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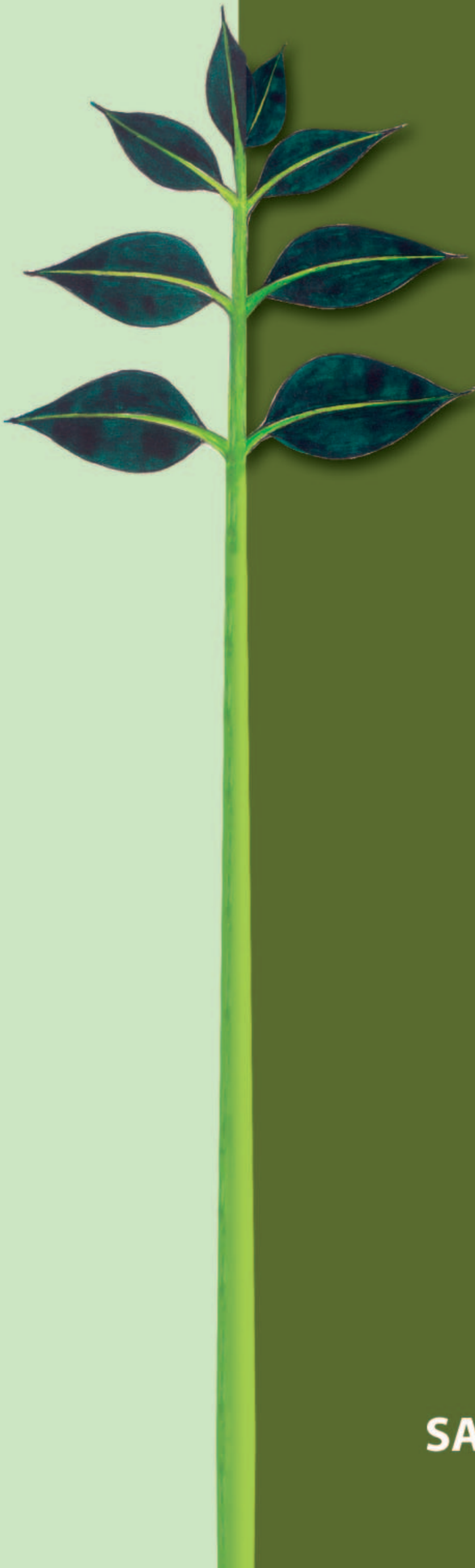

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IDENTIFICATION OF STABLE AND ADAPTABLE HYBRID RICE GENOTYPES

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ABSTRACT

Development of varieties with high yield potential coupled with wide adaptability is an important plant breeding objective. Presence of genotype and environment (G×E) interaction plays a crucial role in determining the performance of genetic materials, tested in different locations in different years. This study was under taken to assess yield performance, stability and adaptability of seventeen hybrid rice genotypes evaluated over 12 environments. The analysis of variance for growth duration and grain yield (t ha^{-1}) for genotype, environment year, environment × genotype, year × environment, year × genotype and year × environment × genotype were highly significant ($p<0.01$) showing the variable response of the genotype across environments and year. GE interaction patterns revealed by AMMI biplot analysis indicated that the hybrid rice genotypes are broadly adapted. Genotypes BRRI53A/BRRI26R, Jin23A/507R, Jin23A/BR7881-25-2-3-12 and IR79156A/F2277R were best for the environment: Gazipur and Rangpur at second and third year. Genotypes Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R showing high yield performance and widely adapted to all environments.

Key words: Adaptation, Hybrid rice, AMMI analysis, GEI, PCA.

INTRODUCTION

Development of varieties with high yield potential coupled with wide adaptability is an important plant breeding objective. Genotype by environment (G×E) interaction plays a crucial role in determining the performance of genetic materials, tested in different locations and in different years, influencing the selection process (Purchase et al., 2000). Multilocation trials provide useful information on genotypic adaptation and stability. The G×E interaction estimates help breeders to

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decide the breeding strategy, to breed for specific or general adaptation, which depends on stability in yield performance under a limited or wide range of environmental conditions.

The AMMI model is a hybrid analysis that incorporates both additive and multiplicative components of the two way data structure. AMMI is the only model that distinguishes clearly between the main and interaction effects and this is usually desirable in order to make reliable yield estimations (Gauch, 1992). AMMI biplot analysis is considered to be an effective tool to diagnose GE interaction pattern graphically. The AMMI model describes the GE interaction in more than one dimension and it offers better opportunities for studying and interpreting GE interaction than analysis of variance (ANOVA) and regression of the mean. In AMMI additive portion is separated from interaction by ANOVA. Then the Interaction Principle Components Analysis (IPCA), which provides a multiplicative model, is applied to analyze the interaction effect from the additive ANOVA model. The biplot display of IPCA scores plotted against each other provides visual inspection and interpretation of the GE interactions. Integrating biplot display and genotypic stability statistics enables genotypes to be grouped based on similarity of performance across diverse environments.

Concerning the use of AMMI in METs (multi-environmental trials) data analysis, which partitions the GE interaction matrix into individual genotypic and environmental scores, an example was provided by Zobel et al. (1988), who studied the GE interaction of a soybean MET. Among multivariate methods, AMMI analysis is widely used for GE interaction investigation. The biplot shows both the genotypes and the environments value and relationship using singulars vectors technique (Tarakanovas and Ruzgas, 2006).

This study was undertaken to interpret GE interaction obtained by AMMI analysis of yield performance of 17 hybrid rice genotypes over 12 environments, visually assess how to vary yield performances across environments based on the biplot and group the genotypes having similar response pattern across environments.

MATERIALS AND METHOD

The experiments were conducted under breeding division of Bangladesh Rice Research Institute (BRRI) at four different agro-ecological zones in the country for three years (2008-09, 2009-10, 2010-11: table1). Seventeen commercial rice varieties including two inbred BRRI dhan28 and BRRI dhan29 as checks and 15 hybrid varieties were evaluated. The experiments were carried out in a randomized complete block design, with three replications. Each experimental plot was comprised of 5 x 6 m. Standard agronomic practices were followed and plant protection measures were taken as and when required. Two border rows were used to minimize the border effects. Ten randomly selected plants were used for recording observations on plant height (cm). The grain yield (t ha^{-1}) data was estimated and corrected at 14% moisture.

Table 1: Code, name of each genotype, environment and growing years

Env	Cropping season	Location	Code of Env	Genotype no.	Genotype	Code of genotype
1	2008-09	Gazipur	A	1	BRRI7A/BR1543-1-1-1-1	G1
2	2009-10	Gazipur	B	2	BRRI11A/F2277R	G2
3	2010-11	Gazipur	C	3	BRRI11A/BR1543-1-1-1-1	G3
4	2008-09	Rangpur	D	4	BRRI13A/PR828R	G4
5	2009-10	Rangpur	E	5	BRRI28A/BRRI26R	G5
6	2010-11	Rangpur	F	6	BRRI48A/3028R	G6
7	2008-09	Comilla	G	7	BRRI48A/BRRI26R	G7
8	2009-10	Comilla	H	8	BRRI33A/BRRI31R	G8
9	2010-11	Comilla	I	9	Jin23A/PR344R	G9
10	2008-09	Satkhira	J	10	BRRI11A/AGR	G10
11	2009-10	Satkhira	K	11	IR79156A/BRRI20R	G11
12	2010-11	Satkhira	L	12	BRRI53A/BRRI26R	G12
				13	Jin23A/BR7881-25-2-3-12	G13
				14	Jin23A/507R	G14
				15	IR79156A/F2277R	G15
				16	BRRI dhan28	G16
				17	BRRI dhan29	G17

AMMI model was used to quantify the effect of different factors (genotype, location and year) of the experiment. It uses to make standard ANOVA for separating the additive variance from multiplicative variance (genotype and environment interaction). Thereafter, it uses a multiplicative procedure- PCA- to extract the pattern from the G x E portion of the ANOVA (Zobel et al., 1988). The AMMI model is:

$$Y_{ge} = \mu + \alpha_g + \beta_e + \sum_{n=1}^{N} \lambda n \gamma_{gn} \delta_{en} + \rho_{ge}$$

Where:

Y_{ge} = yield of the genotype (g) in the environment (e)

μ = grand mean

α_g = genotype mean deviation

β_e = environment mean deviation

N= No. of IPCAs (Interaction Principal Component Axis) retained in he model.

λn = singular value for IPCA axis **n**

γ_{gn} = genotype eigenvector values for IPCA axis **n**

δ_{en} = environment eigenvector values for IPCA axis **n**

ρ_{ge} = the residuals

The model further provides graphical representation of the numerical results (Biplot analysis) with a straight-forward interpretation of the underlying causes of G x E (Gauch, 1998).

RESULTS

Analysis of variance was done to determine the effects of year, location, genotypes and interaction among these factors on growth duration and grain yield of promising hybrid rice genotypes. There were genotype × location, year × location, year × genotype and three way interaction, genotype × location × year significant for growth duration and grain yield ($p<0.01$; Table 2). However, genotypic main effect averages are presented in table and even in the presence of cross-over interactions in a data set, when it comes to select widely adapted genotypes, breeders are interested in selecting lines with high genotypic effect (average over location and years) and with low fluctuation in yield or other traits of interest (stable).

The effects of genotype × environment interaction could be divided into four components, ie. IPCA1, IPCA2, IPCA3 and IPCA4 where first three components were significantly different for yield but last component were not significant (Table 3). In case of growth duration IPCA1 is significant but IPCA2, IPCA3 and IPCA4 were not significant. The variation in soil structure and moisture across the different environments were considered as a major under lying causal factors for the G × E interaction.

Among the genotypes BRRI7A/BR1543-1-1-1-1,BRRI11A/F2277R, BRRI11A/BR1543-1-1-1-1 and BRRI dhan28 showed negative phenotypic index (Pi), insignificant regression coefficient (bi) and deviation from regression (S^2di) indicating the stability of genotypes over all environments with short growth duration

(Table 4). Shorter growth duration is favorable for hybrid rice. On the other hand, BRRI13A/PR828R and BRRI48A/3028R showed the negative phenotypic index (Pi), significant regression coefficient (bi) and insignificant deviation from regression (S^2di) indicating shorter growth duration and highly adapted to the environments of Gazipur 3rd year, Rangpur 1st year, Comilla 1st and 3rd year, Satkhira 1st, 2nd and 3rd year. Variation in grain yield was recorded among genotypes BRRI28A/BRRI26R, Jin23A/PR344R, BRRI11A/AGR, IR79156A/BRRI20R, BRRI53A/BRRI26R and Jin23A/507R showed higher yield as well as stable over environment (Table 5). Genotypes BRRI48A/BRRI26R, Jin23A/BR7881-25-2-3-12, IR79156A/F2277R and BRRI dhan29 were higher yielding but had significant regression coefficient (bi) and non significant deviation from regression (S^2di) indicating they are highly responsive to the favorable environments Gazipur 1st year, Comilla 1st year, Satkhira 1st and 3rd year.

As shown table 6, based on IPCA score, a genotype in the AMMI analysis are an indication of the adaptability over environments and association between genotypes and environments can be clearly observed (Albert, 2004). Regardless of positive or negative signs, genotypes with large scores have high interaction and unstable where as genotypes with small scores close to zero have low interaction and stable (Zobel et al., 1988). Thus genotypes BRRI48A/BRRI26R, Jin23A/BR7881-25-2-3-12 and IR79156A/F2277R have large IPCA scores and are unstable genotypes, whereas the genotypes Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R have small IPCA1 scores close to zero and are stable. Of the three stable genotypes in IPCA1 scores have a grain yield greater than grand mean. Among the environment Comilla 2nd and 3rd year, Satkhira 1st, 2nd and 3rd year have small IPCA scores close to zero and are stable. Remaining seven environments have large IPCA1 scores and are unstable environments.

In the AMMI model biplot, the IPCA scores of genotypes and environments are plotted against their respective means, the plot is helpful to visualize the average productivity of the genotypes, environments and their interaction for all possible genotype-environment combinations. The magnitude of interaction can be visualized for each genotype and each environment using IPCA1 vs. IPCA2 biplot model (Yan and Hunt, 1998; Fentie et al., 2013). The AMMI 1 biplot for grain yield of seventeen genotypes at twelve environmental conditions is presented in Fig. 1. AMMI biplot gave a best model for fit of 84.75%. This result is in agreement with the findings of Misra et al., 2009; Chrispus, 2008; Yan and Hunt, 1998; Naveed and Islam, 2007.

According to AMMI biplot environment showed high variation in both main effect and interactions (IPCA1). Environments Gazipur 2nd and 3rd year, Rangpur 1st, 2nd and 3rd year have large positive IPCA1 scores, which interact positively with genotypes that had positive IPCA1 scores and negatively those genotypes with negative IPCA1 scores. Environment Gazipur and Comilla 1st year had large negative IPCA1 score which interact positively with genotypes had negative IPCA1 scores and negatively with genotypes that had positive IPCA scores. Environment Comilla 2nd and 3rd year, Satkhira 1st, 2nd and 3rd year have relatively small IPCA1 scores, suggesting that it had little interaction with genotypes indicating stable environment.

The genotypes BRRI28A/BRRI26R, BRRI48A/BRRI26R, BRRI53A/ BRRI26R, Jin23A/BR7881-25-2-3-12, Jin23A/507R and IR79156A/F2277R had higher average yields and these genotypes adapted to favorable environments. Genotypes Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R placed closer to the biplot origin and were, therefore the most stable, but had average main effects close to the grand mean. Genotypes BRRI48A/3028R, BRRI33A/BRRI31R and BRRI dhan29 had relatively higher average mean grain yield but had large IPCA1 scores, which made them unstable genotypes. Genotypes BRRI7A/BR1543-1-1-1-1, BRRI11A/F2277R, BRRI11A/ BR1543-1-1-1-1, BRRI13A/PR828R and BRRI dhan28 had low yield and large IPCA1 scores, which are unstable. The result is an agreement with the findings by Alberts, 2004; Misra et al., 2009; Yan and Hunt, 1998; Naveed and Islam, 2007; Anandan et al., 2009.

On the basis of AMMI2 the environment felt into four section with respect to the environments Gazipur 2nd and 3rd year for the genotypes BRRI53A/BRRI26R and Jin23A/507R were the best respectively. For the environments of Rangpur 2nd and 3rd year the genotypes of Jin23A/BR7881-25-2-3-12 and IR79156A/F2277R were the best (Figure2). For the environment Rangpur 1st year the genotype BRRI28A/ BRRI26R and BRRI48A/BRRI26R were the best. The specific responsive environments might have been due to evenly distribution of rainfall, temperature, soil and other abiotic stresses. Genotypes located near the plot origin were less responsive than the vertex genotypes. Genotypes Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R gave the highest average yield (largest IPCA1 scores) but was relatively stable in across environments.

In contrast the non adapted genotypes of BRRI11A/F2277R, BRRI11A/ BR1543-1-1-1-1, BRRI13A/PR828R and BRRI dhan28 low yielded and small IPCA2 score as indicated they are relatively stable. In this fact relative large IPCA2 score and BRRI48A/3028R and BRRI48A/BRRI26R genotypes have unstable. The biplot shows not only the average yield of a genotype but also how it is achieved stability. That is the biplot also shows the yield of a genotype at individual environments.

DISCUSSION

There are two major strategies for developing genotypes with low G × E interactions. The first in sub-division or stratification of a heterogeneous area into smaller more homogeneous sub-regions, with breeding programs aimed at developing genotypes for specific sub-regions. However, even with this refinement, the level of interaction can remain high, because breeding area does not reduce the interaction of genotypes with locations and years. The second strategy for reducing G

× E interaction involved selecting genotypes with better stability across a wide range of environments in order to better predict behaviour (Eberhart and Russell, 1966). Various methods use G × E interaction to facilitate genotype characterization and as a selection index together with the mean yield of the genotypes.

Numerous methods have been used for an understanding of the causes of G × E interaction (van Eeuwijk et al., 1996). Among the multivariate approaches AMMI model is widely used (Mahalingam et al., 2006; Das et al., 2008). The AMMI model describes the GE interaction in more than one dimension and it offers better opportunities for studying and interpreting GE interaction than analysis of variance (ANOVA) and regression of the mean. In AMMI, the additive, portion is separated from interaction by ANOVA. Then the Interaction Principle Components Analysis (IPCA), which provides a multiplicative model, is applied to analyze the interaction effect from the additive ANOVA model. The biplot display of IPCA scores plotted against each other provides visual inspection and interpretation of the GE interactions. Integrating biplot display and genotypic stability statistics enables genotypes to the grouped based on similarity of performance across diverse environments.

In this study the result of AMMI analysis indicated that the AMMI model fits the data well and justifies the use of AMMI2. This made it possible to construct the biplot and calculate genotypes and environments effects (Kaya et al., 2002). The Interaction Principle Component Axes (IPCA) scores of a genotype in the AMMI analysis indicate the stability of a genotype across environments. The closer the IPCA scores to zero, the more stable the genotypes are across their testing environments (Carbonell et al., 2004). In this study, Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R gave the higher average yield and small IPCA scores that was relatively stable over the environments. This result is in agreement with the findings of Muthuramu et al., 2011. In contrast the non adapted genotypes of BRRI11A/F2277R, BRRI11A/BR1543-1-1-1-1, BRRI13A/PR828R and BRRI dhan28 low yielded and small IPCA2 scores as indicated they are relatively stable. In this fact relative large IPCA2 score and BRRI48A/3028R and BRRI dhan29 genotypes have unstable.

The most accurate model for AMMI can be predicted by using the first two IPCAs (Kaya et al., 2002). Conversely, Sivapalan et al. (2000) recommended a predictive AMMI model with the first four IPCAs. These results indicate that the number of the terms to include in an AMMI model cannot specify a prior without first trying AMMI predictive assessment. In general, factors like type of crop, diversity of the germplasm and range of environmental conditions will affect the degree of complexity of the best predictive model (Crossa et al., 1990).

However, the prediction assessment indicated that AMMI with only two interaction principal component axes was the best predictive model (Zobel et al., 1988). Further interaction principal component axes captured mostly noise and therefore did not help to predict validation observations. In this study, the interaction of the 17 genotypes with 12 environments was best predicted by the first two principal components of genotypes and environments.

AMMI Stability Value (ASV) is in effect the distance from the coordinate point to the origin in a two dimensional scattergram of IPCA1 scores against IPCA2 scores (Purchase et al., 2000). Stability in itself should however not be the only parameter for selection, as the most stable genotype wouldn't necessarily gives the best yield performance. As example, consider G8 which was the highest yield performance but large IPCA1 value is not stable.

Genotypes evaluation must be conducted in multiple locations for multiple years to fully sample the target environment (Cooper et al., 1997). Genotype in the presence of unpredictable G×E interaction is a perennial problem in plant breeding (Bramel-Cox, 1996). To select for superior genotypes, it seems that there is no easier way other than to test widely (Troyer, 1996) and select for both average yield and stability (Kang, 1997).

CONCLUSION

In conclusion, the multivariate approaches have shown that the largest proportion of the total variation in grain yield was attributed to environments in this study. Genotypes Jin23A/PR344R, BRRI11A/AGR and IR79156A/BRRI20R had the highest yield and were hardly affected by the GEI effects as a result of which they will perform well across a wide range of environments. Environments Comilla at second and third year and Satkhira at first, second and third year were stable for all the genotypes. Genotypes BRRI53A/BRRI26R, Jin23A/507R, Jin23A/BR7881-25-2-3-12 and IR79156A/F2277R were specifically adapted to the environment Gazipur second and third year, Rangpur second and third year respectively. Genotypes BRRI7A/BR1543-1-1-1-1, BRRI11A/F2277R, BRRI11A/BR1543-1-1-1-1 and BRRI13A/PR828R were low yielded and unstable these genotypes needed further improvement.

REFERENCES

Albert, M.J.A. 2004. A Comparison of statistical methods to describe genotype × environment interaction and yield stability in multi location maize trials. Ph.D. Diss., Department of Plant Sciences (Plant Breeding), Faculty of Natural and Agricultural Sciences of the University of the Free State. Bloemfontein, South Africa, pp: 7-35.

Anandan, A., Eswaran, R., Sabesan, T. and Prakash, M. 2009. Additive main effects and multiplicative interaction analysis of yield performances in rice genotype under coastal saline environments. *Advance in Biological Research*, 3: 43-47

Bramel-Cox, P.J. 1996. Breeding for reliability of performance across unpredictable environments. In Genotype-by environment Interaction. Kang, M.S. and Gauch, H.G. (Eds). CRC press, Boca Raton, FL, pp. 309-339

Carbonell, S.A., Filho, J.A., Dias, A.A., Garcia and Morais, L.K. 2004. Common bean genotypes and lines interactions with environments. Science Agriculture. (Piracicaba braz), 61: 169-177

Chrispus, O.A. 2008. Breeding Investigation of Finger millet characteristics including blast disease and striga resistance in Western Kenya, A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (PhD) in Plant Breeding, University of KwaZu;u- Natal Republic of South Africa

Cooper, M., Stucker, R.E., Delacy, I.H. and Harch, B.D. 1997. Wheat breeding nurseries, target environments and indirect selection for grain yield. *Crop Science*, 37: 1168-1176

Crossa, J., Gauch H.G.and Zobel R.W. 1990. Additive main effects and multiplicative interaction analysis of two international maize genotype trials. *Crop Science*, 30: 493-500

Das, S., Mishra, R.C. and Sinha, S.K. 2008. Variation in seedling growth inhibition due to maleic hydrazide treatment of rice (*O. sativa*) and ragi (*E coracana*) genotypes and its relationship with yield and adaptability. *Journal of Crop Science Biotechnology*, 11(3): 215-222

Eberhart, S. A. and Russel W. A. 1966. Stability parameters for comparing varieties. Crop Science, 6: 36-40

Fentie, M., Assefa, A. and Belete, K. 2013. AMMI analysis of yield performance and stability of finger millet genotypes across different environments. *World Journal of Agricultural Science*, 9: 231-237

Gauch, H. G. 1998. Model selection and validation for yield trials with interaction. *Biometrics*, 44: 705-705

Gauch, H.G. 1992. Statistical analysis of regional yield data: AMMI analysis of factorial designs. Elsevier, New York, New York. 278 pages. Chinese edition 2001, China National Rice Research Institute, Hangzhou, China; also includes a Chinese translation of Gauch and Zobel 1997 article on mega-environments in Crop Science, 37: 311-326

Kang, M.S. 1997. Using genotype-by environment interaction for crop genotype development. *Advance Agronomy*, 62: 199-252

Kaya, Y., Palta, C. and Taner, S. 2002. Additive main effects and multiplicative interaction analysis of yield performance in breed wheat genotypes across environments. *Turk Journal of Agriculture*, 26: 275-270

Mahalingam, L., Mahendran, S., Chandra, R. and Atlin, G. 2006. AMMI analysis for stability of grain yield in rice (*O. sativa* L.). *International Journal of Botany*, 2: 104-106

Misra, R.C., Das, S. and Patnaik, M.C. 2009. AMMI model Analysis of Stability and Adaptability of Late Duration Finger Millet (*Eleusine coracana*) genotypes. *World Applied Science Journal*, 6: 1650-1654

Muthuramu, S., Jebaraj, S. and Gnanasekaran, M. 2011. AMMI biplot analysis for drought tolerance in rice (*Oryza sativa* L.). *Research Journal of Agricultural Science*, 2: 98-100

Naveed M. Nadeem and Islam, N. 2007. AMMI analysis of some upland cotton genotypes for yield stability in different milieus. *World Journal Agricultural Science*, 3: 39-44

Purchase, J.L. Hatting, H. and Van Devanter C.S. 2000. Genotype environment interaction of winter wheat in south Africa: II. Stability analysis of yield performance. *South African Journal of Plant Soil*, 17: 101-107

Sivapalan, S., Brien L.O., Ferrara G.O., Hollamby G.L., Barclay I. and Martin P.J. 2000. An adaptation analysis of Australian and CIMMYT/ICARDA wheat germplasm in Australian production environments. *Australian Journal Agricultural Research*, 51: 903-915

Tarakanovas, P. and Ruzgas, V.2006. Additive main effects and multiplicative interaction analysis of grain yield of wheat varieties in Lithuana. *Agronomy Research*, 4: 91-98

Troyer, A.F. 1996. Breeding for widely adapted popular maize hybrids. *Euphytica*, 92: 163-174

van Eeuwijk, F.A., Denis, J.B. and Kang, M.S. 1996. Incorporate additional information on genotypes and environments in models for two-way genotype- by environment tables. In: genotype-by Environment Interaction. Kang, M.S. and Gauch, H.G. (Eds.). CRC press, Boca Raton, FL, p. 15-49

Yan, W. and Hunt, L.A. 1998. Genotype by environment interaction and crop yield. *Plant Breeding Review*, 16: 35-178

Zobel, R.W., Wright M.J. and Gauch H.G. 1988. Statistical analysis of a yield trial. *Agronomy Journal*, 80: 388-393

Table 2: Mean square values of combined analysis of variance (ANOVA) for hybrid rice and their components analyzed over 4 locations in 3 years

Source of variation	df	Mean sum of squares	
		Days to maturity	Yield (t ha^{-1})
Year	2	421.36**	3.29**
Location	3	196.61**	9.93**
Replication	2	153.77**	0.54^{ns}
Genotype	16	270.62**	38.15**
Location x Genotype	48	10.78**	1.14**
Year x Location	6	85.52**	20.32**
Year x Genotype	32	17.36**	0.88**
Year x Location x Genotype	96	6.51**	1.81**
Error	406	1.65	0.17

** Significant level at p<0.01, * Significant level at p<0.05

Table 3: Full joint analysis of variance including the partitioning of the G x E interaction of commercial rice hybrids

Source of variation	df	Mean sum of squares	
		Days to maturity	Yield (t ha^{-1})
Genotype (G)	16	90.21**	12.72**
Environment (E)	11	58.96**	4.80**
Interaction (GEI)	176	3.22**	0.49**
AMMI Component 1	26	11.25**	1.87**
AMMI Component 2	24	3.00ns	0.56**
AMMI Component 3	22	2.56ns	0.37*
AMMI Component 4	20	1.80ns	0.23ns
G x E (Linear)	16	14.99**	2.81**
Pool deviation	84	1.30	0.128
Pooled error	160	2.04	0.25

** Significant level at p<0.01, ns= Not significant, * Significant level at p<0.05

Table 4: Stability analysis for growth duration of 17 commercial rice hybrids over 12 environments.

Gn	Environments												Over all mean	Pi	bi	S^2di
	A	B	C	D	E	F	G	H	I	J	K	L				
G1	149.7	150.0	147.7	148.7	150.7	152.0	148.7	151.7	147.7	149.0	151.0	151.7	149.9	-0.6	0.604	1.25
G2	151.0	150.0	146.7	147.0	150.3	152.0	148.3	152.3	146.3	150.0	152.0	151.0	149.8	-0.7	0.833	2.47
G3	149.0	149.7	146.7	148.7	150.7	150.7	151.7	153.0	149.0	149.7	149.3	149.3	149.8	-0.7	0.565	1.59
G4	150.0	150.0	147.3	148.7	150.3	152.7	148.0	151.0	149.7	151.0	151.0	148.3	149.8	-0.7	0.613*	1.13
G5	150.3	150.7	144.0	148.3	154.3	155.7	149.0	151.0	150.0	151.7	149.3	153.3	150.6	0.1	1.487*	1.73
G6	150.0	149.3	148.3	147.7	149.3	150.7	148.0	149.7	150.0	150.0	148.7	151.0	149.4	-1.1	0.306*	0.84
G7	148.3	152.0	147.7	149.3	155.0	155.3	147.0	151.0	151.7	151.7	152.3	148.3	150.8	0.3	0.973	4.60
G8	152.0	151.0	150.7	151.7	151.0	151.3	152.0	151.3	151.0	151.0	151.3	152.0	151.4	0.9	0.056*	0.22
G9	151.7	152.3	151.7	151.3	152.7	152.7	153.0	152.7	152.3	150.7	152.3	152.3	152.1	1.6	0.166*	0.40
G10	156.3	154.0	148.0	152.7	157.0	161.7	153.3	153.0	152.7	149.7	151.3	151.7	153.4	2.9	1.664	3.63
G11	153.0	149.0	147.7	149.0	154.7	155.0	152.0	151.3	148.0	149.7	150.0	149.7	150.8	0.3	1.166	1.46
G12	155.7	153.0	146.7	152.0	159.7	158.7	153.0	152.7	150.0	152.0	151.7	150.0	152.9	2.4	1.769*	2.62
G13	153.3	150.3	144.7	147.3	153.0	154.3	152.0	150.7	152.0	151.3	150.7	151.0	150.9	0.4	1.268	1.54
G14	153.3	151.3	144.3	147.3	158.7	157.7	153.0	152.0	149.0	149.0	149.3	150.7	151.3	0.8	2.075*	1.73
G15	153.0	153.0	145.7	147.3	155.3	160.3	152.0	152.3	148.7	153.0	147.7	150.3	151.6	1.1	1.968*	2.81
G16	141.7	139.3	135.3	139.7	142.7	143.3	142.0	140.0	140.0	141.3	141.3	143.3	140.8	-9.7	0.973	1.76
G17	154.3	153.3	148.3	149.3	152.7	151.3	154.0	152.7	152.3	153.7	154.0	153.0	152.4	1.9	0.520	2.86
Mean	151.3	150.5	146.5	148.6	152.8	153.8	150.4	151.1	149.4	150.3	150.2	150.4	150.5			
Ei(Ij)	0.8	0.0	-4.0	-1.9	2.3	3.3	-0.1	0.6	-1.1	-0.2	-0.3	-0.1				
LSD (0.05)	2.84	2.64	2.55	2.66	2.73	2.63	1.17	1.03	0.95	1.00	1.47	1.53				

Genotype: G1= BRRI7A/BR1543-1-1-1-1, G2= BRRI11A/F2277R, G3= BRRI11A/BR1543-1-1-1-1, G4= BRRI13A/PR828R,G5= BRRI28A/BRRI26R, G6= BRRI48A/3028R, G7= BRRI48A/BRRI26R, G8= BRRI33A/BRRI31R, G9= Jin23A/PR344R, G10= BRRI11A/AGR, G11= IR79156A/BRRI20R, G12= BRRI53A/BRRI26R, G13= Jin23A/BR7881-25-2-3-12, G14= Jin23A/507R, G15= IR79156A/F2277R, G16= BRRI dhan28 and G17= BRRI dhan29

Environment: A=Gazipur 1st year, B= Gazipur 2nd year, C=Gazipur 3rd year, D=Rangpur 1st year, E=Rangpur 2nd year, F=Rangpur 3rd year, G=Comilla 1st year, H=Comilla 2nd year, I=Comilla 3rd year, J=Satkhira 1st year, K=Satkhira=2nd year and L=satkhira 3rd year

Table 5: Stability analysis for yield of 17 commercial rice hybrids over 12 environments.

Gn	Environments												Over all mean	Pi	bi	S^2di
	A	B	C	D	E	F	G	H	I	J	K	L				
G1	4.801	5.442	5.301	5.509	5.591	5.333	5.239	5.405	5.605	5.450	4.400	5.509	5.299	-1.084	0.352*	0.10
G2	4.285	5.496	4.780	4.643	5.160	5.300	5.166	5.348	5.629	5.599	5.515	5.181	5.175	-1.208	0.239*	0.17
G3	4.122	4.047	4.149	4.373	4.707	4.313	4.635	4.339	4.378	4.484	4.471	4.500	4.376	-2.007	0.010*	0.04
G4	4.902	5.266	5.617	5.595	5.175	5.111	5.517	5.550	5.141	5.937	5.458	5.279	5.379	-1.004	0.046*	0.09
G5	4.669	6.952	6.414	7.856	8.419	7.507	4.206	7.399	6.658	6.511	7.238	7.536	6.780	0.397	1.917	0.55
G6	6.766	6.366	6.926	6.279	6.832	6.730	7.053	6.526	6.519	5.756	5.784	6.123	6.472	0.089	-0.02*	0.20
G7	4.607	7.137	7.171	7.795	7.029	8.598	4.573	6.497	6.671	5.777	7.322	6.559	6.645	0.262	2.031*	0.27
G8	8.534	7.645	8.019	8.655	7.735	8.522	8.170	8.219	8.188	7.763	7.577	7.950	8.081	1.698	-0.034*	0.15
G9	6.410	7.162	7.115	7.292	7.578	7.767	6.569	7.649	7.677	7.432	6.717	7.444	7.234	0.851	0.683	0.08
G10	4.823	6.617	7.088	7.236	7.793	8.220	6.622	7.397	6.853	5.947	7.219	7.499	6.943	0.56	1.386	0.28
G11	5.214	8.036	7.803	7.706	7.194	9.062	6.376	7.561	6.509	6.735	7.273	5.668	7.095	0.712	1.596	0.45
G12	5.004	8.225	9.092	6.823	7.386	8.412	5.931	6.337	7.173	6.613	5.962	7.074	7.003	0.62	1.784	0.50
G13	4.656	7.951	7.756	7.750	8.618	8.698	4.628	6.828	7.556	7.098	6.720	6.201	7.038	0.655	2.368*	0.23
G14	5.771	7.954	7.778	8.176	8.627	8.460	6.210	5.768	7.410	6.485	5.331	7.203	7.098	0.715	1.712	0.54
G15	4.185	6.954	8.115	8.144	7.946	8.689	4.292	6.120	6.151	6.480	5.940	7.340	6.696	0.313	2.605*	0.24
G16	4.319	4.503	4.437	4.455	4.346	5.135	4.486	4.691	4.568	4.921	4.640	4.762	4.605	-1.778	0.175*	0.05
G17	6.031	6.252	6.149	6.596	6.500	6.672	6.412	7.097	6.521	6.894	6.958	6.965	6.587	0.204	0.151*	0.12
Mean	5.241	6.588	6.689	6.758	6.861	7.208	5.652	6.396	6.424	6.228	6.148	6.400	6.383			
Ei(Ij)	-1.142	0.205	0.306	0.375	0.478	0.825	-0.731	0.013	0.041	-0.155	-0.235	0.017				
LSD (0.05)	1.06	0.81	0.67	0.56	0.71	0.47	0.54	0.50	0.37	0.46	0.37	0.56				

Genotype: G1= BRRI7A/BR1543-1-1-1-1, G2= BRRI11A/F2277R, G3= BRRI11A/BR1543-1-1-1-1, G4= BRRI13A/PR828R,G5= BRRI28A/BRRI26R, G6= BRRI48A/3028R, G7= BRRI48A/BRRI26R, G8= BRRI33A/BRRI31R, G9= Jin23A/PR344R, G10= BRRI11A/AGR, G11= IR79156A/BRRI20R, G12= BRRI53A/BRRI26R, G13= Jin23A/BR7881-25-2-3-12, G14= Jin23A/507R, G15= IR79156A/F2277R, G16= BRRI dhan28 and G17= BRRI dhan29

Environment: A=Gazipur 1st year, B= Gazipur 2nd year, C=Gazipur 3rd year, D=Rangpur 1st year, E=Rangpur 2nd year, F=Rangpur 3rd year, G=Comilla 1st year, H=Comilla 2nd year, I=Comilla 3rd year, J=Satkhira 1st year, K=Satkhira=2nd year and L=satkhira 3rd year

Table 6: AMMI mean yield and IPCA1 scores for 17 rice hybrids grown in 12 environments.

