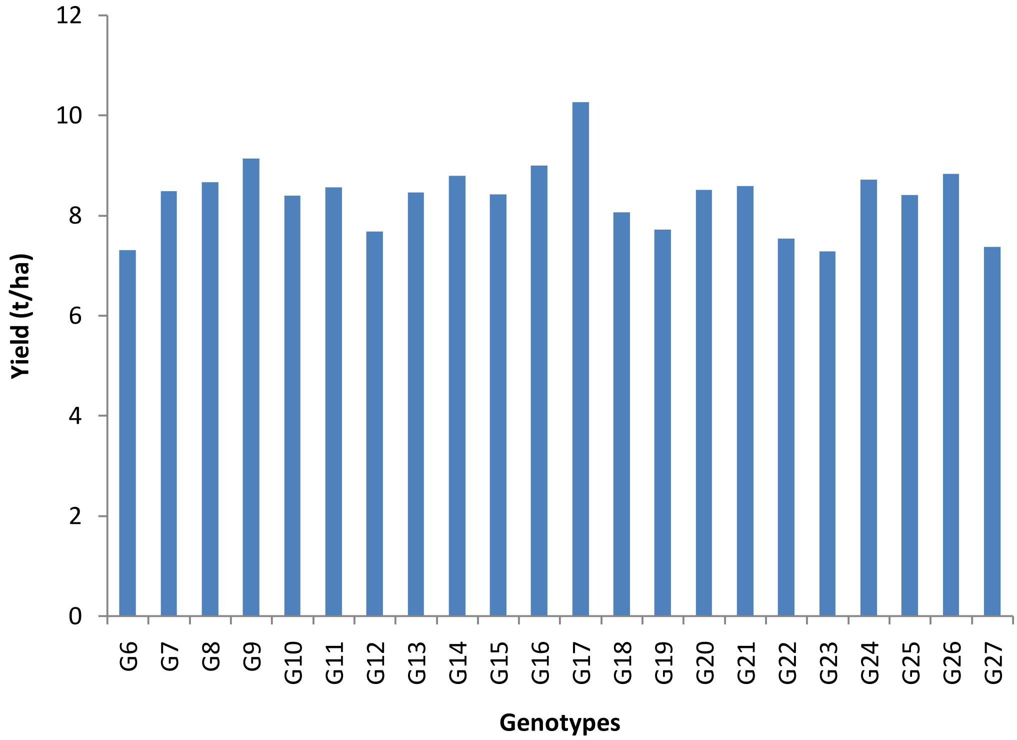


Figure 6. Variations in yield per hectare of 22 genotypes of F_4 generations

4.2. Genetic parameters

The genotypic variance (σ^2g), phenotypic variance (σ^2p) and environmental variance (σ^2e), genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), environmental co-efficient of variation (ECV) for all the quantitative characters under study are presented in Table 4 and Figure 7. The difference between genotypic and phenotypic coefficient of variation was less for all characters studied except panicle length and number of unfilled grains per panicle, which in the indication of the more influence of the environment over this two characters. The slight difference between GCV and PCV was also reported by Mustafa and Isheikh (2007), Kole *et al.* (2008) and Seyoum *et al.* (2012).

4.2.1 Days to flowering

Phenotypic and genotypic variance for days to flowering was observed as (47.82) and (45.01), respectively with little differences between them, suggested considerable influence of environment on the expression of the genes controlling this trait. The phenotypic coefficient of variation (PCV) (5.71) was higher than the genotypic coefficient of variation (GCV) (5.54) (Table 4).There was a little difference between GCV and PCV on this character. Such values of GCV with least difference were also observed by Padmaja *et al.* (2008) for days to flowering.

4.2.2 Days to maturity

Phenotypic and genotypic variance for days to maturity was observed (56.31) and (55.14), respectively with moderate differences between them, suggested moderate influence of environment on the expression of the genes controlling this trait. The moderate phenotypic coefficient of variation (PCV) (11.59%) was close to genotypic coefficient of variation (GCV) (11.47%) (Table 4), which suggested that environment has a role on the expression of this trait.

4.2.3 Plant height (cm)

Phenotypic variance and genotypic variance were observed as 23.06 and 16.02 respectively. The phenotypic variance appeared to be higher than the genotypic variance which suggested considerable influence of environment on the expression of the genes controlling this trait. The estimates of PCV (7.42) and GCV (6.18) also indicated presence of variability among the genotypes for this trait (Table 4). Ketan and Sarker (2014) also showed that the PCV was higher than the GCV in this character.

Table 4. Estimation of genetic parameters of 27 genotypes in *Oryza sativa* L.

Parameters	σ^2p	σ^2g	σ^2e	PCV (%)	GCV (%)	ECV (%)
Days to flowering	47.82	45.01	2.80	5.71	5.54	1.38
Days to maturity	56.31	55.14	1.18	11.59	11.47	1.67
Plant Height (cm)	23.06	16.02	7.04	7.42	6.18	4.10
Total no. of tillers/ plant	2.80	2.32	0.48	2.58	2.35	1.07
No. of effective tillers/ plant	2.75	2.33	0.41	2.56	2.36	0.99
Panicle length (cm)	3.40	2.56	0.84	2.85	2.47	1.42
No. of primary branches/panicle	2.02	1.80	0.22	2.20	2.07	0.73
No. of secondary branches/ panicle	20.09	16.34	3.76	6.92	6.24	2.99
No. of filled grain /panicle	433.56	398.25	35.31	32.16	30.82	9.18
No. of unfilled grain of /panicle	46.06	27.17	18.89	10.48	8.05	6.71
Total no. of spikelet/ panicle	441.53	407.28	34.25	32.45	31.17	9.04
Yield/ plant (g)	23.88	22.53	1.35	7.55	7.33	1.79
1000 seed weight (g)	11.36	10.25	1.11	5.20	4.94	1.63
Yield (ton/ hectare)	3.00	2.72	0.28	2.68	2.55	0.82

σ^2 p = Phenotypic variance, σ^2g = Genotypic variance and σ^2 e = Environmental variance, GCV = Genotypic Coefficient of Variation, PCV = Phenotypic Coefficient of Variation and ECV = Environmental Coefficient of Variation

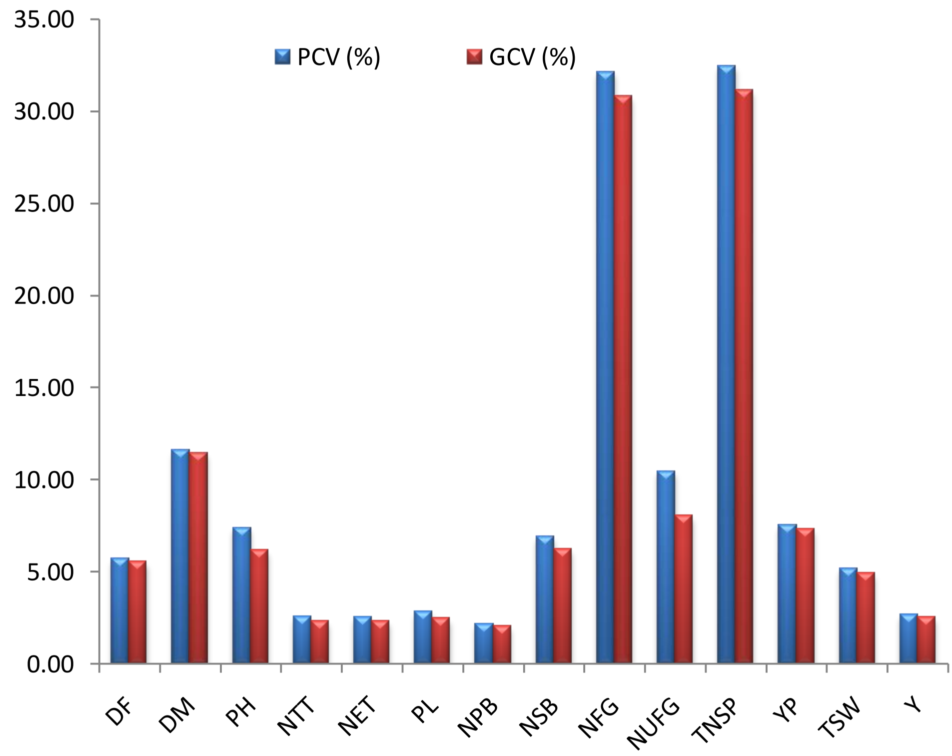


Figure 7. Genotypic and phenotypic coefficient of variation in *Oryza sativa* L.

4.2.4 Total number of tillers per plant

Phenotypic variance and genotypic variance were observed as 2.80 and 2.32, respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this trait. The PCV (2.58) and GCV (2.35) were relatively low indicating the apparent variation not only due to genotypes but also due to the influence of environment (Table 4). Tuwar *et al.* (2013) found high GCV and PCV value in this character.

4.2.5 Number of effective tillers per plant

Phenotypic variance and genotypic variance were observed as 2.75 and 2.33, respectively. The phenotypic variance appeared to be higher than the genotypic variance which suggested considerable influence of environment on the expression of the genes controlling this trait. Relatively low difference between PCV (2.56%) and GCV (2.36%) value indicating the apparent variation not only due to genotypes but also due to the influence of environment (Table 4).

4.2.6 Panicle length (cm)

Length of panicle showed phenotypic variance (3.40) and genotypic variance (2.56) with low difference between them indicating that they were minimum responsive to environmental factors for their phenotypic expression and relatively lower PCV (2.85%) and GCV (2.47%) indicating that the genotype has minimum variation for this trait (Table 4). Padmaja *et al* (2008) found low GCV and PCV along with little difference between them.

4.2.7 Number of primary branches per panicle

Phenotypic variance and genotypic variance were observed as 3.40and 2.56, respectively. The phenotypic variance appeared to be higher than the genotypic variance suggesting considerable influence of environment on the expression of the genes controlling this trait and relatively low difference between PCV (2.20%) and GCV (2.07%) value indicating the apparent variation not only due to genotypes but also due to the influence of environment (Table 4). Karim *et al.* (2007) found higher differences between GCV and PCV for this trait

4.2.8 Number of secondary branches per panicle

Phenotypic variance and genotypic variance were observed as 20.09and 16.34, respectively. Low PCV (6.92%) and GCV (6.24%) values are closely to each other which indicated the presence of considerable variability among the genotypes for this trait (Table 4). Ketan and Sarker (2014) also observed PCV value was higher than the GCV value in number of secondary branches per panicle.

4.2.9 Total number of spikelet per panicle

Phenotypic variance and genotypic variance were observed as 441.53and 407.28, respectively. Higher estimate of PCV (32.45%) and GCV (31.17%) values indicated presence of considerable variability among the genotypes for this trait (Table 4).

4.2.10 Number of filled grains per panicle

The phenotypic and genotypic variances for this trait were 433.56 and 398.25, respectively. The phenotypic variance appeared to be higher than the genotypic variance suggesting considerable influence of environment on the expression of the genes controlling this trait. The value of PCV and GCV were (32.16%) and (30.82%) respectively for number of filled grain per panicle which indicating that medium variation exists among different genotypes (Table 4). Similar variability was also recorded by Bisne *et al.* (2009).

4.2.11 Number of unfilled grains of per panicle

The phenotypic and genotypic variances for this trait were 46.06 and 27.17, respectively. The phenotypic variance appeared to be higher than the genotypic variance suggesting considerable influence of environment on the expression of the genes controlling this trait. The value of PCV and GCV were 10.48% and 8.05%, respectively for number of unfilled grain per panicle which indicated that medium variation exists among different genotypes (Table 4).

4.2.12 Yield/ Plant (g)

The yield/plant showed high genotypic (22.53) and phenotypic (23.88) variance with little differences indicating that they were low responsive to environmental factors.

The phenotypic coefficient of variation (7.55%) was greater than genotypic coefficient of variation (7.33%) (Table 4). There was a very little difference between phenotypic and genotypic co-efficient of variation, indicating minor environmental influence on this character. Dhanwani *et al.* (2013) and Singh et *al.* (2013) found higher phenotypic co-efficient of variation (PCV) than the genotypic co-efficient of variation (GCV) for spikelet yield/plant.

4.2.13 1000 seed weight (g)

Thousand seed weight showed genotypic (10.25) and phenotypic (11.36) variance with little differences indicating that they were low responsive to environmental factors. The phenotypic coefficient of variation (5.20%) and genotypic coefficient of variation (4.94%) were close to each other (Table 4). There was a very little difference between phenotypic and genotypic co-efficient of variation, indicating minor environmental influence on this character.

4.2.14 Yield (ton/ hectare)

The phenotypic variances and genotypic variances for this trait were 3.00 and 2.72, respectively. The values were very close to each other indicated less environmental influences on this trait. The values of GCV and PCV were 2.55% and 5.71% indicating lower environmental influence in the expression of this character (Table 4).

4.3 Heritability and genetic advance

4.3.1 Days to flowering

Days to flowering exhibited high heritability (94.14%) with moderate genetic advance as percentage of mean (11.08%) indicated that this trait was controlled by additive gene and moderate possibility of selecting genotypes that would mature earlier (Table 5). This results support the reports of Hasan *et al.* (2011) and Singh *et al.* (2006).

4.3.2 Days to maturity

Days to maturity showed high heritability (97.91%) with moderate genetic advance as percentage of mean (10.52%) indicated that this trait was controlled by additive gene and moderate possibility of selecting genotypes that would mature earlier (Table 5).

Table 5. Estimation of heritability and genetic advance of 27 genotypes in *Oryza sativa* L.

Parameters	Heritability	Genetic advance (5%)	Genetic advance (% mean)
Days to flowering	94.14	13.41	11.08
Days to maturity	97.91	15.14	10.52
Plant Height (cm)	69.48	6.87	6.17
Total no. of tillers/ plant	82.84	2.85	21.45
No. of effective tillers/ plant	85.03	2.90	22.75
Panicle length (cm)	75.19	2.86	11.99
No. of primary branches/panicle	88.99	2.61	24.37
No. of secondary branches/ panicle	81.31	7.51	22.44
No. of filled grains /panicle	91.86	39.40	25.42
No. of unfilled grains/panicle	58.99	8.25	41.77
Total no. of spikelet/ panicle	92.24	39.93	22.85
Yield/ Plant (g)	94.36	9.50	26.98
1000 seed weight (g)	90.22	6.26	29.63
Yield (ton/ hectare)	90.54	3.23	38.58

4.3.3 Plant height (cm)

Plant height showed high heritability (69.48%) with low genetic advance as percentage of mean of (6.17%) which indicated that this trait was controlled by non-additive gene (Table 5).

4.3.4 Total number of tillers per plant

Total number of tiller per plant showed high heritability (82.84%) with high genetic advance as percentage of mean (21.45%) indicating that this trait was controlled by additive gene and higher possibility of selecting genotypes (Table 5). High heritability coupled with high genetic advance for this trait was also observed by Roy *et* al (2011).

4.3.5 Total number of effective tillers per plant

Total number of effective tiller per plant showed high heritability (85.03%) with high genetic advance as percentage of mean (22.75%) indicating that this trait was controlled by additive gene and higher possibility of selecting genotypes (Table 5). Satheeshkumar *et al.* (2012) also found high heritability with high genetic advance as percentage of mean for the character of effective tillers per plant.

4.3.6 Panicle length (cm)

Panicle length showed high heritability (75.19%) with medium high genetic advance as percentage of mean (11.99%) indicating that this trait was controlled by additive gene (Table 5). High heritability coupled with moderate genetic advance for this trait was observed by Padmaja *et al.* (2008).

4.3.7 Number of primary branches per panicle

Number of primary branches per panicle exhibited moderately high heritability (88.99%) with high genetic advance as percentage of mean of (24.37%) which revealed that this trait was controlled by additive gene (Table 5). As a whole, the high heritability and the consequent high genetic advance indicated the higher possibility of selecting genotypes for this trait.

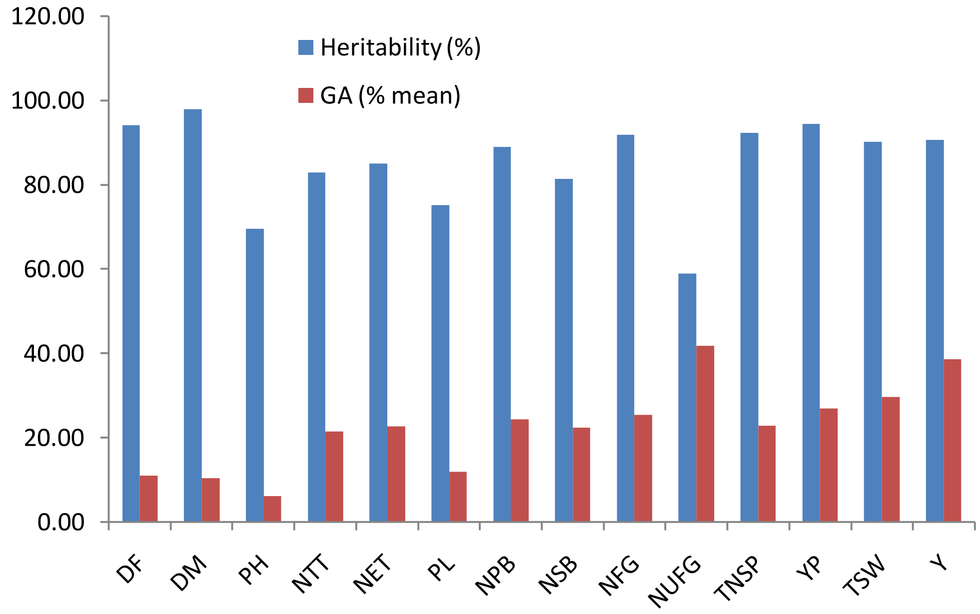


Figure 8. Heritability and Genetic Advance as percentage of mean in *Oryza sativa L.*

4.3.8 Number of secondary branches per panicle

Number of secondary branches per panicle exhibited moderately high heritability (81.31%) with high genetic advance as percentage of mean (22.44%) such results revealed that this trait was controlled by additive gene (Table 5). As a whole, the high heritability and the consequent high genetic advance indicated the higher possibility of selecting genotypes. High heritability coupled with high genetic advance was also found by Ketan and Sarkar (2014).

4.3.9 Total number of spikelet per panicle

Total number of spikelet per panicle exhibited high heritability (92.24%) with high genetic advance as percentage of mean (22.85%), such results revealed that this trait was controlled by additive gene (Table 5). As a whole, the high heritability and the consequent high genetic advance indicated the higher possibility of selecting genotypes. Dhanwani *et al.* (2013) also found such results.

4.3.10 Number of filled grains per panicle

Number of filled grain per panicle exhibited moderately high heritability (91.86%) with high genetic advance as percentage of mean (25.42%), such results revealed that this trait was controlled by additive gene (Table 5). As a whole, the moderately high heritability and the consequent high genetic advance indicated the effective possibility of selecting genotypes. Tuwar *et al*. (2013) and Singh et *al.* (2011) also found high heritability coupled with high genetic advance as percentage of mean for the trait of filled grains per panicle.

4.3.11 Number of unfilled grains of per panicle

Number of unfilled grain per panicle exhibited moderate heritability (58.99%) with and high genetic advance as percentage of mean (41.77%), such results revealed that this trait was controlled by non-additive gene (Table 5).

4.3.12 Yield/ plant (g)

Seed yield per plant in dried condition showed high heritability (94.36%) with high genetic advance as percentage of mean (26.98%) indicating this trait was controlled by additive gene and selection for this character would be more effective (Table 5).

High heritability coupled with high genetic advance for this trait was also observed by Mishra and Verma (2002).

4.3.13 1000 seed weight (g)

Thousand seed weight exhibiting high heritability (90.22%) with high genetic advance as percentage of mean (29.63%) revealed that this trait was controlled by additive gene and selection of this character would be more effective (Table 5). Bharadwaj *et al*. (2007) also observed high heritability with high genetic advance as percentage of mean for this trait.

4.3.14 Yield (ton/ hectare)

Yield (ton per hectare) showed high heritability (90.54%) with high genetic advance as percentage of mean (38.58%) indicated this trait was controlled by additive gene and selection for this character would be highly effective (Table 5).

4.4 Correlation coefficient

Yield is a complex product being influenced by several inter-dependable quantitative characters. Thus selection for yield may not be effective unless the influence of other yield components on it directly or indirectly are taken in to consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated characters. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeder for making improvement through selection vis-à-vis provide a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors (Dewey and Lu 1959). Genotypic and phenotypic correlation co-efficient of different characters of 27 *Oryza sativa* L. genotypes are shown in (Table 6a and 6b). Most of the characters showed the genotypic correlation co-efficient higher than the corresponding phenotypic correlation co-efficient suggesting a strong inherent association between the characters under study and consequently lower. In few cases, phenotypic correlation co-efficient were higher than their corresponding genotypic correlation co-efficient suggesting that both environmental and genotypic correlation acted in the same direction and finally maximized their expression at phenotypic level.

4.4.1 Days to flowering

Days to flowering showed highly significant and positive correlation with days to maturity (G = 0.741**, P = 0.676**), effective tiller per plant (G = 0.435**, P = 0.370**), indicated that if days to flowering increased then days to maturity and effective tiller per plant also will be increased (Table 6a & 6b). It showed positive and significant correlation with plant height (G=0.311*, P=0.296*) (Table 8a & 6b). It also exhibited significant and positive correlated with number of total number tiller per plant (G=0.262*), number of primary branches per panicle (G=0.287*), number of unfilled grain per panicle (G=0.272*) at genotypic level only. But it exhibited significant and negative correlation with panicle length (G= -0.350**, P=-0.303*), number of secondary branches per panicle (G= -0.314*, P=--0.293*) and yield per plant (G= -0.309*, P= -0.286*). Palaniswamy and Kutty (1990) showed that panicle was negatively correlated with flowering duration. But it was negative and positively correlated with yield per hectare at genotypic level (G= -0.271*).

It had insignificant and positive correlation with number of total number tiller per plant (G=0.203), number of primary branches per panicle (G=0.211) and number of unfilled grain per panicle (G=0.223) at phenotypic level. However, it had insignificant and negative interaction with total number of spikelet per panicle (G=-0.170, P=-0.160) and thousand seed weight (G=-0.142, P=-0.089). It also showed insignificant and negative correlation with yield per hectare (P=-0.220). Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors (Table 6a & 6b).

4.4.2 Days to maturity

Days to maturity showed highly significant and positive correlation with number of total tiller per plant (G= 0.436**, P= 0.398**), number of effective tiller per plant (G= 0.468**, P= 0.436**), number of primary branches per panicle (G=0.427**, P=0.375**) and number of secondary branches per panicle (G=0.534**, P=0.480**) (Table 6a & 6b). It indicated that if maturity increased, then number of total tiller per plant, number of effective tiller per plant, number of primary branches per panicle and number of secondary branches per panicle also be increased. It had significant and positive correlation with thousand seed weight (G=0.321*, P=0.293*) and yield per hectare (G=0.326*, P=0.277*) (Table 6a & 6b). It indicated that if maturity is increased, then thousand seed weight and yield per hectare will also be increased.

Table 6a. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of *Oryza sativa L.*

	DM	PH	NTT	NET	PL	NPB	NSB	NFG	NUG	TNSP	YP	TSW	Y (t/ha)
DF	0.741**	0.311*	0.262*	0.435**	-0.350**	0.287*	-0.314*	-0.227	0.272*	-0.170	-0.309*	-0.142	-0.271*
DM		0.235	0.436**	0.468**	0.033	0.427**	0.534**	0.270*	-0.297*	0.063	0.126	0.321*	0.326*
PH			-0.590**	-0.611**	0.815**	0.292*	0.448**	0.462**	0.252	0.508**	0.297*	-0.571**	0.281*
NTT				0.804**	-0.490**	0.236	0.559**	0.540**	0.044	0.501**	0.273*	-0.448**	0.255*
NET					-0.500**	0.264*	0.551**	0.543**	-0.053	0.515**	0.156	-0.434**	0.396**
PL						0.516**	0.473**	0.575**	0.314*	0.651**	0.544**	0.550**	0.320*
NPB							0.585**	0.627**	-0.029	0.592**	0.416**	0.216	0.113
NSB								0.870**	0.322*	0.791**	0.350**	0.273*	0.339*
NFG									0.277*	0.752**	0.478**	-0.725**	0.375**
NUFG										0.288*	0.037	0.715**	-0.398**
TNSP											0.462**	0.256	0.354**
YP												0.462**	0.344**
TSW													0.322*

**, * Correlation is significant at the 0.01 and 0.05 level, respectively.
DF = Days to 50% flowering, DM = Days to 80% maturity, PH= Plant height, NTT = Number of total tiller per plant, NET=Number of effective tiller per plant, PL= Panicle length, NPB=Number of primary branches per panicle, NSB= Number of Secondary branches per panicle, NFG = Number of filled grain per panicle, NUFG= Number of unfilled grain per panicle, TNSP= Number of total spikelet per panicle, , YP= Yield per plant (gram) ,TSW= Weight of thousand seed (gram), Y(t/ha) = Yield (ton per hectare).

Table 6b. Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of *Oryza sativa L.*

	DM	PH	NTT	NET	PL	NPB	NSB	NFG	NUFG	TNSP	YP	TSW	Y (t/ha)
DF	0.676**	0.296*	0.203	0.370**	-0.303*	0.211	-0.293*	-0.216	0.223	-0.160	-0.286*	-0.089	-0.220
DM		0.222	0.398**	0.436**	0.031	0.375**	0.480**	0.257	-0.259	-0.062	0.122	0.293*	0.277*
PH			-0.551**	-0.570**	0.739**	0.244	0.398**	0.439**	0.196	0.482**	0.266*	-0.515**	0.208
NTT				0.808**	-0.404**	0.160	0.496**	0.507**	-0.027	0.455**	0.264*	-0.403**	0.173
NET					-0.416**	0.187	0.502**	0.511**	-0.099	0.471**	0.153	-0.395**	0.288*
PL						0.384**	0.388**	0.508**	0.247	0.581**	0.463**	0.455**	0.297*
NPB							0.438**	0.535**	-0.063	0.495**	0.367**	0.177	0.092
NSB								0.780**	0.280*	0.723**	0.324*	0.205	0.286*
NFG									0.168	0.749**	0.459**	-0.637**	0.251
NUFG										0.276*	0.024	0.550**	-0.206
TNSP											0.443**	0.234	0.259
YP												0.410**	0.288*
TSW													0.272*

**, * Correlation is significant at the 0.01 and 0.05 level, respectively.
DF = Days to 50% flowering, DM = Days to 80% maturity, PH= Plant height, NTT = Number of total tiller per plant, NET=Number of effective tiller per plant, PL= Panicle length, NPB=Number of primary branches per panicle, NSB= Number of Secondary branches per panicle, NFG = Number of filled grain per panicle, NUFG= Number of unfilled grain per panicle, TNSP= Number of total spikelet per panicle, YP= Yield per plant (gram) ,TSW= Weight of thousand seed (gram) ,Y (t/ha) = Yield (ton per hectare).

It also showed positive and significant correlation with number filled grain per panicle at genotypic level only (G=0.270*). But it had negative and significant correlation with number of unfilled grain per panicle at genotypic level only (G=-0.297*). It also showed insignificant and positive correlation with plant height (G=0.235, P=0.222), panicle length (G= 0.033, P= 0.031) and yield per plant (G=0.126, P=0.122) at both genotypic and phenotypic level (Table 6a & 6b). But it also showed insignificant and positive correlation with number of total spikelet per panicle at genotypic level (G=0.063). However, it had insignificant and negative interaction with number of total spikelet per panicle at phenotypic level (P=-0.062) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits was largely influenced by environmental factors. Iftekharuddaula *et al.* (2001), Sadeghi (2011) and Rangare *et al.* (2012) reported positive and significant correlation with yield.

4.4.3 Plant height (cm)

Plant height showed highly significant and positive correlation with panicle length (G= 0.815**, P=0.739**), number of secondary branches per panicle (G=0.448**, P=0.398**), number of filled grain per panicle (G=0.462**, P= 0.439**) and number of total spikelet per panicle (G=0.508**, P=0.482**). It indicated that if panicle length is increased then panicle length, number of secondary branches per panicle, number of filled grain per panicle, and number of total spikelet per panicle will also be increased. It had significant and positive correlation with yield per plant (G=0.297*, P=0.266*). Sohrabi *et al.* (2012), Akter *et al.* (2007) and Habib *et al.* (2005) also found this finding. But Zahid *et al.* (2005) found negative correlation. It also had positive and significant correlation with number of primary branches per panicle (G=0.292*) and yield per hectare (G=0.281*) at genotypic level only. It had highly significant and negative interaction with number of total tiller per plant (G=-0.590**, P=-0.551**), number of effective per plant (G=-0.611**, P=-0.570**) and thousand seed weight (G=-0.571**, P=-0.515**). It indicated that if panicle length increased then number of total tiller per plant, number of effective per plant number and thousand seed weight will be decreased. It had insignificant and positive correlation with number of unfilled grain per panicle (G=0.252, P=0.196). It also had insignificant and positive correlation with number of primary branches per panicle (P=0.244) and yield per hectare (P=0.208) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits was largely influenced by environmental factors.

4.4.4 Total number of tillers per plant

Total number of tillers per plant showed highly significant and positive correlation with total number of effective tiller per plant (G= 0.804**, P=0.808**), number of secondary branch per panicle (G=0.559**, P=0.496**), number of filled grain per panicle (G= 0.540**, P=0.507**) and total number of spikelet per panicle (G= 0.501**, P=0.455**) (Table 6a & 6b). It indicated that if total number of tiller per plant is increased then number of effective tiller per plant, number of secondary branch per panicle, number of filled grain per panicle and total number of spikelet per panicle will also be increased. It had significant and positive correlation with yield per plant (G=0.273*, P=0.264*) (Table 6a & 6b). Akinwalel *et al.* (2011) showed same results. But it showed significant and positive correlation with yield per hectare (G=.255*) at genotypic level only. It had highly significant and negative interaction with panicle length (G= -0.490**, P= -0.404**) and thousand weight (G= -0.448**, P= -0.403**) (Table 6a & 6b). It indicated that if total number of tiller per plant is increased then panicle length and thousand seed weight will also be decreased. It had insignificant and positive interaction with number of primary branches per panicle (G=0.236, P=0.160). But it showed insignificant and positive interaction with number of unfilled grain per panicle. (G= 0.044) at genotypic level. It also showed insignificant and positive interaction with yield per hectare (P=0.173) at phenotypic level. However, it had insignificant and negative correlation with number of unfilled grain per panicle (P= -0.027) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits was largely influenced by environmental factors. Tomar *et al.* (2000), Prasad *et al.* (2001), Sankar *et. al.* (2006), Agahi *et al.* (2007), Ghosal *et al.* (2010), Watto *et al.* (2010) and Sadeghi *et al.* (2011) showed positive and significant correlation of yield with effective tillers per plant.