Genotypes	ID	AMMI mean yield (t ha^{-1})	IPCA1 scores
BRRI7A/BR1543-1-1-1-1	1	5.299	-0.462
BRRI11A/F2277R	2	5.175	-0.548
BRRI11A/BR1543-1-1-1-1	3	4.376	-0.67
BRRI13A/PR828R	4	5.379	-0.638
BRRI28A/BRRI26R	5	6.78	0.639
BRRI48A/3028R	6	6.472	-0.675
BRRI48A/BRRI26R	7	6.645	0.748
BRRI33A/BRRI31R	8	8.081	-0.687
Jin23A/PR344R	9	7.234	-0.26
BRRI11A/AGR	10	6.943	0.161
IR79156A/BRRI20R	11	7.095	0.385
BRRI53A/BRRI26R	12	7.003	0.57
Jin23A/BR7881-25-2-3-12	13	7.038	0.958
Jin23A/507R	14	7.098	0.525
IR79156A/F2277R	15	6.696	1.124
BRRI dhan28	16	4.605	-0.565
BRRI dhan29	17	6.587	-0.605
Environments	Year		
Gazipur	1st	5.241	-1.359
Gazipur	2nd	6.588	0.545
Gazipur	3rd	6.689	0.664
Rangpur	1st	6.758	0.64
Rangpur	2nd	6.861	0.765
Rangpur	3rd	7.208	1.061
Comilla	1st	5.652	-1.426
Comilla	2nd	6.396	-0.317
Comilla	3rd	6.424	-0.079
Satkhira	1st	6.228	-0.329
Satkhira	2nd	6.148	-0.136
Satkhira	3rd	6.400	-0.027

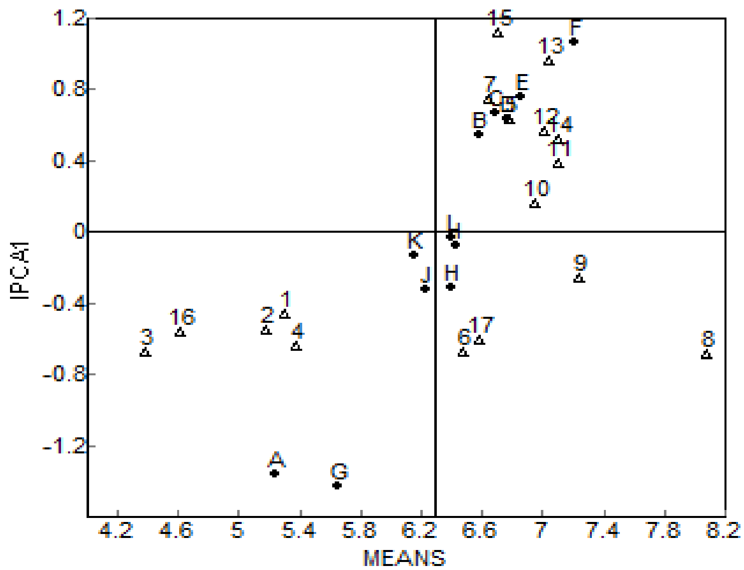

Figure 1: Biplot of the first AMMI interaction (IPCA 1) score (Y-axis) plotted against mean yield (t ha^{-1}) (X-axis) for seventeen hybrid rice genotypes over 12 environments.

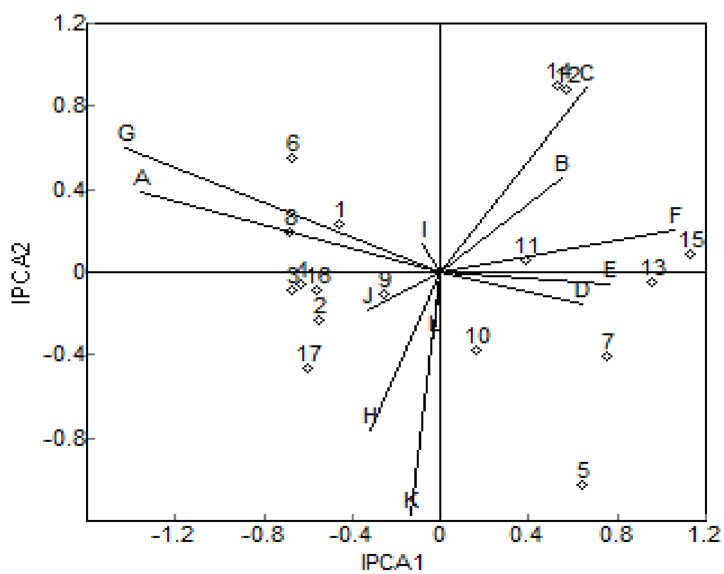

Figure 2: Graphic of AMMI biplot interaction of seventeen genotypes over 12 environments.

In graph, it is better to write the genotype name instead of just number

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EFFECT OF SEED COATING MATERIAL AND STORAGE CONTAINERS ON GERMINATION AND SEEDLING VIGOUR OF SOYBEAN (*Glycine max* L.)

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ABSTRACT

A laboratory experiment was conducted to evaluate the effect of different seed coating materials and storage containers on germination, seedling vigour and suitability of packaging material for soybean seed. Seed of soybean varietyPS1024 was used for coating purpose with 6 coating treatments viz., T_0 (control), T_1 (Polymer coating i.e. Polykote @ 3 ml kg^{-1} of seed diluted with 5 ml of water), T_2 (Flowable Thiram i.e. Royal flow 40 SC @ 2.4 ml kg^{-1} of seed), T_3 (T_1 + T_2), T_4 (Vitavax 200 i.e.thiram 37.5 % and carboxyl 37.5% @ 2 g kg^{-1} of seed and T_5(T_1+ T_4). The coated seeds were stored in two kinds of containers i.e. jute canvas bag, high density poly ethylene (HDPE) non- laminated bag and bimonthly observation on germination and seedling vigour were recorded. After 8^{th} month of storage, germination and vigour index in polythene bag stored seeds were significantly higher than the seed stored in cloth bag. Among seed coating treatments, maximum %germination was recorded in polymer coating @ 3 ml kg^{-1} followed by vitavax 200 @ 2 g $kg^{-1}$of seed treatment (T_5) which was significantly higher than rest of the coated treatment including untreated control seeds (T_0). Similarly, maximum seed vigour index was observed in T_5 and minimum vigor index was recorded with T_0 (untreated control).

Key words: Fungicide treatment, Polymer, Seed coating, Soybean, Storage container

INTRODUCTION

Quality seed is the basis for profitable production and expansion of soybean crop. Loss of viability and vigour under high temperature and humid conditions is a common phenomenon in many crop seeds but it is well marked in soybean (Burris,

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1980; Tatipata, 2009). Proper seed treatment with fungicide will improve the germination of poor quality seed if the low quality is due to fungal infection. A fungicide treatment also protects the seeds and young seedlings from many seed borne and soil borne pathogens (Taylor et al., 1998).

Polymer coating is used in pharmaceutical and confectionary industries for uniform application of material to seeds. The film formulation consists of mixture of polymer, plasticizer and colorants that are commercially available as ready to use as liquids (Ni, 1997).Polymer coating acts as a temperature switch and protective coating by regulating intake of water by seed coat, until the soil has warmed to a pre-determined temperature. It enables accurate and even dose of chemicals and reduces chemical wastage. It also provides resistance against mechanical damage in the seed drill. Thus improves the appearance and quality of treated seeds. Seed coating materials were reported to improve the germination and increase the seedling emergence at changing soil moisture regime especially in the sub-optimal range (Scott., 1989; Sherin and Susan John., 2003). It is due to increase in the rate of moisture imbibition where the fine particles in the coating act as a 'wick' or moisture attracting material or perhaps to improve seed soil contact. Coating with hydrophilic polymer regulates the rate of water uptake, reduce imbibition damage and improve the emergence of soybean seeds *(*Vanangamudi et al., 2003). Polymer coating makes sowing operation easier due to the smooth flow of seeds. Addition of colorants helps in visual monitoring of placement accuracy, enhance the appearance, marketability and consumer preference.

Soybean seeds lose viability within 3-4 months if the storage arrangement and the condition of seed are not proper (Sadjad, 1980). Types of container also regulate temperature, relative humidity and seed moisture contents. High temperature, relative humidity and moisture in the storage environment appear to be main factor involved in deterioration of seed quality. Maintenance of seed quality during storage period is important not only for crop production in the following year but also for the maintenance seeds because of their constant threat and of genetic erosion. In view of the above facts, the present research work was undertaken to evaluate the effect of different coating materials and storage container on germination and seedling vigour of stored soybean seed.

MATERIALS AND METHODS

A laboratory study was carried out at G. B. Pant University of Agriculture and Technology, Pantnagar,Uttarakhand (India). Breeder seeds of soybean (G*lycine max* L.) variety PS 1024 were used for coating purpose. It was collected from Breeder Seed Production Centre, Pantnagar. There were 6 coating treatments viz., T_0 (control), T_1 (Polymer coating i.e. Polykote @ 3 ml kg^{-1} of seed diluted with 5 ml of water), T_2 (FlowableThiram i.e., Royal flow 40 SC @ 2.4 ml kg^{-1} of seed), T_3 (T_1 + T_2), T_4 (Vitavax 200 i.e. thiram 37.5 % and carboxyl 37.5% @ 2 g kg^{-1} of seed and

T_5 (T_1 + T_4). Prior to coating initial seed moisture content, germination percentage, seedling dry weight, seedling vigour index and field emergence were recorded. After performing seed coating treatments increase in seed weight was recorded .Then seeds were stored at 8.0% moisture content in two types of containers viz., cloth bag (moisture pervious container) and 250-gauge polyethylene bag (moisture impervious container) under ambient storage condition. During storage, seed germination and seedling vigour were recorded at bimonthly to retain Indian Minimum Seed Certification Standard i.e. 70 per cent germination. For determining moisture content, five grams of ground and sieved seed sample was weighed from each treatment in three replications and kept in an oven maintained at 103^{o}C temperature for a period of 18 hours (Government of India, Department of Agriculture and Cooperation, Ministry of Agriculture, 1993) .The moisture content of seeds was determined on wet weight basis. Standard germination test was conducted in four replications as per International Rules for Seed Testing (ISTA, 1993). At the end of the standard germination test, ten normal seedlings were randomly selected and kept in an oven at 80±2^{0}C for 72 hours until the weight become constant for measuring seedling dry weight. Seedling vigour index was computed by multiplying germination into average seedling dry weight. Field emergence was recorded at the end of 4 months of storage. For recording field emergence 100 seeds in four replications were sown in the field and on eighth day number of seeds emerged were counted and field emergence per cent was calculated as per standard germination test (ISTA, 1993). Thus total 12 treatment combinations were analyzed in 2 factors RBD (first factor storage containers and second factor seed coating treatments) (Gomez and Gomez, 1984). Standard error of means (S. Em.±) was computed and critical differences (C.D.) at 5% level of probability were worked out for comparing treatments in case of significant 'F' test.

RESULTS AND DISCUSSION

The data pertaining to germination (%), seedling dry weight (mg/seedling), vigour index , field emergence and moisture content as influenced by seed coating treatments and storage containers are presented in the Table 1 and in figures 1 and 2. The results showed significant difference with respect to germination and vigour due to seed coating treatments and storage containers whereas seed coating treatments.

Effect of seed coating materials

Up to 6 months of storage, all the seed coating treatments of soybean seed showed germination above Minimum Seed certification Standard (MSCS) i.e. 70.0% germination (Table 1), but at the end of the 8th month of storage, polymer coating followed by vitavax 200 @ 2 g kg^{-1}of seed (T_5=T_1+T_4) resulted highest (75.7%) germination which was significantly higher than rest of the coating treatments including control. The reason may be that the fine particles in the polymer coating act as a ‘wick’ or moisture attracting material. Coating with hydrophilic polymer regulates the rate of water uptake, reduce imbibition damage and improve the emergence of soybean seeds. Omar and Rahhal (1993) recorded that seed coating with thiram increased the percentage of seedling survival in soybean compared to untreated control. The lowest germination (66.2%) was found in untreated control (T_0) which was below MSCS level. Polymer coating alone (T_1) also improved germination percentage of soybean seed. The value of germination per cent (71.2%) was significantly higher than untreated control and lower to rest of the seed coating treatments. The polymer film may act as physical barrier, which has been reported to reduce the leaching of organic substances from the seed coverings and may restrict oxygen diffusion to the embryo (Vanangamudi et al., 2003). These results are in agreement with Chachalis and Smith, (2001) wherein they reported that soybean seed coating with polymer regulated the rate of water uptake, reduced imbibitional damage and improved the germination and seedling emergence in flooded soil condition. Wilson and Geneve (2004) also reported that corn seed coated with polymer and fungicide resulted higher germination (98.5%), less number of abnormal seedlings compared to control (89.0%, During initial months of storage seedling vigour index of all the seed coating treatments was superior to that of control. Among different treatment combinations the seeds coated with polymer @ 3ml kg^{-1} followed by vitavax 200 @ 2 g $kg^{-1}$of seed (T_5) treatment recorded significantly higher vigour index (9077) which was at par with Polymer + Flowable Thiram (Royal flow 40 SC) @ 2.4 ml kg^{-1} of seed treatment (T_3) at the end of storage. The lowest vigour index (7854) was noticed in untreated control seeds (Table1). It may be due to age induced decline in germination, decrease in dry matter accumulation in seedling and decrease in seedling dry weight. Similar findings were reported by Savitri et al. (1994) in sorghum and Savitri et al. (1998) in groundnut. Dadlani et al. (1992) recorded higher root length (34.80 mm), shoot length (170.20 mm) and dry weight of seedling (52.80 mg $seedling^{-1}$) as compared to control (33.63 mm, 147.60 mm and 48.30 mg $seedling^{-1}$, respectively) when seeds of IR 20 coated with polymer. The field emergence differed significantly among different treatments. Significantly highest field emergence of 79.7 % was recorded in polymer coating @ 3 ml kg^{-1} followed by vitavax 200 @ 2 g $kg^{-1}$of seed (T_5) which is 10.9 % highest over control followed by 79.0 in Polymer + Flowable Thiram (Royal flow 40 SC) @ 2.4 ml kg^{-1} of seed (T_3) as compared to control (71.0%) after 4 months of storage (Figure 2B). This decrease in the field emergence may be due to age induced deteriorative changes in cell and cell organells and germinative capacity of seed under natural soil conditions. These results are in conformity with the findings of Raj et al. (2002) in soybean.

Effect of Storage Containers

Higher moisture in seeds enhances seed deterioration, which ultimately reduces the planting value of seeds in the field (Justice and Bass, 1978; Vertucci and Roos, 1993). Preset study revealed that the moisture content of the seed increases with advancement of storage period. The fluctuation in seed moisture was more in seeds stored in cloth bag than polythene bag (Figure 1A). As seed is highly hygroscopic in nature; it absorbs moisture from air if it is stored in an environment where relative humidity is higher than seed moisture content (Harrington 1973). The relative humidity was above 75 % throughout the storage period. For this reason, seeds absorbed moisture from the ambient air and tended to equilibrium with relative humidity. The rate of absorbance was higher in cloth bag because of cloth bags are moisture pervious container but polythene bags are moisture impervious. Similarly values of standard germination gradually declined with increase in storage period under both cloth bag and polythene bag with latter showing significantly higher values (Table 1). It was observed that upto sixth months of storage germination per cent was above MSCS Level in both the containers but with the increase in storage period it was decreased. At the end of 8^{th} month of storage, germination per cent in polythene bag was 74.3%, which was significantly higher than the seed stored in cloth bag (68.7%). The reduction in germination was higher in cloth bag in comparison to polythene bag. The seeds of cloth bag absorbed moisture from the surrounding atmosphere. Due to increase in moisture content of seeds, respiratory activity and other physiological activities of the stored seeds increased and the rate of deterioration in terms of formation of abnormal seedling and dead seeds increased. These results are in agreement with Monira et al. (2012) wherein they reported that the moisture content increased with advanced of storage period but the increasing rate was higher in the seeds of cloth bag. The shoot length, root length of seedling and seedling vigour was lowest at the end of storage in cloth bag. Rahman and Rahman (1997) also reported that the highest germination and lowest prevalence of fungi in the seeds stored in tin followed by polythene bag and cloth bag with polythene. Field emergence of soybean seeds was significantly higher in the seeds stored in polythene bag (79.6%) than cloth bag (76.8%) after four months of storage (Figure 1B).This may be due to ageing, which resulted in deterioration of seed resulting the decrease in the field emergence.

CONCLUSION

Polymer coating prior to fungicide seed treatment improve the efficacy of fungicide maintaining higher germination of soybean seed after storage. Among two types of containers, polythene bags were found superior for maintaining viability of soybean seed. Cloth bag is not safe for soybean seed storage for longer time because the rate of moisture migration was higher in cloth bag than polythene bag.

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REFERENCES

Burris, J.S. 1980.Maintenance of soybean seed quality in storage as influenced by moisture and genotype. *Iowa State Journal of Research,* 54:377–389

Chachalis, D. and Smith, M. L. 2001. Hydrophilic polymer application reduces imbibition rate and partially improve germination or emergence of soybean seedlings. *Seed Science and Technology,* 29(1): 91-98

Dadlani, M., Shenoy, V. V. and Seshu, V.1992. Seed coating to improve stand establishment in rice. *Seed Science and Technology*, 20: 307-3217

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. 2nd Ed. John Wiley & Sons, Inc., New York

Government of India, Department of Agriculture and Cooperation, Ministry of Agriculture.1993. Handbook of Seed Testing (Agrawal, P. K. ed.). New Delhi

Harrington, J.F.1973. Biochemical basis of seed longevity. *Seed Science and Technology*, 1:453–461

International Seed Testing Association, 1993. International Rules for Seed Testing. *Seed Science and Technology,* 13: 299-355

Justice, O.L. and Bass, L.N. 1978. Principle and practices of seed storage. Agricultural Handbook No. 506. U.S. Government Printing Office, Washington, DC

Monira, U.S., Amin, M. H. A., Marin, M. and Mamun, M.A.A. 2012. Effect of containers on seed quality of storage soybean seed. Bangladesh Reserach. *Publication Journal*, 7(4): 421-427. Retrieve from http://www.bdresearchpublications.com/admin/journal/upload/09364/09364pdf

Ni, B. R. 1997. Seed coating, film coating and pelleting. In: *Seed Industry and Agricultural Development*, Chinese Association of Agricultural Sciences, DOA, Ministry of Agriculture, Beijing, China Agriculture Press, pp. 737-747

Omar, S. A. M. and Rahhal, M. M. H. 1993. Influence of fungicides on damping off disease and yield of soybean. *Egyptian Journal of Agricultural Research*, 71: 65-74

Rahman, M. M. K. and Rahman, G. M. M. 1997. Effect of container and length of storage on germination and seed-borne associated with jute seed. *Bangladesh Journal of Plant Pathology,* 13(1-2): 13-16

Raj, R.M., Kant, K. and Kulshreshta, D.D. 2002.Screening soybean cultivars for seed mycoflora and effect of thiram treatments. *Seed Research*, 30(1): 118-121

Sajad, S. 1980. The quality of seed forestry in Indonesia. Agriculture Institute Bogor.205p

Savitri, H., Suganakar Reddy, M. and Muralimohan Reddy, B. 1994.Effect of seed treatment with fungicides and insecticides on seed borne fungi, storage insect pest, seed viability and seedling vigour of sorghum. *Seed Research*, 22(2): 146-155

Savitri, H., Sugunakar Reddy, M. and Muralimohanreddy, B. 1998. Effect of seed treatment with fungicides and insecticides on seed borne fungi, storage insect pests,seed viability and seedling vigour of groundnut seed. *Seed Research*, 26(1): 62-72

Scott, J. M. 1989.Seed coating treatments and their effects on plant establishment.*Adv.Agron*.32: 43-83

Sherin and Susan John. 2003. Seed film coating technology using polykote for maximizing the planting value, growth and productivity of maize. Cv. Col. M.Sc. (Agri.) Thesis, Tamil Nadu Agril. Univ., Coimbatore (India)

Tatipata, A. 2009. Effect of seed moisture content, packaging and storage period on mitochondria inner membrane of soybean seed. *Journal of Agricultural Technology*, 5(1): 51-64

Taylor, A.G., Allen, P.S., Benett, M.A., Bradford, K.J., Burris, J.S. and Misra, M.K.1998. Seed enhancements. *Seed Science and Research,* 8:245-256

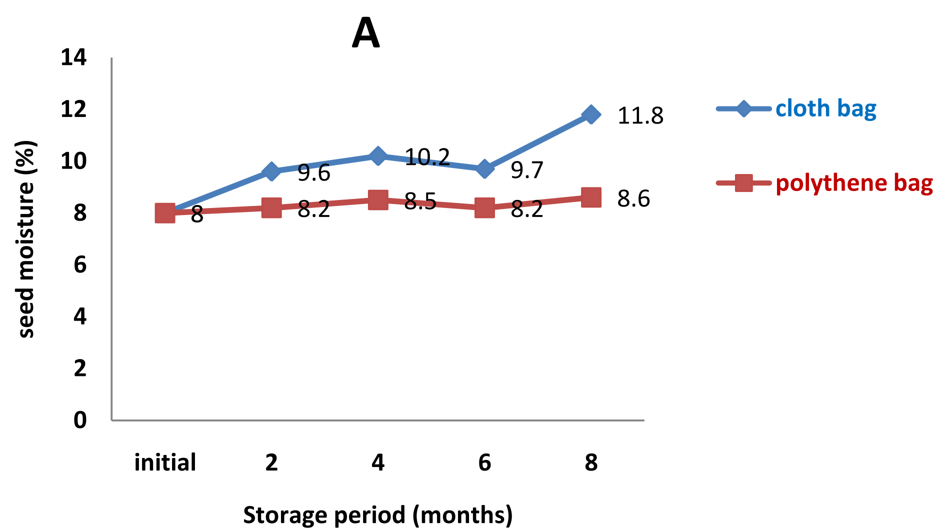
Vanangamudi, K., Srimathi, P., Natarajan, N. and Bhaskaran, M. 2003, Current scenario of seed coating polymer.*ICAR Short Course on Seed Hardening and Pelleting Technologies for Rainfed Garden Land Ecosystem*, p. 80-100

Vertucci, C .W. and Roos, E.E. 1993. Theoretical basis of protocols for seed storage II.The influence of temperature on optimal moisture levels. *Seed Science and Research*, 3:201–213

Wilson, T. T. and Geneve,R.L. 2004.The impact of film coating on initial water uptake and imbibitional chilling injury in high and low vigour sh2sweet corn seeds. *Seed Science and Technology, 32:* 271-281

Table 1: Effect of storage containers and seed coating on germination, seedling dry weight and seedling vigour index of soybean seed in storage

Treatment	Germination (%)				Seedling dry weight (mg seedling $^{-}$)				Seedling vigour Index			
	Storage period (in months)				Storage period (in months)				Storage period (in months)			
	2	4	6	8	2	4	6	8	2	4	6	8
Storage containers												
Clothe bag	85.7	81.4	74.9	68.7	122.1	121.5	120.3	119.2	10464	9893	8992	8245
Polythene bag	86.9	83.4	78.9	74.3	122.3	121.7	120.8	119.9	10622	10181	9539	8967
SEm±	0.29	0.32	0.39	0.33	0.09	0.05	0.11	0.09	35	38	50	60
C.D.(5%)	0.8	0.9	1.1	1.0	NS	0.1	0.3	0.3	102	112	146	177
Seeds coating Treatments												
T0(untreated control)	84.8	79.8	73.3	66.2	121.8	121.2	120.0	118.7	10326	9677	8797	7854
T1(Polymer coating @3 ml kg $^{-1}$ of seed)	86.2	82.2	76.5	71.2	122.1	121.5	120.5	119.5	10518	9984	9218	8510
T2(Flowable Thiram@2.4 ml kg $^{-1}$of seed)	85.8	81.8	76.0	71.5	122.1	121.5	120.5	199.7	10479	9939	9160	8557
T3(T1+T2)	86.8	84.0	78.2	72.7	122.3	121.9	120.7	199.7	10623	10240	9438	8868
T4(Vitavax 200 @2 g kg $^{-1}$of seed)	86.3	82.2	77.5	72.0	122.1	121.5	120.5	199.5	10544	9987	9327	8771
T5(T1+T4)	87.8	85.2	80.2	75.5	122.6	122.1	121.1	120.0	10768	10395	9652	9077
S.Em.±	0.50	0.55	0.97	0.57	0.15	0.10	0.19	0.15	60	66	86	104
C.D. (5%)	NS	1.6	2.0	1.7	0.4	0.3	0.6	0.5	177	195	264	306



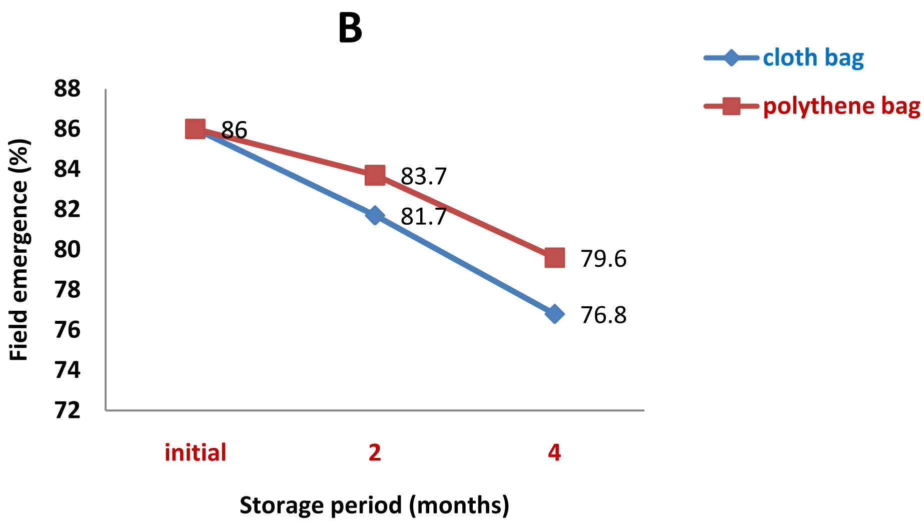


Figure 1: Effect of storage containers on seed moisture content (A) and field emergence (B) of soybean seed when stored at ambient storage

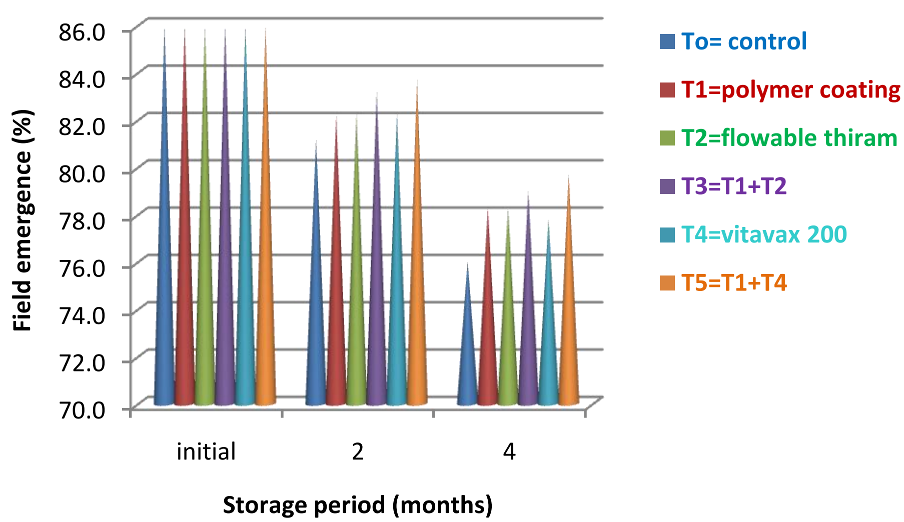


Figure 2: Effect of different seed coating on field emergence of soybean seed

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GENETIC DIVERSITY IN EGGPLANT GENOTYPES FOR HEAT TOLERANCE

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ABSTRACT

Genetic divergence in eighteen eggplant genotypes was studied at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh during February 2007 to December 2008 using multivariate analysis. Eggplant genotypes were evaluated for different quantitative characters. Among the genotypes wide variations were observed for plant, flower and fruit size, shape and color. Out of 18 genotypes only 8 were found to be suitable for summer and summer rainy season cultivation as heat tolerance. The 18 genotypes were grouped into four distinct clusters. Cluster I comprised of 2 genotypes, cluster II had 3, cluster III had 3 and cluster IV had 10 genotypes. Clustering pattern of the genotypes was not correlated with their geographical distribution. The highest inter cluster distance was between cluster I and IV (764.67) while, it was the lowest between cluster II and III (213.30). The highest and lowest intra cluster distance was displayed in cluster II (94.14) and cluster I (28.79) respectively. Yield per plant, number of fruits per plant, plant canopy, fruit weight, fruit length and number of harvest had the highest contribution towards total divergence. Moderate to high Shannon-Weaver Diversity Indices (SWDI) was found among the genotypes for most of the studied qualitative characters. Quantitative vegetative characters had high diversity among the genotypes, while it was moderate to high diversity for both flower and fruit characters. Eight eggplant genotypes were selected as heat tolerance based on genetic diversity of morphological characters in eggplant.

Key words: Eggplant, Genetic diversity, Genotype, Heat tolerance, Qualitative character.

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INTRODUCTION

Eggplant ((*Solanum melongena* L) is an important and popular vegetable crop of Bangladesh. There is an increasing demand of its varieties throughout the year for different culinary purposes. It is imperative to assess the relative magnitude of genetic variability, nature and extent of character association with yield and its related characters for a sound breeding program. A new variety can be developed from an assembled diverse genetic stock of any crop. Hence the success of any breeding program depends much on the genetic variability available to the breeders and the judicious selection of the parents (Islam, 2008). The quantification of genetic divergence through biometrical procedures has made it possible to choose genetically diverse parents for a successful hybridization program. Moreover, evaluation of genetic diversity is important to know the source of genes for a particular trait within the available germplasm (Tomooka, 1991). The utility of multivariate analysis for measuring the degree of genetic divergence and for assessing the relative contribution of different characters to the total divergence in self and cross pollinated crops has been established by several workers (Kete, 2001; Thuy, 2002; Emannuel, 2002 and Uddin, 2003 and 2005). Mahalanobis's generalized distance has been used as an efficient tool in the quantitative estimation of genetic diversity and a rational choice of potential parents for a successful hybridization program. Such study permits to choose genetically diverse parents for obtaining desirable recombinant in segregating generations. Since information on genetic divergence of eggplant during summer and summer rainy season is not available in Bangladesh, the present study was undertaken to find out genetic diversity of collected eggplant genotypes, to identify the most diverged genotypes in relation to yield and yield contributing characters and to find out the characters, which contribute towards divergence of the genotype.

MATERIALS AND METHODS

A study on enetic diversity in eggplant genotypes was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during February 2007 to September 2009. A total of eighteen eggplant genotypes viz., SM001, SM002, SM003, SM004, SM005, SM006, SM024, SM034, SM057, SM058, SM061, SM062, SM064, SM065, SM066, SM067, SM068 and SM069, were collected from different parts of the country including Jessore, Tangail, East-West Seed Co. Ltd, Bangladesh, Horticulture Research Center and Plant Genetic Resources Center of Bangladesh Agriculture Research Institute, Gazipur during 2006-2007. Eighteen eggplant genotypes were evaluated during summer and summer rainy season 2008 and 2009 for diversity study against hot humid condition of Bangladesh. The experiment was laid out in randomized complete block design with three replications. The minimum and maximum temperature during the study period was 26.8^{o}C and 33.49^{o}C, respectively. The fruits were harvested at marketable stage starting from June to September every year. Data on 34 quantitative characters (plant, leaf, flower and fruit characters) were recorded following the descriptor of eggplant (IBPGR, 1988).

Multivariate analysis including Principal Component Analysis, Principal Coordinate Analysis, Canonical vector analysis/ Euclidean D^2 values (Singh and Choudhury., 1985) and Shannon-Weaver Diversity Index (Yu Li et al., 1996) were performed with the data for each character using MS Excel, MSTATC and SPSS program for genetic diversity study.

RESULTS AND DISCUSSION

Genetic diversity of 18 eggplant genotypes were determined by using the multivariate analysis and the results are presented in table 1 to 10 and discussed under the following headings:

Principal Component Analysis (PCA)

Eigen values and eigen vectors of corresponding ten principal component axes and percentage of total variation accounting for them obtained from the principal component analysis are presented in table 1 and 2 respectively. Table 1 represents that the cumulative eigen values of first four principal components accounted for 99.15 per cent of the total variation among the genotypes. The first principal component accounted for 93.32 per cent of the total variation; the second, third and fourth components accounted for 2.83%, 1.58% and 1.42% of the total variation respectively. The rest of the components accounted for only 0.85% of the total variation. The minimum acceptable value of cumulative eigen value of the principal component for coconut is 75% (Emannuel, 2002).

Latent vectors presented in table 2 revealed that for principal component 1 (PRIN 1), yield per plant contributed the highest loading (0.998) for the variation among the genotypes followed by fruit per plant, east-west canopy (cm), north-south canopy (cm), individual fruit weight (g), fruit length (mm) and number of harvest contributing loads of 0.030, 0.026, 0.020, 0.018, 0.011 and 0.011 respectively. For principal component 2, fruit length (mm) contributed the highest loading (0.912) followed by plant height (0.138). For principal component 3, N-S canopy of the plant contributed the highest loading (0.715) followed by E-W canopy (0.603). For principal component 4, individual fruit weight (g) contributed the highest loading (0.846) followed by plant height (cm) (0.168). From the observation of principal component 1 to 4 it was clear that yield and yield contributing characters contributed to diversity of the genotypes. The first principal component accounts for as much of the variability in the data as possible and each succeeding component accounts as much of the remaining variability as possible (http:// www.fon.hum uva. hl/ praat manual/ Principal component_analysis, 2003)

The principal component analysis revealed that among the significant descriptors contributing to the first principal component, yield per plant contributed mostly to the total variation (loading-0.998). The findings of the present study corroborated to Rahman (1999) who found that the yield per plant contributed the highest for total variation of eggplant genotypes. The author further noted that fruit weight, fruit length, number of fruit per plant and days to 50% flowering were also important to some extent for the variation. Similar observations were noted by Kete (2001), Thuy (2002) and Uddin (2003, 2005) in coconut and Rajput et al. (1996) in eggplant. Rajput et al. (1996) found that plant height, fruit/plant, fruit weight, fruit length and percent fruit set were the main characters contributed to yield in eggplant.

Intra cluster distance

The magnitudes of the intra cluster distances were not always proportional to the number of genotypes in the clusters (Table 4). Statistical distances represent the extent of genetic diversity among the clusters. The highest intra cluster distance was obtained from cluster II (94.14) composed of 3 genotypes followed by cluster IV (83.43) and cluster III (72.67), composed of 10 and 3 genotypes respectively. The lowest intra cluster distance was noted in cluster I (28.79) composed of 2 genotypes. The lowest intra cluster distance indicated the close relationship between the genotypes of this cluster. The higher intra cluster distances indicated that the genotypes in the same cluster were more heterogeneous than the genotypes consisting on the other clusters.

Inter cluster distance

Inter cluster distances presented in table 4 revealed that the inter cluster distance was highest between cluster I and IV (764.67) followed by cluster I and III (493.85), cluster II and IV (482.81) and the lowest inter cluster distance was noted between cluster II and III (213.30). The higher value of inter cluster distances indicated that the genotypes belonging to all the clusters were far diverged. Again it was observed that the inter cluster distances were larger than the intra cluster distances suggested wider genetic diversity among the genotypes of different clusters/groups. Rahman (1999) and Chowdhury (2005), Islam (2008) also obtained larger inter cluster distance than the intra cluster distances in eggplant and hyacinth bean respectively.

The genotypes of distant clusters could be used in hybridization program for obtaining a wide range of variation among the segregants. Similar reports were also made by Islam (2008) in hyacinth bean. Wenxing et al. (1994) reported the beneficial effect of crossing carried out between sesame genotypes belonging to different groups having genetic distance (D^2) greater than 12.5. In the present study, the intra cluster distances of all the clusters and inter cluster distances among all the clusters were higher than 12.5 suggesting suitability of crossing between the desirable genotypes of any of the clusters for getting greater heterotic effect.

Cluster mean

Cluster means of 34 quantitative characters are presented in table 5. Although cluster IV composed of the largest number of genotypes (Table 3), yield and yield contributing characters earned the lower mean values. Most of the yield contributing characters earned maximum mean values in cluster III, cluster I and cluster II. There was significant difference among the clusters for yield and yield contributing characters. Cluster means presented in table 5 revealed that cluster I composed of 3 genotypes (Table 3) earned the maximum mean value for yield per plant (847.16 g), number of fruit per plant (32.05) and number of harvest (11.10) followed by cluster II (566.41g, 10.10 and 9.67 respectively) and cluster III (362.46g, 5.22 and 7.00 respectively). On the other hand cluster IV earned the lowest value for these characters (85.75g, 2.68 and 2.65 respectively). Cluster II earned maximum values for individual fruit weight (79.60g) followed by cluster III (79.54g). On the other hand, cluster I earned the lowest value in this respect (26.20g). Among the clusters, cluster I showed the earliness (61.90 days for first flowering). The second early genotypes comprising in the cluster II (79.40 days) and the genotypes of other clusters were late in flowering. Fruit length was the highest in genotypes of cluster III (121.98mm) followed by cluster I (91.34 mm). The shortest fruit was exhibited by genotypes under cluster II (76.00 mm). The highest fruit breadth was found in the genotypes under cluster (II) (55.67 mm) followed by cluster III (52.54 mm). Pulp thickness was the highest in cluster I (8.01mm) followed by cluster III and II (7.65 mm and 7.60 mm respectively).

From the findings of the present study it was clear that cluster I, II and III showed the higher cluster mean values for yield and yield contributing characters (Table 5). Considering the highest and foremost contribution of yield per plant for diversity among the genotypes, the genotypes of cluster I, II and III could be selected for future hybridization program to get the higher heterotic effect.

D^2 statistics (Euclidean Distance)

Considering the similarity of the genotypes it was clear that the genotypes SM001 and SM002 were closely related to each other and the distance was only 57.70 (Table 6). These two genotypes are far distant from others. The genotypes SM004, SM006 and SM024 were more closely related to each other than the other genotypes. The distance between SM004 and SM024 was only 69.26 and the distance between SM006 and SM024 was 127.02 and between SM002 and SM006 was 161.13. The genotypes SM057, SM067 and SM034 were more closely related to each other. Among these three genotypes, the distance was lower between SM057 and SM067 (106.03). The distance between SM034 and SM057 was 183.89 and between SM034 and SM067 were 186.88. The genotypes SM003, SM005, SM061, SM062, Sm064, SM065, SM066, SM058, SM068 and SM069 were more or less closely related to each other. The distance between SM003 and SM061 was 84.08; between SM003 and SM062 were 81.25; between SM003 and SM065 was 56.97 and between SM003 and SM066 was 83.54. The similarity or dissimilarity of the genotypes was mainly based on yield parameter of the genotypes that could be confronted from Table 2. The highest distance was noticed between SM002 and SM066 (836.41) followed by the distance between SM002 and SM064 (835.84), between SM002 and

SM061 (831.38) and between SM002 and SM062 (827.31). This indicated that SM001 and SM002 were far distance from SM066, SM0064, SM0061, and SM062.

Shannon-Weaver Diversity Index (H')

Shannon-Weaver Diversity Indices (H') were calculated by using twenty three qualitative and 34 quantitative characters related to vegetative (plant and leaf), flower and fruit characters to determine the diversity among the eggplant genotypes.

SWDI (H') for qualitative characters

Low to high diversity was found among the studied genotypes for qualitative characters. The SWDI (H') values for qualitative characters among the eggplant genotypes ranged from 0 to 0.85. Most of the qualitative characters had moderate to high diversity among the genotypes with a mean of 0.48 for plant and leaf characters and 0.62 for flower and fruit characters which also indicated the low to moderate diversity. The highest diversity among the genotypes was observed for fruit apex shape (H'=0.85) followed by plant growth habit, plant stem color, flower pedicel color (H'= 0.82 for each character). Low diversity (H'= 0.20-0.47) was found for nine qualitative characters of eggplant. Among these nine characters, the lowest diversity was found among the genotypes for the presence of prickles on stem (0.20), while there was no diversity among the genotypes for presence of prickles on upper surface of leaf (Table 7a).

Jamago (2000) classified the diversity of mungbean based on morphological characters as high (H'= >0.750), moderate (H'= 0.50-0.75) and low (H'= <0.50) diversity. The same classification was followed by Kete (2001), Thuy (2002), Emannuel (2002) and Uddin (2003 and 2005) in coconuts. Thuy (2002) found low diversity for qualitative vegetative characters while Uddin (2003 and 2005) found moderate to high diversity for those in coconut. The current findings corroborates with Uddin (2003 and 2005).

SWDI (H') for quantitative characters

Quantitative vegetative characters

High diversity (H' =0.76-0.86) was found among the studied genotypes for all the vegetative characters except number of branches per plant. Moderate diversity (H' =0.70) was observed for number of branch per plant. The SWDI (H') values for quantitative vegetative characters among the eggplant genotypes ranged from 0.70 to 0.86 with a mean of 0.81 which also indicated the high diversity. The highest diversity among the genotypes was observed for north-south canopy, leaf petiole length and leaf blade width (H'=0.86) followed by leaf petiole diameter, leaf blade length (H'= 0.82 for each character) and plant height (H'=0.81) (Table 8).

Thuy (2002) and Emannuel (2002) found moderate diversity for quantitative vegetative characters while for those characters Uddin (2003) found high diversity except bunch per palm and number of leaves per palm in coconut. The current findings corroborates with Uddin (2003).

Quantitative flower characters

High diversity (H' =0.76-0.82) was found among the studied genotypes for fifty per cent of the flower characters and for the rest fifty per cent had moderate diversity (H' =0.59-0.72). The SWDI (H') values for quantitative flower characters among the eggplant genotypes ranged from 0.59 to 0.82 with a mean of 0.71 which also indicated the moderate diversity. The highest diversity among the genotypes was observed for stamen length (H'=0.82) followed by style length and flower calyx length (H'= 0.79 and 0.77 respectively) (Table 9). Thuy (2002) and Emannuel (2002) found moderate diversity for quantitative flower characters, while for those characters Uddin (2003 and 2005) found high diversity in coconut. The current findings corroborates with Uddin (2003 and 2005).

SWDI (H') for quantitative fruit characters

The SWDI (H') values among the eggplant genotypes for quantitative fruit characters ranged from 0.52 to 0.84 with a mean of 0.71 which indicated the moderate diversity. Among the studied characters fifty per cent of the fruit characters had high diversity (H' =0.76-0.84) and the rest fifty per cent had moderate diversity (H' =0.52-0.73). The highest diversity among the genotypes was observed for pedicel length (H'=0.84) followed by core diameter (0.80) and fruit calyx length (H'= 0.79) and fruit pulp thickness ((H'= 0.78) (Table 10). Kete (2001) and Emannuel (2002) found low to moderate diversity for quantitative fruit characters, while for those, Uddin (2003) found high diversity in coconut.

CONCLUSION

It was concluded that moderate to high diversity was present among the genotypes for quantitative characters. Yield and yield contributing characters contributed more towards diversity among the genotypes. All the genotypes were grouped in to 4 clusters. Eight genotypes viz., SM001, SM002, SM004, SM006, SM024, SM034, SM057 and SM067 were selected as heat tolerance based on genetic diversity of morphological characters in future hybridization program for heterotic effects.

REFERENCES

Chowdhury, M.S.I. 2005. Study of genetic diversity and characterization of some cultivars of eggplant (*Solanum melongena* L.). MS Thesis. Dept. of Horticulture, BSMRAU, Gazipur, Bangladesh

Emannuel, E.E. 2002. Morphometric traits and DNA profiles of three generations of selected coconut genotypes. M.S. Thesis. Plant Genetic Resources Conservation and Management, University of Philippines (UPLB), Los Baños, Laguna, Philippines. p. 89

http://www.fon.hum.uva.nl/praat/manual/Principal_component_analysis.html. 2003. Google search. Principal Component Analysis

Islam, M.S. 2008. Genetic Diversity, combining ability and heterosis in hyacinth bean (*Lablab purpureus* (L.) Sweet). PhD. Dissertation. Dept of Horticulture. BSMRAU, Gazipur, Bangladesh. p. 190

Jamago, J.M. 2000. Morpho-agronomic and molecular diversity of the Philippines mungbean germplasm. M.S. Thesis. Plant Genetic Resources Conservation and Management, University of Philippines (UPLB), Los Baños, Laguna, Philippines. p. 141

Kete, T.N. 2001.GIS-aided morphological diversity assessment of coconut (*Cocos nucifera* L.) in three southern Tagalog Provinces, Philippines. M.S. Thesis. Plant Genetic Resources Conservation and Management, University of Philippines (UPLB), Los Baños, Laguna, Philippines. p. 115

Rahman, A.B.M. 1999. Genetic divergence in brinjal. MS Thesis. Dept. of Genetics and Plant Breding, BSMRAU, Gazipur, Bangladesh

Rajput, J.C., S.S. Pandit, S.L. Patil and V.H. Patil. 1996. Variability, heritability and inter-relationship of important quantitative characters in eggplant. *Annals of Agricultural Research*, 17(3): 235-240

Singh, R.K. and B.D. Choudhury. 1985. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi. pp. 102-138

Tomooka, N. 1991. Genetic diversity and landrace differentiation of mungbean, *Vigna radiata* (L) Wilcsek and evaluation of its wild relatives as breeding materials. tech. p. 1. Bull. Tropical Research Centre, Japan. No. 28. Ministry of Agriculture. Forestry and Fisheries. Japan

Thuy, N.T. L. 2002. Morphological diversity, genetic erosion and indicators of in situ conservation of coconut (*Cocos nucifera* L.) in Vietnum. M.S. Thesis. Plant Genetic Resources Conservation and Management, University of Philippines (UPLB), Los Baños, Laguna, Philippines

Uddin, M. Sharaf. 2003. Diversity and on-farm conservation of coconut (*Cocos nucifera* L.) in northern Luzon, Philippines. M.S. Thesis. Plant Genetic Resources Conservation and Management, University of Philippines (UPLB), Los Baños, Laguna, Philippines

Uddin, M. S., J.B. Sangalang and T.H. Borromeo. 2005. Study on Diversity of Selected Coconut populations in Northern Luzon, the Philippines. *Bangladesh Journal of Agricultural Research*, 31 (1):139-152

Wenxing, W, Z. Hong, Y.L. Feng, W. Shuang Ling, W.X. Wei, H. Zhang, F.Y. Lu and S.L. Wei. 1994. Principal components analysis and genetic distance estimation and their application in sesame breeding program. *Acta Agriculture Borali Sinica*, 9(3): 29-33.

Yu Li, W.K. Shuzhi, Yongsheng Cao and X. Zhang. 1996. A pehnotypic diversity analysis of foxtail millet (*Setaria italica* L.P. Beauv) landrace of Chinese origin. *Genetic Resources and Crop Evolution*, 43:377-384

Table 1: Eigen values and percentage of variation of dispersion matrices of principal components for 34 quantitative characters of eggplant genotypes

Principal component	Latent roots/ Eigen values	Percentage of variance	Cumulative variance
PRIN 1	1337264.652	93.315	93.315
PRIN 2	40599.378	2.833	96.148
PRIN 3	22659.272	1.581	97.729
PRIN 4	20396.295	1.423	99.152
PRIN 5	5467.447	0.382	99.534
PRIN 6	3085.153	0.215	99.749
PRIN 7	1540.678	0.108	99.857
PRIN 8	866.352	0.060	99.917
PRIN 9	524.160	0.037	99.954
PRIN10	298.490	0.021	99.974

Table 2: Latent vectors/eigen vectors of 34 quantitative characters of eggplant in the first four principal components

Characters	Latent vectors in descending orders			
	PRIN 1	**PRIN 2**	**PRIN 3**	**PRIN 4**
Yield/plant (g)	0.998	-0.004	-0.028	-0.006
Fruits/plant	0.030	0.001	0.026	-0.114
East-west plant canopy (cm)	0.026	-0.155	0.604	0.037
North-south plant canopy (cm)	0.020	-0.148	0.715	0.017
Fruit weight (g)	0.018	-0.072	-0.127	0.846
Fruit length (mm)	0.011	0.912	0.132	0.116
Harvest number	0.011	0.009	-0.004	0.001
Plant height (cm)	0.005	0.138	0.195	0.168
Branches/plant	0.003	0.001	-0.011	0.001
Pulp thickness (mm)	0.003	-0.009	0.007	0.016
Fruit pedicel length (mm)	0.002	0.098	0.114	0.194
Flowers/inflorescence	0.001	0.007	-0.007	-0.007
Fruits/inflorescence	0.001	-0.001	-0.004	-0.006
Bisexual flowers/inflorescence	0.001	0.002	-0.006	-0.004
Stamen length (mm)	0.000	-0.002	0.002	0.013

Characters	Latent vectors in descending orders			
	PRIN 1	PRIN 2	PRIN 3	PRIN 4
Fruit length/breadth ratio	0.000	0.039	0.003	-0.004
Fruit pedicel. diameter (mm)	0.000	-0.007	-0.004	0.036
Style length (mm)	0.000	-0.004	0.002	-0.002
Leaf petiole. thickness (mm)	-0.000	0.004	0.009	0.012
Stamen length (mm)	-0.000	-0.001	0.001	-0.004
Leaf petiole diameter. (mm)	-0.000	0.004	0.010	0.011
Flower calyx length (mm)	-0.001	0.035	0.002	0.096
Flower pedicel diameter (mm)	-0.001	-0.004	0.001	0.007
Corolla length (mm)	-0.002	0.005	-0.008	0.036
Leaf blade length (cm)	-0.002	-0.000	0.016	0.004
Flower pedicel length. (mm)	-0.002	0.000	0.007	0.023
Leaf petiole length. (mm)	-0.003	-0.017	0.027	-0.006
Flower calyx length. (mm)	-0.003	0.023	-0.007	0.039
Leaf blade width. (cm)	-0.004	-0.003	0.030	0.023
Core diameter (mm)	-0.004	-0.146	-0.070	0.246
Fruit breadth (mm)	-0.005	-0.178	-0.031	0.244
Relative fruit calyx length.	-0.010	-0.167	-0.038	0.099
Days to 50%flowering	-0.018	0.050	0.163	0.167
Days to 1st flowering	-0.019	0.040	0.045	0.132

Table 3: Cluster Membership/Distribution and place of collection of 18 eggplant genotypes in four clusters

Cluster	Number of genotypes	Genotypes	Source/Place of collection
I	2	SM001	HRC, BARI
		SM002	Tangail
II	3	SM034,	PGRC, BARI
		SM057	PGRC, BARI
		SM067	Jessore
III	3	SM004	HRC, BARI
		SM006	HRC, BARI
		SM024	PGRC, BARI
IV	10	SM003	HRC, BARI
		SM005	East-West Seed Co.
		SM058	PGRC, BARI
		SM061	Jessore
		SM062	Jessore
		SM064	Jessore
		SM065	Jessore
		SM066	Jessore
		SM068	Tangail
		SM069	Tangail

Table 4: Intra (bold) and inter cluster distances between final cluster centers of 18 eggplant genotypes

Cluster	I	II	III	IV
I	**28.79**	295.28	493.85	764.67
II		**94.14**	213.30	482.81
III			**72.67**	285.59
IV				**83.43**

Table 5: Final cluster centers/mean values for first ten contributing characters of eggplant genotypes

Characters	Cluster centers/Cluster means			
	I	**II**	**III**	**IV**
Yield/plant (g)	847.16	566.41	362.46	85.75
Fruits/plant	32.05	10.10	5.22	2.68
East-west plant canopy (cm)	128.60	101.20	107.93	96.46
North-south plant canopy (cm)	148.60	97.33	114.00	107.08
Fruit weight (g)	26.20	74.60	79.54	35.69
Fruit length (mm)	91.34	76.00	121.98	81.05
Harvest number	11.10	9.67	7.00	2.56
Plant height (cm)	83.10	74.93	106.93	81.46
Branches/plant	4.20	6.20	4.13	3.26
Pulp thickness (mm)	8.01	7.60	7.65	6.21

Table 6: D^2 statistics of Euclidean distances among 18 eggplant genotypes during summer in Bangladesh.

Genotype	D^2 statistics (Euclidean Distance)																	
	SM001	**SM002**	**SM003**	**SM004**	**SM005**	**SM006**	**SM024**	**SM034**	**SM057**	**SM058**	**SM061**	**SM062**	**SM064**	**SM065**	**SM066**	**SM067**	**SM068**	**SM069**
SM001		**57.70**	741.73	484.51	770.39	502.37	449.51	178.2	325.56	664.21	795.07	791.68	801.04	778.85	799.53	341.75	635.86	704.44
SM002			779.50	519.31	**811.93**	544.79	486.49	211.49	366.22	**706.11**	**831.38**	**827.73**	**835.89**	**816.30**	**836.41**	376.75	674.72	740.07
SM003				284.97	122.06	291.00	304.18	576.10	440.28	131.50	84.08	81.25	133.11	56.97	83.54	431.78	121.68	77.83
SM004					328.29	161.13	69.26	316.59	206.40	234.08	333.31	334.31	348.57	321.63	344.22	156.34	209.33	248.17
SM005						280.05	336.22	605.18	476.29	106.85	133.48	137.00	155.11	119.89	136.80	469.42	190.72	162.70
SM006							127.02	341.71	249.78	180.63	339.65	338.55	343.67	322.88	346.94	237.76	224.55	267.32
SM024								278.13	175.75	235.08	353.61	351.68	364.87	340.18	362.16	148.98	215.23	270.40
SM034									183.89	500.35	626.41	622.94	631.82	612.15	632.64	186.88	473.91	538.20
SM057										371.60	497.29	494.18	513.60	474.61	497.78	106.03	331.75	414.46
SM058											178.69	178.75	198.19	156.85	181.86	367.40	123.93	142.26
SM061												24.90	69.64	55.96	37.163	484.03	185.37	107.27
SM062													68.66	49.91	31.636	483.89	180.39	105.95
SM064														99.70	81.581	497.78	222.39	128.26
SM065															38.951	468.09	161.41	105.28
SM066																491.22	182.06	117.26
SM067																	338.18	396.46
SM068																		125.4
SM069																		

Table 7a: Shannon-Weaver diversity indices (H') for qualitative plant and leaf characters of different eggplant genotypes

Characters	SWDI (H')
Plant growth habit	0.82
Stem color at flowering stage	0.82
Fruit position on the plant	0.42
Presence of prickles on stem	0.20
Presence of prickles on upper surface of leaf	0.00
Presence of prickles on lower surface of leaf	0.25
Leaf petiole color	0.68
Leaf blade color (upper surface)	0.43
Mid rib color	0.64
Leaf blade lobing	0.41
Leaf blade tip angle	0.60
Mean	**0.48**

Table 7b: Shannon-Weaver diversity indices (H') for qualitative flower and fruit characters of different eggplant genotypes

Corolla color	0.42
Flower pedicel color	0.82
Extent of pollen production	0.79
Fruit color at commercial ripeness	0.47
Fruit color distribution at commercial ripeness	0.68
Fruit color at physiological ripeness	0.67
Fruit flavor at commercial ripeness	0.63
Fruit curvature	0.43
Fruit apex shape	0.85
Position of widest part from base to tip	0.78
Fruit cross section	0.28
Fruit flesh density	0.63
Mean	**0.62**

Table 8: Shannon- Weaver diversity indices (H') for quantitative plant and leaf characters of different eggplant genotypes

Characters	SWDI (H')
Plant height (cm)	0.81
East-west plant canopy (cm)	0.76
North-south plant canopy (cm)	0.86
Number of branches/plant	0.70
Leaf petiole length (cm)	0.86
Leaf petiole diameter (mm)	0.84
Leaf petiole thickness (mm)	0.81
Leaf blade length (cm)	0.83
Leaf blade width (cm)	0.86
Average	**0.81**

Table 9: Shannon- Weaver diversity indices (H') for quantitative flowering characters of different eggplant genotypes

Characters	SWDI (H')
Days to first flowering	0.59
Days to 50% flowering	0.72
Number of flowers/inflorescence	0.60
Number of bisexual flowers/inflorescence	0.59
Flower pedicel length (mm)	0.76
Flower calyx length (mm)	0.77
Stamen length (mm)	0.82
Style length (mm)	0.79
Relative style length (longer than stamen)	0.71
Corolla length (mm)	0.80
Average	**0.71**

Table 10: Shannon- Weaver diversity indices (H') for quantitative fruit characters of different eggplant genotypes

Characters	SWDI (H‘)
Fruit length (mm)	0.62
Fruit breadth (mm)	0.77
Fruit length breadth ratio	0.61
Fruit calyx length (mm)	0.79
Relative fruit calyx length	0.76
Fruit pedicel length (mm)	0.84
Fruit pedicel diameter (mm)	0.78
Number of fruit/inflorescence	0.52
Fruit pulp thickness (mm)	0.78
Fruit core diameter (mm)	0.80
Number of harvest	0.73
Fruit weight (g)	0.62
Fruits/plant	0.59
Yield/plant (g)	0.71
Average	**0.71**

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GENETIC VARIABILITY, ASSOCIATION AND DIVERSITY ANALYSIS IN UPLAND RICE (*Oryza sativa* L)

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ABSTRACT

High heritability coupled with high to moderate phenotypic and genotypic coefficient of variation and genetic advance as per cent of mean was recorded for grain yield per plant, plant height, test weight, fertile spikelet per panicle, total grains per panicle and number of effective tillers per plant. Positive and significant association were observed for days to 50 per cent flowering, days to maturity, plant height, panicle length, fertile spikelet per panicle, total grains per panicle and spikelet fertility with grain yield per plant at both genotypic and phenotypic level, while highest positive direct effect on grain yield was recorded by fertile spikelet per panicle, total number of grains per panicle, plant height and days to 50% flowering. Based on ten quantitative traits the accessions were clustered into seven groups, the cluster III contained highest 14 accessions, followed by clusters I comprised 11 accessions and cluster VI, VII, V, IV and II have 9, 8, 7, 6 and 5 accessions, respectively. The first four principal components accounted for 77.13% of total variation of all the traits.

Key words: Correlation, Path analysis, Variability and Upland rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is a highly domesticated crop, and domestication processes are reported to be accompanied by genetic erosion, which causes a reduction in genetic diversity among traditional varieties and gradual loss of landraces from the fields (Brush, 2000). Modern rice cultivars have been developed through the hybridization of elite lines and subsequent selection for yield and quality traits. The genetic potential and magnitude of heterogeneity are still present in local landraces need to characterize in available upland rice germplasm.

Grain yield is dependent on many yield contributing traits as well as on the environmental influence. Genetic variability of yield contributing traits and

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interrelationship among them and their relation with yield are necessary for a successful breeding program. Knowledge of heritability is essential for selection based improvement. Before placing strong emphasis on breeding for yield improvement trait, the knowledge on the association between yield and yield attributes will immense help the breeder in the improvement of yield. The correlation coefficient may also help to identify characters that have little or no importance in the selection programme. The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all (Oad et al., 2002). Path coefficient analysis proposed by Wright (1921) help the partition the total correlation into direct and indirect effects of various causes. The spectrum of variability in segregating generation for grain yield traits depends on the genetic diversity of the combining parents. Hence, estimation of genetic diversity for yield traits among accessions is important for planning the future crossing programmes. Thus, the present investigation was undertaken to assess the genetic variability, association among the traits, their path coefficient and diversity analysis for grain yield and other traits.

MATERIALS AND METHODS

Panicles of sixty upland rice germplasm accessions were collected from natural habitat of Eastern India and DBT Networking Project, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during wet 2008-09 and their seeds were multiplied during next wet season 2010. The accessions were evaluated in randomized block design with three replications during *kharif* 2011 and 2012. Twenty days old single seedlings were transplanted with a spacing of 20 x 15 cm in 3.0 x 1.5 m plot. The recommended packages of practices were followed to raise a healthy crop. Where are fertilizer dosages? The source of upland rice germplasm accessions are presented in table 1.

The observations were recorded on days to 50% flowering, days to maturity, plant height, panicle length, effective tillers per plant, fertile spikelet per panicle, total number of grains per panicle, spikelet fertility percentage, test weight and grain yield per plant. Randomly ten plants are selected from each replication in each germplasm excluding border rows. Ten randomly selected plants in each accession in each replication were tagged for recording observation. The panicles of accessions showing shattering characteristics were observed daily and fertile spikelets were plucked one by one before shattering and stored.

The mean value of both years were pooled over and used for statistical analysis. The data was analyzed for variability as per procedure given by Panse and Sukhatme (1985). The genotypic and phenotypic coefficients of variability were worked out as per Burton and De-Vane (1953); heritability and genetic advance were estimated as per formula given by Allard (1960). Estimates of correlation coefficient were worked as per Al-Jibouri et al. (1958) and path analysis given by Dewey and Lu (1959). Cluster and principle component analysis (PCA) were carried out by using SPSS 16.0 version software.

RESULTS AND DISCUSSION

Variation and genetic parameters among accessions

The analysis of variance revealed highly significant difference among the germplasm accessions for all the traits indicating a large amount of variability was present in the set of material for effective selection (Table 2). The magnitude of phenotypic coefficient of variations was higher for yield and yield attributing traits but the difference is very less indicates the presence of environmental influence to some degree in the phenotypic expression of the traits (Table 3). Similar results were reported by Subudhi et al. (2011). The highest estimate of PCV and GCV were observed for fertile spikelet per panicle, total grains per panicle, grain yield per plant and number of effective tillers per plant, while the lowest in days to maturity and days to 50 per cent flowering . Similarly, Bhadru et al, (2012) reported high PCV and GCV for number of grains per panicle, fertility percentage and grain yield per plant in rice. The estimate of heritability were high for test weight (98.30%), plant height (97.83%), grain yield per plant (96.52%), days to 50 per cent flowering (94.50%) and days to maturity (93.94%) due to genetic causes rather only by environmental effects. High heritability does not always indicate high genetic gain; heritability coupled with high genetic advance should be used in predicting the ultimate effect for selecting superior varieties. High heritability along with high genetic advance as per cent of mean was recorded for grain yield per plant, fertile spikelet per panicle, total number of grains per panicle, plant height and number of effective tillers per plant indicated that the less influence of environmental effect in the inheritance of these traits. High heritability coupled with low genetic advance as per cent mean were observed in days to maturity and days to 50% flowering. Similar results were also reported by Pratap et al. (2012) and Gangashetty et al. (2013).

Character association and path analysis

The estimates of phenotypic and genotypic correlation coefficient are presented in table 4. The genotypic correlation coefficient was found to be higher than phenotypic correlation coefficient except for days to maturity indicating a strong inherent association for grain yield per plant and other traits also. Days to 50 per cent flowering, days to maturity, plant height, panicle length, fertile spikelet per panicle, total grains per panicle and spikelet fertility showed strong positive and significant association with grain yield per plant both at genotypic and phenotypic levels. The association studied indicating grain yield of rice can be improved by selecting germplasm having higher performances for these traits. These results are in conformity with findings of Singh et al. (2013a). The grain yield per plant had a negative significant association with test weight, while negative non-significant with number of effective tillers per plant. The result of path coefficient analysis between yield and yield related traits showed that, the traits via fertile spikelet per panicle, days to maturity, number of effective tillers per plant and plant height exhibited direct positive effect on grain yield. The strong positive association of fertile spikelet per panicle with grain yield was mainly observed through its direct effect, whereas total grains per panicle through its indirect effect of fertile spikelet per panicle (Table 5). Kumar and Saravanan (2012) and Minnie et al. (2013) reported similar results for days to maturity, number of productive tillers per plant, panicle length, fertile spikelet per panicle and spikelet fertility.

Cluster and principal component analysis

Rice accessions collected for the study were statistically analyzed for similarities in their quantitative traits using cluster observations analysis by Ward method. The accessions were partitioned into seven clusters based on similarities in characteristics (Figure 1). The cluster III contained the highest 14 accessions followed by clusters I and VI comprised 11 and 9 accessions. Cluster VII contained 8 accessions, while cluster V, IV and II have 7, 6 and 5 accessions, respectively. The clustering pattern indicates wide diversity between different groups of accessions. Accessions falling in a particular cluster indicate their close relationship among themselves as compared to the other clusters. Therefore, it could be expected that accessions within a cluster were less genetically different with each other, and were diverse from the cultivars belonging to other clusters. These finding are conformity with the results of Singh et al. (2012) and Singh et al. (2013b). The genetic distance between the parents largely governs the variability spectrum generated in the segregating generation. Therefore, diverse accessions could be used in breeding programme for improvement of quality traits.

Principal component analysis was further used to establish the patterns and interrelationships existing between the accessions and their quantitative traits. The first four principal components explained a total of 77.13% of the total variability in the all qualitative traits. The analysis of eigenvectors gave the information of qualitative traits for percentage of variation to the first four principal components, which were 39.20, 15.41, 12.11 and 10.41%, respectively (Table 6). Similarly, Singh et al. (2013b) reported the first three principal components accounting for 62.72% of total variation among thirty five wild rice germplasm.

CONCLUSION

The accessions were clustered into seven clusters. The cluster I could be hybridized with cluster VI and VII to achieve a wide spectrum of variation among the segregates. Principal component analysis indicated 77.13% of the total variation showed by first four principal components. PCA and cluster analysis complemented each other with some slight inconsistencies in terms of cluster composition. The separation and selection of varieties based on high heritability along with high genetic advance of traits make it easy for breeders to exploit their knowledge and skill in transgressive segregation breeding programme. In this experiment, grain yield per plant, plant height, test weight, fertile spikelet per panicle, total grains per panicle and number of effective tillers per plant had high heritability with high genetic advance, while traits days to maturity, plant height and fertile spikelet per panicle positive direct effect and significant association with grain yield per plant at phenotypic and genotypic levels. Therefore, selections of diverse accessions combine with desirable traits are to be effective in accumulation of favourable genes for bringing together into the common genetic background of cultivated *indica* rice *Oryza sativa* L.