4.4.5 Number of effective tillers per plant

Number of effective tillers per plant showed highly significant and positive interaction with number of secondary branches per panicle (G=0.551**, P=0.502**), number of filled grain per panicle (G=0.543**, P=0.511**), total number of spikelet per panicle (G=0.501**, P=0.471**) and yield per hectare (G=0.396**, P=0.288*)

(Table 6a & 6b). Prasad *et al.* (2001) showed that number of effective tiller per plant has significant and positive interaction with yield. It indicated that if total number of effective tiller per plant is increased then number of secondary branches per panicle, number of filled grain per panicle, total number of spikelet per panicle and yield per hectare will also be increased which would be effective for selection. It showed positive and significant correlation with number of primary branches per panicle (G=0.264*) at genotypic level only. It had highly significant and negative interaction with panicle length (G=-0.500**, P= -0.416**) and thousand seed weight (G=-0.434**, P= -0.395**) (Table 6a & 6b). It indicated that if number of effective tiller per plant then panicle length and thousand seed weight also be decreased. It also showed insignificant and positive interaction with yield per plant (G=0.156, P=0.153). It had negative and insignificant interaction with number of unfilled grains per panicle (G= -0.053, P= -0.099) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits was largely influenced by environmental factors.

4.4.6 Panicle length (cm)

Panicle length showed highly significant and positive interaction with number of primary branches per panicle (G=0.516**, P=0.384**), number of secondary branch per panicle (G=0.473**, P=0.388**), number of filled grain per panicle (G=0.575**, P=0.508**), total number of spikelet per panicle (G=0.651**, P=0.581**), yield per plant (G= 0.544**, P=0.463**), thousand seed weight (G=0.550**, P=0.455**). It also showed significant and positive interaction with yield per hectare (G= 0.320*, P=0.297*) (Table 6a & 6b). It indicating that if panicle length is increased then number of primary branches per panicle, number of secondary branch per panicle, number of filled grain per panicle, total number of spikelet per panicle, thousand seed weight and yield per hectare will also be increased which would be effective criteria for selection. Panicle length had significant and positive interaction with number of unfilled grain per panicle (G=0.314*) at genotypic level but at phenotypic level it showed positive and insignificant correlation (P=0.247) (Table 6a & 6b). Insignificant association of these trait indicated that the association between these traits was largely influenced by environmental factors. Akter *et al.* (2007) also observed that panicle length has positive and significant relation with grain yield.

4.4.7 Number of primary branches per panicle

Number of primary branches per plant showed highly significant and positive interaction with number of secondary branch per panicle (G = 0.585**, P = 0.438**), number of filled grain per panicle (G=0.627**, P= 0.535**), total number of spikelet per panicle (G=0.592**, P= 0.495**), and yield per plant (G=0.416**, P=0.367**) (Table 6a & 6b). It indicated if number of primary branches per plant is increased, then number of secondary branch per panicle, number of filled grain per panicle, total number of spikelet per panicle and yield per plant will also be increased. It had insignificant and positive correlation with thousand seed weight (G = 0.216, P = 0.177) and yield per hectare (G = 0.113, P = 0.092). It also showed insignificant and negative correlation with number of unfilled grain per panicle (G=-0.029, P=-0.063) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors.

4.4.8 Number of secondary branches per panicle

Number of secondary branches per panicle showed highly significant and positive interaction with number of filled grain per panicle (G=0.870**, P= 0.780**), total number of spikelet per panicle (G= 0.791**, P= 0.723**) and yield per plant (G=0.350**, P=0.324*). It had significant and positive interaction with number of unfilled grain per panicle (G=0.322*, P= 0.280*) and yield per hectare (G=0.339*, P=0.286*) (Table 6a & 6b). It indicated if number of secondary branches per panicle is increased then number of filled grain per panicle, total number of spikelet per panicle, yield per plant and yield per hectare would also be increased which would be effective criteria for selection. It had significant and positive correlation with thousand seed weight (G= 0.273*) at genotypic level but at phenotypic level, it had insignificant and positive correlation (P=0.205) (Table 6a & 6b).

4.4.9 Number of filled grains per panicle

Number of filled grain per panicle showed highly significant and positive interaction with total number of spikelet per panicle (G=0.752**, P=0.749**) and yield per plant (G=0.478**, P=0.459**) (Table 6a & 6b). It indicated that if number of filled grain per panicle is increased then total number of spikelet per panicle and yield per plant will also be increased. Akter *et al.* (2007) also observed these result. It had highly significant and positive interaction with yield per hectare at genotypic level (G= 0.375**). It also showed positive and significant correlation with number of unfilled grain per panicle (G=0.277*). It showed highly significant and negative interaction with thousand seed weight (G=-0.725**, P=-0.637**). It showed positive and insignificant correlation with number of unfilled grain per panicle (P= 0.168) and yield per hectare (P=0.251) at phenotypic level (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors. Singh *et al.* (2013) showed significant and positive interaction of number of filled grain per panicle with yield per plant.

4.4.10 Number of unfilled grains of main tiller

Total number of unfilled grain per panicle showed highly significant and positive interaction with thousand seed weight (G=0.715**, P=0.550**). It had significant and positive interaction with total number of spikelet per panicle (G=0.288*, P=0.276*) (Table 6a & 6b). It indicated that if number of unfilled grain per panicle is increased, then thousand seed weight and yield per hectare will be increased. It had highly significant and negative correlation with yield per hectare (G= -0.398**) at genotypic level but showed insignificant and negative relation at phenotypic level (P=-0.206). However, it had insignificant and positive interaction with yield per plant (G=0.037, P= 0.024) (Table 6a & 6b). Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors.

4.4.11 Total number of spikelet per panicle

Total number of spikelet per panicle showed highly significant and positive interaction with yield per plant (G=0.462**, P=0.443**) (Table 6a & 6b). Singh *et al.* (2013) also showed this result. It had highly significant and positive interaction with yield per hectare (G=0.354**) at genotypic level. It indicated that if total number of spikelet per panicle is increased then yield per plant and yield per hectare will also be increased which would be desirable for selection. It showed positive and insignificant interaction with thousand seed weight (G=0.256, P=0.234) (Table 6a & 6b). It also had positive and insignificant interaction with yield per hectare (P=0.259) at phenotypic level. This insignificant association between these traits is largely influenced by environmental factors.

4.4.12 Yield/ plant (g)

Yield per plant showed highly significant and positive interaction with thousand seed weight (G=0.462**, P=0.410**) and with yield per hectare (G= 0.344**). Chaubey and Richharia (1993), Vange (2009), Nandeshwar *et al.*(2010), Sadeghi *et al.* (2011)and Akinwale *et al.* (2011) also reported that yield per plant was positively and significantly correlated with yield. It also showed highly significant and positive interaction with yield per hectare at phenotypic level (P=0.288*). It indicated that if yield per plant is increased then thousand seed weight and yield per hectare will also be increased which would be desirable character for selection(Table 6a & 6b).

4.4.13 1000 seed weight (g)

Thousand seed weight showed significant and positive interaction with yield per hectare (G=0.322*, P=0.272*) (Table 6a & 6b). It indicated that if thousand seed weight is increased then yield per hectare will also be increased which would be effective character for selection. These findings are showing similar to the reports of Hasan *et al.* (2011).

4.5 Path Co-efficient analysis

Association of character determined by correlation co-efficient may not provide an exact picture of the relative importance of direct and indirect influence of each of yield components on seed yield per hector. In order to find out a clear picture of the inter-relationship between seed yield per plant and other yield attributes, direct and indirect effects were determined out using path analysis at genotypic level which also measured the relative importance of each component. Seed yield per plant was considered as a resultant (dependent) variable and flowering, days to maturity, plant height (cm), total number of tiller /plant, total number of effective tiller/plant, panicle length (cm), number of primary branches per panicle, number of secondary branches per panicle, number of filled grain per panicle, number of unfilled grain per panicle, Yield/ Plant (gm),thousand seed weight (g) and yield (ton/ hectare) were causal (independent) variables. Estimation of direct and indirect effect of path co-efficient analysis for *Oryza sativa* L. is presented in Table 7.

The residual effect was 0.214, indicated that contribution of component characters on yield per hectare was 78.6% by the thirteen characters studied in path analysis, the rest 21.4% was the contribution of other factors such as characters not studied and sampling error.

4.5.1 Days to flowering

Path co-efficient analysis revealed that, days to flowering had negative direct effect (-0.719) on yield per hectare. This trait showed indirect positive effect on days to maturity (0.704), plant height (0.064), number of effective tiller per plant (0.077), panicle length (0.229) and number of secondary branches per panicle (0.098). On the other hand, it showed indirect negative effect on total number of tiller per plant (-0.176), number of primary branches per panicle (-0.052), number of filled grain per panicle (-0.079), number of unfilled grain per panicle (-0.134), total number of spikelet per panicle (-0.148), yield per plant (-0.119) and thousand weight (-0.028). Finally it made negative and significant correlation with yield per hectare (-0.271*) (Table 7). These results indicated that if days to flowering is decreased then yield per hectare would be decreased mostly through the positive indirect effect of flowering with other characters. Abarshahr *et al.* (2011) revealed that days to flowering had negative direct effect on yield per hectare.

4.5.2 Days to maturity

Path co-efficient analysis revealed that, days to maturity had positive direct effect (0.950) on yield per hectare**.** This trait had positive indirect effect through plant height (0.048), number of effective tiller per plant (0.083), number of filled grain per panicle (0.094), number of unfilled grain per panicle (0.147), total number of spikelet per panicle (0.055), yield per plant (0.048) and thousand seed weight (0.063). On the other hand, days to maturity had negative indirect effect via days to flowering (-0.603), total number of tiller per plant (-0.293), panicle length (-0.021), number of primary branches per panicle (-0.078) and number of secondary branches per panicle (-0.166). Finally it made positive and significant correlation with yield per hectare (0.326*) (Table 7). These results indicated that if days to maturity is increased then yield per hectare would be increased mostly through the positive indirect effect of maturity with other characters. Ghosal *et al.* (2010) observed that growth duration (days) had positive direct and indirect effect on yield per hectare.

4.5.3 Plant height (cm)

Path analysis revealed that plant height had positive direct effect (0.205) on yield per hectare. It had positive indirect effect on days to maturity (0.223), total number of tiller per plant (0.396), number of filled grain per panicle (0.161), total number of spikelet per panicle (0.441), and yield per plant (0.114) (Table 7). Plant height had negative indirect effect via days to flowering (-0.224), number of effective tiller per plant (-0.108), panicle length (-0.534), number of primary branches per panicle (-0.053), number of secondary branches per panicle (-0.139), number of unfilled grain per panicle (-0.124) and thousand seed weight (-0.112) (Table 7). Plant height finally made positive and significant correlation with yield per hectare (-0.32*).These results indicated that if plant height is increased then yield per hectare would be increased mostly through the positive indirect effect of plant height with other characters. Rokonuzzaman *et al.* (2008) and Habib *et al.* (2005) also reported direct positive result for this character.

4.5.4 Total number of tillers per plant

Path co-efficient analysis revealed that, total number of tillers per plant had negative direct effect (-0.672) on yield per hectare. This trait had positive indirect effect through days to maturity (0.414), number of effective tiller per plant (0.142), panicle length (0.321 number of filled grain per panicle (0.188), total number of spikelet per panicle (0.435) and yield per plant (0.105) (Table 7). On the other hand, total number of tiller per plant had negative indirect effect via days to flowering (-0.236), plant height (-0.121), number of primary branches per panicle (-0.043), number of secondary branches per panicle (-0.174), number of unfilled grain per panicle (-0.022) and thousand seed weight (-0.088) (Table 7). Finally it made positive correlation with yield per hectare (0.255*) (Table 7). These results indicated that if total number of tiller per plant is increased then yield per hectare would be increased mostly through the positive indirect effect of total number of tiller per plant with other characters. Karad *et al.* (2008) and Yadav *et al.* (2010) showed positive direct effect of total tillers per plant on yield.

Table 7. Path coefficient analysis showing direct and indirect effects of different characters on yield (t/ha) of *Oryza sativa L.*

	DF	DM	PH	NTT	NET	PL	NPB	NSB	NFG	NUFG	TNSP	YP	TSW	Genotypic correlation with yield (t/ha)
DF	**-0.719**	0.704	0.064	-0.176	0.077	0.229	-0.052	0.098	-0.079	-0.134	-0.148	-0.119	-0.028	-0.271*
DM	-0.603	**0.950**	0.048	-0.293	0.083	-0.021	-0.078	-0.166	0.094	0.147	0.055	0.048	0.063	0.326*
PH	-0.224	0.223	**0.205**	0.396	-0.108	-0.534	-0.053	-0.139	0.161	-0.124	0.441	0.114	-0.112	0.281*
NTT	-0.236	0.414	-0.121	**-0.672**	0.142	0.321	-0.043	-0.174	0.188	-0.022	0.435	0.105	-0.088	0.255*
NET	-0.313	0.445	-0.125	-0.540	**0.177**	0.328	-0.048	-0.171	0.189	0.026	0.448	0.060	-0.085	0.396**
PL	0.032	0.031	0.167	0.329	-0.272	**-0.655**	-0.094	-0.147	0.200	-0.155	0.566	0.210	0.108	0.320*
NPB	-0.306	0.305	0.060	-0.214	0.047	-0.360	**-0.182**	-0.182	0.218	0.014	0.514	0.160	0.042	0.113
NSB	0.131	0.201	0.092	-0.376	0.097	-0.310	-0.206	**-0.311**	0.302	-0.159	0.687	0.135	0.053	0.339*
NFG	0.164	0.257	0.095	-0.363	0.096	-0.377	-0.129	-0.270	**0.348**	-0.137	0.653	0.184	-0.142	0.375**
NUFG	-0.196	-0.282	0.083	-0.030	-0.009	-0.106	0.305	-0.100	0.026	**-0.494**	0.250	0.014	0.140	-0.398**
TNSP	0.206	0.060	0.104	-0.337	0.091	-0.427	-0.108	-0.291	0.201	-0.242	**0.869**	0.178	0.050	0.354**
YP	0.222	0.119	0.061	-0.184	0.009	-0.357	-0.236	-0.114	0.166	-0.218	0.402	**0.385**	0.091	0.344**
TSW	0.102	0.305	-0.117	0.301	-0.077	-0.360	-0.039	-0.085	-0.175	-0.124	0.222	0.178	**0.196**	0.322*
Residual effect	0.214													

Diagonally **bold figures** indicate the direct effect

**, * Correlation is significant at the 0.01 and 0.05 level, respectively. DF = Days to 50% flowering, DM = Days to 80% maturity, PH= Plant height, NTT = Number of total tiller per plant, NET=Number of effective tiller per plant, PL= Panicle length, NPB=Number of primary branches per panicle, NSB= Number of Secondary branches per panicle, NFS = Number of filled grain per panicle, NUFS= Number of unfilled grain per panicle, TNSP= Number of total spikelet per panicle, , YP= Yield per plant (gram) ,TSW= Weight of thousand seed (gram), Y= Yield (ton per hectare).

4.5.5 Total number of effective tillers per plant

Path co-efficient analysis revealed that, total number of effective tillers per plant had positive direct effect (0.177) on yield per hectare**.** This trait had positive indirect effect through days to maturity (0.445), panicle length (0.328), number of filled grains per panicle (0.189), number of unfilled grain per panicle (0.026), total number of spikelet per panicle (0.448) and yield per plant (0.060) (Table 7). On the other hand, total number of effective tillers per plant had negative indirect effect via days to flowering (-0.313), plant height (-0.125), total number of tillers per plant (-0.540), number of primary branches per panicle (-0.048), number of secondary branches per panicle (-0.171) and thousand seed weight (-0.085). Finally it made highly positive correlation with yield per hectare (0.396**) (Table 7). These results indicated that if total number of effective tiller per plant is increased then yield per hectare would be increased mostly through the positive indirect effect of total number of effective tiller per plant with other characters. Ghosal *et al.* (2010) revealed that total effective number of tillers per hill had positive direct effect on yield per hectare.