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REFERENCES

Al-Jibouri, H. A., Miller, P.A. and Robinson, H.F. 1958. Genotypic and environmental variations and covariance in upland cotton cross of interspecific origin. *Agronomy Journal,* 50: 633-36

Allard, R.W. 1960. Principles of Plant Breeding. John Wiley and Sons, Inc. New York, p. 485

Bhadru, D., Rao, V. Tirumala, Mohan, Y. Chandra and Bharathi, D. 2012. Genetic variability and diversity studies in yield and its component traits in rice (*Oryza sativa* L.). *SABRAO Journal of Breeding and Genetics,* 44(1): 129-137

Brush S.B. 2000. The Issues of *in Situ* Conservation of Crop Genetic Resources. In: Genes in the Field: On-Farm Conservation of Crop Diversity (Brush SB, ed.). IPGRI, IDRC

Burton, G.W. and De-Vane, E.H. 1953. Estimating heritability in tall fescue *Festuca arundinaceae* from replicated clonal material. *Agronomy Journal*, 45: 578-581

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal,* 51: 515-18

Gangashetty, P., Salimath, P. and Hanamaratti, N. 2013. Genetic variability studies in genetically diverse non-basmati local Aromatic genotypes of rice (*Oryza sativa* L). *Rice Genomics and Genetics*, 4(2): 4-8

Kumar, P.S. and Saravanan, K. 2012. Genetic variability, correlation and path analysis in rice (*Oryza Sativa* L.). *International Journal of Current Research,* 4(9): 082-085

Minnie, C.M., Reddy, T.D. and Raju, C.S. 2013. Correlation and path analysis for yield and its components traits (*Oryza sativa* L.). *Journal of Research ANGRAU,* 41(1): 132-134

Oad, F.C., Samo, M.A., Hassan, Z.U., Pompe, S.C. and Oad, N.L. 2002. Correlation and path analysis of quantitative characters of rice ratoon cultivars and advance lines. *International journal of Agricultural and Biology*, 4(2): 204-207

Panse, V.G. and Sukhatme, P.V. 1985. Statical methods for Agricultural workers. 4th edition ICAR, New Delhi

Pratap, N., Singh, P.K., Shekhar, R., Soni S.K. and Mall A.K. 2012. Genetic variability, character association and diversity analyses for economic traits in rice (*oryza sativa* L.). *SAARC Journal of Agriculture*, 10(2): 83-94

Singh, A., Singh, A.K., Parveen, S. and Singh, P.K. 2013a. Studies on genetic characteristic of upland rice (*Oryza sativa* L.). *International Journal of Agriculture, Environment and Biotechnology*, 6(4): 515-520

Singh, A., Singh, B., Panda, K., Rai, V.P., Singh, A.K., Singh, S.P., Chouhan, S.K., Rai, V., Singh, P.K. and Singh, N.K. 2013b. Wild rice of Eastern Indo-Gangetic plains of India constitutes two sub-populations harbouring rich genetic diversity, *Plant Omics Journal*, 6(2): 121-127

Singh, Praveen, Pandey, Anil, Mishra S.B. and Kumar, Rajesh 2012. Genetic divergence study in aromatic rice (*Oryza sativa* L.), *SABRAO Journal of Breeding and Genetics*, 44(2): 356-369

Subudhi, H.N., Das, S., Swain, D. and Singh, O.N. 2011. Variability, correlation and path analysis for quality characters in rice. *Oryza*, 48(4): 319-323

Wright, S. 1921. Systems of mating. *Genetics*, 6: 111-178

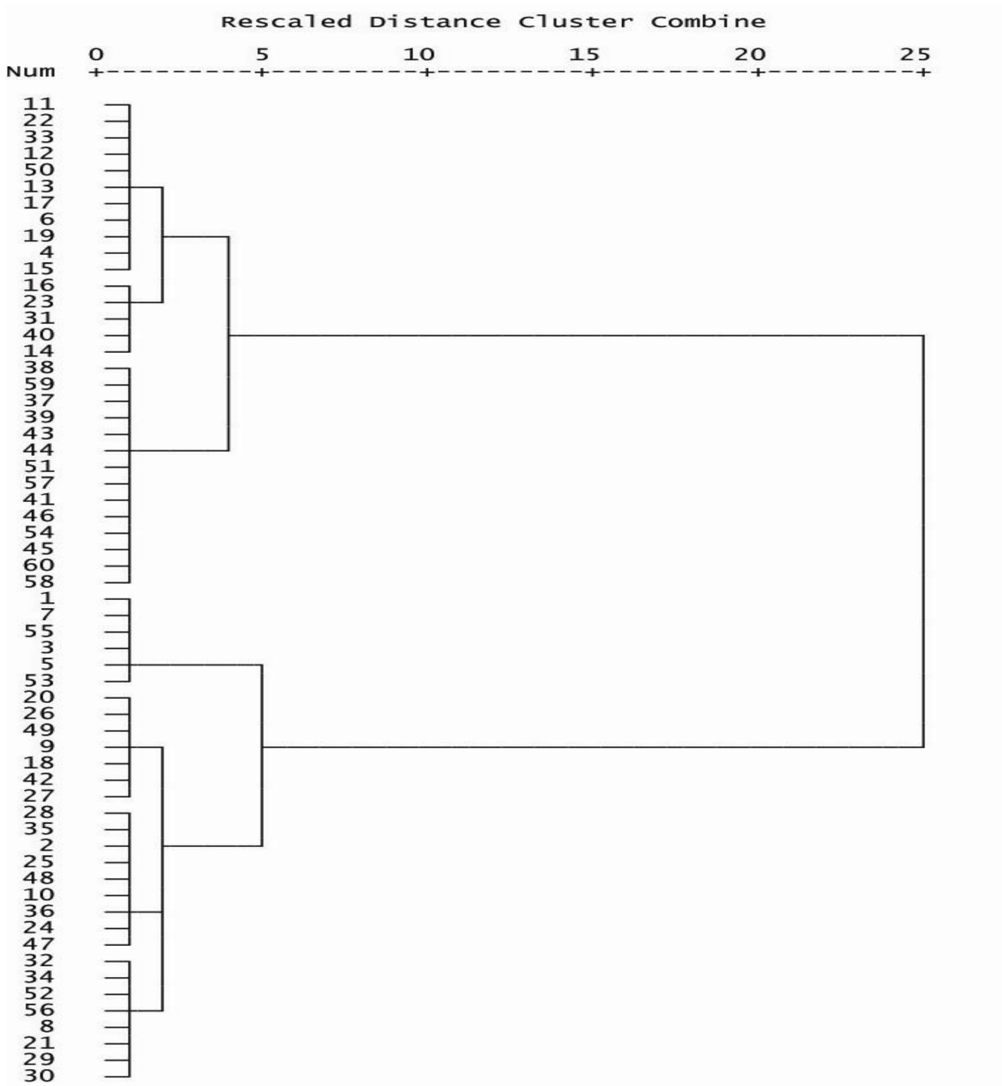

Figure1: Dendrogram showing clusters of 60 upland rice germplasm accessions formed by Ward method and numbers 1-60 represent rice germplasm accessions as described in table 1.

Table 1: List of sixty upland rice germplasm accessions and their collection site

S.N.	Accession Number	Collection site (Village, Block, District, Country)/Source
1	PKSLGR-1	Hingutarghar, Dhanapur, Chandauli, India
2	PKSLGR-2	Nakenampur, Dhanapur, Chandauli, India
3	PKSLGR-3	Bhaluadai, Shahabganj, Chandauli, India
4	PKSLGR-4	Bishunpura, Chakiya, Chandauli, India
5	PKSLGR-5	Mamarakpur, Shahabganj, Chandauli, India
6	PKSLGR-6	Ramghar, Chakiya, Chandauli, India
7	PKSLGR-7	Muzafferpur, Chakiya, Chandauli, India
8	PKSLGR-8	Diberiya, Chakiya, Chandauli, India
9	PKSLGR-9	Nawajganj, Chakiya, Chandauli, India
10	PKSLGR-10	Ghorawal, Newarpura, Sonbhadra, India
11	PKSLGR-11	Dumahar, Babhani, Sonbhadra, India
12	PKSLGR-12	Dadvahani, Babhani, Sonbhadra, India
13	PKSLGR-13	Satvahani, Babhani, Sonbhadra, India
14	PKSLGR-14	Chhiyari, Babhani, Sonbhadra, India
15	PKSLGR-15	Mahuariya, Babhani, Sonbhadra, India
16	PKSLGR-16	Nibi, Vijaypur, Mirzapur, India
17	PKSLGR-17	Tilai, Vijaypur, Mirzapur, India
18	PKSLGR-18	Joya, Vijaypur, Mirzapur, India
19	PKSLGR-19	Tamua, Madiyan, Mirzapur, India
20	PKSLGR-20	Katariya, Madiyan, Mirzapur, India
21	PKSLGR-21	Barakachha, Madiyan, Mirzapur, India
22	PKSLGR-22	Gulalpur, Madiyan, Mirzapur, India
23	PKSLGR-23	Dhanawal, Madiyan, Mirzapur, India
24	PKSLGR-24	Ninwar, Lalganj, Mirzapur, India
25	PKSLGR-25	Sikhar, Sikhar, Mirzapur, India
26	PKSLGR-26	Baburi, Vijaypur, MirzapurI, India
27	PKSLGR-27	Shisotar, Nawanagar, Ballia, India
28	PKSLGR-28	Maturi, FatehpurManda, Ballia, India
29	PKSLGR-29	Deorara, Bansdih, Ballia, India
30	PKSLGR-30	Mehnagar, Meghnaghar, Ajamghar, India
31	PKSLGR-31	Naretha, Jahanaganj, Azamgarh, India
32	PKSLGR-32	Shahpur, Jahanaganj, Azamgarh, India

S.N.	Accession Number	Collection site (Village, Block, District, Country)/Source
33	PKSLGR-33	Kotila, Rani Kisarai, Azamgarh, India
34	PKSLGR-34	Mehnagar, Meghnaghar, Ajamghar, India
35	PKSLGR-35	Naretha, Jahanaganj, Azamgarh, India
36	PKSLGR-36	Shahpur, Jahanaganj, Azamgarh, India
37	PKSLGR-37	Kotila, Rani Kisarai, Azamgarh, India
38	PKSLGR-38	Ganjari Dheeh, Gangapur,Varanasi, India
39	PKSLGR-39	Raghunathpur, Sewapuri, Varanasi, India
40	PKSLGR-40	Bhainsa, Sewapuri, Varanasi, India
41	IC346813	DBT, New Delhi, India
42	IC346880	DBT, New Delhi, India
43	IC356117	DBT, New Delhi, India
44	IC356422	DBT, New Delhi, India
45	IC356429	DBT, New Delhi, India
46	IC356431	DBT, New Delhi, India
47	IC356432	DBT, New Delhi, India
48	IC362206	DBT, New Delhi, India
49	IC383441	DBT, New Delhi, India
50	IC383559	DBT, New Delhi, India
51	IC391524	DBT, New Delhi, India
52	IC418382	DBT, New Delhi, India
53	IC426012	DBT, New Delhi, India
54	IC426017	DBT, New Delhi, India
55	IC426058	DBT, New Delhi, India
56	IC426061	DBT, New Delhi, India
57	IC426137	DBT, New Delhi, India
58	IC438644	DBT, New Delhi, India
59	EC545051	DBT, New Delhi, India
60	EC545061	DBT, New Delhi, India

Table 2: Analysis of variance for ten quantitative traits in sixty upland rice germplasm

Source of variation	Df	Mean sum of squares									
		DF	DM	PH	PL	ET	FSP	TGP	SF%	TW	GYP
Replication	2	4.87	6.16	16.70	0.21	1.84	30.58	338.07	50.18	0.90	0.89
Treatment	59	130.04**	159.87**	1266.42**	23.26**	10.75**	4218.73**	4696.65**	174.49**	32.97**	72.84**
Error	118	2.47	3.36	9.30	1.45	1.10	227.49	296.43	30.99	0.189	0.86

**Significant at 1% level of significance.

DF= Days to 50 % flowering, DM= Days to maturity, PH= Plant height, PL= Panicle length, ET= Number of effective tillers per plant, FSP= Fertile spikelet per panicle, TGP= Total number of grains per panicle, SF%= Spikelet fertility, TW= Test weight and GYP= Grain yield per plant.

Table 3: Variability parameters for ten quantitative traits in sixty upland rice germplasm.

TraitsParameter		DF	DM	PH	PL	ET	FSP	TGP	SF%	TW	GYP
Range	Min.	74	94.33	82.47	15.53	3.89	46.5	52.6	61.67	12.07	8.45
	Max.	106.66	130.67	158.95	30.24	12.33	190.07	210.8	96.20	28.14	27.83
Grand mean		85.38	113.81	111.79	24.05	7.56	108.19	122.21	87.96	21.11	16.65
SE of mean (±)		0.91	1.05	1.75	0.69	0.60	8.64	9.94	3.21	0.25	0.54
Phenotypic variance		44.99	55.54	428.34	8.72	4.32	1557.90	1763.17	78.82	11.12	24.86
Genotypic variance		42.52	52.17	419.04	7.27	3.22	1330.41	1466.74	47.83	10.93	23.99
Variability (%)	PCV	7.86	6.55	18.51	12.28	27.47	36.48	34.36	10.09	15.79	29.94
	GCV	7.64	6.35	18.31	11.21	23.72	33.71	31.34	7.86	15.66	29.71
	ECV	1.84	1.61	2.73	5.02	13.87	13.94	14.09	6.33	2.06	5.58
Heritability (Broad sense) (%)		94.50	93.94	97.83	83.32	74.52	85.40	83.19	60.89	98.30	96.52
Genetic advance as % of mean		15.29	12.67	37.31	21.08	42.18	64.18	58.88	12.62	31.98	59.52

DF= Days to 50 % flowering, DM= Days to maturity, PH= Plant height, PL= Panicle length, ET= Number of effective tillers per plant, FSP= Fertile spikelet per panicle, TGP= Total number of grains per panicle, SF%= Spikelet fertility, TW= Test weight and GYP= Grain yield per plant.

Table 4: Phenotypic (r^{ph}) and genotypic (r^{g}) correlation coefficients among ten traits in sixty upland rice germplasm

Traits		DM	PH	PL	ET	FSP	TGP	SF%	TW	GYP
DF	r^{ph}	0.800**	0.172 *	0.280 **	-0.149 *	0.441 **	0.474 **	0.055	0.016	0.392**
	r^{g}	0.793**	0.177*	0.312**	-0.174*	0.498**	0.539**	0.079	0.022	0.409**
DM	r^{ph}		0.107	0.310 **	- 0.140 *	0.211 **	0.238**	0.091	-0.054	0.292**
	r^{g}		0.109	0.341**	-0.175*	0.248**	0.277**	0.127	-0.049	0.305**
PH	r^{ph}			0.484 **	-0.32**	0.470 **	0.359 **	0.397 **	-0.099	0.422**
	r^{g}			0.523**	-0.388**	0.515**	0.402**	0.508**	-0.102	0.433**
PL	r^{ph}				-0.144	0.361**	0.344 **	0.188 *	0.099	0.228**
	r^{g}				-0.189*	0.341**	0.315**	0.249**	0.107	0.254**
ET	r^{ph}					-0.211 **	0.202 **	0.107	0.114	-0.036
	r^{g}					-0.262**	-0.251**	-0.181*	0.145	-0.090
FSP	r^{ph}						0.956 **	0.307**	0.240**	0.651**
	r^{g}						0.969**	0.322**	-0.259**	0.714**
TGP	r^{ph}							0.042	-0.167 *	0.579**
	r^{g}							0.089	-0.181*	0.642**
SF%	r^{ph}								-0.267**	0.326**
	r^{g}								-0.341**	0.422**
TW	r^{ph}									-0.262**
	r^{g}									-0.268**

* & **: Significant at 5% and 1%, respectively.

Table 5: Phenotypic (P) and genotypic (G) matrix of direct and indirect effect on grain yield per plant in sixty upland rice germplasm

Traits		DF	DM	PH	PL	ET	FSP	TGP	SF%	TW	Correlation with GYP
DF	P	0.030	0.164	0.034	-0.028	-0.025	0.501	-0.277	-0.005	-0.001	0.393***
	G	-0.051	0.226	0.007	-0.016	-0.021	1.245	-0.961	-0.020	-0.001	0.408**
DM	P	0.024	0.204	0.021	-0.031	-0.025	0.240	-0.139	-0.008	0.005	0.291**
	G	-0.040	0.285	0.004	-0.018	-0.021	0.619	-0.494	-0.031	0.001	0.305**
PH	P	0.005	0.022	0.199	-0.049	-0.055	0.534	-0.210	-0.034	0.009	0.421**
	G	-0.009	0.031	0.037	-0.027	-0.046	1.286	-0.716	-0.125	0.002	0.433**
PL	P	0.008	0.063	0.097	-0.100	-0.025	0.411	-0.201	-0.016	-0.009	0.228**
	G	-0.016	0.097	0.019	-0.051	-0.023	0.852	-0.561	-0.061	-0.002	0.254**
ET	P	-0.005	-0.030	-0.064	0.014	0.171	-0.239	0.118	0.009	-0.010	-0.036
	G	0.009	-0.050	-0.014	0.010	0.120	-0.653	0.447	0.045	-0.003	-0.089
FSP	P	0.013	0.043	0.094	-0.036	-0.036	1.137	-0.558	-0.026	0.021	0.652**
	G	-0.025	0.071	0.019	-0.018	-0.031	2.498	-1.726	-0.079	0.005	0.714**
TGP	P	0.014	0.049	0.072	-0.035	-0.035	1.087	-0.584	-0.004	0.015	0.579**
	G	-0.027	0.079	0.015	-0.016	-0.030	2.421	-1.781	-0.022	0.004	0.643**
SF%	P	0.002	0.019	0.079	-0.019	-0.018	0.349	-0.024	-0.085	0.024	0.327**
	G	-0.004	0.036	0.019	-0.013	-0.022	0.804	-0.159	-0.246	0.007	0.422**
TW	P	0.001	-0.011	-0.019	-0.010	0.019	-0.273	0.098	0.023	-0.088	-0.260**
	G	-0.001	-0.014	-0.004	-0.006	0.017	-0.648	0.323	0.084	-0.019	-0.268**

Table 6: Eigen vectors and eigen values of the first four principal components

Variable	PC 1	PC 2	PC 3	PC 4
Days to 50 % flowering	0.67	0.63	-0.08	-0.22
Days to maturity	0.54	0.63	0.06	-0.50
Plant height	0.65	-0.37	0.46	0.13
Panicle length	0.55	0.12	0.59	0.16
Number of effective tillers per plant	-0.37	0.14	-0.37	0.17
Fertile spikelets per panicle	0.89	-0.11	-0.26	0.30
Total number of grains per panicle	0.83	0.06	-0.31	0.40
Spikelet fertility percentage	0.44	-0.54	0.20	-0.42
Test weight	-0.27	0.50	0.46	0.50
Grain yield per plant	0.77	-0.14	-0.29	0.05
Eigen Value	3.92	1.54	1.21	1.041
Variance (%)	39.20	15.41	12.11	10.41
Cumulative variance (%)	39.20	54.61	66.72	77.13

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SUITABILITY OF MAIZE-LEGUME INTERCROPS WITH OPTIMUM ROW RATIO IN MID HILLS OF EASTERN HIMALAYA, INDIA

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ABSTRACT

Maize (*Zea mays* L.) being a widely space crop were tried with different combinations of legumes cowpea (*Vigna unguiculata* L. Walp), frenchbean (*Phaseolus vulgaris* L.) and blackgram (*Vigna mungo* L.) as intercrops at different planting geometry to find out their suitability during 2009, 2010 and 2011 at eastern Himalayan, Arunachal Pradesh, India. Three experiments were carried out in sequence to identify suitable planting geometry to accommodate intercrops, screening best legume crops and subsequently best performed row ratio of maize and legume crops were intercropped in third experiment with 1:1, 1:2 and 1:5 row proportions. Sole maize gave the maximum grain yield with 4571.1 kg ha^{-1}, whereas, stover yield was highest with maize-cowpea intercrop at 1:2 row ratios (8013.4 kg ha^{-1}) and 57.1 kg ha^{-1} day^{-1} production efficiency followed by frenchbean and least with blackgram. Competition indices like land equivalent ratio (LER) was highest with 1:2 row ratio of maize-frenchbean (1.66), land equivalent coefficient (0.67). But, highest area time equivalent ratio (ATER) noticed with 1:2 row ratio of maize-blackgram (1.47). Relative crowding coefficient (K) and competition ratio were noticed higher with 1:2 row ratio of maize-cowpea, whereas, cowpea combinations has better crowding coefficient and blackgram combinations registered better competitiveness. Monetary advantage index (MAI) was 6433.2 with 1:2 row ratio of maize-blackgram followed by maize-cowpea and lowest with maize-frenchbean with the trend of 1:2>1:5>1:1 row ratios.

Key words: Competition indices, Intercropping, Maize, Monetary advantage index, Planting geometry

INTRODUCTION

Eastern Himalaya of India is a rocky terrain with hills and sloppy land, where slash and burn cultivation, locally known as "*jhum kheti*" is commonly practiced.

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Farmers put as many as 35 crops without following any row arrangement and seeding ratio resulted competition and yield reduction (Choudhary et al., 2012). But in recent years, trend of agricultural production system have changed drastically to achieve the high productivity and promote sustainability over time (Dhima et al., 2007). Intercropping is promising production technology which not only ensure efficient utilization of natural resources like light, nutrient, water and space (Ghosh, 2004; Dhima et al., 2007), but also conserve it by reducing soil erosion and lodging, suppress weed growth thereby helps in yield increment and maintain greater stability in crop yields (Banik et al., 2006). Intercropping is a viable agronomic means of risk minimizing farmers' profit and subsistence- oriented, energy efficient and sustainable venture (Sheoran et al., 2010). Since maize (*Zea mays* L.) is a widely spaced crop, inter row space could be profitably utilized for legumes. Maize- legumes intercropping system, besides increasing productivity and profitability also improves soil health, conserves soil moisture and increases total out turn. Inclusion of legumes as intercrop with cereals not only supply the additional nutrients to crop plant by converting and fixing atmospheric nitrogen in available form through symbiosis with *rhizobial* strains also conserve the soil. However, several factors like cultivar selection, seeding ratio, planting pattern and competition between mixture components affect the growth of species in intercropping (Singh et al., 2008).

A number of indices such as land equivalent ratio (LER), relative crowding coefficient (RCC), competitive ratio (CR), actual yield loss (AYL), monetary advantage index (MAI), and intercropping advantage (IA) have been proposed to evaluate the efficient intercropping system (Dhima et al., 2007). Indices describe competition with row ratios of system for economic advantages and land utilization efficiency. Competition among component crops is thought to be the major aspect affecting yield as compared with solitary cropping of cereals. Spatial arrangement and plant population in an intercropping system have important effects on the balance of competition between component crops and their overall productivity (Ghosh, 2004; Dhima et al., 2007). However, such indices have not been used for maize with different legumes as intercrops to evaluate the competition among species and also economic advantages of each intercropping system in the eastern Himalaya. Therefore, the present study was conceived to find out the suitable planting geometry of maize to accommodate intercrops and screen best legume crops under mid hill condition of eastern Himalaya for higher productivity.

MATERIALS AND METHODS

Climatic and soil characteristics of experimental site

The field experiments were conducted at the experimental farm of ICAR research complex for NEH Region, Basar, Arunachal Pradesh, India (27°95'N latitude and 94°76'E longitude, 631 m above MSL, under humid sub tropical climate) during 2009 to 2011. The daily temperature during a year varies widely between minimum 4^{o}C and maximum 35^{o}C. The experimental site received average annual rainfall of 2400 mm with high degree of monthly variations. The soil of experimental site is silty loam in texture, acidic in reaction (pH 5.3), high in organic carbon (Walkaley and Black, 1.32 g kg^{-1}), low in available nitrogen (alkaline permanganate N, 193.8 kg ha^{-1}), low in available phosphorus (Bray P, 10.4 kg ha^{-1}) and medium in available potassium (ammonium acetate K, 210.5 kg ha^{-1}).

Imposition of experiments

Experiment-1: Identifying suitable planting geometry for maize

The first field experiment was conducted during rainy season (2009 and 2010) with four planting geometry of maize *viz.*, 60 x 20, 60 x 30, 90 x 20 and 90 x 30 cm in a randomized complete block design (RCBD) with five replications. The plot size was 4.8 m x 4.0 m. Maize cv. *All rounder* was sown in the first fortnight of April as per treatment. Two seeds were placed in individual site and thinned after eight days to maintain one plant at each site and harvested 125 days after sowing (DAS). Maize crop was fertilized with 40 kg N, 60 kg P and 40 kg K ha^{-1} in the form of urea (46% N), single super phosphate (16% P) and muriate of potash (60% K), at the time of sowing. The remaining 40 kg of N was top dressed at 40 DAS. Standard scientific cultivation practices are followed to obtain good crop yield.

Experiment-2: Evaluation of different legume crops

The second field experiment was conducted during rainy season of 2009 and 2010 with five legume crops *viz.*, cowpea (var. CP-04), frenchbean (var. Anupama), blackgram (var. PU-31), groundnut (var. ICGS-76) and soybean (var. JS-335) in a randomized complete block design (RCBD) with four replications. The plot size was 3.6 x 2.0 m with spacing of 30 x 10 cm for all the crops. Crops were sown at first fortnight of April and fertilized as per recommended dose, cowpea (25 kg N, 75 kg P and 60 kg K ha^{-1}), frenchbean (62.5 kg N, 100 kg P and 75 kg K ha^{-1}), blackgram, groundnut and soybean (25 kg N, 60 kg P and 50 kg K ha^{-1}). Standard scientific cultivation practices recommended for each crop was followed to obtain good yield.

Experiment-3: Studying the influence of intercrop on the main and supplementary crops

Best suitable options are selected from the experiment 1 and 2 and third experiment was conducted using those combinations along with sole maize (90 x 20 cm). Cowpea, frenchbean and blackgram were selected as intercrops. The field experiment was conducted during the rainy season of 2010 and 2011 on maize with three selected legumes with 1:1, 1:2 and 1:5 row ratios with sole maize and three legumes (data no presented). The recommended basal dose of fertilizer for maize (40 kg N, 60 kg P and 40 kg K ha^{-1}), cowpea (25 kg N, 75 kg P and 60 kg K ha^{-1}), french bean (62.5 kg N, 100 kg P and 75 kg K ha^{-1}) and blackgram (25 kg N, 60 kg P and 50 kg K ha^{-1}) were applied at sowing and incase of maize, remaining nitrogen (40 kg N ha^{-1}) was top dressed at 40 DAS. For the intercropping treatments, fertilizers were applied proportionate to the sole optimum population for main and intercrop separately.

Observations

Yield of maize was recorded from the net plot area (2.4 x 3.0 m) for experiment 1 and 3. Cobs were harvested manually at physiological maturity period and the yield was recorded at 15% moisture content. Yield of legumes crops were recorded from net plot (2.4 x 1.6 m) for experiment 2 and 3. Cowpea and blackgram was plucked four times and frenchbean was plucked twice, whereas, soybean and groundnut were harvested once at the end of physiological maturity.

In intercropping, yield was recorded for individual companion crop along with maize and subjected to various intercropping indices. The yield advantage of intercropping was determined by calculating land equivalent ratio (LER), competition ratio (CR) and monetary advantage index (MAI) according to the methods described by Willey and Rao (1980). Land equivalent coefficient (LEC) as suggested by Adetiloye et al. (1983), area time equivalent ratio (ATER) as proposed by Hiebsch and McCollum (1987), relative crowding coefficient (K), aggressivity (A) was measured as suggested by Mc Gilchrist (1965), whereas, actual yield loss (AYL) and intercropping advantage (IA) was calculated as recommended by Banik et al. (2000).

The different parameters were statistically analyzed using SAS 9.2 programme. The significance of treatment effects was determined using the F-test. The significance of the difference between means of two treatments was tested using least significant difference (LSD) at 5% probability level. In most of the cases, there was no significant effect of year and/or year x intercropping; therefore, pooled results were presented.

RESULTS AND DISCUSSION

Rainfall distribution

During the experimentation it was noticed that the overall rainfall was comparatively lower during 2009 followed by 2011 and highest during 2010. July of 2010 and 2011 was the rainy month, whereas, August was the rainy month during 2009. But overall, the rainfall during the season was nearer to normal rainfall of the area, except 2009 (Figure 1).

Maize yield influenced by planting geometry

Planting geometry of maize with 60 x 30 and 90 x 20 cm has 55,500 plants ha^{-1} whereas; 60 x 20 cm and 90 x 30 cm registered 83,300 and 37,000 plants ha^{-1} respectively (Table 1). Maximum grain yield of maize was recorded with 60 x 30 cm spacing (4434 kg ha^{-1}) but was statistically comparable with 90 x 20 cm and significantly ($p<0.05$) superior over maize yield obtained with 90 x 30 cm. Planting geometry of maize at 90 x 30 cm and 60 x 20 obtained yield reduction of 22.15 and

7.72%, respectively than the 60 x 30 cm. This might be due to better utilization of solar radiation, space, nutrients etc. which, induce the plant to produce more yield attributes and finally contributed to higher grain yield. Stover yield was maximum with 60 x 20 cm (6508 kg ha^{-1}) followed by 60 x 30 and 90 x 20 cm and lowest with 90 x 30 cm. This was mainly due to more plants per unit area, resulted in more vegetative growth but these could not convert to yield attributes. Consequently, harvest index was higher in 90 x 20 cm (0.42) followed by 60 x 30 cm but was statistically comparable and least with 90 x 30 cm.

Legume crop yield

Individually legume yield was recorded and highest economic yield was obtained in cowpea (5267.5 kg ha^{-1}) followed by frenchbean and blackgram (Table 2). Similarly, stover yield and harvest index followed the trend of economic yield and the highest for cowpea (8057.5 kg ha^{-1} and 0.40, respectively). The performance of various legumes was evaluated with the cowpea equivalent yield and the highest was obtained with cowpea which was 92.8% higher than frenchbean followed by groundnut and blackgram (27.2 and 17.3% respectively). As per the cowpea equivalent yield and need of the farmers' three legume viz., cowpea, frenchbean and blackgram were selected as intercrops with maize.

Grain and stover yield, maize equivalent yield, production efficiency and land equivalent ratio

Maximum grain yield was recorded with sole maize (4571.7 kg ha^{-1}) followed by 1:1 row ratio of maize-cowpea (4413.3 kg ha^{-1}) and lowest yield under 1:5 of maize-frenchbean (2606.7 kg ha^{-1}). However, it was noticed that, maize in association with maize-blackgram (4411.7 and 4327.7 kg ha^{-1} under 1:2 and 1:1 row ratio, respectively) and frenchbean (4346.7 and 4146.7 kg ha^{-1} under 1:2 and 1:1 row ratio, respectively) produced similar trend of maize yield as per the above row ratio (Table 3). This was mainly due to better utilization of resources available at site and least competition offered. Similar finding was also reported by Ghosh (2004) and Dhima et al. (2007). Stover yield was recorded highest with 1:2 of maize-cowpea (8013.4 kg ha^{-1}) followed by 1:2 of maize-frenchbean (7922.5 kg ha^{-1}). However, it was noticed that the trend of stover yield was highest for 1:2 row ratios followed by 1:1 and lowest with 1:5 row ratios. Intercrop yield was mainly dependent on row ratios, it was noticed that as row ratio increased, plant population of intercrop gradually increased and registered higher intercrop yield. Therefore, 1:5 row ratios has higher yield followed by 1:2 and 1:1 row ratio.

The maize equivalent yield (MEY) was higher with 1:2 row ratios followed by 1:5 row ratios of maize-cowpea, which were 84.8 and 64.4%, respectively higher over sole maize. Different row ratio of frenchbean and blackgram registered considerably lower MEY than maize-cowpea system but was better than sole maize. The productivity followed the trend of MEY and was higher with 1:2 of maize-cowpea followed by 1:5 of maize-cowpea. It was also noticed that productivity was followed the trend of 1:2>1:1>1:5 row ratios, which was registered the increment of 55.3%>32%>27.8%, respectively whereas, among crops trend with cowpea>frenchbean>blackgram (Table 3).

Land equivalent ratio (LER) reflected the extra advantages of intercropping system; the partial LER of maize was lowered only by 3% with 1:2 row ratio of maize-cowpea/blackgram and 1:1 row ratio of maize-cowpea over sole maize followed by 1:2 of maize-frenchbean and 1:1 of maize-blackgram with 5% reduction (Table 3). In contrary, partial LER of intercrop was lowered by 15% with 1:5 row ratio of maize-frenchbean/blackgram over sole intercrops. The cumulative LER was noticed 31-66% higher than sole maize. This was due to considerably higher yield harvested. However, 1:2 row ratios have higher LER followed by 1:5 and 1:1, and among crop frenchbean was higher followed by cowpea and then blackgram.

Land equivalent coefficient, area time equivalent ratio, aggressivity and relative crowding coefficient

Land equivalent coefficient followed the trend of LER and measured highest LEC with 1:2 of maize-frenchbean (Table 4). Realistic comparison of the yield advantage and resource utilization of intercropping system was assessed by ATER. It was noticed that 1:2 row ratio of maize-blackgram has 47% higher ATER followed by 1:2 of maize-cowpea. Among the row ratio, 1:2 had 32-47% higher ATER followed by 1:1 and lowest with 1:5 row ratios, whereas, among the intercrops, the trend with blackgram>cowpea>frenchbean was recorded (Table 4). Similar findings were reported by Muhammad et al. (2008) in cotton+ cowpea intercropping and Singh et al. (2008) in maize based intercropping.

Aggressivity (A) assess the dominance of the crop species in intercropping, A of maize was measured more negative value at 1:1 row ratio of maize-frenchbean followed by 1:2 row ratio of maize-cowpea. However, lowest negative value for A of maize was noticed under 1:5 row ratio (Table 4). A of intercrops were noticed inverse trend over A of maize. Similar findings were also reported by Khan and Khaliq (2004).

Relative crowding coefficient (K) of maize was higher under 1:2 row ratio of maize-cowpea followed by 1:2 row ratio of maize-blackgram. The K of maize was recorded more than 1 for all the row ratios, which showed that the cereals were dominated over the legumes (Table 4). Such result was expected since cereals are more competitive than legumes (Ghosh, 2004; Dhima et al., 2007; Wahla et al., 2009). In contrary to this, K of intercrop was higher on 1:5 row ratios. This was due to lowered maize density and higher density of intercrops. The total K was followed the trend of 1:2>1:1>1:5 row ratio with cowpea>blackgram>frenchbean.

Competition ratio, actual yield loss and monetary advantage index

The competition ratio (CR) for maize was higher on 1:5 row ratios of maize-cowpea followed by blackgram and frenchbean with similar row ratio (Table 5). It was observed that row ratio has followed the trend of 1:5>1:2>1:1, whereas, among the crops blackgram>cowpea>frenchbean. Similarly, CR for intercrop was higher under 1:1 row ratio followed by 1:2 and lowest with 1:5 row ratio. The trend of CR in intercrop was highest with frenchbean followed by cowpea lowest with blackgram. Similar finding was also corroborated by Banik et al. (2000).

Actual yield loss (AYL) offered more accurate information than the other indices on inter- and intra-specific competitions in intercropping systems. AYL of maize was lower under 1:1 row ratio with maize-frenchbean. Frenchbean has recorded more yield loss followed by blackgram and lowest with cowpea (Table 5). It is also evident that intercropping of frenchbean has more yield loss followed by cowpea and lowest with blackgram.

Monetary advantage index (MAI) was higher with 1:2 of with maize-blackgram followed by 1:5 of maize-blackgram and lower with 1:1 row ratio of maize-frenchbean. Table 5 clearly depicted that among the maize-legume intercropping, blackgram has given highest monetary advantage followed by cowpea and lowest with frenchbean. Among the different row ratio, 1:2 gave the highest monetary advantages followed by 1:5 and the lowest with 1:1. MAI was mainly influenced by market price of produce and economic yield harvested, resulted in higher MAI. Ghosh (2004) and Dhima et al. (2007) also reported that if LER and K were higher then MAI also get improved. Higher seed yield and net income under planting pattern with differed row ratios may be explained in higher total productivity under intercropping with relatively less input investment (Banik et al., 2006).

CONCLUSION

The results of our study suggest that planting geometry of maize with 60 x 30 cm and 90 x 20 cm gave the similar yield. Growers of the region have more apathy towards cowpea, frenchbean and blackgram than others. The different row ratio of legumes on maize showed significant impact on productivity and various competition indices. Most of the intercropping indices were better with 1:2 of maize-cowpea with yield advantages of intercropping and optimum utilization of the environmental resources over sole maize. Among the legumes, blackgram had highest monetary benefit followed by cowpea. Therefore, in sole maize area, maize with 1:2 and 1:5 row ratios of cowpea and blackgram may be included to obtain higher system productivity. Apart from these, further studies are needed to determine how intercropping can be helpful to curtail inorganic nutrient use and weed suppression.

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REFERENCES

Adetiloye, P.O., Ezedinma, F.O.C. and Okigho, B.N. 1983. A land equivalent coefficient concept for the evaluation of competitive and productive interactions on simple complex crop mixtures. *Ecological Modeling,* 19: 27-39

Banik, P., Midya, A., Sarkar, B.K. and Ghose, S.S. 2006. Wheat and chickpea intercropping systems in an additive series experiment: advantages and weed smothering. *European Journal of Agronomy,* 24: 325-332

Banik, P., Sasmal, T., Ghosal, P.K. and Bagchi, D.K. 2000. Evaluation of mustard (*Brassica Compestris* var. Toria) and legume intercropping under 1:1 and 1:2 row replacement series system. *Journal of Agronomy and Crop Science,* 185: 9-14

Choudhary, V.K., Kumar, P.S., Kanwat, M. and Bhagawati, R. 2012. Improvement of *jhum* with crop model and carbon sequestration techniques to mitigate climate change in Eastern Himalayan Region, India. *Journal of Agricultural Science*, 4(4): 181-189

Dhima, K.V., Lithourgidis, A.A., Vasilakoglou, I.B. and Dordas, C.A. 2007. Competition indices of common vetch and cereal intercrops in two seeding ratio. *Field Crops Research,* 100: 249-256

Ghosh, P.K. 2004. Growth, yield, competition and economics of groundnut/cereal fodder intercropping systems in the semi-arid tropics of India. *Field Crops Research,* 88: 227-237

Hiebsch, C.K. and McCollum, R.E. 1987. Area x time equivalency ratio: a method of evaluating the productivity of intercrops. *Agronomy Journal*, 79: 15-22

Khan, M.B. and Khaliq, A. 2004. Studies on intercropping summer fodders in cotton. *Journal of Research Sciences*, 15: 325-331

McGilchrist, C.A. 1965. Analysis of competition experiments. *Biometrics*, 21: 975-985

Muhammad, A., Umer, E.M. and Karim, A. 2008. Yield and competition indices of intercropping cotton (*Gossypium hirsutum* L.) using different planting patterns. *Tarim Bilimleri Dergisi*, 14(4): 326-333

Sheoran, P., Sardana, V., Singh, S. and Bharat Bhusan. 2010. Bio-economic evaluation of rainfed maize (*Zea mays*)- based intercropping system with black gram (*Vigna mungo*) under different spatial arrangements. *Indian Journal of Agricultural Sciences,* 80(3): 244-247

Singh, U. Saad, A.A. and Singh, S.R. 2008. Production potential, biological feasibility and economic viability of maize (*Zea mays*)- based intercropping system under rainfed conditions. *Indian Journal of Agricultural Sciences,* 78 (12): 1023-1027

Wahla, I.H., Ahmad, R., Ahmad, E. A. and Jabbar, A. 2009. Competitive function of components crops in some barley based intercropping systems. *International Journal of Agricultural Biology,* 11: 69-72

Willey, R.W. and Rao, M.R. 1980. A competitive ratio for quantifying competition between intercrops. *Experimental Agriculture,* 16: 117-125

Table 1: Yield and harvest index of maize with different planting geometry (mean value of 2009 and 2010)

Planting geometry	Plant population	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
60 x 20 cm	83,300	4092	6508	0.38
60 x 30 cm	55,500	4434	6258	0.41
90 x 20 cm	55,500	4424	6196	0.42
90 x 30 cm	37,000	3452	5424	0.39
LSD at 0.05		287.6	202.7	0.01

Note: LSD: least significant difference; different letters in the same column are statistically significant at P=0.05% and same letters are statistically similar

Table 2: Yield and harvest index of different legumes crop (mean value of 2009 and 2010)

Crops	Days to mature	Economic yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Cowpea equivalent yield (kg ha^{-1})
Cowpea	83	5267.5±132.0	8057.5±328.5	0.40±0.010	5267.5
French bean	75	3415.0±115.0	5440.0±82.9	0.39±0.006	2732.0
Black gram	107	1335.0±44.4	3062.5±137.7	0.31±0.006	3204.0
Groundnut	110	1287.5±29.9	3212.5±85.4	0.29±0.005	3476.3
Soybean	112	1842.5±123.4	2337.5±188.7	0.37±0.013	3040.1
LSD at 0.05					292.47

Note: price of the produce (Rs ton^{-1}): maize: 9000; cowpea: 10000; frenchbean: 8000; blackgram: 24000; soybean: 16500; groundnut: 27000; [1$ equivalent to 58 Rs]

LSD: least significant difference; ± standard deviation from mean; different letters in the same column are statistically significant at P=0.05% and same letters are statistically similar

Table 3: Grain and stover yield, maize equivalent yield, production efficiency and land equivalent ratio as influenced by maize-legumes intercropping (mean value of 2010 and 2011)

Crops	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})*	Intercrop yield (kg ha^{-1})	Maize equivalent grain yield (kg ha^{-1})	Production efficiency (kg $ha^{-1}day^{-1}$)	Land equivalent ratio of maize	Land equivalent ratio of intercrop	Total land equivalent ratio
Sole maize	4571.7a	7860.0	-	4571.7	32.0	-	-	-
1:1 of maize-cowpea	4413.3b	7740.0	2280.0	6938.4	47.9	0.97	0.43	1.39
1:2 of maize-cowpea	4428.3b	8013.4	3620.0	8450.5	57.1	0.97	0.68	1.65
1:5 of maize-cowpea	2736.7d	4270.0	4300.0	7514.5	49.8	0.60	0.81	1.41
1:1 of maize-frenchbean	4161.7c	7515.0	1953.3	5898.0	40.7	0.91	0.48	1.40
1:2 of maize- frenchbean	4346.7b	7922.5	2841.7	6872.6	46.8	0.95	0.71	1.66
1:5 of maize- frenchbean	2606.7d	4255.0	3322.5	5560.0	36.8	0.57	0.83	1.40
1:1 of maize-blackgram	4327.7b	7776.7	465.0	5566.7	38.1	0.95	0.36	1.31
1:2 of maize- blackgram	4411.7b	7755.0	868.3	6727.2	45.2	0.97	0.68	1.64
1:5 of maize- blackgram	2661.7d	4789.2	1071.7	5519.5	36.1	0.58	0.83	1.41
LSD at 0.05	132.53	401.85		228.65	1.86	0.03	0.04	0.05

LSD: least significant difference, *stover yield of maize and intercrop is jointly presented as there was no price difference for stover yield

Table 4: Land equivalent coefficient, area time equivalent ratio, aggressivity and relative crowding coefficient as influenced by maize-legumes intercropping (mean value of 2010 and 2011)

Crops	Land equivalent coefficient	Area time equivalent ratio	Aggressivity of maize	Aggressivity of intercrop	Relative crowding coefficient of maize	Relative crowding coefficient of intercrop	Total relative crowding coefficient
1:1 of maize-cowpea	0.41	1.22	-0.43	0.42	28.88	0.76	21.72
1:2 of maize-cowpea	0.66	1.36	-0.13	0.13	41.69	2.15	90.46
1:5 of maize-cowpea	0.49	1.06	-0.06	0.06	1.50	4.36	6.58
1:1 of maize-frenchbean	0.44	1.17	-0.66	0.66	11.31	1.01	10.24
1:2 of maize- frenchbean	0.67	1.32	-0.19	0.19	19.89	2.86	56.86
1:5 of maize- frenchbean	0.47	1.00	-0.12	0.12	1.34	5.30	6.95
1:1 of maize-blackgram	0.34	1.04	-0.22	0.22	19.74	0.57	11.11
1:2 of maize- blackgram	0.65	1.47	-0.12	0.12	30.40	2.11	61.63
1:5 of maize- blackgram	0.48	1.18	-0.11	0.11	1.41	5.13	7.08
LSD at 0.05	0.03	0.09	0.08	0.07	5.34	1.21	15.87

LSD: least significant difference

Table 5: Competition ratio, actual yield loss and monetary advantage index as influenced by maize-legumes intercropping (mean value of 2010 and 2011)

Crops	Competition ratio of maize	Competition ratio of intercrop	Actual yield loss of maize	Actual yield loss of intercrop	Monetary advantage index
1:1 of maize-cowpea	0.69	1.44	-0.03	0.39	2690.8
1:2 of maize-cowpea	0.88	1.13	-0.03	0.10	3746.3
1:5 of maize-cowpea	0.95	1.06	0.00	0.05	2759.5
1:1 of maize-frenchbean	0.60	1.73	-0.09	0.57	2404.6
1:2 of maize- frenchbean	0.85	1.20	-0.05	0.14	3356.3
1:5 of maize- frenchbean	0.89	1.13	-0.05	0.07	2414.4
1:1 of maize-blackgram	0.81	1.23	-0.05	0.17	3887.7
1:2 of maize- blackgram	0.89	1.13	-0.03	0.09	6433.2
1:5 of maize- blackgram	0.90	1.11	-0.03	0.08	4835.8
LSD at 0.05	0.06	0.08	0.03	0.05	255.32

LSD: least significant difference

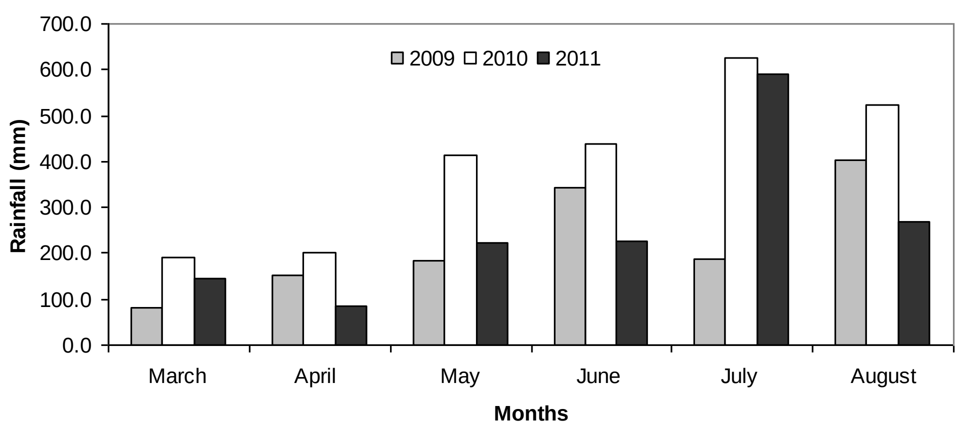

Figure 1: Rainfall distribution during the experimental period (2009, 2010 and 2011)

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STUDIES ON VARIABILITY IN *Alternaria alternata* (KESSLER) CAUSING LEAF BLIGHT OF ISABGOL (*Plantago ovata)*

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ABSTRACT

All the five isolates of *Alternaria alternata* isolated from different agro climate zone of Rajasthan were tested for their variability in terms of cultural, conidial, pathogenic characteristics and toxin production. All the five isolates differed in cultural characters i.e. dark black colored and very fast mycelial growth with smooth margins (90.00 mm), light black with white at centre and fast growing (80.00 mm), dark brown and medium mycelium growth with smooth margins (75.00 mm), black colored, medium flat mycelial growth with smooth margins (68.00 mm) and white with slightly black in colour with slow mycelial growth (65.00 mm) were observed in Aa-1, Aa-2, Aa-3, Aa-4 and Aa-5 respectively. The variability in conidial morphology of five different isolates was simple, septate, pale to dark brown in colour, often geniculate with one conidial scar. In respect of pathogenic variability, showed significant variations in terms of disease intensity and incubation periods. The isolates Aa-1 was highly pathogenic on Isabgol cv. RI-89 under artificial inoculation conditions showing 52.12% disease intensity followed by Aa-3 ,Aa-2, Aa-4 and Aa-5 isolates. The variability in toxin production was reflected in terms of time taken in inducing wilting symptoms of Isabgol cuttings. Isolate Aa-1 was highly toxic followed by isolates Aa-2, Aa-3, Aa-4 and Aa-5.

Key words: *Alternaria alternata*, Cultural, Spore Morphology, pathogenic, Toxin variability and *Plantago ovata*

INTRODUCTION

Isabgol, *Plantago ovata*, belongs to a large genus of herbs distributed mostly in the temperate regions and a few in the tropics. It comprises about 800 species, of

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which 10-14 are natives of India. In India, it is mainly cultivated in Mehsana and Banaskantha districts of Gujarat and adjoining districts of Rajasthan and to a limited extent in Haryana. Presently, Rajasthan is a dominating state of Isabgol production. Isabgol is cultivated in about 2,27,705 hectares of land in Rajasthan with the production of 1,39,998 tons (Anon., 2009-10). Isabgol growing districts of Rajasthan are Jalore, Barmer, Jodhpur, Bikaner, Pali, Sirohi, Chittorgarh and Udaipur. Its seeds and husk are used in the indigenous medicine for many centuries. Seed is the important plant part which has medicinal values. The husk has the property of absorbing and retaining water and therefore it works as an anti-diarrhoea drug.

Mandal (2010) reported that a number of plant diseases like wilt (*Fusarium oxysporum* Schlechtemend snyd and Hnns.), damping off (*Pythium ultimum* Trow.), leaf blight (*Alternaria alternata (*Fr.) Keissler), downy mildews (*Peronospora plantaginis* Underwood, *P eronospora alta* Fuckel and *Pseudopernospora plantaginis*) and powdery mildew (*Erysiphe cichoracearum* D.C.) blight (*Alternaria*) attack Isabgol. In recent years, the diseases become serious problem of the medicinal plant. It has been found that downy mildew infected the plants are more prone to be attacked by *Alternaria alternata*. It causes considerable damage every year and sometimes become very severe which results in total yield. The present investigations were conducted to find variability in *Alternaria alternata* (Kessler) causing leaf blight of Isabgol.

MATERIAL AND METHODS

Isolation, Purification and Identification of *A. alternata*

Five isolates of *A. alternata* were collected from five different Agro climate zones of Rajasthan i.e., R.C.A. farm (Udaipur), Kapasan (Chittorgarh), Mandore (Jodhpur), Sumerpur (Pali) and Keshwana (Jalore). On the basis of morphological, cultural and pathogenic characteristics, the isolates were identified as *Alteraria alternata* (Fr.) Keissler. Pathogenicity test was performed according Koch's postulates for all the five isolates. The identity of R.C.A. farm (Udaipur) isolate was confirmed by Indian Type Culture Collection (ITCC), Division of Plant Pathology, IARI, New Delhi-110012 (The ITCC Code no.6317, 2008).

Cultural variability

For cultural variability, five isolates of the pathogen were grown on potato dextrose agar (PDA) medium to record their growth pattern. The plates were inoculated with 5 mm discs cut from PDA culture of the isolates. The discs were placed at the centre of the Petri plates containing PDA. All inoculated plates were incubated at 25 ± 1ºC temperature in BOD incubator. Each isolate was replicated thrice (Petri dishes). The growth rate was measured and colony characters, pigmentation, growth habit and sporulation were recorded after 24 hrs of incubation till the growth of the pathogen in Petri plate completes.

Variability in spore morphology

Purified culture of each isolate was prepared following single spore method. For this purpose, a conidial suspension was prepared in sterilized distilled water from 10 days old culture on PDA and flooded on 2% plain agar in Petri plates. The excess suspension was drained off and the Petri plates were incubated in inverted position at 25 $\pm 1^0$C. After eight hours of incubation, a single germinating spore was marked with the help of dummy objective and then transferred individually with a piece of plane agar medium to PDA slants by inoculating needle under aseptic conditions. These monoconidial isolates were maintained on PDA slants and used to study spore morphology. Observations on variation in conidial dimension of five isolates of *A. alternata* were recorded with the help of Ocular and Stage Micrometer.

Pathogenic variability

Pathogenic variability is the genetic characters of fungi which may vary amongst isolates. Healthy seeds of Isabgol variety RI-89 were surface sterilized with 0.1% $HgCl_2$ and were sown in pot containing sterilized soil @ 10 seeds per pot and replicated thrice (three pots). Leaves, stems and branches of six weeks old Isabgol plants were randomly selected, and these were injured gently by delicate brush and ten days old culture suspensions of individual isolates were sprayed with an automizer in early morning, when dew deposition was observed on the leaves of the plants. Simultaneously, un-inoculated check was maintained by spraying sterilized distilled water on the plants. The inoculated plants were observed daily to record the incubation period for disease development. The disease intensity was calculated with the help of disease rating scale (1-5) where,

1=1-20% infection or 1-20% leaves of the plant are infected, 2= 21-40% infection or 1-40% leaves of the plant are infected, 3= 41-60% infection or 41-60% leaves of the plant, 4= 61-80% infection or 61-80% leaves of the plant are infected and 5= 81-100% infection or 81-100% leaves of the plant are infected.

Per cent disease index (PDI) was calculated data following standard formula (Wheeler (1969), as given:

$$\text{PDI} = \frac{\Sigma\, 1\text{x n}+2\text{ x n}+3\text{x n}+4\text{x n}+5\text{ x n}}{\text{N}} \text{X} \frac{100}{\text{Maximmum score (5)}}$$

Where, n = Number of plants in each score

N= Total number of plants checked

Toxin variability

For determining toxin variability, 25 ml Richards' medium having pH 6.5 was poured in 100 ml sterilized flasks were inoculated with 5 mm diameter fungal discs of 10 days old culture of different isolates of *A. alternata* grown on PDA and incubated at 25 ± 1ºC for 15 days. The culture filtrate was obtained by filtration through Whatman No.42 filter paper. The culture filtrates obtained from 15 days old cultures of *A. alternata* were centrifuged at 600 rpm for 20 min. The clear supernatant was collected in clean sterilized conical flasks and pellet sedimented at the bottom of the centrifuge tube was discarded. The clear supernatant solutions served as samples of crude toxin produced by different isolates were used to study toxin variability using detached (Salvik,1974).Observations were recorded regarding toxicity symptom expressions like necrosis, leaf drooping, wrinkling and drying of leaves at regular intervals of6, 12, 18, 20 and 24 hrs.

RESULTS AND DISCUSSION

Cultural variability

Considerable variability in all five in terms of colony characters like dark black colourd and very fast mycelial growth with smooth margin, light black with white at centre and fast growing, dark brown and mycelial growth with smooth margin, black colored, flat mycelial growth with smooth margin, and white with slightly black in colored with slow mycelial growth were observed in Aa-1, Aa-2, Aa-3, Aa-4 and Aa-5 respectively. The average radial growth of isolate Aa-1 was highest i.e. 90.00 mm while, in isolate Aa-2, Aa-3, Aa-4 and Aa-5, it was comparatively less i.e. 80.00 mm, 75.00 mm, 68.00 mm and 65.00 mm respectively on 7^{th} day of incubation under uniform environments and medium. Sporulation was recorded in all five isolates but very good sporulation was observed in Aa-1. In view of the results obtained for cultural variation, it is clear that all the five isolates differed with respect to mycelial growth of *A. alternata* attained after 7^{th} day for sporulation and colony characters. (Table 1) The results are also in similarity with the results obtained by Verma et al. (2007), Raja and Reddy (2007) and Tetarwal et al. (2008).

Variability in spore morphology

Clear variations among the isolates of *A. alternate* was observed (Table 2) The spore characteristics of individual isolates are described below:

Aa-1: Conidia were simple, obclavate, pale to dark brown formed in chains. Conidia have both transverse and vertical septa measuring 23-31 x 14-19 µm (with beak) and 6-18 x 6-11 µm (without beak).

Aa-2: Conidia were light brown to dark brown, obclavate, measuring 22-28 x 13-16 µm (with beak) and 9-11 x 7-10 µm (without beak).

Aa-3: Conidia dark brown colored, long beak and both transverse and vertical septa were present. The size of conidia measuring 29-36 x 14-23 µm (with beak) and 7-21 x 8-11 µm (without beak).

Aa-4: Conidia obclavate, shorten beak and light brown to dark brown in colour measuring 20-24 x 14-17 µm (with beak) and 8-12 x 6-9 µm (without beak).

Aa-5: Conidia were light brown and measuring 18-31 x 12-22 µm (with beak) and 10-15 x 7-9 µm (without beak).

The findings of the present investigation supported with the findings of Raja and Reddy (2007) collected the samples of leaf spot and fruit rot caused by *Alternaria alternata* from brinjal growing areas and it was found that The size of conidia varied from 35.2 -43.5 µm and 12.4-13.9 µm wide, with average beak length of 9.6 -12.4 µm. Horizontal and vertical septations of conidia varied form 1.8 and 0.3, respectively and conidia were produced in chain.

Pathogenic variability

The isolates of the pathogen collected from different geographical areas may show difference in virulence. The isolates Aa-1 was found to be highly pathogenic on Isabgol cv. RI-89 under artificial inoculation conditions, which showing 52.12% disease intensity followed by Aa-3 (47.56%), Aa-2 (41.40%), Aa-4 (38.20%) and Aa-5 (35.48%). However, data were recorded 4-5 days of incubation in Aa-1 followed by Aa-3 (4-6), Aa-2 (4-6), Aa-4 (5-7) and Aa-5 (5-7). The seedlings grown applying sterilized distilled water without inoculation did not produce any blighted symptoms and grew healthy (Table 3). The pathogenic variability have also been carried out by Verma et al. (2007) and Kumar et al. (2008) on *A. solani*. They recorded pathogenic variability among different isolates of *A. solani*. Tetarwal et al. (2008) observed variability among six isolates of *A. alternata* infecting Senna (*Cassia angustifolia*)

Toxin variability

The details of the experimental results are presented in Table 4. The culture filtrate is assumed as 100 per cent toxin concentration. This was simply an indicator test for toxin production. The symptoms like drooping of leaves, blackening of leaves was initiated at 6 hours and continued up to twenty-four hours, finally leading to wilting and necrosis, thus revealing the existence of variation among the isolates in producing toxic metabolites in the culture medium, which was reflected in terms of inducing wilting of Isabgol cuttings. The results indicated that Aa-1 isolate showed very severe toxic effect where initial toxicity symptom expression was within six hours, leading to complete and severe necrosis of leaves with distinct black colourations. Similarly, severely toxic , moderately toxic, slight toxic and least toxic effect were observed in cultural filtrate toxin of Aa-2, Aa-3, Aa-4 and Aa-5 isolates, respectively. This suggests that the toxin has active role in causing disease as well as mortality. Such phytotoxic effects produced by culture filtrate were also reported by Reddy and Chaudhary (1990) where, they observed that, when pigeon pea seeds were soaked in culture filtrate of six *Fusarium udum* isolates for 6, 12, 24 h, no germination occurred after 24 h and radial length was also decreased with increasing in soaking time. Maiero et al. (1991) stated that *A. solani* produced phytotoxic metabolites, and tomato seedlings exposed to culture filtrates for 20 h exhibited marginal and inter veinal leaf necrosis and subsequently wilting.

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REFERENCES

Government of Rajasthan. 2009-10. District wise, area, production and yield of Rabi crops. Directorate of Agriculture, Government of Rajasthan. (www.rwjasthankrishi.gov.in, Retrieved on 21-09-2011)

Kumar, V., Haldar, S., Pandey, K.K., Singh, R.P., Singh A.K. and Singh, P.C. 2008. Cultural, morphological, pathogenic and molecular variability amongst tomato isolates of *Alternaria solani* in India. *World Journal Microbiology and Biotechnology*, 24:1003-1009

Maiero, M., Bean, G. A. and Ng, T. J. 1991. Toxin production by *Alternaria solani* and its related phytotoxicity to tomato breeding lines. *Phytopathology*, 81:1030−1033

Mandal, K. 2010. Disease of some important medicinal crops and their management. Microbial Diversity and Plant Disease management. VDM Verlag Dr. Muller, Germany, 509

Raja, P. and Reddy, A.V. Ramama. 2007. Morphological and biological variability of *Alternaria* spp. causing leaf spot and fruit rot of brinjal. *Journal of Mycology and Plant Pathology*, 37 (2): 336-338

Reddy, N.P.E. and Chaudhary, K.C.B. 1990. Effect of culture filtrates of *Fusarium udum* on the seeds on pigeon pea. *Madras Agricultural Journal*, 77 (2): 109-111

Salvik, B. 1974. Methods of studying plant water relations. Academia Publishing House of the Czechoslovak Academy of Sciences. pp-449

Tetarwal, M. L., Rai P.K. and Shekhawat, K.S. 2008. Morphological and pathogenic variability of *Alternaria* infecting senna. *Journal of Mycology and Plant Pathology*, 38 (2): 375-377

Verma, P. K., Singh, S., and Gandhi, S.K. 2007. Variability among *Alternaria solani* isolates causing early blight of tomato. *Indian Phytopathology*, 60 (2): 180-186

Wheeler, B. E.J. 1969. An Introduction of Plant Diseases. John Willey and Sons Ltd. London. pp. 301

Table 1: Cultural variability among five isolates of *Alternaria alternata* on PDA

Sl. No.	Isolates	Location of collection of isolates	Radial mycelial growth in (mm)	Sporulation	Colony characters
1.	Aa-1	Udaipur	90.00	+ + + +	Dark black colourd, very fast mycelial growth with smooth margin.
2.	Aa-2	Chittorgargh	80.00	+ + +	Light black with white at centre and fast growing.
3.	Aa-3	Jodhpur	75.00	+ + +	Dark brown and medium mycelial growth with smooth margin.
4.	Aa-4	Pali	68.00	+ +	Black colourd, flat mycelial growth with smooth margin.
5.	Aa-5	Jalore	65.00	+ +	White with slightly black in colour and slow mycelial growth.
	SEm±		0.865		
	CD at 5%		2.821		
	CV%		2.46		

*Average of three replications

Note: ++ = Fair, +++ = Good, ++++ = very good.

Table 2: Variation in conidial morphology of five isolates of *Alternaria alternata*

S. No.	Isolates	Conidial morphology with beak (µm)				Conidial morphology without beak (µm)			
		Length		Width		Length		Width	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
1.	Aa-1	28.05± 1.68	23-31	17.18± 1.00	14-19	12.93± 1.76	6-18	8.73±0.69	6-11
2.	Aa-2	24.84± 1.26	22-28	15.23± 0.76	13-16	10.22± 0.51	9-11	8.47±0.42	7-10
3.`	Aa-3	32.19± 1.69	29-36	20.08± 1.48	14-23	16.67± 4.02	7-21	9.55±0.46	8-11
4.	Aa-4	22.22± 0.99	20-24	15.23±0.76	14-17	9.30± 0.72	8-12	7.88±0.44	6-9
5.	Aa-5	28.01± 2.90	18-31	18.95±1.91	12-22	12.07± 1.00	10-15	8.43±0.44	7-9
	SEm±	0.26		0.19		0.34		0.05	
	CD at 5%	0.74		0.55		0.97		0.16	
	CV%	9.80		11.35		8.40		6.84	

* Mean no. of 25 conidia and ± S.D. of mean value

Table 3: Pathogenic variability of five isolates *Alternaria alternata* under artificial inoculation conditions.

S.No.	Isolates	Disease Intensity (%)*	Incubation periods (days)*
1.	Aa-1	52.12 (52.12)	4-5 days
2.	Aa-2	41.40 (41.39)	4-6 days
3.`	Aa-3	47.56 (47.56)	4-6 days
4.	Aa-4	38.20 (38.19)	5-7 days
5.	Aa-5	35.48 (35.48)	5-7 days
6.	Spray with water (Control)	0.00 (0.00)	-
	SEm±	0.569	
	CD at 5%	1.792	
	CV%	2.41	

*Average of three replications

Figures in parentheses are angular transformed values

Table 4: Toxin variability among five isolates based on their culture filtrates (crude toxin) toxicity symptoms on Isabgol leaves.

S.No.	Isolates	Toxicity symptoms observed	Grade
1.	Un-inoculated broth	Did not show any toxicity.	Non toxic
2.	Aa-1	Initial toxicity symptom expression in six hours, leading to complete and severe necrosis of leaves with distinct black colourations.	Very Severely Toxic
3.	Aa-2	Initial toxicity symptom expression in twelve hours, leading to complete leaf drooping, wrinkling, drying and brittling of leaves.	Severely Toxic
4.	Aa-3	Initial toxicity symptoms expression in eighteen hours, leading to complete wrinkling and necrosis.	Moderately Toxic
5.	Aa-4	Initial toxicity symptoms expression in twenty hours, leading to slight necrosis.	Slight Toxic
6.	Aa-5	Initial toxicity symptoms expression after twenty-four hours, leading to least toxic.	Least toxic

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PRODUCTION POTENTIAL AND ECONOMICS OF HYBIRD RICE UNDER SYSTEM OF RICE INTENSIFICATION AND ITS MANIPULATION

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ABSTRACT

The study was conducted at Indira Gandhi Krishi Vishwavidyalaya, Chhattisgarh (21^{o}16´ N and 81^{o}36´ E) during wet season of 2007-08 and 2008-09 in silty clay loam soil to assess the effects of system of rice intensification (SRI) and its manipulation involving two age of seedlings (10 and 14 days), three manuring (organic alone, inorganic alone, 50% nutrients through organic + 50% nutrients through inorganic), two weeding practices (Mechanical weeding through conoweeder and chemical weeding), two water management practices (application of 2 cm water at hairline crack development stage and cyclic submergence of 5 cm water at 3 days after disappearance of ponded water) and one local recommended practices on hybrid rice (*Oryza sativa* L.). The results revealed manipulated SRI (10 days aged seedlings+100% nutrients through inorganic or 50% through organic + 50% through inorganic + irrigation as per SRI) gave 13.52% higher grain yield and 16.80% higher net income over recommended practices of hybrid rice.

Key words: INM, Inorganic, Mechanical weeding, Organic, Seedling age, SRI

INTRODUCTION

Rice plays a pivotal role in ensuring food security of India. Rice alone contributes to 43% of total food grain production and 46% of the total cereal production. India is largest rice growing county in the world but productivity is very low (1.94 t ha^{-1}) as compared to China (4.24 t ha^{-1}). Appropriate set of agronomical management is required for increasing the productivity. SRI i.e. system of rice intensification has been proved to be one of the sound and promising agronomic practice in enhancing the productivity of rice (Uphoff, 2001). Hybrid rice is although gaining popularity among the Indian farmers but its potential is yet to be exploited fully through hybrid rice cultivation. The hybrid rice offers 10-15% yield advantage

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over the best conventional inbred varieties which may further enhanced by adoption of SRI due to use of early seedling and maintaining uniform geometry.

System of rice intensification (SRI) originated in Madagascar and by adopting this method average rice yield can be about the double without changing the cultivars or the use of purchased input (Wang et al., 2003). SRI is based on the assumptions that micro scale modification of soil, water and nutrient management practices which may be suppressed by crop when growing as irrigated rice. SRI methods appears to be promising, but it is essential to test whether the agronomic practices recommended holds good for our agro ecological conditions as well. Its quantitative analysis will have to carry out and factors responsible for higher yield are to be identified. This information helps for adoptability and increasing the regional productivity, which is presently lower than the national average. Moreover, adoption of all the principles of SRI are also not a easy task, therefore, it is essential to alter these in view of existing agro climatic condition and resource availability of the farmers. Keeping in view, the present investigation was conducted to assess the production potential and economics of hybrid rice under system of rice intensification and its manipulation.