4.5.6 Panicle length (cm)

Path analysis revealed that panicle length had direct negative effect (-0.655) on yield per hectare. This trait had positive indirect effect through days to flowering (0.032), days to maturity (0.031), plant height (0.167), total number of tiller per plant (0.329) panicle length (0.256), number of filled grain per panicle (0.200), total number of spikelet per panicle (0.566), yield per plant (0.210) and thousand seed weight (0.108)(Table 7). On the other hand, it had negative indirect effect via number of effective tiller per plant (-0.272), number of primary branches per panicle (-0.094), number of secondary branches per panicle (-0.147) and number of unfilled grain per panicle (-0.155). Finally it made positive correlation with yield per hectare (0.320*) (Table 7).

4.5.7 Number of primary branches per panicle

Path analysis revealed that number of primary branches per panicle had direct negative effect (-0.182) on yield per hectare. This trait had positive indirect effect through days to maturity (0.305), plant height (0.060), number of effective tiller per plant (0.047number of filled grain per panicle (0.218), number of unfilled grain per panicle (0.014)), total number of spikelet per panicle (0.514), yield per plant (0.160) and thousand seed weight (0.042) (Table 7). On the other hand, **it** had negative indirect effect via days to flowering (-0.306), total number of tiller per plant (-0.214), panicle length (-0.360) and number of secondary branches per panicle (-0.182). Finally it made positive correlation with yield per hectare (0.113) (Table 7).

4.5.8 Number of secondary branches per panicle

Path analysis revealed that number of secondary branches per panicle had direct negative effect (-0.311) on yield per hectare. This trait had positive indirect effect through days to flowering (0.131), days to maturity (0.201), plant height (0.092), number of effective tiller per plant (0.097), number of filled grain per panicle (0.302), total number of spikelet per panicle (0.687), yield per plant (0.135) and thousand seed weight (0.053) (Table 7). On the other hand, it had negative indirect effect via total number of tiller per plant (-0.376), panicle length (-0.310), number of primary branches per panicle (-0.206) and number of unfilled grain per panicle (-0.159). Finally it made significant and positive correlation with yield per hectare (0.339*) (Table 7).

4.5.9 Number of filled grains per panicle

Path analysis revealed that number of filled grain per panicle had direct positive effect (0.348) on yield per hectare. This trait had positive indirect effect through days to flowering (0.164),days to maturity (0.257), plant height (0.095), number of effective tiller per plant (0.096), total number of spikelet per panicle (0.653) and yield per plant (0.184) (Table 7). On the other hand, it had negative indirect effect via total number of tiller per plant (-0.363), panicle length (-0.377), number of primary branches per panicle (-0.129), number of secondary branches per panicle (-0.270), number of unfilled grain per panicle (-0.137) and thousand seed weight (-0.142). Finally it made highly positive and significant correlation with yield per hectare (0.375**) (Table 7). These results indicated that if number of filled grain per panicle is increased then yield per hectare would be increased mostly through the positive indirect effect of number of filled grain per panicle with other characters. Prasad *et al.* (2001) reported that number of filled grain per panicle had direct positive effect on yield.

4.5.10 Number of unfilled grains of per panicle

Path analysis revealed that number of unfilled grain per panicle had direct negative effect (-0.494) on yield per hectare. This trait had positive indirect effect through plant height (0.083), number of primary branches per panicle (0.305), number of filled grain per panicle (0.026),total number of spikelet per panicle (0.250), yield per plant (0.014) and thousand seed weight (0.140) (Table 7). On the other hand, it had negative indirect effect via days to flowering (-0.196), days to maturity (-0.282), total number of tiller per plant (-0.030), number of effective tiller per plant (-0.009), panicle length (-0.106) and number of secondary branches per panicle (-0.100). Finally it made significant and negative correlation with yield per hectare (-0.398**) (Table 7).

4.5.11 Total number of spikelet per panicle

Path analysis revealed that total number of spikelet per panicle had direct positive effect (0.869) on yield per hectare. This trait had positive indirect effect through days to flowering (0.206), days to maturity (0.060), plant height (0.104), number of effective tiller per plant (0.091), number of filled grain per panicle (0.201), yield per plant (0.178) and thousand seed weight (0.050) (Table 7). On the other hand, it had negative indirect effect via total number of tiller per plant (-0.337), panicle length (-0.427), number of primary branches per panicle (-0.108), number of secondary branches per panicle (-0.291) and number of unfilled grain per panicle (-0.242). Finally it made highly positive and significant correlation with yield per hectare (0.354**) (Table 7). These results indicated that if total number of spikelet per panicle is increased then yield per hectare would be increased mostly through the positive indirect effect of total number of spikelet per panicle with other characters. Seyoum *et al.* (2012) reported that grins per panicle had direct positive effect on yield per hectare.

4.5.12 Yield per plant (g)

Path analysis revealed that number of yield per plant had direct positive effect (0.385) on yield per hectare. This trait had positive indirect effect through days to flowering (0.222), days to maturity (0.119), plant height (0.061), number of effective tiller per plant (0.009), number of filled grain per panicle (0.166), total number of spikelet per panicle (0.402) and thousand seed weight (0.091) (Table 7). On the other hand, it had negative indirect effect via total number of tiller per plant (-0.184), panicle length (-0.357), number of primary branches per panicle (-0.236), number of secondary branches per panicle (-0.114) and number of unfilled grain per panicle (-0.218).Finally it made highly positive and significant correlation with yield per hectare (0.344**) (Table 7). These results indicated that if yield per plant is increased then yield per hectare would be increased mostly through the positive indirect effect of yield per plant with other characters.

4.5.13 1000 seed weight (g)

Path analysis revealed that thousand seed weight had direct positive effect (0.196) on yield per hectare. This trait had positive indirect effect through days to flowering (0.102), days to maturity (0.305), total number of tiller per plant (0.301), total number of spikelet per panicle (0.222) and yield per plant (0.178) (Table 7). On the other hand, it had negative indirect effect via plant height (-0.117), number of effective tiller per plant (-0.077), panicle length (-0.360), number of primary branches per panicle (-0.039), number of secondary branches per panicle (-0.085), number of filled grain per panicle (-0.175) and number of unfilled grain per panicle (-0.124). Finally it made significant and positive correlation with yield per hectare (0.322*) (Table 7). These results indicated that if thousand seed weight is increased then yield per hectare would be increased mostly through the positive indirect effect of thousand seed weight with other characters. Ghosal *et al.* (2010) reported that thousand seed weight had direct positive effect on yield ton per hectare.

The path coefficient and genotypic correlation studies indicated that number of effective tiller per plant, number of filled grain per panicle, total number of spikelet per panicle and yield per plant were the most important contributors to yield per hectare which could be taken in consideration for future hybridization program. Days to maturity, plant height, total number of tiller per plant, panicle length, number of secondary branches per panicle and thousand seed weight were also the important contributors to yield per hectare.

4.6 Selection of individual plant

Genotype G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) showed better performance as it required 143 days to maturity, had 16 effective tiller per plant, 221 total number of spikelet per panicle and 61.5 gram yield per plant (Table 8a), (Plate 2a and 2b) . On the other hand, check variety BRRI dhan 29 required 161.6 days to maturity, had 15.02 effective tillers per plant, 182.6 total number of spikelet per panicle and 41.91 gram yield per plant (Table 8b). So, G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) was better than the check variety BRRI dhan 29.

Genotype G_{9} (BR 21 × BRRI dhan 28, S-5, P-4) showed better performance as it required 142 days to maturity, had 15 effective tiller per plant, 150 total number of spikelet per panicle and 50 gram yield per plant (Table 8a), (Plate 3a and 3b). On the other hand, check variety BRRI dhan 28 required 148.8 days to maturity, had 15.18 effective tillers per plant, 134.9 total number of spikelet per panicle and 33.27 gram yield per plant. So, Genotype G_{9} (BR 21 × BRRI dhan 28, S-5, P-4) was selected for future trial.

Genotype G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) showed better performance as it required 139 days to maturity, had 16 effective tiller per plant, 209 total number of spikelet per panicle and 54.3 gram yield per plant (Table 8a) (Plate 4). On the other hand, check variety BRRI dhan 29 required 161.6 days to maturity, had 15.02 effective tillers per plant, 182.6 total number of spikelet per panicle and 41.91 gram yield per plant (Table 8b). So, G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) was better than the check variety BRRI dhan 29 and suitable for selection.

Genotype G_{14} (BR 21 × BRRI dhan 29, S-6, P-4) showed better performance as it required 141 days to maturity, had 11 effective tiller per plant, 190 total number of spikelet per panicle and 52.3 gram yield per plant (Table 8a) (Plate 5).. It took 141.1 days to maturity but the check variety BRRI dhan 29 took 161.6 days (Table 8b) which indicating that, required time was lesser than parent. Again its yield per plant (g) was higher than the check variety. So it was suitable for selection of early high yielding materials for future use. Therefore, Genotype G_{14} (BR 21 × BRRI dhan 29, S-6, P-4) was chosen for selection.

Table 8a. Selection of promising early high yielding plants from the F_4 materials of different genotypes

Cross combinations	Selected plant No.	DM	NET	TNSP	YP (g)
G_{17} (BR 21 × BRRI dhan 29, S-6, P-7)	9	143	16	221	61.5
G_9 (BR 21 × BRRI dhan 28, S-5, P-4)	7	142	15	150	50
G_{16} (BR 21 × BRRI dhan 29, S-6, P-6)	8	139	16	209	54.3
G_{14} (BR 21 × BRRI dhan 29, S-6, P-4)	1	141	11	190	52.3
G_{27} (BR 24 × BRRI dhan 29, S-5, P-4)	7	145	20	202	68
G_{13} (BR 21 × BRRI dhan 29, S-6, P-3)	9	139	14	274	52.7
G_{15} (BR 21 × BRRI dhan 29, S-6, P-5)	3	146	22	200	64.3

DM= Days to maturity, NET= Number of effective tiller, TNSP= Total number of spikelet per panicle, YP= Yield per plant (gram)

Table 8b. Mean performance table of important traits of five check variety of *Oryza sativa* L.

Cross combinations	DM	NET	TNSP	YP (g)
G_1 (BR 21)	151.9	13.53	196.8	38.03
G_2 (BR 24)	141.3	11.75	198.7	29.16
G_3 (BRRI dhan 28)	148.8	15.18	134.9	33.27
G_4 (BRRI dhan 29)	161.6	15.02	182.6	41.91
G_5 (BRRI dhan 36)	147.0	14.31	167.1	36.58

DM= Days to maturity, NET= Number of effective tiller, TNSP= Total number of spikelet per panicle, YP= Yield per plant (gram)

Plate 2a. Comparison of days to maturity of G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) & BRRI dhan 29

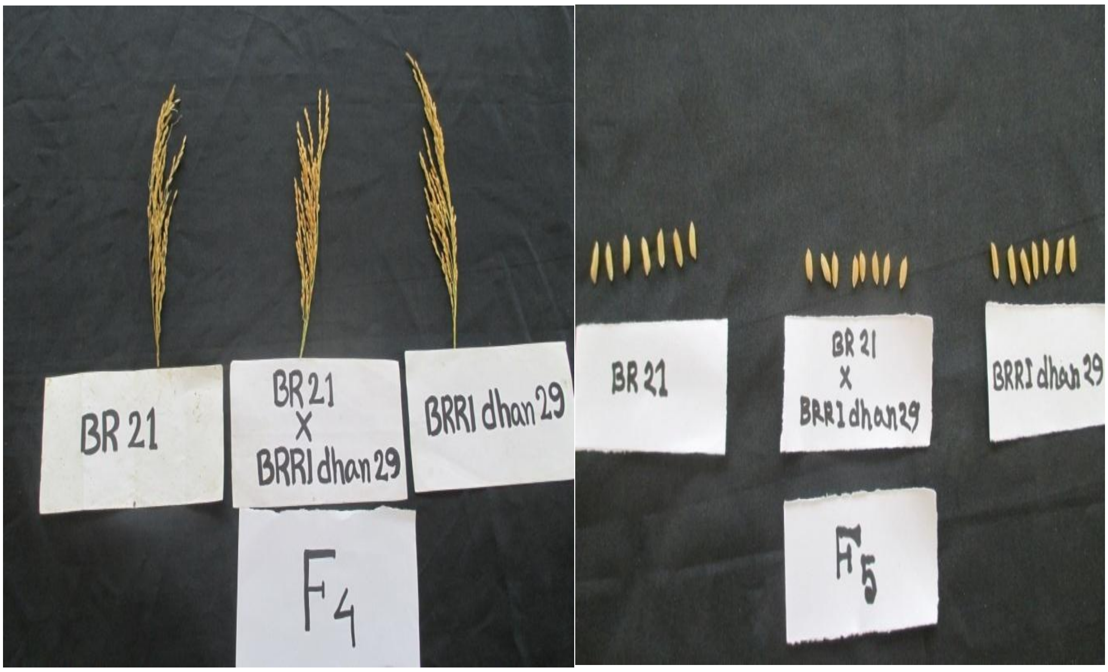


Plate 2b. Comparison of panicle length and grain size of G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) & BRRI dhan 29

Plate 3a. Comparison of days to maturity of G_9 (BR 21 × BRRI dhan 28, S-5, P-4) & BRRI dhan 28

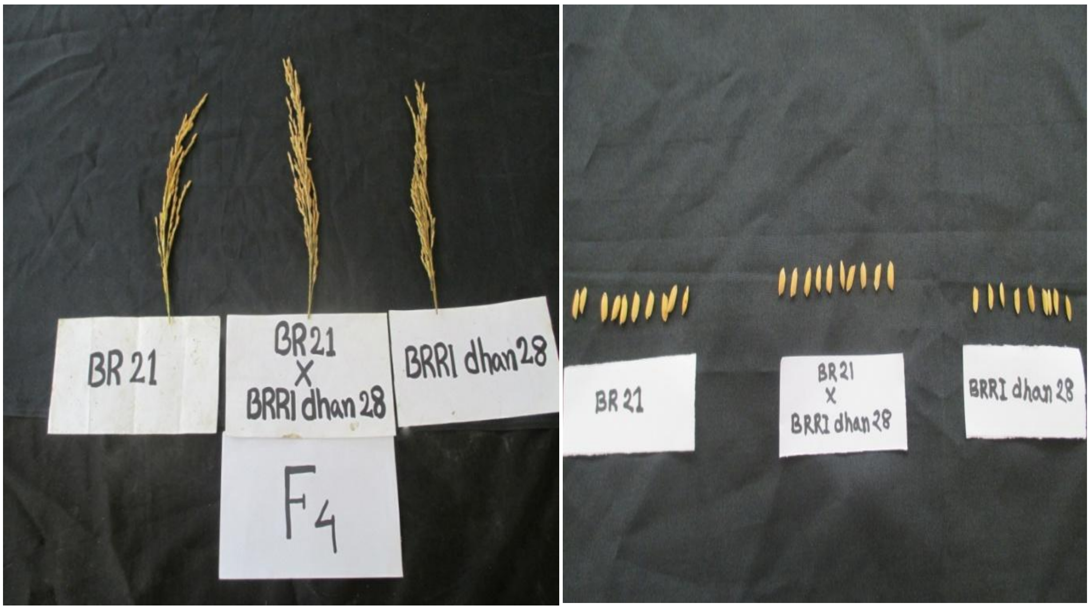


Plate 3b. Comparison of panicle length and grain size of G_9 (BR 21 × BRRI dhan 28, S-5, P-4) & BRRI dhan 28