MATERIALS AND METHODS

Field experiment was carried out during kharif 2007-08 and 2008-09 at Research cum Instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The soil of the experimental field was deep clay loam in texture and taxonomically classified as typic Haplustaff. The soil was low in available N (214 kg N ha^{-1}), medium in available P (18.8 kg P ha^{-1}) and high in available K (293 kg K ha^{-1}). The electrical conductivity of the soil was 0.51 ds m^{-1} and the pH was 7.3. Mechanical analysis of the soil showed 6.92, 13.55, 43.22 and 35.81% of coarse sand, fine sand, silt and clay, respectively. The rice hybrid Proagro 6444 was used in trial as test crop with field duration of 120 days.

Poultry manure and FYM were used as a source of organic manure. The poultry manure and FYM were applied to the puddle soil and was incorporated manually. The NPK content in FYM and poultry manure on dry weight basis were 1.41, 0.51, 1.80 and 2.66, 1.50, 2.01, respectively. In all 7 t ha^{-1} of FYM and 2.5 t ha^{-1} poultry manure was applied before the transplanting as per the treatments. Fertilizers were applied at the rate of 150 -75 - 60 kg ha^{-1} of N, P_2O_5, K_2O ha^{-1} (convert PK), respectively in the form of urea, single super phosphate and muriate of potash. The whole amount of phosphorus and potassium was applied as basal, whereas, nitrogen was applied as 40 per cent as basal, 25 per cent at tillering, 25 per cent at panicle initiation and 10 per cent at flowering stages. The experiment was laid out in a randomized block design with three replications. Data were collected on number of weeds / m2, flag leaf number of leaves and dry matter at, 54, 65, 54 and 90 DAT. Economic analysis was also done on the basis of prevailing market price. The details of the treatments and the notations used are as follows:

Table 1: Treatment details of the experiment

Treatment	Treatment details	Notations used
T_1	10 days seedlings + 100% manure + Mechanical weed management + Application of 2 cm water at hairline crack development stage (SRI)	$A_{10}M_{100}W_mI_s$
T_2	10 days seedlings + 100% manure + Chemical weed management + Irrigation as per SRI	$A_{10}M_{100}W_cI_s$
T_3	10 days seedlings + 100% manure + Mechanical weed management + Cyclic submergence of 5 cm water at 3 days after disappearance (DAD) of ponded water	$A_{10}M_{100}W_mI_{3D}$
T_4	14 days seedlings + 100% manure + Mechanical weed management + Irrigation as per SRI	$A_{14}M_{100}W_mI_s$
T_5	14 days seedlings + 100% manure + Mechanical weed management + Cyclic submergence at 3 DAD of ponded water	$A_{14}M_{100}W_mI_{3D}$
T_6	10 days seedlings + 100% fertilizer + Mechanical weed management + Irrigation as per SRI	$A_{10}F_{100}W_mI_s$
T_7	10 days seedlings + 100% fertilizer + Chemical weed management + Irrigation as per SRI	$A_{10}F_{100}W_cI_s$
T_8	14 days seedlings + 100% fertilizer + Mechanical weed management + Irrigation as per SRI	$A_{14}F_{100}W_mI_s$
T_9	10 days seedlings + 50% manure + 50% fertilizer + Mechanical weed management + Irrigation as per SRI	$A_{10}M_{50}F_{50}W_mI_s$
T_{10}	10 days seedlings + 50% manure + 50% fertilizer + Chemical weed management + Irrigation as per SRI	$A_{10}M_{50}F_{50}W_cI_s$
T_{11}	14 days seedlings + 50% manure + 50% fertilizer + Mechanical weed management + Irrigation as per SRI	$A_{14}M_{50}F_{50}W_mI_s$
T_{12}	Recommended practices of hybrid rice (21days seedling + 100% fertilizer + Two hand weeding at 20 and 40 DAT + Cyclic submergence at 3 DAD of ponded water)	$A_{21}F_{100}W_HI_{3D}$

A–Age of seedling; M–Manure; F–Fertilizer; W_m, W_c & W_H– Mechanical, chemical & hand weeding, respectively; I_s & I_{3D}- Irrigation as per SRI & at 3 DAD, respectively

RESULTS AND DISCUSSION

Growth characters

Treatments involved in manipulation of different crop management and inputs i.e. seedling age, nutrient, water and weed management practices of SRI revealed that the planting of 10 days aged seedlings + 100% nutrients applied through inorganic + mechanical weeding + irrigation as per SRI ($A_{10}F_{100}W_mI_s$) produced the tallest plant (120.10 cm) and maintained its superiority over other treatments except planting of 10 days aged seedlings + 50% nutrients applied through inorganic + 50% nutrients applied through organic + mechanical weeding + irrigation as per SRI ($A_{10}M_{50}F_{50}W_mI_s$) (Table 1). Transplanting of younger seedlings (10 days aged) supported with sufficient nutrients and aerated soil condition favoured the plant growth and increased plant height, number of leaves, flag leaf area, SPAD value, number and weight of tillers, root and shoot dry biomass because of higher cell division and cell enlargement resultant of more photosynthetic rate as also reported by Krishna (2000), Shrirame et al. (2000) and Lokanadhan et al. (2007).

Weed density and biomass

Weed density and biomass was highest under $A_{10}M_{100}W_cI_S$ at harvest due to reduction of toxic effect of herbicide with the advancement of crop age resulting in increase in weed growth (Table 1). Similar results also reported by Mitra et al. (2005). Whereas, under mechanical weeding through Cono weeder weeds were incorporated from both the directions of the crop resulted in reduction of weed density and biomass ($A_{10}F_{100}W_mI_S$ or $A_{10}M_{50}F_{50}W_mI_S$ or $A_{10}M_{100}W_mI_S$). Moreover, number and weight of tillers also increased under these treatments suggests that more area occupied by rice plant suppressed the weed density and growth. This is in accordance with the findings of Vijaykumar et al. (2006).

Yield attributes and yield

The combination of 10 days aged seedlings, 100% nutrients through inorganic, incorporation of weeds by mechanical weeder and irrigation as per SRI ($A_{10}F_{100}W_mI_S$) produced the maximumgrain yield, which was at par to $A_{10}M_{50}F_{50}W_mI_S$ (Table 2). The combination of $A_{10}F_{100}W_mI_S$ produced higher grain yield (7.52 t ha^{-1}) than recommended practices of hybrid rice (6.50 t ha^{-1}) with the increase in grain yield was 13.52%. These results are in agreement with the findings of Krishna et al. (2008). Almost all yields attributes (effective tillers, weight of panicle and fertile grains $panicle^{-1}$) except weight of 1000- grain and sterility percentage were favourably influenced by these treatments. This might be due to efficient utilization of resources and less inter and intra space competition among plants which may be assigned as the reason for superiority in these yield attributes of hybrid rice and consequently increased yield. Padmavati et al. (1998) also reported the similar findings. The lower yield was recorded under the treatment of $A_{10}M_{100}W_cI_S$. A decrease in leaf area causes a reduction in area for interception and absorption of the specific wavelength of light necessary for photosynthesis resulted in reduction of root and plant dry biomass thereby reducing absorption of nutrients subsequently reducing the yield attributes and yield.

Water requirement

The total water requirement (823 mm) was increased where irrigation applied as per SRI i.e., 2 cm water at hairline crack development stage ($A_{10}F_{100}W_mI_S$) due to more frequency of irrigation than irrigation applied at 3 DAD i.e. cyclic submergence of 5 cm water at 3 days after disappearance of ponded water ($A_{21}F_{100}W_HI_{3D}$) (Table 1).

Economics

The maximum net income was received under $A_{10}F_{100}W_mI_S$ which was at par with the treatment of $A_{10}M_{50}F_{50}W_mI_S$ due to higher grain yield. The combination of $A_{10}F_{100}W_mI_S$ increased 16.80 per cent higher net income over recommended practice of hybrid rice ($A_{21}F_{100}W_HI_{3D}$). However, labour productivity was comparable but B: C ratio increased in $A_{10}F_{100}W_mI_S$ due to higher economic yield. The labour productivity was highest under $A_{10}F_{100}W_cI_S$ due to the use of chemical which required less number of labours for weeding and also application of chemical fertilizer and irrigation gave higher grain yield. This is accordance with the findings of Thiyagarajan et al. (2002). However, B: C ratio was increased under the treatment of $A_{10}M_{50}F_{50}W_mI_S$ but at par with $A_{10}F_{100}W_mI_S$. This is due to less input cost and higher economical yield. The lowest net income and BCR was recorded under $A_{10}M_{100}W_cI_S$ but at par with $A_{10}M_{100}W_mI_S$ and $A_{14}M_{100}W_mI_S$.

CONCLUSION

The combination of 10 days aged seedlings, 100% nutrients through inorganic sources or 50% through inorganic + 50% through organic sources, weeds controlled thrice mechanically by cono weeder and irrigation as per SRI i.e., 2 cm at hairline crack development stage ($A_{10}F_{100}W_mI_s$ or $A_{10}M_{50}F_{50}W_mI_s$) gave similar and maximum growth characters, yield attributes and yield of hybrid rice. The total water requirement was highest under SRI i.e., 10 days aged seedlings, 100% nutrients through organics, mechanical weeding and application of 2 cm water at hairline crack development stage ($A_{10}M_{100}W_mI_s$) and manipulated SRI ($A_{10}F_{100}W_mI_s$ or $A_{10}M_{50}F_{50}W_mI_s$) than recommended practices of hybrid rice ($A_{21}F_{100}W_HI_{3D}$). Economic viability of hybrid rice revealed that manipulated SRI ($A_{10}F_{100}W_mI_s$ or $A_{10}M_{50}F_{50}W_mI_s$) proved to be superior over SRI ($A_{10}M_{100}W_mI_s$) and recommended practices of hybrid rice ($A_{21}F_{100}W_HI_{3D}$).

REFERENCES

Krishna, A. 2000. Effect of age of seedlings on performance of rice (*Oryza sativa* L.) cultivars under late planted condition. *Journal of Research ANGRAU,* 28: 73-74

Krishna, A., Biradarpatil, N.K. and Channappagoudar, B.B. 2008. Influence of system of rice intensification (SRI) cultivation on seed yield and quality. *Karnataka Journal of Agricultural Sciences,* 21(3): 369-372 Lokanadhan, S., Ravichandran, V., Suresh, S., Rabindran, R., Thiyagarajan, K. and Mohanasundaram, K. 2007. Efficient resource utilization in SRI method of rice (CORH 3) cultivation-An analysis. p. 79-81. In Proc. *National symposium on SRI in India*, 2^{nd}, 3-5 October 2007. Tripura, India

Mitra, B.K., Karim, A.J.M.S., Haque, M.M., Ahmed, G.J.U. and Bari, M.N. 2005. Effect of weed management practices on transplanted Aman rice. *Journal of Agronomy,* 4(3): 238-241

Padmavati, P., Singh, S. and Prasad, R. 1998. Effect of planting patterns and levels of nitrogen on performance of conventional and hybrid rice variety. p. 109-113 In Proc. First International Agronomy Congress, 23-27 Nov., 1998 at New Delhi, India

Shrirame, M.D., Rajgire, H.J. and Rajgire, A.H. 2000. Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. *Journal of Soils and Crops,* 10(1): 109-113

Thiyagarajan, T.M., Senthikumar, K., Brindavan, P.S., Hengsdijk, H., Ramasumy, S. and Velu, V. 2002. Crop management options for increasing water productivity in rice. *Journal of Agricultural Resource Management,* 1: 169-181

Uphoff, N. 2001. Understanding SRI? *Appropriate Technology,* 28(3):12-13

Vijayakumar, M., Ramesh, S., Prabhakaran, N.K., Subbian, P. and Chandrasekaran, B. 2006. Influence of system of rice intensification (SRI) practices on growth characters, days to flowering, growth analysis and labour productivity of rice. *Asian Journal of Plant Science,* 5(6): 984–989

Wang, S., Cao, W., Jiang, D., Dai, T. and Zhu, Y. 2003. Effect of SRI technique on physiological characteristics and population development in rice. *Chinese Journal of Rice Science,* 17(1): 31-36

Table 2: Growth, weed parameters and water requirement of hybrid rice as influenced by system of rice intensification (SRI) and its manipulation (mean data of 2 years)

Treatment	Plant height at harvest (cm)	No. of leaves plant^{-1} at 90 DAT	No. of tillers plant^{-1} at harvest	Weight of tillers plant^{-1} at 90 DAT	Dry weight at 60 DAT (g plant^{-1})		Flag leaf Area at 65 DAT (cm^2)	Spade value of Flag leaf at 65 DAT	Weed density at 54 DAT (No. m^{-2})	Weed biomass at 54 DAT (g m^{-2})	Water requirement (mm)
					Root	Shoot					
$A_{10}M_{100}W_mI_S$	98.90	106.31	32.88	4.58	10.77	35.81	42.44	37.83	27.21	13.59	823
$A_{10}M_{100}W_cI_S$	90.67	91.82	27.75	3.34	9.21	29.86	30.17	35.33	38.34	21.66	823
$A_{10}M_{100}W_mI_{3D}$	101.67	107.25	32.10	4.69	10.89	36.22	43.10	38.16	24.33	12.87	790
$A_{14}M_{100}W_mI_S$	99.47	105.20	32.28	4.63	10.30	36.47	43.90	37.73	27.25	13.82	803
$A_{14}M_{100}W_mI_{3D}$	100.28	107.89	32.05	4.63	10.87	36.16	42.48	37.70	24.30	12.90	800
$A_{10}F_{100}W_mI_S$	120.10	147.78	41.28	7.30	12.61	43.56	59.09	44.80	19.79	6.18	823
$A_{10}F_{100}W_cI_S$	108.31	131.33	37.11	6.11	11.50	39.46	52.30	41.06	24.71	10.44	823
$A_{14}F_{100}W_mI_S$	112.17	133.67	37.78	6.18	11.49	39.41	51.48	41.47	23.48	9.29	803
$A_{10}M_{50}F_{50}W_mI_S$	118.73	145.20	40.91	7.29	12.60	43.44	57.91	44.55	20.78	6.29	823
$A_{10}M_{50}F_{50}W_cI_S$	101.27	107.74	33.61	4.58	10.80	35.86	42.30	37.93	27.12	13.77	823
$A_{14}M_{50}F_{50}W_mI_S$	109.50	133.53	38.41	6.06	11.44	39.29	50.72	41.68	23.74	9.19	803
$A_{21}F_{100}W_HI_{3D}$	108.87	66.33	18.65	3.28	5.94	20.17	50.25	40.35	26.28	13.97	800
S Em±	2.14	1.52	0.91	0.52	0.53	1.23	1.17	0.91	0.86	1.11	-
CD (P=0.05)	4.42	3.14	1.89	1.08	1.09	2.53	2.41	1.89	1.78	2.31	-

A–Age of seedling; M–Manure; F–Fertilizer; W_m, W_c & W_H– Mechanical, chemical & hand weeding, respectively; I_s & I_{3D}- Irrigation as per SRI & at 3 DAD

Table 3: Yield attributes, yield and economics of hybrid rice as influenced by system of rice intensification (SRI) and its manipulation (pooled data of 2 years)

Treatment	Effective panicles (No.m^{-2})	Weight of panicles (g panicle^{-1})	Fertile grains (No.)	Sterility (%)	Weight of 1000-seed (g)	Grain yield (t ha^{-1})	Total cost (000'Rs. ha^{-1})	Gross margin (000'Rs. ha^{-1})	BCR	Labour productivity (Rs. Output Rs.input^{-1})
$A_{10}M_{100}W_mI_S$	292.48	4.18	141.18	29.99	22.57	5.99	21.40	35.01	1.64	5.82
$A_{10}M_{100}W_cI_S$	253.12	3.22	125.50	33.15	22.09	5.20	19.30	30.15	1.56	8.16
$A_{10}M_{100}W_mI_{3D}$	289.80	4.14	139.83	30.18	22.58	5.98	20.72	35.61	1.72	5.81
$A_{14}M_{100}W_mI_S$	290.35	4.06	136.89	30.08	22.56	5.94	21.40	34.54	1.61	5.77
$A_{14}M_{100}W_mI_{3D}$	287.64	4.10	138.01	30.05	22.55	5.95	20.72	35.31	1.70	5.74
$A_{10}F_{100}W_mI_S$	342.72	5.94	175.33	25.02	23.48	7.52	22.62	47.21	2.09	7.20
$A_{10}F_{100}W_cI_S$	303.84	4.76	156.11	29.33	23.07	6.54	20.47	40.92	2.00	10.14
$A_{14}F_{100}W_mI_S$	309.92	4.85	158.56	28.12	23.17	6.83	22.62	41.10	1.82	6.57
$A_{10}M_{50}F_{50}W_mI_S$	324.80	5.82	172.13	25.24	23.43	7.39	21.99	46.82	2.13	7.10
$A_{10}M_{50}F_{50}W_cI_S$	293.48	4.16	145.78	30.13	22.56	6.01	19.88	36.64	1.84	9.33
$A_{14}M_{50}F_{50}W_mI_S$	311.52	4.80	156.51	28.04	23.15	6.81	21.99	41.60	1.89	6.56
$A_{21}F_{100}W_HI_{3D}$	304.85	4.71	156.50	30.03	23.05	6.50	21.76	39.28	1.81	7.13
S Em±	4.16	0.14	4.49	0.85	0.18	0.16	-	1.40	0.04	0.16
CD (P=0.05)	8.60	0.29	9.29	1.76	0.37	0.33	-	2.90	0.10	0.33

A–Age of seedling; M–Manure; F–Fertilizer; W_m, W_c & W_H– Mechanical, chemical & hand weeding, respectively; I_s & I_{3D}- Irrigation as per SRI & at 3 DAD

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DIETARY EFFECT OF MULBERRY LEAF (*Morus alba*) MEAL ON GROWTH PERFORMANCE AND SERUM CHOLESTEROL LEVEL OF BROILER CHICKENS

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ABSTRACT

To investigate the effect of dietary mulberry leaf meal on body weight, feed conversion efficiency and blood cholesterol level, 240 day-old broiler chicks (Cobb 500) were divided into 6 treatments, each with 4 replications (10 birds/ per replicate) and offered manually prepared diets supplemented with 2.5, 3.5, 4.5% mulberry leaf meal (MLM), MLM Extract and 0.5% for a period of six weeks. Average body weight (g) gain increased (P> 0.05) at 2.5 or 4.5% supplementation of MLM and with MLM extract compared to control and antibiotic group. Feed conversion ratio was better at 4.5% supplementation (1.67) and on addition of MLM extract (1.63) compare to control (1.79). Total cholesterol, HDL-cholesterol and triglyceride of broiler chicks in different dietary treatments of during experimental periods were non-significant at day 10 to 15 but total cholesterol and triglyceride decreased significantly (P>0.05) at d 15 to 22 compared to control and antibiotic group. Significant (P<0.05) reduction of total cholesterol and triglyceride with supplementation of mulberry leaf meal at 2.5, 3.5, 4.5% MLM, MLM extract were also observed at d 22 to 42 compared to control and antibiotic group. The result suggests that inclusion of mulberry leaf meal (both 3.5% powder and extract) may be used to formulate low-cost broiler grower diet in order to produce low-cholesterol broiler meat.

Key Words: Mulberry Leaf Meal (MLM), Antibiotic, Broiler, Serum cholesterol

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INTRODUCTION

The cost of feed constitutes is the major proportion between 60-75% of the total cost of poultry production and protein cost account for over 40% of the total feed cost in livestock and poultry farming (Ojewola et al., 2005). Besides, the price of conventional protein feeds resources such as groundnut cake, fish meal and soybean meal are in high cost and cannot permit profit maximization in poultry ventures. In view of this, current research interest in the poultry industry is aimed at finding alternatives to this elusive feed ingredient. The list of possible feed alternatives includes tree fodder mulberry leaves (*Morus alba*) as a source of dietary protein for commercial livestock and poultry operations. Mulberry grows well in the tropics and subtropics, and is reported to have excellent nutritional value as forage. It is grown extensively for its leaves, which are used for raising silkworms in the sericulture industry. Mulberry leaves are rich in protein (15-35%), minerals (2.42-4.71% Ca, 0.23-0.97% P) and metabolizable energy (1,130-2,240 kcal kg^{-1}) with absence of or negligible anti-nutritional factors (Omar et al., 1999; Sarita et al., 2006). Mulberry leaves contain β-carotene, which can be converted with varying efficiency by animals to vitamin A and the xanthophylls, which can be a good source of the pigmentation of egg yolk (Sarita et al., 2006). Excellent results have been obtained with using mulberry leaves as ruminant feed (Rojas and Benavides, 1994; Gonzalez et al., 1996; Omar et al., 1999). Information on feeding mulberry to non-ruminants is scanty but it has been used in pigs (Trigueros and Villalta, 1997), laying hens (Narayana and Setty, 1977), and rabbits (Deshmukh et al., 1993). Dot et al. (2000) demonstrated that the intake of mulberry leaves reduced the concentration of serum lipids and atheromatous thickening of arterial intima in hypercholesterolemic rabbits. Although much work has been done on the utilization of rats, mice and rabbits, reports on the use of mulberry leaves in poultry feeds are limited. Thus there is a need to study the effect of mulberry leaves inclusion in poultry diets on production performance, cholesterol and triglyceride in blood, meat and egg.

Antibiotics as feed additives have been used for years. Antibiotics have also been widely used in animal feed in many other countries although a number of individual countries and the European Union have restricted the sub therapeutic use of some antibiotics (Aarestrup, 2000). So, there is a great interest in developing natural alternatives to antibiotic growth promoters in order to maintain both bird performance and health (Cross et al., 2007). As a result, numerous medicinal herbs have been suggested to livestock producers as alternatives to antibiotic growth promoters (Doyle, 2001). Several researchers have reported the possibility of growth-promoting and antioxidative effects for some traditional medicinal herbs (Liu et al., 2006). These medicinal herbs are considered to be natural products, so consumers may willingly allow them to be included in livestock feeds. Thus the objective of the present experiment was to evaluate the effect of graded level of mulberry leaf meal in the broiler diets in order to observe the performance, feed efficiency and cholesterol level.

MATERIALS AND METHODS

Preparation of *Morus alba* leaf powder

Morus alba was collected from local area of Dinajpur district in Bangladesh. The leaves were sundried, coarsely powdered manually and then directly mixed with manually prepared diets in appropriate doses (Table 1, 2 & 3).

Preparation of other feed ingredients

Sundried and grinded corns, meat meal, bone meal, rice polish, soybean meal, soybean oil and other feed items were collected from local market of Dinajpur, Bangladesh and then directly mixed with manually prepared diets in appropriate doses (Table 1, 2 & 3). Vitamin premix used in the formulated diets was made of reputed veterinary Medicine Company.

Birds and experimental design

A total of 240 one day-old broiler chick (Cobb 500) were reared at brooding house to adjust with the environmental condition up to 10 days. After that, chicks were randomly allocated to six dietary treatment groups having 40 birds in each group; each treatment was composed of four replicates with 10 birds in each in a complete randomized design. The birds were housed on floor and routinely managed as any other commercial broiler flock. Heating was provided by a single electric brooder, where the initial temperature was set at 32 $^{\circ}$C and decreased by 2°C per week to final temperature of 20°C at the end of experiment.

Experimental diets

The experimental diets in mash form and drinking water was provided *adlibitum.* All the diets were formulated manually to meet the nutrient requirements of broiler (NRC, 1994). The chicks were fed starter diet from 1 to 10 days, grower diet from 11-20 days and a finisher diet from 21 to 42 days old broiler (Table 1, 2 &3). Diets were analyzed for dry matter, crude protein, crude fibre and crude fat according to the AOAC (1980) methods. The experimental diets were designed as T_0= control, T_1= 2.5% MLM, T_2= 3.5% MLM, T_3= 4.5% MLM, T_5= MLM Extract and T_5= 0.5% antibiotic (oxytetracycline, Trade name ®, Renata Ltd)

Observation of birds

All birds were examined twice daily for any visible physical changes like restlessness, lordosis, abnormal gait, vices and depression as well as changes of feeding style during treatment. All birds were vaccinated against Newcastle and Gumboro as per instruction of the manufacturers.

The performance trial

Initial body weight was recorded before the on set of the trial. Then body weight and feed consumption were recorded daily. Final weight of the birds was also recorded. These data were used to calculate body weight gain and feed conversion ratio.

Blood collection and estimation of serum lipid profile

The blood was collected at the last date of the experiment from each group (3 birds) with a syringe and needle directly through wing vein puncture without using any anticoagulant. After centrifugation of the clotted blood, the supernatant was carefully collected by a micropipette and preserved in eppendrof vial. The collected serum was stored at -15ºC until estimation of total cholesterol, high-density lipoprotein (HDL)-cholesterol and triglycerides using lipid profile kit (Crescent Diagnostics).

Statistical Analysis

The data was analyzed by using the MSTATC program. Differences among treatments, when significant, were also ordered using Tukey’s test (Kuehl, 1994). Statements of statistical significance were based on $P<0.05$ or $P<0.01$.

RESULTS AND DISCUSSION

Body weight gain, feed consumption and feed efficiency of the birds

The average body weight gain and total feed consumption of the birds fed different formulated MLM and antibiotic diets has been shown in table 4. The results shows that average body weight gain did not increased significantly while supplemented with different doses of MLM and antibiotic diets. However, average body weight gain increased more than 15% in MLM supplemented diets compared to control (To) and antibiotic fed group (T_5). This result is in agreement with Panja (2013) who observed non significant improvement of body weight gain in broilers supplemented with mulberry leaves at 0, 0.5, 1.0, 1.5 and 2.0 % of diet. This might be because all diets were isocaloric and isonitrogenous (Tan et al., 1988). The average feed consumption ranged 2300-2700g was also non-significant among treatments. This result is similar to Seeang (2001) and Simol et al. (2012) who reported that the supplementation of mulberry leaves in the layer diets had no effects on feed intake. Besides, Panja (2000) showed that native chicken and hybrid native chicken which received the same diet also had no effects on the feed consumption.

The feed conversion ratio (FCR) of birds fed different diets has been indicated in the Table 4. The results indicate that FCR could not affect by the supplemented diets. However, FCR was better at T_4 (1.63) followed by T_3 (1.67), T_1 (1.80), T_2 (1.81), T_0 (1.83) and T_5 (1.90). Similar results were also obtained by Simol et al. (2012) who showed that mulberry leaf powder can substitute up to 30% of commercial feed without any adverse effect on the feed intake, growth and FCR of the broiler chicken. But improvement of FCR might be due to stimulation of digestive enzymes followed by better digestion and utilization of feed. Moreover, dietary interactions between fat-protein, protein-minerals or minerals-fats may create the differences. It is known that high fibre content reduces feed intake in broilers (Janssen and Carré, 1985) but the better amino acid composition in mulberry leaves (Al-Kirshi et al., 2010) could have compensated for this effect.

Serum lipid profile contents of broilers

The effects of MLM supplemented diets on serum lipids like total cholesterol, HDL-cholesterol, and triglycerides of broilers are shown in table 5. Total cholesterol, HDL-cholesterol and triglyceride of broiler chicks in different dietary treatments during experimental periods were almost statistically similar and the differences were not significant (P<0.05) from 10 to 15 days. However, from the table (5), it was observed that the values of total cholesterol level in T_3, T_2, T_1, T_4 groups were 130.7, 91.67 mg dl^{-1}, 141.7 and116.3 respectively. All the values were found to be lower than that of control groups T_0 (168.0 mg dl^{-1}), T_5 (164.3 mg dl^{-1}) and significantly differing from other groups. In the T_2 and T_4 groups i.e. both 3.5% MLM supplemented and their acetone extract was found total cholesterol content significantly lower than that of control fed groups. Total cholesterol and triglyceride were significantly reduced compared to control and antibiotic group (Table 5). Similar results were reported by Panja (2000) who supplemented with mulberry leaves at 0, 0.5, 1.0, 1.5 and 2.0 % of diet in broiler. This is perhaps because of its crude fiber content. Balmer and Zilversmit (1974) reported that fiber is an indigestible feed component affecting cholesterol metabolism and concentration of cholesterol in blood. Tasi et al. (1976) reported serum cholesterol levels in rats decreased as dietary fiber content increased. Similar results were observed in laying hens (Menge et al., 1974). Similarly, Kawrhung (1996) reported that rabbits fed a high cholesterol diet and mulberry leaves at 2.5 %, showed a decrease in the levels of cholesterol in their blood by a half during 10 weeks.

CONCLUSION

From above observation, it may be concluded that the MLM supplemented diets had limited effect on mortality rate and had no detrimental effect on fat content. The performances of broiler i.e., final body weight, feed intake, and feed conversion ratio were improved by feeding MLM supplemented diets at different levels. The positive effect of these was on serum lipids. Among the MLM supplemented diets, our findings suggest that supplementation of both 3.5% MLM powder and extracts of MLM has high potential as commercial applications for production of low-cholesterol and healthy broilers.

REFERENCES

Aarestrup, F.M. 2000. Occurrence, selection and spread of resistance to antimicrobial agents used for growth promotion for food animals in Denmark. APMIS, 108 (Suppl. 101):5–48

Al-Kirshi, R.A., Alimon, A.R., Zulkifli, I., Sazili, A.Q., Zahari, W.M., Ivan, M. 2010. Utilization of mulberry leaf meal (*Morus alba*) as protein supplement in diets for laying hens. *Italy Journal of Animal Science*, 9:51

AOAC, 1980. Association of official analytical chemists, official methods of analysis. 13th Edition. Washington, DC

Balmer, J. and Zilversmit, D.B. 1974. Effect of dietary roughage on cholesterol absorption, cholesterol turnover and steroid excretion in the rat. *Journal of Nutrition,* 104, 1319-28

Cross, D.E., McDevitt, R.M., Hillman, K. and Acamovic, T. 2007. The effect of herbs and their associated essential oils on performance, dietary digestibility and gut microflora in chickens from 7 to 28 days of age. *British Poultry Sci*ence, 48: 496-506

Deshmukh, S.V., Pathak, N.V. and Takalikah, D. A. 1993. Nutritional effect of mulberry (*Morus alba*) leaves as sole ration of adult rabbits. *World Rabbit Science,* 1:67-69

Dot, K., Kojima, T. and Fujimoto, Y. 2000. Mulberry leaves extract in habits the oxidative modification of rabbit and human low density lipoprotein. *Biological & Pharmaceutical Bulletin,* 23:1066-71

Doyle, M.E. 2001. Alternatives to antibiotic use for growth promotion in animal husbandry. *FRI BRIEFINGS*, http://fri.wisc.edu/docs/pdf/antibiot.pdf

Gonzalez, C., Tepper, R. and Ly, J. 1998. An approach to the study of the nutritive value of mulberry leaf and palm oil in growing pigs. *Revista Cientifica,* ISSN 0798-2259

Janssen, W.M.M.A. and Carré, B. 1985. Influence of fiber on digestibility of broiler feeds. In Recent Advances in Animal Nutrition, DJA Cole and W Haresign, eds (Butterworth-Heinemann, London) pp. 78-93

Kawrhung, W.1996. Utilization and Products of Mulberry, Mulberry and Silk Research Institute Department of Agriculture Minister of Agriculture and Cooperation, Bangkok, p. 24

Kuehl, R.O. 1994. Statistical principles of research design and analysis. Duxbury press, Belmont, CA, pp 686

Liu, J. X., Yao, J., Yan, B. and Wang, X. Q. 2006. Nutritional evaluation of mulberry leaves as feeds for ruminants. *Livestock Research for Rural Development*, 12:125-131

Menge, H., LittleField L.H., Frobish, L.T. and Weinland, B.T. 1974 Effect of cellulose and cholesterol on blood and yolk lipids and reproductive efficiency of the hen. *Journal of Nutrition,* 104:1554-6

Narayana, H. and Setty, S. V. S. 1977. Studies on the incorporation of mulberry (*Morus indica*) leaves in layers mash on health, production and egg quality. *Indian Journal of Animal Sci*ence, 47: 212-215

National Research Council (NRC), 1994. Nutrient Requirements of Poultry.9th rev. ed. National Academy Press, Washington, DC, USA

Ojewola, G. S., Okoye, F. C. and Ukoha, O. A. 2005. Comparative utilization of three animal protein sources by broiler chickens. *International Journal of Poultry Science*, 4970: 462-467

Omar, S.S., Shayo, C.M. and Uden, P. 1999. Voluntary intake and digestibility of mulberry (*Morus alba*) diets by growing goats. *Tropical Grasslands,* 33: 177-181

Panja P. 2013. The Effects of Dietary Mulberry Leaves (*Morus alba* L.) on Chicken Performance, Carcass, Egg Quality and Cholesterol Content of Meat and Egg. *Walailak Journal of Science & Technology,* 10(2): 121-129

Panja, P. 2000. Study on growth performance and carcass quality of native and hybrid Native chickens. *Thammasat International Journal of Science and Technology,* 8: 39-43

Rojas, H. and Benavides, J.E. 1994. Produccion deleche de cabras alimentadas con pastro y suplementadas con altos niveles de morera (*Morus sp*.) In: Benavides, J.E. (ed.) Arboles y arbustos forrajeros en America Central. Volumen I. CATIE, Turrialba, *Costa Rica*, 305-317

Sarita, S., Rashmi, K., Anju, T. and Prakash, R. 2006. Nutritional quality of leaves of some genotypes of mulberry (*Morus alba*). *International Journal of Food Science and Nutrition*, 57: 305-313

Seeang, S. 2001, The study of Mulberry Leaves as a Protein Supplement in Layer Diet. M. Sc. Thesis. Kasetsart Univ, Bangkok, p. 44

Simol, C.F., Tuen, A.A., Khan, H.H.A., Chubo, J.K., King, P.J.H. and Ong, K.H. 2012. Performance of chicken broilers fed with diets substituted with mulberry leaf powder. *African Journal of Biotechnology*, 11: 16106-16111

Tan, J.Z., Chen H.I. and Zeng, A.Q. 1988. Energy and protein requirement of putain laying duck. *Chinese Journal of Animal Science,* 6:3-8

Tasi, A.C., Elies, J., Kely, J.J., Lin, R.S. and Robson, J.R. 1976. Influence of certain dietary fibers on serum and tissue cholesterol levels in rats. *Journal of Nutrition*, 106:118-23.