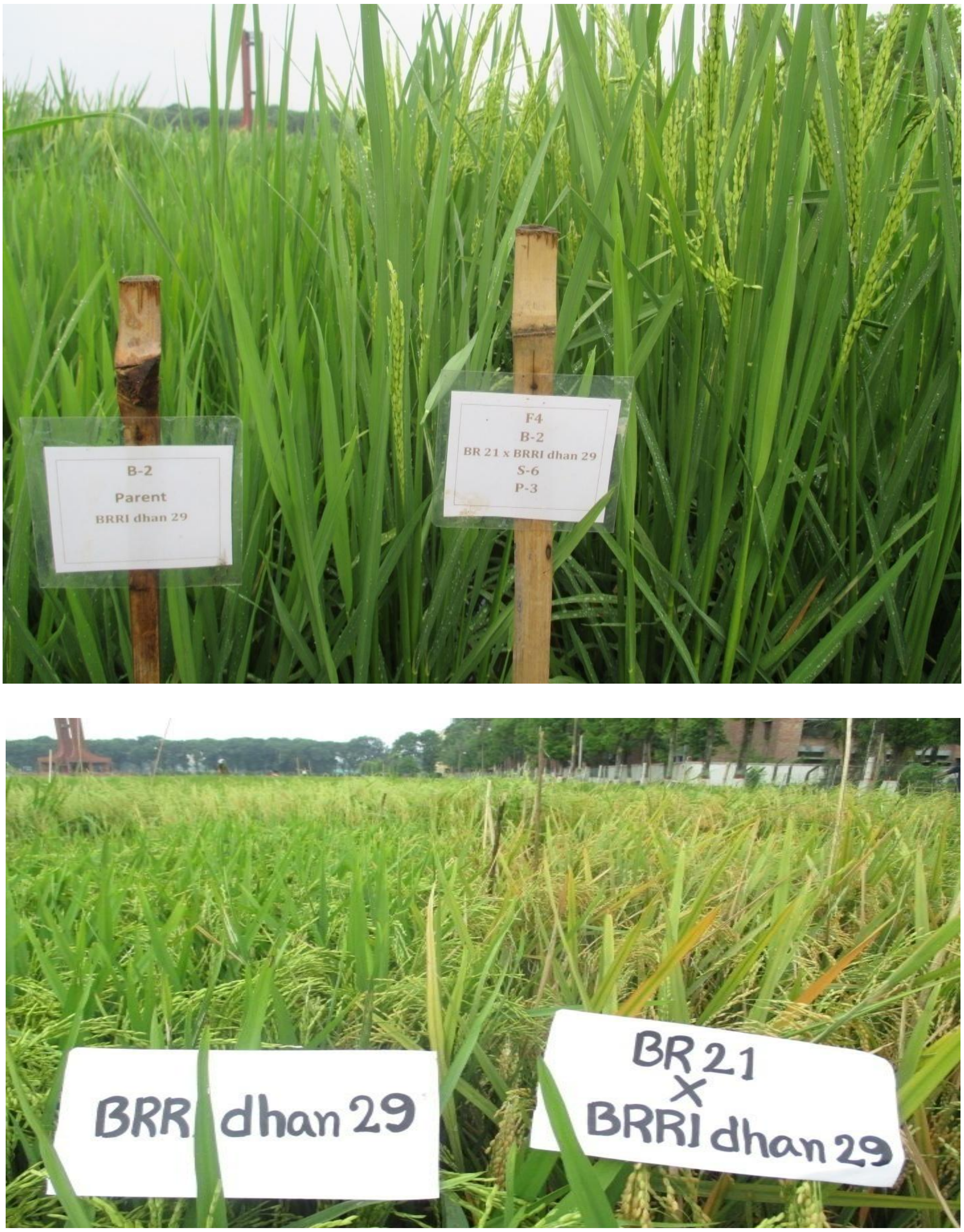


Plate 4. Comparison of days to maturity of G_{16} (BR 21 × BRRI dhan 28, S-6, P-6) & BRRI dhan 29

Plate 5. Comparison of days to maturity of G_{14} (BR 21 × BRRI dhan 29, S-6, P-4) & BRRI dhan 29

Genotype G_{27} (BR 24 × BRRI dhan 29, S-5, P-4) showed better performance as it required 145 days to maturity, had 20 effective tiller per plant, 202 total number of spikelet per panicle and 68 gram yield per plant (Table 8a) (Plate 6). On the other hand, check variety BRRI dhan 29 required 161.6 days to maturity, had 15.02 effective tillers per plant, 182.6 total number of spikelet per panicle and 41.91 gram yield per plant (Table 8b). As we say Genotype G_{27} (BR 24 × BRRI dhan 29, S-5, P-4) was better than the check variety BRRI dhan 29 aspect of maturity and yield.

Genotype G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) showed better performance as it required 139 days to maturity, had 14 effective tiller per plant, 274 total number of spikelet per panicle and 52.7 gram yield per plant (Table 8a) (Plate 7). It showed that it took 139 days to maturity but the check variety BRRI dhan 29 took 161.6 days (Table 8b) which indicating that, required time was lesser than the check variety. Again its yield per plant (g) was higher than the check variety. Therefore, Genotype G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) was selected as early high yielding boro lines.

Genotype G_{15} (BR 21 × BRRI dhan 29, S-6, P-5) showed better performance as it required 146 days to maturity, had 22 effective tiller per plant, 200 total number of spikelet per panicle and 64.3 gram yield per plant (Table 8a). On the other hand, check variety BRRI dhan 29 required 161.6 days to maturity, had 15.02 effective tillers per plant, 182.6 total number of spikelet per panicle and 41.91 gram yield per plant (Table 8b). So Genotype G_{15} (BR 21 × BRRI dhan 29, S-6, P-5) was better than the check variety BRRI dhan 29 aspect of maturity and yield (Table 8a and 8b).

Therefore, considering the variability, genetic parameter, heritability, correlation and path coefficient analysis seven (7) genotypes G_{17} (BR 21 × BRRI dhan 29, S-6, P-7), G_9 (BR 21 × BRRI dhan 28, S-5, P-4), G_{16} (BR 21 × BRRI dhan 29, S-6, P-6), G_{14} (BR 21 × BRRI dhan 29, S-6, P-4), G_{27} (BR 24 × BRRI dhan 29, S-5, P-4), G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) and G_{15} (BR 21 × BRRI dhan 29, S-6, P-5) were selected as early high yielding boro lines for future use.

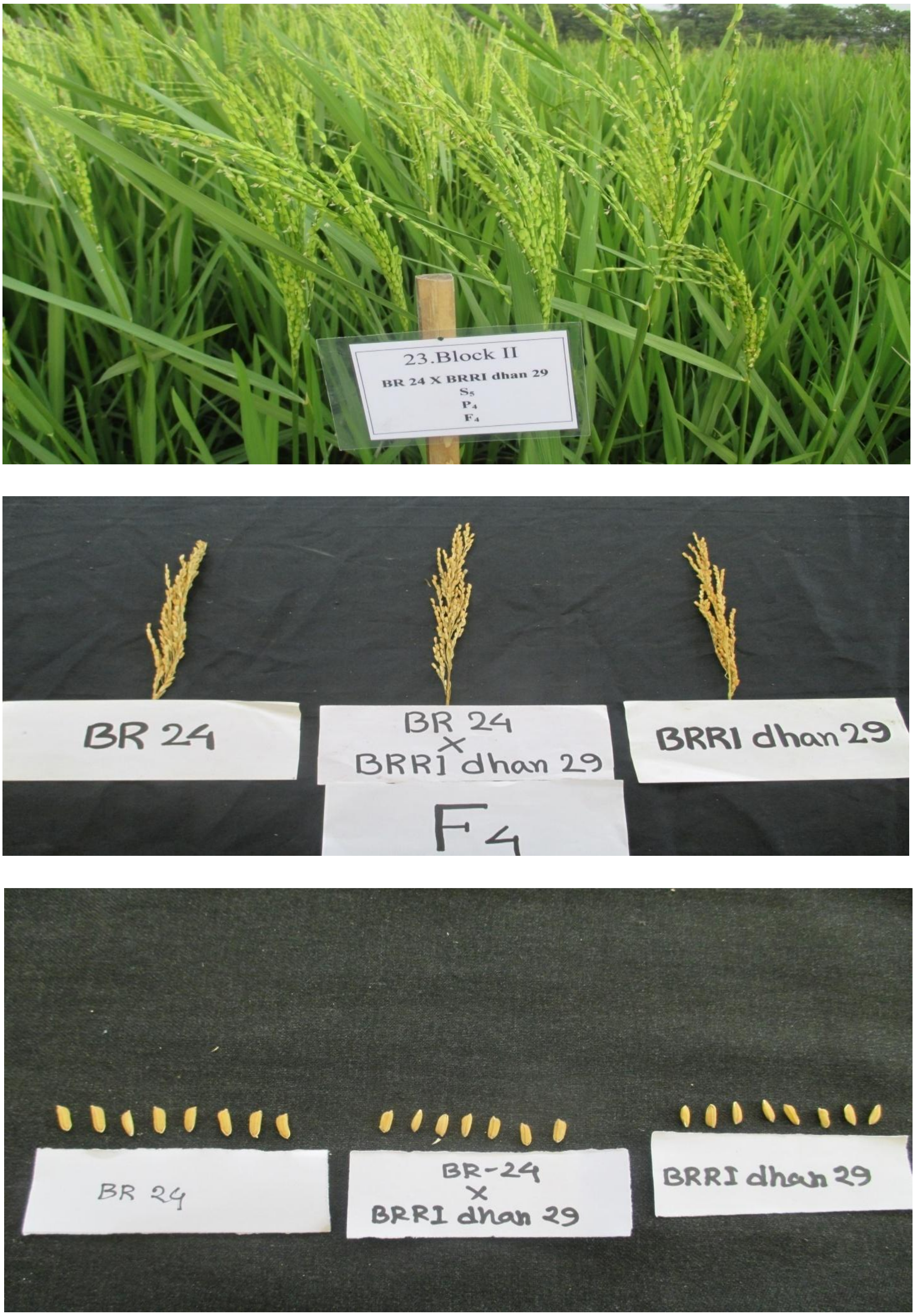


Plate 6. Comparison of days to maturity, panicle length and spikelet of G_{27} (BR 24 × BRRI dhan 29, S-5, P-4) & BRRI dhan 29

Plate 7. Comparison of days to maturity of G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) & BRRI dhan 29

CHAPTER V

SUMMARY AND CONCLUSION

The present study was undertaken with 27 genotypes (22 F_4 materials and 5 check varietis) of *Oryza sativa* L. at the Sher-e-Bangla Agricultural University Farm, Bangladesh during November 2013 to May 2014. Seedlings were transplanted in the main field in Randomized Complete Block Design (RCBD) with three replications. Data on various yield attributing characters such as, days to flowering, days to maturity, plant height (cm), total number of tiller /plant, total number of effective tiller/plant, panicle length (cm), number of primary branches per panicle, number of secondary branches per panicle, number of filled grain per panicle, number of unfilled grain per panicle, Yield/ Plant (gm), thousand seed weight (g) and yield (ton/ hectare were recorded.

From variability analysis of F_4 progenies, it was observed that significant variation existed among all the genotypes used for most of the characters studied. Plant height exhibited the highest plant height (133.9 cm) in G_{23} (BR 24 × BRRI dhan 28, S-10, P-2) where as the minimum plant height (91.69 cm) was observed in G_{21} (BR 21 × BRRI dhan 36, S-1, P-4). The days to flowering were observed the lowest (117.7 Days) in G_6 (BR 21 × BRRI dhan 28, S-5, P-1) and highest (122.7 days) was observed in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3). The lowest days to maturity (139.5 days) was observed in G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) and the maximum days to maturity (146.1days) was observed in G_{15} (BR 21 × BRRI dhan 29, S-6, P-5). The highest number of total tiller per plant (17.07) was observed in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3); whereas the minimum number of total tiller per plant (10.36) was observed in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7).The highest number of effective tiller per plant (16.53) was observed in G_{20} (BR 21 × BRRI dhan 36, S-1, P-3); whereas the minimum number of primary branches/plant (9.936) was observed in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7).

Length of panicle was observed the highest (27.04 cm) in G_6 (BR 21 × BRRI dhan 28, S-5, P-1) and the minimum length of panicle (21.36 cm) was observed in G_{21} (BR 21 × BRRI dhan 36, S-1, P-4). The highest number of primary branches per panicle (12.26) was observed in G_6 (BR 21 × BRRI dhan 28, S-5, P-1); whereas the minimum number of primary branches/plant (9.844) was observed in G_{14} (BR 21 × BRRI dhan 29, S-6, P-4). The highest number of secondary branches/plant (39.85) was observed in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7), whereas the minimum number of secondary branches/plant (26.90) was observed in G_{18} (BR 21 × BRRI dhan 36, S-1, P-1). The highest total number of spikelet per panicle (207.9) was observed in G_6 (BR 21 × BRRI dhan 28, S-5, P-1), whereas the minimum total number of spikelet per panicle (134.3) was observed in G_{19} (BR 21 × BRRI dhan 36, S-1, P-2) (134.3). The number of filled grain per panicle (189.60) was observed highest in G_{16} (BR 21 × BRRI dhan 29, S-6, P-6) and the minimum number of filled grain per panicle (133.4) was observed in G_{22} (BR 21 × BRRI dhan 36, S-1, P-5). The number of unfilled grain per panicle (33.60) was observed highest in G_{12} (BR 21 × BRRI dhan 29, S-6, P-2) and the minimum number of unfilled grain per panicle (12.37) was observed in G_{22} (BR 21 × BRRI dhan 36, S-1, P-5).

The yield per plant (47.87 gm) was found maximum in G_8 (BR 21 × BRRI dhan 28, S-5, P-3) whereas the minimum weight of yield per plant (28.19 gm) was found in G_{12} (BR 21 × BRRI dhan 29, S-6, P-2). Thousand seed weight (26.29 gm) was found maximum in G_7 (BR 21 × BRRI dhan 28, S-5, P-2) where as the minimum thousand seed weight (18.25 gm) was found in G_{26} (BR 24 × BRRI dhan 29, S-5, P-3). The highest yield (10.26 ton/ha) was recorded in G_{17} (BR 21 × BRRI dhan 29, S-6, P-7) and the minimum number of yield (7.281 ton/ha) was recorded in G_{23} (BR 24 × BRRI dhan 28, S-10, P-2).

However, the phenotypic variance and phenotype coefficient of variation were higher than the corresponding genotypic variance and genotypic coefficient of variation for all the characters under study. Number of filled grain per panicle and total number of spikelet per panicle showed higher influence of environment for the expression of these characters. Days to maturity and number of unfilled grain per panicle showed moderate influence of environment for the expression of these characters.

On the other hand, days to maturity, days to flowering, plant height, total number of tiller per plant, total number of effective tiller per plant, panicle length, number of primary branches per panicle, number of secondary branches per panicle, yield per plant, thousand seed weight and yield per hectare showed least difference phenotypic and genotypic variance suggesting additive gene action for the expression of the characters.

Days to maturity exhibits the highest value of heritability (97.91) while number of unfilled grain per panicle (58.99) exhibits the lowest value of heritability. High heritability with high genetic advance in percent of mean was observed for total number of tiller per plant, total number of effective tiller per plant, number of primary branches per panicle, total number of spikelet per panicle, number of filled grain per panicle, yield per plant, thousand seed weight and yield per hectare indicating that these traits were under additive gene control and selection for genetic improvement for these traits would be effective.

High heritability with moderate genetic advance was observed for days to flowering, days to maturity and panicle length indicating medium possibility of selecting genotypes. Number of secondary branches per panicle exhibited moderate heritability (58.99%) with and high genetic advance as percentage of mean (41.77%), such results revealed that this trait was controlled by non-additive gene. Number of unfilled grain per panicle exhibited moderate heritability (58.99%) with and high genetic advance as percentage of mean (41.77%), such results revealed that this trait was controlled by non-additive gene and not suitable for selection.

High heritability with low genetic advance in percent of mean was observed for days to plant height indicating that non-additive gene effects were involved for the expression of these characters and selection for such traits might not be rewarding.

Correlation coefficients among the characters were studied to determine the association between yield and yield components. In general, most of the characters showed the genotypic correlation co-efficient were higher than the corresponding phenotypic correlation co-efficient suggesting a strong inherent association between the characters under study and suppressive effect of the environment modified the phenotypic expression of these characters by reducing phenotypic correlation values.

Yield per hectare showed the highly significant and positive correlation with number of effective tiller per plant (G=0.396**), number of filled grain per panicle (G=0.375**), total number of spikelet per panicle (G=0.354**) and yield per plant (G=0.344**) at genotypic level. It had significant and positive correlation with days to maturity (G=0.326*, P=0.277*), panicle length (G=0.320*, P=0.297*), number of secondary branches per panicle (G=0.339*P=0.286*) and thousand seed weight (G=0.322*, P=0.272*). It also showed positive and correlation with plant height

(G=0.281*) and total number of tiller per plant (G=0.255*) at genotypic level. However it made positive and correlation with number of effective tiller per plant (P=0.288*) and yield per plant (P=0.288*) at phenotypic level. Again it showed highly significant and negative correlation unfilled grain per panicle (G= -0.398**) at genotypic level. It had significant and negative correlation with days to flowering (G=-0.271*) at genotypic level. Moreover, it showed insignificant and positive correlation with number primary branches per panicle (G=0.113, P=0.092). It also made insignificant and positive correlation with plant height (P=0.208), total number of tiller per plant (P=0.173), number of filled grain per panicle (P=0.251) and total number of spikelet per panicle (P=0.259) at phenotypic level. It had insignificant and positive correlation with days to flowering (P= -0.220) and unfilled grain per panicle (P= -0.206).

Path co-efficient analysis revealed that days to maturity, plant height, number of effective tiller per plant, number of filled grain per panicle, total number of spikelet per panicle, yield per plant and thousand seed weight had the positive direct effect on yield per hectare. Whereas, days to flowering, total number of tiller per plant, panicle length, number of primary branches per panicle, number of secondary branches per panicle and number of unfilled grain per panicle had the negative direct effect on yield per hectare.

The path coefficient and genotypic correlation studies indicated that number of effective tiller per plant, number of filled grain per panicle, total number of spikelet per panicle and yield per plant were the most important contributors to yield per hectare which could be taken in consideration for future hybridization program. Days to maturity, plant height, total number of tiller per plant, panicle length, number of secondary branches per panicle and thousand seed weight also were the important contributors to yield per hectare which could be taken in consideration for future hybridization program.

Therefore, considering the variability, heritability, correlation and path coefficient analysis, the seven (7) genotypes viz. G_{17} (BR 21 × BRRI dhan 29, S-6, P-7), G_9 (BR 21 × BRRI dhan 28, S-5, P-4), G_{16} (BR 21 × BRRI dhan 29, S-6, P-6), G_{14} (BR 21 × BRRI dhan 29, S-6, P-4), G_{27} (BR 24 × BRRI dhan 29, S-5, P-4), G_{15} (BR 21 × BRRI dhan 29, S-6, P-5), G_{13} (BR 21 × BRRI dhan 29, S-6, P-3) were selected as early high yielding Boro lines for future use.

REFERENCES

Abarshahr, M., Rabiei, B. and Lahigi, H.S. (2011). Genetic variability, correlation and path analysis in rice under optimum and stress irrigation regimes. *Not. Sci. Biol*. **3**(4): 134-142.

Agahi, K., Fotokian, M.H. and Farshadfar, E. (2007). Correlation and Path Coefficient Analysis for Some Yield-Related Traits in Rice Genotypes (*Oryza sativa* L.). *Asian J. Plant Sci.* **6**(3): 513-517.

Akinwale, M.G., Gregorio, G., Nwilene, F., Akinyele, B.O., Ogunbayo, S.A. and Odiyi, A.C. (2011). Heritability and Correlation Coefficient Analysis for Yield and Its Components in Rice (*Oryza sativa* L.). *African J. Plant Sci.* **5**(3): 207-212.

Akter, K., Habib, S.H., Bashar, M.K. and Nurunnabi, A.M. (2007). Genetic analysis and selection criteria in advanced breeding lines of deep water rice. *Bangladesh J. Plant Breed. Genet.* **20**(1): 39-45.

Allard, R.W. (1960). Principles of Plant Breeding. John Willey and Sons, Inc, New York. p. 36.

Alim, A. (1982). Bangladesh Rice. Alim publication, Dhaka. p. 30.

Amirthadevarathinam, (1983). Genetic variability, correlation and path analysis of yield components in upland rice. *Madras Agric. J*. **70**: 781-785.

Ananthi. N., Jebaraj, S. and Riwana, B. (2006). Variability studies in two-line rice (*Oryza sativa* L.) Indian J. Genet. Plant Breed. **7**(1): 140-142.

Anonymous. (1989). Annual Report of Bangladesh Agricultrural Research Institute. Joydebpur, Gazipur. p. 133.

Ashikari, M.H., Sakakibara, S. Lin, Yamamoto T. and Takashi T. (2005). Cytokinin oxidase regulates rice spikelet production. *Sci*ence. **309**: 741-745.

Ashvani, D.R., Panwar, P.S. and Kumar, V. (2007). Genetic variability and heritability studies in rice. *Int. J. Agric. Res*. **20**(1): 47-49.

Ashvani, D.R., Panwar, P.S. and Kumar,V. (2007). Path analysis of spikelet yield in rice (*Oryza sativa* L.). *Int. J. Agric. Res.* **20**(1): 27-28.

Ashvani, P., Shanna, R.K. and Panwae, A. (1997). Genetic variability and interrelationship in rice. *Adv. Plant Sci*. **10**(1): 29-32.

Atwal, D.S. and Singh, R.S. (2001). Genetic and variability and character association in semi-dwarf indica rice. *Madras Agril. J*. **87**(6): 183-191.

Awasthi, L.P. and Pandey, V.K. (2000). Genetic variation in morphological traits of aromatic rice. *Crop Res. Hisar*. **19**(2): 361-363.

Awasthi, L.P. and Sharma, A.K. (1996). Studies on morphological traits of aromatic rice (*Oryza sativa* L.). *New Agriculturist*. **7**(1):79-83.

Bai, N.R., Devika, R., Regina, A. and Joseph, C.A. (1992). Correlation of yield and yield components in medium duration rice cultivars. *Env. Ecol.* **10**(2):459-470.

Bansal, U.K., Saini, R.G., Rani, N.S. and Kuar, A. (1999). Genetic divergence in quality rice *Oryza sativa.* **36**(1): 20-23.

BES (Bangladesh Economic Survey). 2014. p.95.

BES (Bangladesh Economic Survey). 2014. p.312.

Bhuiyan, N.I., Paul, D.N.R. and Jabbar, M.A. (2002). Feeding the extra millions by 2025 challenges for rice research and extension in Bangladesh. A key note paper presented on national workshop on rice research and extension 2002. Held on 29-31 January, 2002, BRRI. p. 9.

Bidhan, R., Hossain, M., Hossain, F. and Roy, B. (2001). Genetic variability in yield components of rice (*Oryza sativa*). *Env. Ecol*. **19**(1): 186-189.

Bihari, P.K., Richharia, A.K. and Sahu, R.S. (2004). Genetic advance for yield attributes in aromatic rice. *J. App. Biol*. **14**(2): 1-5.

BINA (Bangladesh Institute of Nuclear Agriculture). (1993). Annual Report for 19992-93. Bangladesh Inst. Nuclear Agric. P.O. Box No. 4. Mymensingh. p. 143.

Bisne, R., Sarawgi, A.K. and Verulkar S.B. (2009). Study of heritability, genetic advance and variability for yield contributing characters in rice. *Bangladesh J. Agril. Res.* **34**(2): 175-179.

BRRI (Bangladesh Rice Research Institute). (1997). Annual report for 1996. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. p. 8-15.

BRRI (Bangladesh Rice Research Institute). (1995). Annual report for 1992.BRRI pub No. 79. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. p. 237.

BRRI (Bangladesh Rice Research Institute). (1999). Adhunik Dhaner Chash. Bangladesh Rice Res. Ins. Joydebpur, Gazipur, Bnagladesh, pp.5-9.

BRRI (Bangladesh Rice Research Institute). (1989). Adhunik Dhaner Chash. Bangladesh Rice Res. Ins. Joydebpur, Gazipur, Bnagladesh, p. 9.

BRRI (Bangladesh Rice Research Institute). (2012). Adhunik Dhaner Chash, Jodebpur, Gazipur. p. 10.

Burton, G.W. (1952). Quantitative inheritance in grass pea. Proc. 6^{th} grassl. Cong. **1**: 277-283.

Chakraborty, S. and Hazarika, M.H. (1994). Association analysis between spikelet yield and its components in rice *Oryza sativa.* **31**: 263-265.

Chanbeni Y., Ovung, G.M. Lal and Rai, P.K. (2012). Studies on genetic diversity in Rice (*Oryza sativa* L.). *J. Agril. Tech.* **8**(3): 1059-1065.

Chand, S.P., Roy, S.K., Mondal, G.S., Mahato, P.D., Panda, S., Sarker, G. and Senapati, B.K. (2004). Gentic variability and character asociation in rainfed lowland Aman paddy (*Oryza sativa* L.). *Env. Ecol*. **22**(2): 430-434.

Chaubey, P.K. and Singh, R.P. (1994). Genetic variability, correlation and path analysis of yield components of rice. *Madras Agril. J.* **81**(9): 468-470.

Chaubey, P.K. and Richharia, A.K. (1993). Genetic variability, correlations and path-coefficients in *indica* rices. *Indian J. Genet. Plant Breed.* **53**(4): 356-360.

Chauhan, J.S., Chauhan, V.S. and Variar, M. (1993). Genetic variation and character association in rainfed upland rice *Oryza sativa*. *J. Rice Res.* **5**: 24-29.

Chen, L., Sun, C.Q., Li, Z.C. and Wang, X.K. (2000). Study on heterotic ecotype of two-line japonica hybrid rice in north China. *J. China. Agric. Univ.* **5**(3): 30-40.

Chen, X. and Hong, D. (2006). Yield performance of F_2 generation and genetic analysis on plant height in hybrid rice. *Hybrid Rice*. **21**(4): 64-68.

Choi, H.C., Chi, J.H. and Cho, S.Y. (1999). Varietal difference in water absorption characteristics of milled rice and its relation to the other spikelet quality components. *Korean J. Crop. Sci*. **44**(3): 288-295.

Choudhury, P. K. D. and Das, P. K. (1988). Genetic variability, correlation and path co-efficient analysis in deep water rice. *Ann. Agril. Res*. **19**(2): 120-124

Chowdhury, M.J.U., Sarker, A.U., Sarker, M.J.R. and Kashem, M.A. (1993). Effect of variety and number of seedlings per hill on the yield and its components on late transplanted aman rice. *Bangladesh J. Agril. Sci*. **20**(2): 311-316.

Clarke, G.M. (1973). *Statistics and Experimental Design*. Edward Arnold. London.

Comstock, K. and Robinson, P.R. (1952). Estimation of genetic advance. *Indian J. Hill*. **6**(2): 171-174.

Das, R.K., Islam, M.A., Howlader, M., Ibrahim, S.M., Ahmed, H.U. and Miah, N.M. (1992). Variability and genetic association in upland rice (*Oryza sativa* L.). *Bangladesh J. Plant Breed. Genet.* **5**(1& 2): 51-56.

Debi, B.R. Ray, P.K. S. and Howladar, M. (1997). Variability and genetic association in irrigated field rice. *J. Biosci. Agric. Res*. **8** (1 & 2): 165-168.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of creast wheat grass seed production. *Agron. J. Hort.* **57**(4): 342-346.

Dabholkar, A.R. (1992). *Elements of Biometrical Genetics*. Concept Publishing, New Delhi, India.

Dhanwani, R.K., Sarawgi, A.K., Solanki, A and Tiwari, J. K. (2013). Genetic variability analysis for various yield attributing and quality traits in rice (*O. sativa* L.). *Bios. Int. Q. J. Life Sci.* **8**(4):1403-1407.

Diaz, S.H., Castro, R. and Morejon, R. (2000). Morpho-agronomic characterization of varieties of rice. Instituo Nacion*al.* De ciencias.

Dutta, P., Dutta, P.N. and Borua, P.K. (2013). Morphological traits as selection indices in rice: A statistical view. *Uni. J. Agril. Res.* **1**(3):85-96.

Dutta, R.K. and Khanam, S. (2002). Plant architecture and growth characteristics of fine spikelet aromatic rice and their relation with grain yield. *IRC Newsl*. **5(1)**: 51-56.

Edris, K.M., Islam, A.T.M.T., Chowdhury, M.S. and Haque, A.K.M.M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. p. 118

Fageria, N.K., Stalon, N.A. and Baligar, V.C. (2003). Nutrient management for improving lowland rice productively and sustainability. *Adv. Agron*. **80**: 63-152.

Fang, P. and Wu, P. (2001). QTL x N- Level interaction for plant height in rice (*Oryza sativa* L.). *Plant Soil*. **236**(2): 237-242.

Futsuhara, Y. and Kikichi, F. (1994). Gene analysis for agronomic traits. **In**: Biology of rice S. Tsunoda and N. Takahashi (ed). *Japan Sci. Soc. Press*. pp. 275-291.

Gallagher, J.N. and Biscoe, P.V. (1978). Radiation absorption, growth and yield of cereals. *J. Agril. Sci*. **91**: 47-60.

Ghosal, S., Biswas, P.L., Khatun, M. and Khatun, S. (2010). Genetic variability and character associations in irrigated rice (*Oryza sativa* L.) *Bangladesh J. Plant Breed. Genet*. **23**(2): 23-27.

Ghose, R.L.M. and Ghatge, M.B. (1960). Rice in India. *Karnataka J. Agric. Sci.* **8**(2):32.

Ghosh, P.K. and Hossain, M. (1988). Genetics evaluation and regression analysis of yield and yield attributes in rice (*Oryza sativa). Indian J. Agril. Sci.* **25**: 485-509.

Ghosh, A.K., Bhattacharya, P.K. and Asthana, A.N. (1981). Genetic variability in indigenous rice varieties of Meghalaya. *Indian J. Agril. Sci*. **51**(5): 281-283.

Gomez, S.M. and Kalamani, A. (2003). Scope of land races for future drought tolerance bredding programme in rice (*Oryza sativa* L.). *Plant Archiv*. **3**(1): 77-79.

Gomosta, A.R., Quayyum, H.A. and Mahbub, A.A. (2006). Tillering , duration and yielding asbility of rice varieties in the winter rice season of bangladesh. Rice research for food security and poverty alleviation-Pocedings of the International Rice Research Conference.

Grafius, J.E. (1964). A geometry of plant breeding. *Crop Sci*. **4:** 241-246.

Guimara, E.P. (2002). Genetic diversity of rice production in Brazil. **In**: V.N. Nguyen, (ed.) Genetic diversity in rice production, Case studies from Brazil, India and Nigeria. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. pp. 11-35.

Guo-Long, B., Luo-Li, J., Xing-Yong, Z., Wang-Yi, P., Mei-Han,W., Qian-Qian, Y. and Cun, S. (2002). Path anlysis for spikelet yield and its components in rice. CNRRI, Hangzhou 310006. *China Rice Res. Newsl*. **10**(2): 5-6.

Habib, S.H., Bashar, M.K., Khalequzzaman, M., Ahmed, M.S. and Rashid, E.S.M.H. (2005). Genetic analysis and Morpho-physiological selection criteria for traditional Biroin Bangladesh rice gramplasms. *J. Biol. Sci*. **5**(3): 315-318.

Haque, M.E., Baset, A., Zeenat, Z. and Miah, N.M. (1991). Path coefficient analysis of seven characters in local tolerant rice. *Bangladesh Rice J.* **2**(1&2): 1-7.