Trigueros, R. O. and Villalta, P. 1997. Nutritive evaluation of mulberry leaf (*Morus alba)*. National Center of Agriculture, Livestock and Forestry Technology (CENTA) ed., San Salvador, El Salvador, 150-155

Table 1: Composition of experimental starter diets fed to broilers

Items	Dietary level of Mulberry leaf meal (MLM)					
Feed ingredients (kg/ 100 kg feed)	T_0, kg (control)	T_1, kg (3.5% MLM)	T_2, kg (3.5% MLM)	T_3, kg (4.5% MLM)	T_4, kg (MLM Extract)	T_5, kg (0.5% Antibiotic)
Maize	52.00	50.00	50.00	50.00	50.00	50.00
Soybean meal	23.00	24.00	23.00	22.50	22.50	22.50
Rice polish	14.50	14.50	14.00	14.00	14.00	14.00
Soybean Oil	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.01	0.01	0.01	0.01	0.01	0.01
Growth promoter	0.50	0.50	0.50	0.50	0.50	0.50
Protein	9.00	7.50	8.00	7.500	7.500	8.00
MLM concentrate	0.00	2.50	3.50	4.50	3.50	0.00
Antibiotic	0.00	0.00	0.00	0.00	0.00	0.50
Vitamin Mineral Premix	0.25	0.25	0.250	0.25	0.25	0.25
Chemical composition						
ME(kcal kg^{-1})	3085	3120	3100.5	3080	3140	3095
CP(gm kg^{-1})	21.35	21.3	21.4	21.5	21.25	21.45
CF(gm kg^{-1})	3.75	3.77	3.72	3.75	3.77	3.77
Ca(gm kg^{-1})	1.12	1.13	1.12	1.11	1.13	1.12
P(gm kg^{-1})	0.56	0.56	0.56	0.54	0.58	0.56
Methionine (gm kg^{-1})	0.48	0.48	0.48	0.48	0.48	0.48
Lysine(gm kg^{-1})	1.18	1.18	1.19	1.18	1.19	1.19

Added broiler premix (Renata Animal Health Ltd.) @ 250 g per 100 kg which contained: vitamin A: 4800 IU; vitamin D: 960 IU; vitamin E: 9.2 mg; vitamin k_3: 800 mg; vitamin B_1: 600 mg; vitamin B_2: 2 mg; vitamin B_3: 12 mg; vitamin B_5: 3.2 mg; vitamin B_6: 1.8 mg; vitamin B_9: 2 mg; vitamin B_{12}: 0.004 mg; Co: 0.3 mg; Cu: 2.6 mg; Fe: 9.6 mg; I: 0.6 mg; Mn: 19.2 mg; Zn: 16 mg; Se: 0.48 mg; DL – Methionine: 20 mg; L- lysine:12 mg.

Table 2: Composition of the experimental grower diets fed to broilers

Items	**Dietary level of Mulberry leaf meal** (MLM)					
Feed ingredients (kg/100 kg feed)	T_0, kg (control)	T_1, kg (2.5% MLM)	T_2, kg (3.5% MLM)	T_3, kg (4.5% MLM)	T_4, kg (MLM Extract)	T_5, kg (0.5% Antibiotic)
Maize	53.00	52.00	52.00	52.00	52.50	53.00
Soybean meal	22.00	20.50	20.50	21.50	21.00	22.00
Rice polish	14.50	14.50	14.00	13.00	13.50	14.50
Soybean Oil	0.50	0.50	0.50	0.50	0.50	0.50
Salts	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.01	0.01	0.01	0.01	0.01	0.01
Growth promoter	0.50	0.50	0.50	0.50	0.50	0.50
Protein	9.00	9.00	8.50	7.50	8.50	9.00
MLM concentrate	0.00	2.50	3.50	4.50	3.50	0.00
Antibiotic	0.00	0.00	0.00	0.00	0.00	0.50
Vitamin Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25
Chemical composition						
ME(kcal kg^{-1})	3098	3130.5	3110.5	3080	3140	3107.5
CP(gm kg^{-1})	20.6	19.5	21	21.3	19.5	21.3
CF(gm kg^{-1})	3.77	3.78	3.76	3.77	3.78	3.78
Ca(gm kg^{-1})	1.18	1.15	1.16	1.15	1.16	1.13
P(gm kg^{-1})	0.59	0.57	0.58	0.57	0.58	0.57
Methionine(gm kg^{-1})	0.48	0.43	0.43	0.43	0.43	0.48
Lysine(gm kg^{-1})	1.05	1.06	1.05	1.05	1.06	1.05

Added broiler premix (Renata Animal Health Ltd.) @ 250 g per 100 kg which contained: vitamin A: 4800 IU; vitamin D: 960 IU; vitamin E: 9.2 mg; vitamin k_3: 800 mg; vitamin B_1: 600 mg; vitamin B_2: 2 mg; vitamin B_3: 12 mg; vitamin B_5: 3.2 mg; vitamin B_6: 1.8 mg; vitamin B_9: 2 mg; vitamin B_{12}: 0.004 mg; Co: 0.3 mg; Cu: 2.6 mg; Fe: 9.6 mg; I: 0.6 mg; Mn: 19.2 mg; Zn: 16 mg; Se: 0.48 mg; DL – Methionine: 20 mg; L- lysine:12 mg.

Table 3: Composition of the experimental finisher diets fed to broilers

Items	**Dietary level of Mulberry leaf meal** (MLM)					
Feed ingredients (kg/ 100 kg feed)	T_0, kg (control)	T_1, kg (2.5% MLM)	T_2, kg (3.5% MLM)	T_3, kg (4.5% MLM)	T_4, kg (MLM Extract)	T_5, kg (0.5% Antibiotic)
Maize	55.00	55.00	55.00	55.00	55.00	55.00
Soybean meal	20.00	20.00	20.00	21.50	19.00	20.50
Rice polish	14.50	14.50	12.50	11.00	13.00	13.50
Soybean Oil	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.02	0.02	0.02	0.02	0.02	0.02
Growth promoter	0.50	0.50	0.50	0.50	0.50	0.50
Protein	9.00	9.00	7.50	7.00	8.50	9.00
MLM concentrate	0.00	2.50	3.50	4.50	3.50	0.00
Antibiotic	0.00	0.00	0.00	0.00	0.00	0.50
Vitamin Mineral Premix	0.25	0.25	0.25	0.25	0.25	0.25
Chemical composition						
ME(kcal kg^{-1})	3115	3130.5	3140.5	3125	3170	3130
CP(gm kg^{-1})	19.5	18.5	18.5	19	18	19.5
CF(gm kg^{-1})	3.72	3.72	3.77	3.65	3.71	3.76
Ca(gm kg^{-1})	1.16	1.08	1.12	1.08	1.08	1.13
P(gm kg^{-1})	0.58	0.52	0.55	0.51	0.52	0.57
Methionine (gm kg^{-1})	0.4	0.4	0.4	0.4	0.4	0.4
Lysine(gm kg^{-1})	1.00	0.99	1.01	1.01	1.01	1.00

Added broiler premix (Renata Animal Health Ltd.) @ 250 g per 100 kg which contained: vitamin A: 4800 IU; vitamin D: 960 IU; vitamin E: 9.2 mg; vitamin k_3: 800 mg; vitamin B_1: 600 mg; vitamin B_2: 2 mg; vitamin B_3: 12 mg; vitamin B_5: 3.2 mg; vitamin B_6: 1.8 mg; vitamin B_9: 2 mg; vitamin B_{12}: 0.004 mg; Co: 0.3 mg; Cu: 2.6 mg; Fe: 9.6 mg; I: 0.6 mg; Mn: 19.2 mg; Zn: 16 mg; Se: 0.48 mg; DL – Methionine: 20 mg; L- lysine:12 mg.

Table 4: Growth performance of the birds fed on the experimental diets

Treatments	Average body weight (g) Initial	Average body weight (g) Final	Average weight gain (g)	Total feed Intake (g)	FCR
T_0	242.8	1550.0	1307.20	2350	1.83
T_1	255.0	1600.0	1500.00	2700	1.80
T_2	245.0	1650.0	1405.00	2550	1.81
T_3	260.0	1750.0	1490.0	2500	1.67
T_4	262.5	1850.0	1587.50	2600	1.63
T_5	240.5	1500.50	1259.5	2400	1.90

Table 5: Serum lipid parameters in broilers fed different levels of MLM supplemented diets

Items	Days	Dietary level of MLM						Level of Significance
		T_0 (control)	T_1 (2.5%)	T_2 (3.5%)	T_3 (4.5%)	T_4 (Extract)	T_5 (Antibiotic)	
Total Cholesterol (mg dl^{-1})	10-15	197.0^{a} ±14.10	182.0^{a} ±4.58	173.3^{b} ±15.69	174.0^{a} ±9.53	181.7^{a} ±6.50	185.3^{a} ±24.00	NS
	15-22	182.0^{a} ±9.16	111.3^{c}±13.65	125.3^{b} ± 4.04	120.7^{bc}±11.5	120.7^{bc}±5.03	171.7^{a} ±7.63	**
	22-42	168.0^{a} ± 6.24	141.7^{bc}±6.65	111.67^{d}± 6.42	130.7^{c}±30.23	116.3^{c} ± 7.50	164.3^{ab}±10.69	*
HDL-Cholesterol (mg dl^{-1})	10-15	43.33^{a} ±2.88	49.00^{a}±6.08	38.33^{a} ±4.16	48.33^{a} ±2.51	46.00^{a} ±6.08	51.33^{a} ±11.06	NS
	15-22	56.33^{a} ±8.14	52.33^{ab}±8.73	48.00^{ab}±2.64	48.67^{ab}±7.02	47.67^{ab}±5.03	42.67^{a} ±2.51	NS
	22-42	46.00^{ab}± 3.51	50.70^{b} ±1.52	52.00^{a} ±3.78	48.00^{b} ±4.58	51.00^{a}± 6.65	45.00 b± 6.24	*
Triglyceride (mg dl^{-1})	10-15	82.00^{a} ± 6.55	94.33^{a}±14.64	89.00^{a} ±2.00	74.0^{a} ±9.53	83.33^{a} ±4.50	85.3^{a} ±24.00	NS
	15-22	81.33^{a} ± 1.52	62.33^{a} ±5.85	73.67^{a} ±5.68	76.7^{bc}± 11.59	72.50^{a} ±3.60	82.0^{a} ±9.16	*
	22-42	102.0^{c} ± 3.00	77.00^{c}±10.96	79.00^{c} ±4.58	80.7^{c} ±30.23	82.00^{c} ±7.54	104.3^{ab}±10.69	*

Different letters in Values are expressed as mean ± standard error of at least three replications each of which contains eight birds. Different letters in a row differ statistically significant ($P < 0.05$). Similar letters in a row statistically non- significant ($P > 0.05$).

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VARIATIONS IN AGRONOMIC TRAITS OF SOYBEAN GENOTYPES

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ABSTRACT

The experiment was conducted at the experimental site of Agronomy Department of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during January to June 2010 to evaluate some important agronomic traits of one hundred and fifteen genotypes of soybean to screen out high yielding soybean genotypes. Considerable genetic variability was observed in the 115 germplasm. Depending on the variability in quantitative traits, the genotypes were grouped in six clusters. The genotypes which have greater morphological similarity were grouped in clusters. The results indicated the presence of high degree of divergence in the genotypes. The clustering pattern of the 115 soybean genotypes in six groups and their inter-group distances revealed that genotypes in Cluster III comprised of BARI Soybean 5, G00083, BARI Soybean 6, G00342, BD 2338, BD 2355, BD 2329, BD 2340, AGS 95, G00056, AGS 129, BD 2336, BGH 02026, BGM 02093, Galarsum, BD 2350, G00084, BD 2331, G00103 indicated better performance which could be marked for the selection of yield potential genotypes through further evaluation.

INTRODUCTION

Soybean (*Glycine max* L.) is one of the most nutritious crops (Yaklich et al., 2002). Its seed contains 42-45% protein and 22% edible oil (Mondal et al., 2002). Recently soybean has become an important crop in Bangladesh as its demand is increasing significantly. It is mostly used as poultry and fish feed in

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our country. Currently, a huge quantity of soybean has been imported to meet the demand in the market.

Bangladesh is a densely populated country. It is facing tremendous pressure of food demand to feed the increasing number of population. The area of cultivable land is also decreasing. The total area of cultivable land reduced alarmingly from 20 million ha in 1983-84 to 14.8 million ha in 2008 (Khan et al., 2008). Therefore essential crops are in competition for getting lands for cultivation. Thus, farmers of Bangladesh grow cereal crops for their food security in the good soils and non-cereals are mostly grown on the marginal lands.

Soybean is one of the non competitive crops for the farmers of Bangladesh and could fit on the marginal lands especially in the char and coastal lands. In Bangladesh thirty percent of the net cultivable areas are in the coast. Of the 2.85 million hectares of the coastal and off-shore areas, about 0.83 million hectares of the arable lands are affected by varying degrees of soil salinity (Karim et al., 1990). Hence, most of the cultivable land remains fallow during winter season due to salinity in southern region of Bangladesh. Increasing the cropping intensity is an important task ahead to improve the agricultural productivity of the coastal saline lands. Exploiting the relatively low saline areas after rainy season rice harvest by growing saline tolerant crops can be a profitable and sustainable option for the farmers. Soybean classified as moderately salt sensitive crop (Katerji et al., 2003). It may be grown in low saline areas. On the other hand, charland areas are estimated to be 0.82 million hectares in Bangladesh, out of which about 64 to 97% area is cultivable (Ahmed et al., 1987). Cultivated soils of chars are mostly loam to silty loam with slightly acidic to slightly alkaline in reaction and deficient in plant nutrients as well as organic matter contents (SRDI, 2002). Islam and Rahman (2011) also reported good performance of soybean in charland.

Being a member of legume family, soybean fetches profitable returns to the growers even with minimum agricultural inputs. However, the ultimate yield of a crop depends upon the interaction between its genetic makeup and environmental factors faced during its entire growing period (Humphreys, 1989; Ashraf, 1994). Therefore, it is needed to find out high yielding soybean genotypes suitable for char lands and also saline belt to utilize fallow lands. A large size of germplasm of a crop might have some considerable genetic variability. The experiment was therefore planned to select soybean genotypes with high yield potential.

MATERIALS AND METHODS

The experiment was conducted at the research field of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh during January to June, 2010. The soil was silty clay in texture with pH of 6.5. The experiment was laid out in a RCB design with three replications. The study comprised of 115 genotypes of soybean including two released varieties viz., BARI Soybean 5 and BARI Soybean 6 as check. The genotypes were collected from BARI and AVRDC.

Seeds were sown in January 16, 2010 and harvested from April 22 to June 20, 2010 due to differences in life span of the genotypes. The seeds of soybean genotypes were sown in lines of one meter length maintaining 10 cm distances. Row to row spacing was 40 cm, maintaining 10 plants per meter. Fertilizers were applied at the rate of 28-30-60-18 kg ha^{-1} of NPKS in the form of urea, TSP, MOP and Gypsum, respectively (FRG, 2005). Half of urea and full doses of other fertilizers were applied at the time of final land preparation. The remaining half of urea was top dressed at flowering stage followed by irrigation. After sowing one-irrigation was applied for uniform emergence and thereafter three additional irrigations were given to the plots for meeting the water at different critical stages of soybean. Soybean plants emerged on January 24. Admire 200SL @ 1 ml $liter^{-1}$ of water was sprayed at 10 and 25 DAE to control Jassids and white flies. Ripcord 10 EC @ 1 ml $liter^{-1}$ of water was sprayed at 45 and 60 DAE to control leaf roller and pod borer. Leaf SPAD values, leaf width and breadth were recorded at 45 DAE and plant height was measured at 75 DAE. After harvest, yield and yield contributing characters were recorded.

Average values of morphological and yield contributing characters viz., seed yield linear $meter^{-1}$, seed yield $plant^{-1}$, 100-seed weight, number of pods $plant^{-1}$, number of seeds pod^{-1}, number of branches $plant^{-1}$, plant height, leaf SPAD value, leaf length, leaf width and days to maturity were analysed for multivariate analysis by using GENESTAT program.

RESULTS AND DISCUSSION

Maximum, minimum and mean values of eleven quantitative traits of the 115 soybean genotypes are presented in table 1. The seed yield per linear meter ranged from 11.80 to 97.76 g. The seed yield per plant ranged from 1.29 to 9.66 g. 100-seed weight ranged from 5.48 to 24.93 g. The number of pods $plant^{-1}$ ranged from 14.33 to 57.78. Number of seeds pod^{-1} ranged from 1.6 to 2.5. Number of branches $plant^{-1}$ ranged from 1 to 6. Plant height ranged from

8.78 to 93.44 cm. Leaf SPAD values ranged from 28.10 to 45.70. Leaf blade length ranged from 5.2 to 10.9 cm. Leaf blade width ranged from 3.3 to 7.6 cm and crop duration ranged from 80 to 149 days. These results of quantitative traits indicated that there were wide variations in 115 soybean genotypes. Variability in quantitative traits could provide a guide line for the selection of best lines of soybean in cropping system improvement. Variations in plant characters of soybean genotypes also were reported by Iqbal et al. (2008).

The grouping of different soybean genotypes in clusters for quantitative traits is presented in table 2. Cluster I comprised of 14 genotypes, which represented 12.17% of the total genotypes. The Cluster II represented 4.35% with 5 genotypes. The Cluster III and Cluster IV, both were accounted for 16.52% of the total, which comprised of 19 genotypes in each. The Cluster V and Cluster VI contributed 25.22% of all and comprised of 29 genotypes in each group. The results indicated the presence of high degree of divergence in the genotypes.

The cluster mean values and standard deviations for different plant characters in groups are presented in table 3. The clusters differed in mean values for almost all the characters. It was observed that maximum seed yield linear meter^{-1} (71.59 g), maximum seed yield plant^{-1} (7.20 g), maximum 100-seed weight (10.06 g), more number of filled pods plant^{-1} (38.71), more number of seeds pod^{-1} were recorded in Cluster III, which was followed by Cluster IV with all contributing traits. However, the least seed yield linear meter^{-1} (14.20 g) and seed yield plant^{-1} (1.59 g), least number of pods plant^{-1} (19.02) and seeds pod^{-1} (1.82) were obtained from Cluster II. The genotypes in Cluster I showed early maturity (83 days) and in Cluster II showed late maturity (143 days). The genotypes which have greater morphological similarity were grouped in clusters. Ghatge and Kadu (1993) reported seven clusters derived from 58 soybean genotypes. Several researchers studied with genetic diversity of soybean and grouped them in clusters (Mehetre et al., 1994; Kumar and Nadarayan, 1994; Iqbal et al., 2008).

It was found in principal component analysis that three components had greater than one eigen values which contributed 71.11% of the total variation among 115 genotypes of soybean (Table 4). It was observed that principal component 1 with eigen value of 3.915 contributed 35.59%, principal component 2 with eigen value of 2.187 contributed 19.89% and principal component 3 with eigen value of 1.720 contributed 15.63% of the total variation.

The traits which were potentially important could be exploited through principal component analysis (Table 5). The genetic variance to principal component 1 and principal component 2 were contributed commonly by 100-seed weight, leaf SPAD value and leaf width. The traits, which contributed positively to 1st principal components, were seed yield plant^{-1} (0.1009), 100-seed weight (0.0233), number of pods plant^{-1} (0.0032), number of seeds pod^{-1} (0.9369), SPAD value (0.0333) and leaf width (0.4834) showed positive eigen vector values while the others had negative values. The positive genetic variance to 2nd principal components were contributed by 100-seed weight (0.0022), number of branched plant^{-1} (0.0772), SPAD value (0.0481), leaf length (0.2542), leaf width (0.0422) and days to maturity (0.0788). The rest of the characters had negative eigen vector values. Iqbal et al. (2008) reported that quantitative traits that contributed positively in principal component analysis could be given considerable importance for the genetic material under investigation.

Graphical illustration of the six cluster groups of soybean according to the first and 2nd discriminators functions is presented in figure 1. Discriminatory analysis revealed that Cluster II and Cluster III only showed complete separation from others. There were mixed up of Clusters in between IV and V, and in Clusters I and VI.

Inter-group distances (D^2) between six clusters of soybean genotypes are presented in table 6. The distances calculated by discriminatory function analysis (DFA) showed maximum distance (12.405) between Cluster I and Cluster II which was followed by the distance (10.531) between Cluster II and Cluster III. But Cluster III and Cluster IV were in closer distance (1.929) as compared to distance from Cluster V (3.553) and Cluster VI (4.924). The closer distance between the cluster groups indicated genetically closeness. The cluster mean values for different yield contributing characters which have considerable importance in clustering of 115 soybean genotypes in six groups and their inter-group distances revealed that genotypes in Cluster III showed better performance which could be marked for the selection of yield potential genotypes. Several researchers also showed this system to characterize and select genotypes of different crops (Ghafoor et al., 2001; Elizabeth et al., 2001; Rabbani et al., 1998; Islam et al., 2007; Amiruzzaman et al., 2013).

CONCLUSION

Considerable genetic variability was identified in the 115 soybean genotypes. The genotypes were grouped in six clusters on the basis of their variability in quantitative traits. The results concluded that the Cluster III comprised of BARI Soybean 5, G00083, BARI Soybean 6, G00342, BD 2338, BD 2355, BD 2329, BD 2340, AGS 95, G00056, AGS 129, BD 2336, BGH 02026, BGM 02093, Galarsum, BD 2350, G00084, BD 2331, G00103 genotypes performed better than others, because of its better quantitative traits and higher inter-group distances.

REFERENCES

Ahmed, M.M., Alam N., Kar N.K., Maniruzzaman A.F.M., Abedin Z. and Jasimuddin G. 1987. Crop production in saline and charlands – Existing situation and potentials. In: *Advances in Agronomic Research in Bangladesh*, 2: 1-27

Amiruzzaman, M., Amin M.N., Talukder M.Z.A., Ahmed A. and Ali M.R. 2013. Genetic diversity among yellow grain maize inbred lines. *Journal of Experimental Biosciences*, 4(2): 71-76

Ashraf, M. 1994. Genetic variation for salinity tolerance in spring wheat. Hereditas. 120: 99–104

Elizabeth, A.V., Schammass E.A., Vencovsky R., Martins P.S. and Bandel. G. 2001. Germplasm characterization of *Sesbania* accessions based on multivariate analyses. *Genetic Resources and Crop Evolution*, 48: 79-90

FRG. 2005. Fertilizer Recommendation Guide-2005. Bangladesh Agricultural Research Council. Farmgate. Dhaka-1215

Ghafoor, A., Sharif A., Ahmad Z., Zahid M.A. and Rabbani M.A. 2001. Genetic diversity in blackgram (*Vigna mungo* (L.) Hepper). *Field Crops Research*, 69: 183-190

Ghatge, R.D. and Kadu R.N. 1993. Genetic diversity in soybean. *Annals of Agricultural Research*, 14(2): 143-148

Humphreys, M.O. 1989. Assessment of pereial ryegrass (*Lolium perenne* L.) for breeding.II. Components of winter hardiness. *Euphytica*, 41: 99-106

Iqbal, Z., Arshad M., Ashraf M., Mahmood T. and Waheed A. 2008. Evaluation of soybean (*Glycine max* (L.) Merrill) germplasm for some important morphological traits using multivariate analysis. *Pakistan Journal of Botany*, 40(6): 2323-2328

Islam, M.R., Hamid A., Khaliq Q.A., Ahmed J.U., Haque M. M. and Karim M.A. 2007. Genetic variability in flooding tolerance of mungbean (Vigna radiate L. Wilczek) genotypes. *Euphytica*, 156: 247-255

Islam, M.N. and. Rahman M.S. 2011. Performance of soybean varieties in the charland area (AEZ-11). In: Charland Research 2007-2010. Charland publication no. 1. Agronomy division, BARI, Joydebpur, Gazipur

Karim, Z., Hussain S.G. and Ahmed M. 1990. A BARC soil publication. BARC. No.33

Katerji, N., Hoorn J.W.V., Hamdy A. and Mastrorilli M. 2003. Salinity effect on crop development and yield, analysis of salt tolerance according to several classification methods. *Agricultural Water Management*, 62: 37-66

Khan, M.S., Rahman M.M., Begum R.A., Alam M.K., Mondol A.T.M.A.I., M.S. Islam and Salahin. 2008. Research Experiences with Problem Soils of Bangladesh, Soil Science Division, BARI, Joydebpur, Gazipur-1701

Kumar, M. and Nadarajan N. 1994. Genetic divergence studies in soybean (*Glycine max* (L.) Merrill). *Indian Journal of Genetics and Plant Breeding*, 54(3): 242-246

Mehetre, S.S., Mahajan C.R.,. Patil P.A and Hajare D.N. 1994. Genetic divergence in soybean (*Glycine max* (L.) Merrill.*). Indian Journal of Genetics and Plant Breeding*, 54(1): 83-88

Mondal, M.R.I., Wahab M.A., Alam M.S., Ahmed M.M.U. and Begum F. 2002. Leaflet of BARI Soybean 5. ORC, BARI, Joyderbpur, Gazipur

Rabbani, M.A., Iwabuchi A., Murakami Y., Suzuki T. and Takayanagi K. 1998. Phenotypic variation and the relationship among mustard (*Brassica juncea* L.) germplasm from Pakistan. *Euphytica*, 101: 357-366

SRDI (Soil Resource Development Institute). 2002. Upazila Bhumi-o-Mrittika Sampad Baboher Nirdeshika (in Bangla). Soil Resource Development Institute, Dhaka-1215

Yaklich, R.W., Vinyard B., Camp M. and Douglass S. 2002. Analysis of seed protein and oil from soybean northern and southern region uniform tests. *Crop Science*, 42: 1504-15

Table 1: Maximum, minimum and mean values of eleven quantitative traits of 115 soybean genotypes

Traits	Maximum	Minimum	Mean
Seed yield linear meter^{-1} (g)	97.76	11.80	46.04
Seed plant^{-1} (g)	9.66	1.29	4.87
100-seed weight (g)	24.93	5.48	11.49
No. of pods plant^{-1}	57.78	14.33	28.87
No. of seeds pod^{-1}	2.50	1.60	2.19
No. of branches plant^{-1}	6.10	1.00	3.72
Plant height (cm)	93.44	8.78	47.03
Leaf SPAD value	45.70	28.10	35.90
Leaf length (cm)	10.90	5.20	8.36
Leaf width (cm)	7.60	3.30	5.48
Days to maturity	149	80	100.5

Table 2: Grouping of soybean genotypes based on six clusters for various traits

Cluster	F	% Age	Cluster membership
Cluster I	14	12.17	G00138, G00343, G00046, G00042, G00207, G00197, G00166, G00351, G00196, G00221, G00041, G00204, G00154, G00053
Cluster II	5	4.35	G00098, G00069, G00091, G00117, G00096
Cluster III	19	16.52	BARI Soybean 5, G00083, BARI Soybean 6, G00342, BD 2338, BD 2355, BD 2329, BD 2340, AGS 95, G00056, AGS 129, BD 2336, BGH 02026, BGM 02093, Galarsum, BD 2350, G00084, BD 2331, G00103
Cluster IV	19	16.52	Shohag, BD 2342, Bangladesh soybean 4, PK 416, BD 2337, BD 2335, G00003, G00015, MTD 453, BD 2327, G00382, G00006, G00032, G00035, BD 2339, ASET 95, G00389, AGS 275, MTD 459

Cluster V	29	25.22	G00336, BD 2326, BD 2349, G00020. BD 2354, G00124, G00060, G00063, G00002, G00108, BD 2353, MTD 10, G00111, G00095, G00019, G00017, G00076, G00105, G00068, G00005, BD 2347, BGM01001, G00073, G00387, BD 2346, ST 2, ASET 93, G00011, PK 327
Cluster VI	29	25.22	AGS 399, G00209, G00061, AGS 313, G00390, G00045, G00329, G00238, G00247, G00078, AGS 400, G00034, G00059, G00312, G00027, G00348, AGS 405, G00256, G00288, G00374, BD 2330, G00193, BD 2332, G00324, G00362, G00331, G00206, AGS 403, G00184

F- Frequency, % Age - percentage

Table 3: Mean values and standard deviation for six clusters based on eleven quantitative traits of 115 soybean genotypes

Traits	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Seed yield linear m^{-1} (g)	34.34±8.43	14.20±2.66	71.59±10.29	49.68±6.55	46.01±8.85	38.08±8.92
Seed yield $plant^{-1}$ (g)	3.75±0.68	1.59±0.27	7.20±1.04	5.03±0.57	4.84±0.77	4.36±1.03
100-seed weight (g)	12.07±1.77	12.54±1.80	10.06±2.66	9.74±2.44	11.17±2.09	13.45±4.30
No. of pods $plant^{-1}$	20.78±2.41	19.02±3.72	38.71±8.02	34.09±8.09	30.20±6.16	23.29±4.75
No. of seeds pod^{-1}	2.15±0.15	1.82±0.16	2.22±0.09	2.23±0.13	2.26±0.09	2.19±0.17
No. of branches $plant^{-1}$	2.20±0.09	4.24±1.00	4.61±0.79	4.11±0.78	4.22±0.67	3.02±0.67
Plant height (cm)	15.07±4.47	75.13±11.67	53.38±6.82	55.29±8.50	55.64±7.04	39.44±6.85
Leaf SPAD value	38.65±3.77	35.36±2.18	35.12±2.36	35.35±2.25	34.73±3.07	36.70±3.41
Leaf length (cm)	7.19±0.78	8.30±0.19	8.53±0.52	8.63±0.70	8.78±0.72	8.22±1.06
Leaf width (cm)	4.71±0.50	5.54±0.24	5.53±0.45	5.57±0.50	5.72±0.47	5.51±0.79
Days to maturity	83.29±7.69	143.00±12.0	103.16±7.17	93.74±3.24	110.59±4.89	94.24±7.05

Table 4: Principal components and extracted eigen values in principal components analysis (PCA)

PCA	Latent root/ Eigen value	Variation (%)	Cumulative variation (%)
1	3.915	35.59	35.59
2	2.187	19.89	55.48
3	1.720	15.63	71.11
4	0.852	7.75	78.86
5	0.749	6.81	85.67
6	0.547	4.97	90.64
7	0.405	3.68	94.32
8	0.224	2.04	96.36
9	0.200	1.82	98.18
10	0.156	1.42	99.60
11	0.045	0.40	100.00

Table 5: Extracted Eigen values and latent vectors associated with two principal components

Plant characters	Latent vectors	
	Vector-1	Vector-2
Seed yield linear m^{-1} (g)	-0.0208	-0.0483
Seed yield $plant^{-1}$ (g)	0.1009	-0.5684
100-seed weight (g)	0.0233	0.0022
No. of pods $plant^{-1}$	0.0032	-0.0541
No. of seeds pod^{-1}	0.9369	-0.6674
No. of branches $plant^{-1}$	-0.4122	0.0772
Plant height (cm)	-0.0947	-0.0332
Leaf SPAD value	0.0333	0.0481
Leaf length (cm)	-0.5985	0.2542
Leaf width (cm)	0.4834	0.0422
Days to maturity	-0.0686	0.0788

Table 6: Inter-group distances (D^2) between six clusters of soybean genotypes

Clusters	1	2	3	4	5	6
1	-	12.405	7.984	6.439	7.180	3.652
2	-	-	10.531	9.422	7.260	9.522
3	-	-	-	1.929	3.553	4.924
4	-	-	-	-	2.162	3.089
5	-	-	-	-	-	3.530
6	-	-	-	-	-	-

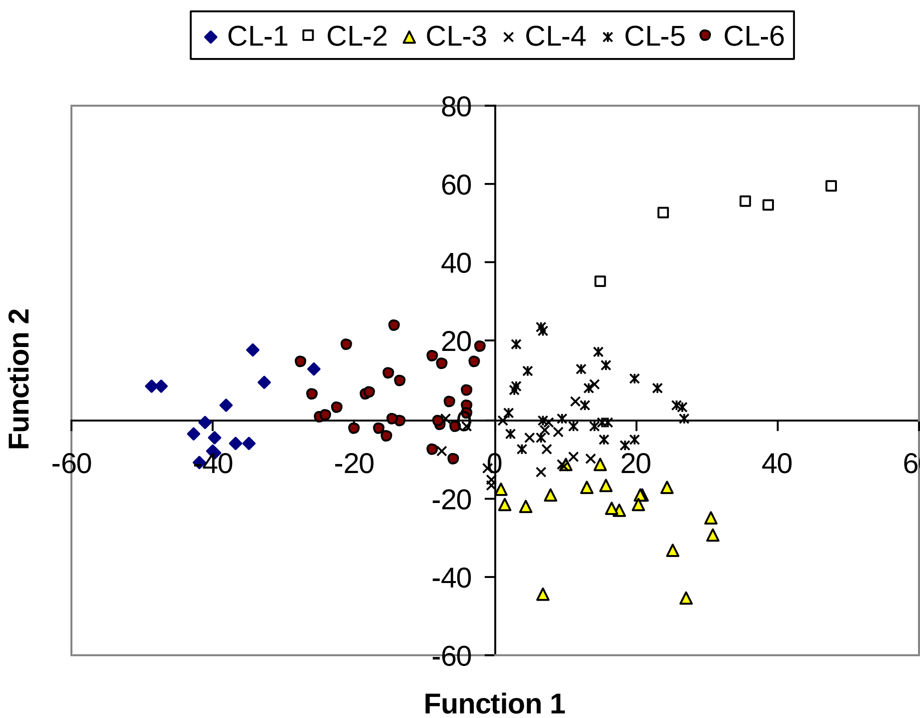

Figure 1: Scatter diagram on cluster diversity for two PCs of 115 soybean genotypes

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HYBRID MAIZE AND SWEET POTATO INTERCROPPING: A TECHNOLOGY TO INCREASE PRODUCTIVITY AND PROFITABILITY FOR POOR HILL FARMERS IN BANGLADESH

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ABSTRACT

The experiment was conducted at the Hill Agricultural Research Station, Khagrachari during two winter seasons of 2010-11 and 2011-12 to find out suitable planting system of the component crops for increasing productivity and profitibility for hill farmers of Bangladesh. Three intercrop combinations viz., (i) maize paired row + 2 rows sweet potato, (ii) maize normal row +1 row sweet potato and (iii) sweet potato normal row + 1 row maize were evaluated against their respective sole crops. In all combinations, light availability was more at early growth stage and reduced gradually with the advancement of canopy development of maize. Light availability was minimum at 100 days after emergence and thereafter slightly increased in three intercrop combinations. Among intercrop combinations, light availability to sweet potato canopy was more in maize paired row + 2 rows sweet potato combination through out the crop period which enhance tuber formation, tuber bulging and tuber yield. Contrary, sweet potato vines provide a mulch cover for maize which preserve soil moisture and reduce weed infestation producing higher yield and yield components of maize. Maize yield (cob yield: 19.82 t ha^{-1}, grain yield: 8.98 t ha^{-1}), tuber yield of sweet potato (17.11 t ha^{-1}) and maize equivalent yield (cob equivalent yield: 42.63 t ha^{-1}, grain equivalent yield: 15.82 t ha^{-1}) were the highest in maize paired row + 2 rows sweet potato combination. Similarly, the highest gross return (for cob: Tk. 1,27,890 ha^{-1}, for grain: Tk. 1,58,200 ha^{-1}), gross margin (for cob: Tk. 87,890 ha^{-1}, for grain: Tk.1,08,200 ha^{-1}) and benefit cost ratio (for cob: 3.20, for grain: 3.16) were also obtained from the same combination. The results revealed that maize paired row + 2 rows sweet

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potato combination might be suitable for increasing productivity and ensure food security for resource poor hill farmers of Bangladesh.