Hasan, M.J., Kulsum, A., Masuduzzaman, A.S.M. and Ramesha, M.S. (2011). Genetic variability and charcter association for agronomic traits in hybrid rice (*Oryza saiva* L.). *Bangladesh J. Plant Breed. Gene.* **24**(1): 45-51

Hemareddy, H.B., Manjunath, A. and Shadakshari, Y.G. (1994). Genetic variability for spikelet yield and its components in the hill zone rice *(Oryza sativa L.)* of Karnataka. *Himachal J. Agril. Res.* **20** (1-2): 75-77.

Hooker, J.D. (1979). The flora of British India. Reeve Co. Kent, England. **2**: 110-115.

Honarnejad, R., AbdollahiS., Salehi M.S.M. and Dorosti H. (2000). Consideration of adaptability and stability of spikelet yield of progressive rice (*Oryza sativa* L.) lines. *Res. Agric. Sci*. **1**:1-9.

Honarnejad, R. and Tarang, A. (2001). Gene effect in controlling quantitative characteristics in rice (*Oryza sativa* L.). *Iranian J. Agril. Sci.* **32**(2): 263-273.

Honarnejad, R. (1995). Study on combining ability and correlation among some morphological characters in six indica rice genotypes. *Seed plant.* **11**(4): 37-52.

Iftekharudduaula, K.M., Badshah, M.S., Hassan, M.S., Basher, M.K. and Akter, K. (2001). Genetic variability, character association and path analysis of yield components in irrigated rice (*Oryza sativa* L.) *Bangladesh J. Plant Breed. Genet*. **14**(2): 43-49.

Ingale, B.V., Waghmode, B.D., Dalvi, V.V. and Rewale, A.P. (2007). Effect of seedling age on flowering of parental lines of Sahyadri rice hybrid. *Crop Improve.* **34**(2): 145-148.

Islam, M.S., Kabir, M.H., Bashar, M.K. (2004). Inheritance of plant height in aromatic rice. *J. Subtrop. Agril. Res. Dev*. **2**(3): 67-71.

Islam, M.S. and Roy, M. (2012). Bigganvittik Dhan Chash. Dhaka. p.7.

Jangale, R.D., Sangave. R.A., Ugale, S.D. and Dumbre, A.D. (1985). Studies on variability, heritability and genetic advance for some quantitative characters in upland paddy. *J. Maharashtra Agril. Univ*. **10**(1): 69-70.

Jiang, G., Zhu, V. and Zhau, K.L. (2002). Study of genetic variability and correlation in some elite breeding lines of rice. *Heriditas China.* **23**(4): 39-41.

Jiang, Z.X., Huang, Z.Q., Li, Y.S., Lou, Z.X. and Shi, F.Z. (2000). Relationship between quantative and qualitative traits of population in hybrid rice. *Chinese J. Rice. Sci*. **143**(3): 179-182.

Jennings, P.R., Coffman, W.R. and Kauffman, H.E. (1979). Rice Improvement. IRRI, Manila, Philippines. p.186.

Johnson, H.W., Robinson, H.W. and Comstock, R.I. (1955). Estimates of genetic and environmental variability in soybean. *Agron. J.* **47**(2): 314-318.

Jones, D.B. and Synder, G.H. (1987). Seeding rate and row spacing effects on yoeld and yield components of ratoon rice. *Agron. J*. **79**:291-297.

Kamal, A.M.A., Azam, M.A. and Islam, M.A. (1998). Effect of cultivar and NPK combination of the yield contributing characters of rice. *Bangladesh J. Agril. Sci*. **15**(1): 105-110.

Karad, S.R. and Pol, K.M. (2008). Character association, genetic variability and path-coefficient analysis in rice (*Oryza sativa* L.). *Int. J. agric. Sci.* **4**(2): 663-666.

Karim, D., Sarkar, U., Siddique, M.N.A., Khaleque, M.A. and Hasnat, M.Z. (2007). Variability and Genetic Parameter Analysis in Aromatic Rice. *Int. J. Sustain. Crop Prod.* **2**(5): 15-18.

Kaul, M. L. M. and Kumar, V. (1982). Genetic divergence in rice. *Annals of Biology*. **15**(1): 35-39.

Kaw, R.N., Aquino, R.C., Moon, H.P., Yae, S.D. and Haq, N. (1999). Variability and interrelationship in rice under cold stress environments (*Oryza saiva)*. *Indian J. Genet.* **36(**1): 14.

Ketan R. and Sarker G. (2014). Studies on variability, heritability, genetic advance and path analysis in some indigenous *Aman rice* (*Oryza sativa* L.). *J. Crop Weed*. **10**(2): 308-315.

Kihupi, A.N. and Doto, A.L. (1989). Genotypic and environmental variability in selected rice characters (*Oryza sativa).). Indian J. Genet.* **26**(2): 129-134.

Kishore, N.S., Ansari, N.A., Babu, V.R., Rani, N.S., Rao, L.V.S. and Ravi C. (2007). Correlation and path analysis in aromatic and non -aromatic rice genotypes. *Agril. Sci. Dig.* **27**(2): 122-124.

Kole, P.C., Chakraborty, N.R. and Bhat, J.S. (2008). Analysis of variability, correlation and path coefficients in induced mutants of aromatic non-basmati rice. *Trop. Agric. Res. Ext.* **11**: 60-64.

Kumar, R., Krishanpal, M., Modal, S.K., Ramashankar, R., Prasad, S.C. and Rai, R. (1994). Genetic studies of major character in upland rice. *Env. Ecol.* **12**(2): 363-365.

Kumar, M. 2001. Variability and correlation studies in rice under rainfed lowland condition. *J. App. Biol.* **14**(2): 6-10.

Kumari, R.U., Rangasamy, P. and Gomez, S.M. (2003). Phenotypic differentiation in *indica-japonica* wide compatible varieties in rice (*Oryza sativa* L.). *Plant Archives*. **3**(1): 141-142.

Li, Q.L., Guo, G.Z., Jiang, G. and Zhu, V. (1991). Study on high yield breeding and genetic analysis of yield components of main rice cultivars in Jilin. *Heriditas China*. **13**(5): 3-6.

Li, Y.C. and Yuan, L.P. (1998). Genetic analysis of fertility restoration in male sterile line of rice. In: Rice Genetics IRRI, Philippines. pp. 67-632.

Liu, W., Shi, Y., Liu, W. and Shi, Y.L. (2001). Preliminary reprot on heterosis of japonica hybrid rice in Ningxia. *Agril. Fores. Sci.* **12**(2): 551-555

Loknathan, T.R., Sakhare, R.S., Kamble, T.C. and Maheshwari, I.J. (1991). Genetic varibilty and heritability in upland rice (*Oryza sativa* L.). *J. Soils Crops*. **1**(2): 150-153.

Mahto, R.N., Yadava, M.S. and Mohan, K.S. (2003). Genetic variation, Character association and Path analysis in rain fed upland rice. *Indian J. Dryland Agril. Res. Dev*. **18**(2): 196-198.

Majumder, K.K., Dey, R.N. and Banerjee, S.P. (1971). Studies on genetic variability in some rice varieties. *Indian J. Agril. Sci*. **15**(1-2): 191-198.

Manual, W.W. and Prasad, M.N. (1993). Genetic variability in medium duration rice *Oryza sativa.* **30**: 355-356.

Mani, S.C., Verma, S.K. and Sharma, R.K. (1997). Genetic variability and character association for panicle traits in Basmati rice. *Agril. Sci. Dig. Karnel*. **17**(3): 155-157.

Mauray, D.M., Singh, S.K. and Singh, R.S. (1986). Genetic variability in 48 lowland rice cultivar of Uttar Pradesh. *Indian Int. Rice Res. Newsl*. **11**(4):13.

Mehertre, S.S., Mahajan, C.R., Pan, P.A., Lad, S.K. and Dhumal, P.M. (1994). Variability, heritability, correlation, path analysis and genetic divergence studies in upland rice. *Int. Rice Res. Newsl.* ***19*** (*1): 8.*

Miller, P.J., Williams, J.C., Robinson, H.F. and Comstock, R.E. (1995). Estimation of genotypic and environmental variance and co-variance in upland rice and their implications in selection. *Agron. J.* **50**: 126-131.

Mishra, D., Mishra, N.C., Das, G.B. and Patra, G.J. (1996). Genetic variability, interrelationship and performance of some scented rice genotypes. *Env. Ecol.* **14**(1): 150-153.

Mishra, D. and Dash, S.K. (1996). Genetic diversity and stability in aromatic rice (*Oryza sativa* L.). *Indian J. Agric. Sci*. **67**(1): 27-32.

Mishra, L.K. and Verma, R.K. (2002). Correlation and Path co-efficient analysis for morphological and quality traits in rice (*Oryza sativa* L.). *Plant Sci*. **16**(1): 251-256.

Mustafa, M.A. and Elsheikh, M.A.Y. (2007). Variability, Correlation and Path Co-Efficient Analysis for Yield and its Components in Rice. *African Crop Sci. J.* **15**(4): 183-189.

Nandeshwar, B.C., Senapati, B.K. and De, D.K. (2010). Genetic variability and character association among Biometrical Traits in F_2 generation of some rice crosses. *Electronic J. Plant Breed*. **1**(4): 758-763.

Narendra, C. and Reddy, R. (1997). Variability and heritability in hybrid genotypes of rice. *Agric. Sci. Dig.* **17**(2): 139-140.

Nayak, A.R., Chaudhury, D. and Reddy, J.N. (2001). Correlation and path-analysis in scented rice (*Oryza sativa* L.). *Indian J. Agril. Res.* **35**(3): 186-189

Neerja, S. and Sharma, N. (2002). Quality characteristics of no-aromatic and aromatic rice (*Oryza sativa*) varieties of Punjab. *Indian J. Agric. Sci*. **27**(7): 408-410.

Padmaja, D., Radhika, K., Rao, S.L.V. and Padma, V. (2008). Studies on variability, heritability and genetic advance for quantatitive characters in rice (*Oryza sativa* L.). *J. Plant Rer*. **21**(3): 196-198.

Padmavathi, N., Mahadevappa, M. and Reddy, O.U.R. (1986). Associations of various yield components in rice (*Oryza sativa* L.) *Crop Res. Hisar*. **12**(3): 353-357.

Palaniswamy, K.M. and Kutty, K.K. (1990). Effect of tiller height and flowering duration on panicle length in 3 rice varieties *Oryza sativa*. **27**(4): 433-435.

Pandey, V.K. and Awasthi, L.P. (2002). Studies on genetic variability for yield contributing traits in aromatic rice. *Crop Res. Hisar*. **23**(2): 214-218.

Patil, P.V., Saragi, A.K. and Sharivastava, M.N. (2003). Genetic analysis of yield and quality traits in traditional aromatic rice accessions of rice. *J. Maharashtra Agril. Univ*. **28**(3): 255-258.

Patil, P.V. and Sarawgi, A.K. (2005). Studies on genetic variability, aromatic rice accessions. *Ann. Plant Physiol*. **19**(1): 92-95.

Patnaik, R.N., Pande, K., Ratho, S.N. and Jachuk, P.J. (1990). Heterosis for yield and yield contributing characters in upland rice. *GAU Res. J.* **20**(1): 162-163.

Pattanyak, A. and Guota, H.S. (1999). Genotypic variability and character association in upland rice genotypes development through anther culture for mid altitude areas of Meghalaya. *Ind. J. Hill Farm*. **12**(2): 100-105.

Paul, S.K. and Sarmath, A.K. (1997). Interrelationship of yield and yield contributing charcters in upland aus rice. *J. Agril. Sci. Soc. North- East India*. **10**(2): 164-167.

Peng-Tao, Zhong-Bing-Qiang, Ling-Ying-Hua, Yang-Zheng-Lin, Zha-Ren-Ming, Xie-Rong, Liu-Cheng-Yuan and He-Guang-Hua. (2009). Developmental genetics analysis for plant height in indica hybrid rice across environments. *Rice Sci*. **16**(2): 111-118.

Purseglove, J.W. (1985). Tropical Crops: Monocotyledons. Vol. 1 and 2 comb. English Language Book Society/ Longman, England. p.168.

Prasad, B., Patwary, A.K. and Biswas, P.S. (2001). Genetic Variability and Selection Criteria in Fine Rice (*Oryza sativa* L.). *Pakistan J. Biol. Sci.* **4**(10): 1188-1190.

Rajesh, S. and Singh, R. (2000). Heterosis studies in rice using `WA' based CMS system for developing hybrids for eastern Uttar Pradesh. *Ann. Agric. Res.* **21**(1): 79-83.

Rangare, N.R., Krupakar, A., Ravichandra, K., Shukla, A.K. and Mishra, A.K. (2012). Estimation of Characters Association and Direct and Indirect Effects of Yield Contributing Traits on Grain Yield in Exotic and Indian Rice (*Oryza Sativa* L.) Germplasm. *Int. J. Agric. Sci.* **2**(1): 54-61.

Ray, J.K. (1985). Introduction to Botany of the Rice Plant. 2nd Ed, p. 5. Rice Research Institute in India. Indian Council of Agricultural Research, New Delhi, India.

Reddy, Y.S. and Kumar, P.V.R. (1996). Studies on genetic variability, correlation and path analysis in rice. *New Botanist*. **23**(1-4): 129-133.

Rita, B., Sarawgi, A.K. and Verulkar, S.B. (2009). Study of heritability, genetic advance and variability for yield contributing characters in rice. *Bangladesh J. Agril. Res*. **34**(2): 175-179.

Rokonuzzaman, M., Zahangir, M.S., Hussain, I. and Hossain, S. (2008). Genotypic variability of the components and their effects on the rice yield: correlation and path analysis study. *Italian J. Agron.* **3**(2): 131-134.

Rothschild, G.H.I. (2007). Introduction: IRRI's role and vision for hybrid rice. Advances in hybrid rice technology. Proc. 3rd inter. Sympo. on hybrid rice. pp.1.

Roy, P.C., Rasul, M.G., Mian, M.A.K. and Molla, M.A.H. (2011). Genetic variability of rice genotypes (*Oryza sativa* L.). *Bangldesh J. Pl. Breed.Genet*. **24**(2): 31-35.

Roy, A., Panwar, D.V.S. and Sarma, R.N. (1995). Genetic variability and causal relationship in rice. *Madras Agril. J.* **82**(4): 251-255.

Sadeghi, S.M. (2011). Heritability, Phenotypic Correlation and Path Coefficient Studies for Some Agronomic Characters in Landrace Rice Varieties. *World Appl. Sci. J.* **13**(5): 1229-1233.

Saha Ray, P.K., Nahar, K., Ahmed H.U., Miah, N.M. and Islam M. A. (1993). Genetics varibility and charcter association in irrigated rice. *Bangladesh J. Pl. Breed. Genet.* **6**(1): 69-74.

Sangeeta M., Girl, D.G., Jahagirdar, S.W., Giri, M.D. and Mahitkar, S. (2000). Correlation studies in upland rice. *Annals plant physiol.* **14**(2): 195-197.

Sanjeev, S. (2005). Genetic analysis of creation mutant lines of Bashmati rice in M_3 Generation. *Crop Res. Hisar*. **29** (3): 462-465.

Sankar, P.D., Sheeba, A. and Anbumalarmathi, J. (2006). Variability and character association studies in rice (*Oryza sativa* L.). *Agric. Sci. Dig*. **26**(3): 182-184.

Sarathe, M.L., Sharma, K.K. and Shrivastara, M.N. (1969). Study of yield attributes and heritability in some varieties of rice (*Oryza sativa* L.). *Indian J. Agric. Sci*. **39**: 925-929.

Sarma, M.K. and Bhuyan, J. (2004). Genetic variability and divergence studies in Aus rice (*Oryza sativa* L.). *Adv. Plant Sci.* **17**(1): 323-328.

Satheeshkumar, P. and Saravanan, K. (2012). Genetic variability, Correlation and Path Analysis in Rice (*Oryza sativa* L.). *Int. J. Curr. Res*. **4**(9): 82-85.

Satyanarayana, P.V., Srinivas, T., Reddy, P.R., Madhavilatha, L. and Suneetha, Y. (2005). Studies on Variability, correlation and path coefficient analysis for restorer in rice (*Oryza sativa* L.). *Res. Crops*. **6**(1): 80-84.

Satyavathi, C.I., Bharadwaj, C. and Subramanyam, D. (2001). Vraiability, correlation and path analysis in rice varieties under different spacing. *Indian J. Agril. Res.* **32**(2): 79-84.

Sawant, D.S., Patil, S.L. and Sodaye, V.V. (1994). Genetic variability and heritability and heritability in segregation of rice crosses. *Ann. Agril. Res*. **16**(2): 201-205

Sawant, D.S. and Patil, S.L. (1995). Genetic variability and heritability in rice. *Ann. Agril. Res.* **16**(1): 59-621.

Sawant, D.S., Patil, S.L. and Bhave, S.G. (1994). Variability, heritability and genetic advance in pure lines of low land rice. *Ann. Agril. Res.* **15**(1): 27.

Seyoum, M., Alamerew, S. and Bantee, K. (2012). Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice (*Oryza sativa* L.). *J. Plant Sci.* **25**(3): 1-10.

Shamsuddin, A.M.; Islam, M.A. and Hossain, A. (1988). Comparative study on the yield and agrononmic characters of nine cultivars of Aus rice. *Bangladesh J. Agril. Sci*. **15**(1): 121-124.

Shanthi, P. and Singh, J. (2001). Variability studies in induced mutants of Mahsuri rice (*Oryza sativa* L.). *Madras Agril. J.* **88**(10-12): 707-709.

Sharma, S.K. and Haloi, B. (2006). Characterization of crop growth variables in some scented rice cultivars of Assam. *Indian J. Plant Physiol.* **6**(2): 166-171

Shashidhar, H.E., Pasha.F., Nanjunath, J., Vinlod, M.S. and Kanbar, A. (2005). Correlation and path co-efficient analysis in traditional cultivars and doubled haploid lines of rain fed lowland Rice (*Oryza sativa* L.). *J. Agric.* **42**(2): 156-159.

Siddique, S., Hassan, G., Ahmed, S.Q. and Farhad, A. (2002). Genotypic performance of rice in Pakhal plains of Mansehra, Sarhad. *J. Agric*. **18**(1): 49-52.

Singh, A.K., Sharma, P. and Singh, P.K. (2013). Studies on genetic characteristic of upland rice (*Oryza sativa* L.). *Int. J. Agril. Env. Biot*. **6**(4): 515-520.

Singh, S.K., Singh, C.M. and Lal, G.M. (2011). Assessment of genetic variability for yield and its component characters in rice (*Oryza sativa* L.). *Res. Plant Bio.* **1**(4): 73-76.

Singh, S.P., Singh, R.P., Srinivasulu, K. and Prasad, J.P. (2006). Studies on genetic variability, character association in diverse lines of international irrigated observation nursery of rice (*Oryza sativa* L). *Res. Crops*. **7**(3): 714-719.

Singh, R.S., Chauhan, S.P. and Mayrya, D. M. (1986).Genetic variability in 98 upland rice cultivars of India. *Int. Rice. Res. Newsl.* **14**(4): 9-10.

Singh, R.K. and Omkar, S. (2006). Inheritance of scent in long spikelets rice genotypes. *Ann. Agril. Res*. **27**(2): 193-194.

Singh, S. and Gangwar, B. (1989). Comparative studies on production potentials in traditional tall and improved rice cultivars. *J. Andaman Sci. Assoc*. **5**(1): 811-821.

Singh, S. and Chaudhury, B.S. (1996).Variability, heritability and genetic advance in cultivars of rice. *Crop Res. Hisar*. **12**(2): 165-167.

Singh, R.K. and Chaudhury, B.D. (1985). Biometrical Method in Quantitative Genetics Analysis (rev.ed.). Kalyain Publishers, New Delhi, India, pp. 78-85.

Singh, L., Singh, J.D. and Sachan, N.S. (2002). Inter character association and path analysis in paddy (*Oryza sativa* L.). *Ann. Bio*. **18**(2): 125-128.

Singh, R.S., Chauhan, S.P. and Mayrya, D.M. (1986). Genetic variability in 98 upland rice cultivars of India. *Int. Rice. Res. Newsl.* **14**(4): 9-10.

Sinha, T.S. and Bhattachrya, R.K. (1980). Note on genetic variability in Sundarban rice varieties under saline soil. *Int. J. Agril. Sci*. **50**(9): 719-721.

Sohrabi, M., Rafii, M.Y., Hanafi, M.M., Akram, A.S.N. and Latif, A. (2012) .Genetic diversity of upland rice germplasm in Malaysia based on quantitative traits. *Sci. World. J.* **3**(2): 1-9.

Srividya, A., Vemireddy, L.R., Hariprasad, A.S., Jayaprada M. and Sridhar S. (2010). Identification and mapping of landrace derived QTL associated with yield and its components in rice under different nitrogen levels and environments. *Int. J. Plant Breed. Genet.* **4**: 210-227.

Srivasta, G.K. and Tripathi, R.S. (1998). Response of hybrid and composition rice to number of seedlings and planting geometry. *Ann. Agril. Res*. **19**(2): 235-236.

Taiben, R.E and Samonte, S.O.P.B (2007). Flowering traits and head rice yield. *Texas Rice Newsl.* **7**(7): 8-9.

Talwar, S.N. (1976). Selection index for spikelet yield and its contributing characters in varietal collection of rice (*Oryza sativa L.*). *Indian Agriculturist*. **30**(2): 26-29.

Tang-YanLin, Wang-FuMin, Huang-JingFeng and Wang-XiuZhen. (2007). New vegetation index and its application in estimating leaf area index of rice. *China Rice Sci*. **14**(3): 195-203.

Thakur, S.K., Paliwal, S.K. and Sharma, N.P. (1998). Genetic variability and character association in F2 population in rice (Oryza *sativa* L.). *J. Soils Crops.* **8**(2): 127-129.

Tomar, J.B., Dabas, B.S., and Gautam, P.L. (2000). Genetic variability, correlation coefficient and path analysis for quantitative characters under rainfed ecosystem in the native landraces of rice. *Indian J. Plant Genet. Res.* **13**(3): 239-246.

Tomooka, J., Kanareugsa, C. and Krasaesindhu, P. (1967). Increasing the yield of photosensitive varieties by modifying their cultural practices. *Intl. Rice Res. Newsl*. **16**(2): 11-39.

Tripathi, A.K., Sinha, S.K. and Bhandarker, S. (1999). Studied on variability, heritability and genetic advance of semi-deep water rice. *Adv. Plant Sci.* **12**(1): 233-235.

Tuwar, A.K., Singh, S.K., Sharma, A. and Bhati, P.K. (2013). Appraisal of Genetic Varibility for Yield and its Component Character in Rice (*Oryza sativa* L.). *Bio. life*. **1**(3): 84-89.

UNDP. (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212.

Vange, T. (2009). Biometrical Studies on Genetic Diversity of Some Upland Rice (*Oryza Sativa* L.) Accessions. *Nat. Sci.* **7**(1): 21-27.

Verma, O.P., Santoshi, U.S. and Srivastava, H.K. (2002). Heterosis and inbreeding depression for yield and certain physiological traits in hybrids involving diverse ecotypes of rice (*Oryza sativa* L.). *Indian J. Genet.* **56**(30): 267-278.

Vishwakarma, D.N. Lalji, B., Maurya, D.M. and Maurya, K.N. (1989). Heriatbility and genetic advance for yield and its components in rice. *Narendra Deva J. Agril. Res.* **4**(1): 37-39.

Vijaykumar, C.H.M., Ahmed, M.I., Viraktamath, B.C. and Ramesha, M.S. (1997). Heterosis: early prediction and relationship with reproductive phase. *Int. Rice Res. Newsl* . **22**(2): 8-9.

Virmani, S.S., Prasad, M.N. and Kumar, J. (1993). Breaking the yield barrier of rice through exploitation of heterosis. *Direct. Rice Res.* **10**(2): 76-85.

Wang-FuMin, Huang-JingFeng, Tang-YanLin and Wang-XiuZhen. (2007). New vegetation index and its application in estimating leaf area index of rice. *China Rice Sci.* **14**(3): 195-203.

Watto, J.I., Khan, A.S., Ali, Z., Babr, M., Naeem, M., Amanullah, M. and Hussain, N. (2010). Study of correaltion among yield realted traits and path coefficient analysis in rice (*Oryza sativa* L.). *African J. Biot*. **9**(46): 7853-7856.

Won-Jong, G. and Yoshida, T. (2000). Combining ability in the *rice* lines *selected* for direct- sedding in flooded paddy field. Faculty of Agriculture, Kyushu University, Fukuoka 812-8581. *Japan Plant Pro. Sci*. **394**: 366-371.

Wong, Y., Kuroda, E., Hirano, M. Murak, T. and Wang, Y.D. (1997). Comparison of growth and yield characteristics and dry matter production. *Japanese Crop Sci.* **66**(2): 293-299.

Xiao, C.L., Virmani, S.S. and Viraktamath, B.C. (1996). Parental line improvement for increasing yield rice breeding efficiency-new approaches. **In**: Abstracts, Proc.3rd Int. sypm. On Hybrid Rice. DRR, Hyderbad, India. p.2.

Yadav, S.K., Suresh, B.G., Pandey, P. and Kumar, B. (2010). Assessment of Genetic Variability, Correlation and Path Association in Rice (*Oryza sativa* L.). *J. Biol. Sci.* **18**(1): 1-8.

Yadav, R.K. (2002). Studies on genetic variability for some quantitative characters in rice (*Oryza sativa* L.). *Adv. Agril. Res. Int.* **13**: 205-207.

Yadav, R.K. (1992). Genetic variability, correlation studies and their implication in selection of high yielding genotypes of rice. *Adv. Plant Sci.* **5:**306-312.

Yang, F., Wang, X.L., Ma, J.Y. and Ling, F.L. (2001). A comparative analysis of yield component factors of the two rice varieties of JND and JND 13. *J. Jilin Argil. Univ*. **23**(4): 21-24.

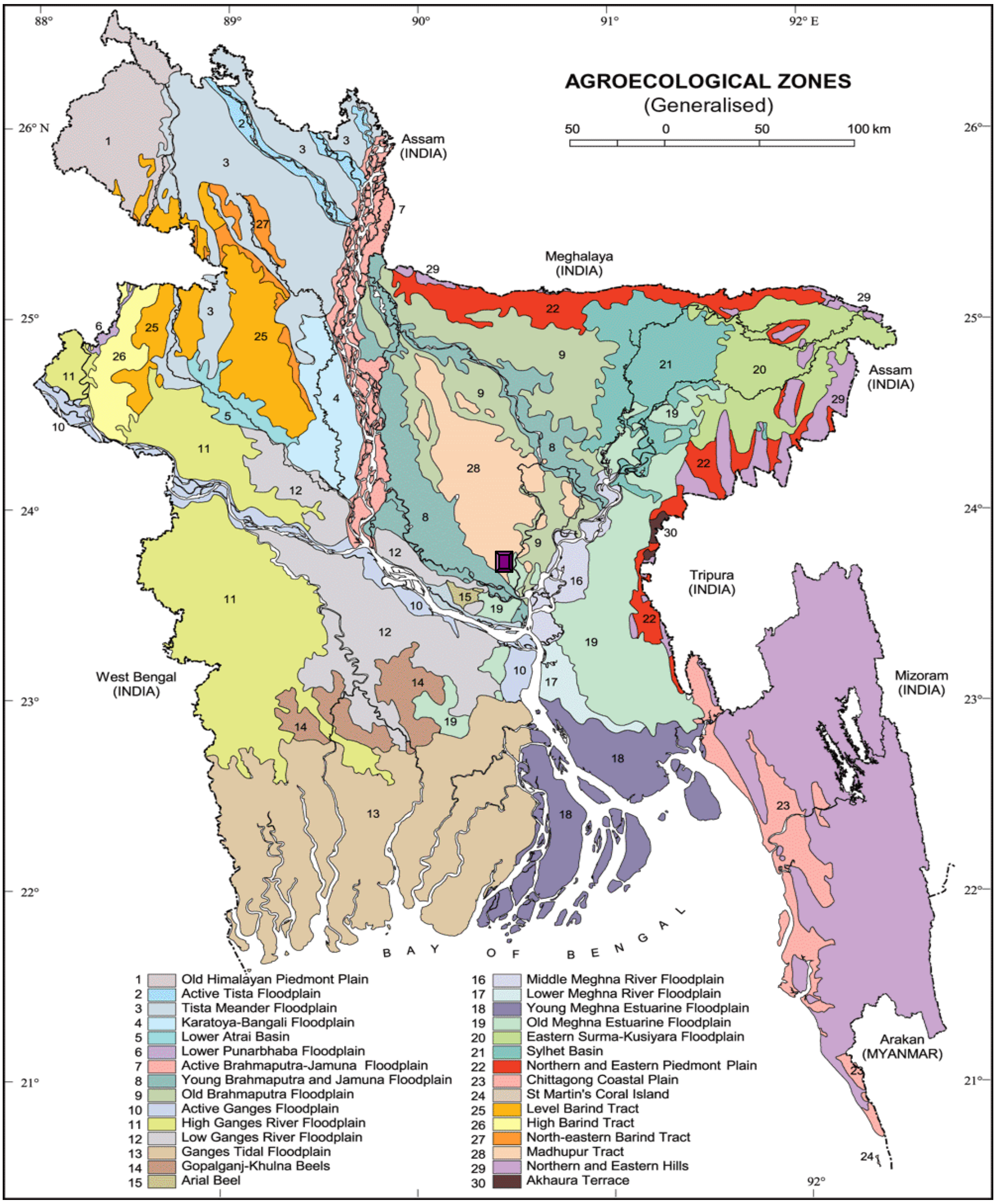
Yoshida, S. (1991). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos Manilla, Phillippines. pp. 269.

Zahid, A.M., Akhtar, M., Sabrar, M., Anwar, M. and Mushtaq, A. (2005). Interrelationship among Yield and Economic Traits in Fine Spikelet Rice. Proceedings of the International Seminar on Rice crop. October 2-3. Rice Research Institute, Kala Shah Kau, Pakistan. pp. 21-24

Zahid, M. A., Akhter, M., Zheen, M., Mazoor, A and Thair, A. (2006). *J. Plant Sci*. **5**(4): 643-645.

APPENDICES

Appendix I. Map showing the experimental site under the study



The experimental site under study

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

A. Physical composition of the soil

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

B. Chemical composition of the soil

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

Source: Central library, Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix III. Monthly average Temperature, Relative Humidity and Total Rainfall and sunshine of the experimental site during the period from November, 2013 to May, 2014

Month	Air temperature (ºc)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
November, 2013	34.8	18.0	77	227	5.8
December, 2013	32.3	16.3	69	0	7.9
January, 2014	20.75	15.0	65	0	3.9
February, 2014	26.18	20.20	59	0	5.7
March,2014	28	21.25	65	0	6.2
April,2014	32	20	54	1	6.3
May, 2014	34	26	55	6	7.1

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka – 1207.

Appendix IV. Dose and method of application of fertilizers in rice field

Fertilizers	Dose(kg/ha)	Application (%)		
		Basal	Installment	
			1st	2nd
Urea	150	33.33	33.33	33.33
TSP	100	100	--	--
MP	100	100	--	--
Gypsum	60	100	--	--
Borax	10	100	--	--

Source: BRRI, 2013, Adhunik Dhaner Chash, Jodebpur, Gazipur.