Key words: Hill farmers, Hybrid maize, Sweet potato, Intercropping, Productivity and Technology

INTRODUCTION

Chittagong Hill Tracts region in Bangladesh lies within 21.25° to 23.45° North latitude and 91.45° to 92.50° East longitudes. The total area of this region is estimated to be 13295 km^2, which is approximately one tenth of the country area (Baten et al., 2009) and about 1.60 million people live there (BBS, 2013). Arable land in hilly areas is continuously being sub-divided into small holdings in the face of increasing population pressure. Majority of the hill families live below the poverty line and have lack money to buy foods from the market (Khandaker et al., 2009). Hence, it is necessary to encourage farmers to adopt innovative integrated crop intensification approaches to increase productivity of their lands. Intercropping is one of the cropping strategies that have been recognized to improve the food security situation and incomes for the farmers (Mahfuza, 2012). Intercropping also helps to reduce weed populations, insect pest's infestation and risk of complete crop failure (Amede, 2001; Islam et al., 2013).

Intercropping system becomes more productive and profitable when it is done properly by selecting compatible crops (Begum et al., 2010), spatial arrangements and population density of component crops (Islam et al., 2006) and judicious application of chemical fertilizers (Basak, 2008). Hybrid maize-sweet potato intercropping is compatible as they possess different photosynthetic pathways, different growth habit and requirement of different growth resources (Islam et al., 2007). This system may be popular in hilly areas for their high yield potential. Both the crops have diversified uses. Roasted maize cobs at dent stage are popular to hill peoples than other uses. Generally, hill farmers grow hybrid maize and sweet potato in hill valleys as sole crops. In that region, productivity and profitability may be increased through growing hybrid maize and sweet potato as intercropping. Hence, the experiment was conducted to find out the suitable planting system of hybrid maize-sweet potato intercropping system for increasing productivity for hill farmers in Bangladesh.

MATERIALS AND METHODS

The experiment was conducted at the valley of Hill Agricultural Research Station, Khagrachari, Bangladesh during two consecutive winter seasons of 2010-11 and 2011-12. The soil of the experimental field was clay loam in texture and strongly acidic in reaction (pH 4.6) under Agro-Ecological Zone-29. The soil was medium in organic matter content (1.88%), very low status in total N (0.09%), low in P (5.4 µg g^{-1}), medium in K (0.24 meq 100g^{-1}), medium in S (16 µg g^{-1}), low in Zn (0.78 µg g^{-1})

and low in B (0.25 µg g^{-1}). The crops received total rainfall of 15.1 mm and 4.2 mm during crop period of 2010-11 and 2011-12, respectively. The monthly mean maximum and minimum air temperature were 26.1^{o}C and 19.1^{o}C, respectively during 2010-11 while 25.9^{o}C and 20.4^{o}C, respectively in 2011-12. Five treatments were evaluated such as: T_1 = Maize paired rows (37.5 cm / 150 cm / 37.5 cm × 25 cm) + 2 rows sweet potato (60 cm × 30 cm) in between two maize paired row (100% MPR: 40 % SP), T_2 = Maize normal row (75 cm × 25 cm) +1 row sweet potato in between two maize rows (100% MNR: 60% SP),T_3 = Sweet potato normal row (60 cm) + 1 row maize after 2 rows sweet potato (100% SP: 50% MNR), T_4 = Sole maize (75 × 25 cm), T_5 = Sole sweet potato (60 cm × 30 cm). The experiment was laid out in a randomized complete block design with five replications. The unit plot size was 4.5 m × 6.0 m. The hybrid maize (var. BARI Hybrid maize 9) and sweet potato (var. BARI Mishtialu-7) were used in this experiment. BARI Hybrid maize 9 is a high yield potential (grain: 10-11 t ha^{-1}) cereal crop and can be grown in hill eco-system. It is moderately drought tolerant. On the contrary, BARI Mishtialu-7 is a high yielding variety (tuber yield: 40-45 t ha^{-1}), rich in vitamin A. It is also moderately drought tolerant. Seeds of maize and vines of sweet potato were sown or planted on 7 December 2010 and 2011 according to treatments. Sole hybrid maize and intercropping treatments were fertilized with 260-55-110-40-4-1 kg ha^{-1} NPKSZnB while sole sweet potato with 100-40-100-10-1 kg ha^{-1} NPKSZn (FRG, 2005). The full amount of P K S Zn B and $^{1}/_{3}$ N were applied as basal in the form of triple super phosphate, muriate of potash, gypsum, zinc sulphate, boric acid and urea, respectively. The remaining N was top dressed in two equal splits at 30 and 60 days after sowing (DAS). Irrigation was given after sowing or planting for proper establishment of crops. Subsequently three irrigations were applied at 30, 60 and 90 DAS. Two hand weeding were done at 20 and 40 DAS to keep the crops reasonably weed free. Each maize plots were divided into two halves of 4.5 m × 3.5 m (5.75 m^2) for harvesting the cobs. Plants m^{-2} for both the crops was recorded from randomly selected three places and yield components from 5 plants at harvest. Maize cobs of were harvested at dent stage (135-140 DAS) and physiological maturity stage (155-160 DAS) at both the years. On the other hand, sweet potato was harvested at maturity stage (156 DAP). Yields of both the crops were taken from whole plot. Maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

$$Meq = Yim + \frac{Yisp \ x \ Psp}{Pm}$$ Where, *Meq* = Maize equivalent yield

Yim = Yield of intercrop maize, *Yisp* =Yield of intercrop sweet potato

Pm = Price of maize, *Psp* = Price of sweet potato

Data on yield and yield components of both the crops for two consecutive years showed similar trend. So, those data were pooled and means were adjudged by LSD test at 5% level of significance. Benefit cost analysis was also done.

RESULTS AND DISCUSSION

Availability of light on sweet potato canopy

Spatial arrangement of maize influenced light availability to under storey sweet potato. Light availability on sole maize and sole sweet potato was 100% through out the growing period as there was no shade due to intercropping. So, light availability on both the sole crops was not shown in Figure 1. Regardless of planting systems, light availability was 100% upto 20 days after sowing (DAS), and then it was reduced gradually with the advancement of canopy development of maize (Figure 1). At 40 DAS, sweet potato in maize paired row + 2 row sweet potato combination received almost full light (96%) which was followed by sweet potato normal row + 1 row maize (93%) and maize normal row + 1 row sweet potato combination (91%); and thereafter it decreased over time due to advancement of canopy development of maize reaching minimum level at 100 DAS. At 100 DAS, sweet potato in maize paired row + 2 row sweet potato combinations got 36% light followed by sweet potato normal row + 1 row maize combination (25%). Light availability on sweet potato canopy was minimum in maize normal row + 1 row sweet potato combination (12%). Then light availability increased to sweet potato crop due to leaf senescence of maize in all treatments. At 140 DAS, light availability on sweet potato canopy was 40, 31 and 18% in maize paired row + 2 row sweet potato, sweet potato normal row + 1 row maize and maize normal row + 1 row sweet potato combination, respectively. Light availability to sweet potato canopy was more in maize paired row + 2 rows sweet potato combination through out the crop period due to widest maize spacing (150 cm) which was followed by sweet potato normal row + 1 row maize (120 cm). On the other hand, availability of light on sweet potato canopy was the lowest in maize normal row (75 cm) +1 row sweet potato combinations. Availability of more light on sweet potato canopy through out the crop period enhance tuber formation, tuber bulging and ultimately tuber yield. Alternately, sweet potato vines provide a mulch cover for maize which preserve more soil moisture, reduce weed infestation and accelerate maize growth producing more no. of cobs or grain yield. Islam (2002) also stated similar results in case of maize-bush bean intercropping system under different spatial arrangement.

Effect on maize yield and yield attributes

Plants m^{-2}, cob weight with husk per plant, single cob weight with husk and cob yield with husk of hybrid maize were influenced significantly due to intercropping with sweet potato under different planting systems (Table 1). Plant population m^{-2} of maize varied mainly due to planting systems. Higher and similar trend of plants m^{-2} of maize was recorded in sole maize (5.2), maize paired row + 2 rows sweet potato (5.3) and maize normal row + 1 row sweet potato (5.0) whereas the lowest plants m^{-2} of maize (2.3) was observed in sweet potato normal row + 1 row maize (120 cm apart rows) combinations. The maximum cob weight with husk per plant (508.8 g) was recorded in maize paired row + 2 row sweet potato which was at par with sweet potato normal row + 1 row maize (498.7 g) where maize sown in 120 cm apart rows. Higher cob weight per plant in aforesaid treatments were observed might be due to lower intra or inter species competition as well as more soil moisture preservation by sweet potato vines. The lowest cob weight with husk per plant (441.4 g) was found from sole maize which was statistically similar to maize normal row + 1 row sweet potato combination (448.6 g).Weight of single cob with husk (318.0 g) was maximum in maize paired row + 2 rows sweet potato which was followed by sole maize (315.3 g) and sweet potato normal row + 1 row maize (3.11.7 g) combination, while the lowest weight (299.1 g) was recorded in maize normal row + 1 row sweet potato. The maximum cob yield with husk (19.82 t ha^{-1}) was found in maize paired row + 2 rows sweet potato which was at par to sole maize (18.36 t ha^{-1}) and maize normal row + 1 row sweet potato combination (17.94 t ha^{-1}). Higher cob yield with husk in maize paired row + 2 rows sweet potato was attributed to the cumulative effect of yield components of maize. This result is in agreement with the finds of Basak et al. (2008). The lowest cob yield with husk (9.18 t ha^{-1}) was recorded in sweet potato normal row + 1 row maize due to mainly minimum plants m^{-2}.

Plants m^{-2} and grain yield of hybrid maize differed significantly in maize-sweet potato intercropping under different planting systems (Table 2). The variation in planting systems was the main reason for the variation in plants m^{-2} of maize in different treatment combinations of maize-sweet potato intercropping. The maximum grain yield (8.98 t ha^{-1}) of maize was produced from maize paired row + 2 rows sweet potato which was at par with sole maize (8.01 t ha^{-1}) while the lowest (4.04 t ha^{-1}) from sweet potato normal row + 1 row maize. Yield variations in different intercropping systems were occurred due to variation in plants m^{-2} as well as other yield attributes. Similar results were reported by Islam et al. (2006). Similar to grain yield, stover yield of maize was recorded as the highest in maize paired row + 2 rows sweet potato (13.21 t ha^{-1}) which was identical with sole maize (12.46 t ha^{-1}) and maize normal row +1 row sweet potato (12.00 t ha^{-1}). The minimum stover yield (5.97 t ha^{-1}) was found from sweet potato normal row + 1 row maize combination.

Effect on sweet potato yield and yield attributes

Plant population m^{-2}, number of tubers per plant, tuber weight per plant, single tuber weight and tuber yield of sweet potato were affected significantly in maize-sweet potato intercropping under different planting systems (Table 3). The maximum plants m^{-2} was recorded in sole sweet potato (4.5) which was identical to sweet potato normal row + 1 row maize (4.3).The lowest plant population m^{-2} was found in maize paired row + 2 rows sweet potato (2.9) and it was at par with maize normal row + 1 row sweet potato combination (3.2). The significant variation in plants m^{-2} was attributed mainly due to planting system. The highest number of tubers per plant was recorded in maize paired row + 2 rows sweet potato (4.5) possibly due to less inter crop competition. Number of tubers per plant decreased with increasing crop competition and the minimum number of tubers per plant was obtained from maize normal row + 1 row sweet potato combination (2.6). Like tuber weight per plant, tuber size i.e. single tuber weight decreased with the increase of crop competition for growth resources and it followed similar trend like tuber weight per plant. The maxumum tuber yield (17.11 t ha^{-1}) of sweet potato was recorded in maize paired row + 2 rows sweet potato (Table 3) which was statistically similar to sole sweet potato (16.98 t ha^{-1}). On the contrary, tuber yield of sweet potato was the lowest (7.18 t ha^{-1}) in maize normal row + 1 row sweet potato combination. Tuber yield in different intercrop combinations was attributed to the cumulative effect of yield components. These results are in conformity with the finds of Islam et al. (2007).

Intercrop efficiency based on equivalent yield and benefit cost

Total productivity in terms of maize cob equivalent yields and economic study of hybrid maize-sweet potato intercropping under different planting systems are presented in table 4. Maize cob equivalent yields in all intercropping systems were more than sole maize or sole sweet potato. Among intercropping systems, the highest maize cob equivalent yield (42.63 t ha^{-1}) was recorded in maize paired row + 2 rows sweet potato combination which was much higher than other combinations. The highest maize cob equivalent yield in this combination was observed because of the higher accumulated yield of maize cob and sweet potato tuber. This result is in line with the findings of Uddin et al. (2006). The lowest maize cob equivalent yield (18.36 t ha^{-1}) was obtained from sole maize. Gross return followed the trend similar to maize cob equivalent yield. Cost of production differed in different planting systems due to involvement of different variable costs. The highest gross margin was obtained from maize paired row + 2 rows sweet potato combination (Tk. 87,890 ha^{-1}). Though the cost of production of this combination was higher than the sole crop but highest gross margin was recorded due to the highest gross return. The highest benefit cost ratio (3.20) was also recorded maize paired row + 2 rows sweet potato indicating profitable combination of maize sweet potato intercropping systems. Other two intercrop combinations failed to show higher benefit than sole sweet potato but higher than sole maize.

Total productivity in terms of maize grain equivalent yields and economic study of hybrid maize-sweet potato intercropping systems were also computed and are presented in table 5. The highest maize grain equivalent yield (15.82 t ha^{-1}) was recorded in maize paired row + 2 rows sweet potato which was 50 % higher than maize normal row + 1 row sweet potato (10.72 t ha^{-1}). Gross return (Tk. 1,58,200 ha^{-1}), gross margin (Tk. 1,08,200 ha^{-1}) and benefit cost ratio (3.16) were also highest in maize paired row + 2 row sweet potato.

Sole sweet potato showed higher BCR than maize normal row + 1 row sweet potato but much higher than sweet potato normal row + 1 row maize. Maize as sole crop failed to show higher benefit than all other combinations so maize as sole crop could be easily replaced by intercropping system. Similar trend was reported by Begum et al. (2010); Islam et al. (2013).

CONCLUSION

The results revealed that maize paired row + 2 rows sweet potato combination could be suitable for increasing productivity and profitability for hill farmers of Khagrachari in Bangladesh.

REFERENCES

Amede, T. and Nigatu, Y. 2001. Interaction of Components of Sweetpotato-maize Intercropping under the Semi-arid conditions of the Rift-Valley, Ethiopia. *Tropical Agriculture*, 78(1): 1-7

Bandyopadhyay, S.N. 1984. Nitrogen and water relations in grain sorghum-legume intercropping systems. Ph. D. Dissertation, Indian Agricultural Research Institute, New Delhi

Basak, N.C., Quayyum, M. A., Uddin, M. J., Islam, M. N. and Mozumder, S.N. 2008. Intercropping bushbean with hybrid maize at different planting geometry and fertilizer levels. *Bangladesh Journal of Agriculture and Environment*, 4(2): 101-106

Baten, M.A., Khan, N. A., Ahammad, R. and Misbahuzzaman, K. 2009. Village Common Forests in Chittagong Hill Tracts, Bangladesh: Balance between Conservation and Exploitation. The paper presented at First International Community Forestry Conference held in Nepal on 15-18 September 2009

BBS (Bangladesh Bureau of Statistics). 2013. Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics, Statistics and informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.p. 35

Begum, S., Islam, M.N., Rahman, M. T., Chowdhury, J. A. and Haque, M.I. 2010. Suitability study of different chili varieties for intercropping with sweet gourd. *Journal of Experimental Biosciences*, 1(2): 1-4

FRG. 2005. Fertilizer Recommendation Guide-2005. Bangladesh Agricultural Research Council (BARC), Farmgate, New Airport Road, Dhaka-1215

Islam, M. N., Hossain, M.A., Khan, M.S.A., Nag, B.L., Sarker, M.A.I., Rahman, M.T. and Ahmed, I. M. 2007. Fertilizer management in hybrid maize-sweet potato intercropping systems. *Bangladesh Journal of Crop Science*, 18 (1): 89-94

Islam, M. N., Haque, M.M. and Hamid, A. 2004. Spatial arrangement and population density effects on productivity of maize–bushbean intercropping systems. *Bangladesh Journal of Agricultural Research*, 29 (3): 467-474

Islam, M. N., Haque, M.M. and Hamid, A. 2006. Planting arrangement and population density effects on the physiological attributes and productivity of maize–bushbean intercropping systems. *Bangladesh Journal of Agricultural Research*, 31(3):353-364

Islam, M.N., Rahman, M. S., Ahmed, F., Alom, M.S. and Akhteruzzaman, M. 2013. Performance of different HYV mustard varieties with sugarcane (Sacchaarum officinarum) as intercrop in farmers' fields. *Bangladesh Journal of Agricultural Research*, 38(1): 137-143

Khandaker, S.R., Bakht, Z. and Koolwal, G.B. 2009. The poverty impacts of rural roads. *Economic development and Cultural Change*, 57: 685-772

Mahfuza, S.N., Islam, M.N., Hannan, A., Akhteruzzaman, M.and Begum, S. 2012. Intercropping different vegetables and spices with pointed gourd. *Journal of Experimental Biosciences*, 3(1): 77-82

Uddin, M.J., Quayyum, M. A., Islam, M. N. and Basak, N. C. 2006. Intercropping of hybrid maize with bush bean at different fertilizer levels. *Bangladesh Journal of Agriculture and Environment*, 2(2): 17-22

Table 1: Cob with husk yield and yield components of hybrid maize as sole and intercropping systems (pooled data of 2010-11 and 2011-12)

Treatment	Plants m^{-2} (no.)	Cobs $plant^{-1}$ (no.)	Cob weight with husk $plant^{-1}$ (g)	Single cob weight with husk (g)	Cob yield with husk (t ha^{-1})
T_1	5.3	1.6	508.8	318.0	19.82
T_2	5.0	1.5	448.6	299.1	17.94
T_3	2.3	1.6	498.7	311.7	9.18
T_4	5.2	1.4	441.4	315.3	18.36
$LSD_{(0.05)}$	0.6	0.1	30.1	14.1	2.45
CV (%)	9.7	4.8	4.6	3.3	10.9

T_1 = Maize paired row + 2 rows sweet potato, T_2 = Maize normal row +1 row sweet potato, T_3 = Sweet potato normal row + 1 row maize, T_4 = Sole maize

Table 2: Grain yield and yield components of hybrid maize in maize sole and intercropping systems (pooled data of 2010-11 and 2011-12)

Treatment	Plants m^{-2} (no.)	Cobs $plant^{-1}$ (no.)	Grains cob^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	5.3	1.6	471	357.0	8.98	13.21
T_2	5.0	1.5	452	345.8	7.85	12.00
T_3	2.3	1.6	463	354.3	4.04	5.97
T_4	5.2	1.4	469	350.2	8.01	12.46
$LSD_{(0.05)}$	0.6	0.1	23	14.1	1.12	1.86
CV (%)	9.7	4.8	3.7	2.9	11.3	12.4

T_1 = Maize paired row + 2 rows sweet potato, T_2 = Maize normal row +1 row sweet potato, T_3 = Sweet potato normal row + 1 row maize, T_4 = Sole maize

Table 3: Tuber yield and yield components of sole sweet potato and intercropping systems (pooled data of 2010-11 and 2011-12)

Treatment	Plants m^{-2} (no.)	Tubers $plant^{-1}$ (no.)	Tuber weight $plant^{-1}$ (g)	Single tuber weight (g)	Tuber yield ($t\ ha^{-1}$)
T_1	2.9	4.5	767.0	170.4	17.11
T_2	3.2	2.6	299.2	115.0	7.18
T_3	4.3	2.8	339.3	121.2	10.94
T_5	4.5	3.1	503.1	162.3	16.98
LSD $_{(0.05)}$	0.4	0.1	17.8	4.3	1.85
CV (%)	8.2	3.1	2.7	2.2	10.3

T_1 = Maize paired row + 2 rows sweet potato, T_2 = Maize normal row +1 row sweet potato, T_3 = Sweet potato normal row + 1 row maize, T_5 = Sole sweet potato

Table 4: Cob equivalent yield and benefit cost analysis of sole maize and intercropping system (pooled data of 2010-11 and 2011-12)

Treatment	Maize cob equivalent yield ($t\ ha^{-1}$)	Gross return ($Tk\ ha^{-1}$)	Cost of production ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	BCR
T_1	42.63	127890	40000	87890	3.20
T_2	27.51	82530	40000	42530	2.06
T_3	23.77	71310	40000	31310	1.78
T_4	18.36	55080	38000	17080	1.45
T_5	22.64	67920	28500	39420	2.38

T_1 = Maize paired row + 2 rows sweet potato, T_2 = Maize normal row +1 row sweet potato, T_3 = Sweet potato normal row + 1 row maize, T_4 = Sole maize, T_5 = Sole sweet potato Local market price ($Tk\ kg^{-1}$): Maize cob: 3/-, Sweet potato: 4/-

Table 5: Maize grain equivalent yield and benefit cost analysis of sole maize and intercropping system (pooled data of 2010-11 and 2011-12)

Treatment	Maize grain equivalent yield ($t\ ha^{-1}$)	Gross return ($Tk\ ha^{-1}$)	Cost of production ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	BCR
T1	15.82	158200	50000	108200	3.16
T2	10.72	107200	50000	57200	2.14
T3	8.42	84200	50000	34200	1.68
T4	8.01	80100	48000	32100	1.67
T5	6.79	67900	28500	39400	2.38

T_1 = Maize paired row + 2 rows sweet potato, T_2 = Maize normal row +1 row sweet potato, T_3 = Sweet potato normal row + 1 row maize, T_4 = Sole maize, T_5 = Sole sweet potato Local market price ($Tk\ kg^{-1}$): Maize grain: 10/-, Sweet potato: 4/-

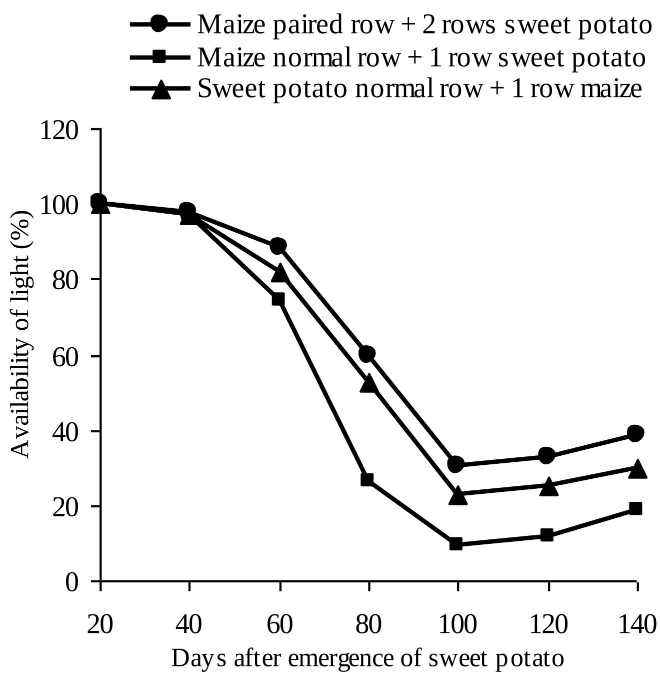

Figure 1: Availability of light on sweet potato in maize/sweet potato intercropping

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POPULATION DYNAMICS OF *Notopterus notopterus* (Pallas, 1769) FROM THE KAPTAI RESERVOIR OF BANGLADESH

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ABSTRACT

Population parameters of *Notopterus notopterus* (Pallas, 1769) from length-frequency data collected from Kaptai Reservoir of Rangamati, Bangladesh from January, 2013 to December, 2013 were calculated by using FiSAT software. The asymptotic total length (L_∞) and growth coefficient *(K)* were estimated to be 34.91cm and 0.38 y^{-1}respectively. The instantaneous rate of natural mortality (*M*), fishing mortality (*F*) and total mortality (*Z*) were estimated to be as 0.91 y^{-1}, 0.28 $y^{-1}$and 1.19 y^{-1} respectively. The value of exploitation rate (*E*) was found to be 0.24 which clearly pointed toward moderate or less fishing pressure (E<0.50) of *N. notopterus* in the Kaptai reservoir of Bangladesh. The recruitment of the species was found throughout the year with two peaks - one from March-April; and another from May- June. Virtual population analysis (VPA) estimated that the maximum numbers of *N. notopterus* were caught between 10.50 cm to 32.50 cm with maximum *F* value (0.80 y^{-1}) in the mid length of 18.30 cm. During the year 2013 the total catch of *N. notopterus* was found to be 664.5 MT, which contributed about 7.78% of the total catch of Kaptai Lake. Relative yield per recruit (*Y'/R*) and biomass per recruit (*B'/R*) suggested that the natural mortality should be reduced to 0.91 y^{-1} by proper management to obtain a maximum sustainable exploitation rate (E_{max}= 0.828) for the species in the reservoir.

Key words: Asymptotic length, Growth coefficient, Mortality, Virtual Population Analysis, Recruitment pattern, Exploitation rate, *Notopterus notopterus*

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INTRODUCTION

Notopterus notopterus (Pallas, 1769) is a member of the family Notopteridae, commonly known as grey featherback and bronze featherback but locally known as Foli and Pholoi in Bangladesh. This species is locally important for its taste and abundance in the Kaptai reservoir. Kaptai Lake, located at Kaptai Upazila in Rangamati district of Bangladesh, is the spawning, nursing and feeding ground of many important fishes. During the last couple of decades availability of this fish in the Reservoir environment has been drastically declined due to several factors, such as siltation caused by deforestation, over fishing, indiscriminate killing of supplemental fingerlings and use of various types of destructive fishing methods (Ahmed and Hambrey, 1999). Effective management of any fishery requires considerable knowledge on population parameters such as length-weight relationship, age and growth, mortality, recruitment pattern and stock position of important species. Estimation of these parameters leads towards the better prediction on fish stock assessment from which fisheries managers can know about the present status of any fishery. Without the information of these parameters, it is not possible to undertake an effective management program for a certain fishery. So, the population dynamics study will give an idea about growth variations of *N. notopterus* in natural water and the need for supplemental stocking if required. To calculate the maximum sustainable yield (MSY) it is also necessary to study the growth parameters in advance. Therefore, the present research was aimed to determine the population parameters of *N. notopterus* using length-frequency based analysis collected from Kaptai reservoir of Rangamati, Chittagong, Bangladesh.

MATERIALS AND METHOD

Experimental Fish

Experimental fish of this research work was *Notopterus notopterus* (Pallas, 1769).

Study Area

The study area of this research work was Kaptai reservoir (22°29′45″N and 92°13′45″E) of Rangamati, Chittagong, Bangladesh which is the largest man-made freshwater body in Bangladesh with a total surface area of 68,800 hectare and average water depth is about 9 meters with maximum depth of 32 meters.

Sampling Station

The selected sampling stations for this research work were fish landing centre of Bangladesh Fisheries Development Corporation (BFDC) and local markets (Natun Bazar, Jetty Ghat Bazar) near Kaptai reservoir

Collection of Data

Total 555 raw fish samples were collected for one year from January 2013 to December 2013. Samplings were done monthly at a regular interval directly from the BFDC fish landing centre and local fish markets (Natun Bazar, Jetty Ghat Bazar) of Rangamati district. These fish samples were collected by the fishermen from Kaptai Lake using gill net and lift net. In case of gill netting, the fishermen used a wide range of mesh sizes (6-14 cm).

Data Processing and Analysis

A. Estimation of Asymptotic Length (L_∞) and Growth Coefficient (*K*)

Month-wise length frequency distribution data were used to estimate the total asymptotic length (L_∞ cm) and growth coefficient (*K* year-1) of the Von Bertalanffy growth equation (Bertalanffy, 1938; Beverton and Holt, 1957). The ELEFAN I and ELEFAN II routines incorporated in FiSAT (FAO ICLARM Stock Assessment Tools) software (Gayanilo and Pauly, 1997) were used to determine $L\infty$ and *K* value following the Powell–Wetherall method (Wetherall et al., 1987). This method was used to provide an initial estimate of L_∞. This initial estimate of L_∞ was then used as seed value to determine the value of *K* (Silvestre and Garces, 2004). Minor adjustments to L_∞ and *K* were made to maximize the "goodness of fit" criterion built into ELEFAN I (Pauly, 1987). This led to a preliminary estimate of L_∞ and *K* that were used to obtain "probabilities of capture" by length class using the routine in FiSAT. These "probabilities of capture" were used to correct the length frequency distribution data to account for incomplete selection and recruitment and the final estimates of $L_\infty$and *K* were obtained by using these corrected length distribution data through ELEFAN I(Silvestre and Garces, 2004). ELEFAN I was used to estimate the growth parameters based on the Von Bertalanffy Growth Formula (VBGF) expressed in the form (Pauly and Gaschutz, 1979):

$$L_t = L_\infty\left(1 - \exp\left[-K\left(t - t_0\right)\right]\right)$$

Where, L_t is the predicted lengths at age t. $L\infty$ is the asymptotic length or mean length of a given stock of fish. K is a growth constant, also called "stress factor" by Pauly (1980), t_o is the "age" the fish would have been at zero length.

Mortality Estimation

In FiSAT software (Gayanilo and Pauly, 1997) package, ELEFAN II was used to estimate the total mortality coefficient, *Z*(*y -1*) using the length-converted catch curve by means of the final estimates L_∞ of *K* and the length frequency distribution data (Beverton and Holt, 1957; 1966) for the species *N. notopterus*. The rate of natural mortality *M* (*y -1*) for each species was estimated using Pauly's empirical equation.

$$\ln[M] = -0.0152 - 0.279\ln[L\infty] + 0.6543\ln[K] + 0.463\ln[T]$$

This formula was used to obtain the estimate of M, given L_∞ (total length in cm), K (the growth constant), and T (the mean environmental temperature C^0).

Once Z and M were obtained and then fishing mortality (F) was derived from the relationship:

$F = Z - M$ (Silvestre and Garces, 2004)

And the exploitation rate (E) was obtained by the relationship:

$E = F / Z = F / (F + M)$ (Beverton and Holt, 1966; King, 1995)

Probability of Capture

Probability of capture calculated from the length-converted catch curve routine was used to estimate the final values of L_{25}, L_{50} and L_{75} (i.e. lengths at which 25%, 50% and 75% of the fish would be vulnerable to the gear such as seine net, cast net and gill net of specific mesh size) (Pauly, 1984).

Recruitment Pattern

Recruitment pattern was obtained by the backward projection of the frequencies onto the time axis of a time-series of samples along a trajectory defined by the Von Bertalanffy growth equation (Moreau and Cuende, 1991). This routine reconstructs the recruitment pulses from a time series of length-frequency data to determine the number of pulses per year and the relative strength of each pulse (Gayanilo et al., 2005).

Virtual Population Analysis (VPA)

Terminal population (N_t) was estimated from $N_t = C_t(M + F_t)/F_t$ where, C_t is the terminal catch and $F_t$is the terminal Fishing Mortality and M is the Natural Mortality. Starting from N_t, successive values of F were estimated by iteratively solving $C_i = N_i + \Delta t(F_i / Z_i)(exp(Z_i \Delta t_i) - 1)$ (Gayanilo et al., 2005)

Where, C_i= catch (in number) for a population during a unit time period *i*

$\Delta t_i = (t_{i+1} - t_i)$, and

$t_i = [t_0 - (1/K)\ln(1 - (L_i / L_\infty))]$.

The population sizes (N_i) was computed from $N_i = N_{i+\Delta t_i} \exp(Z_i)$. The last two equations were used alternatively until the population sizes and fishing mortality for all length groups have been computed (Jones and Zalinge, 1981; Moreau and Cuende, 1991).

Relative Yield-per-Recruit and Biomass-per-Recruit

Relative yield-per-recruit (Y/R) was computed using the following formula (Gayanilo and Pauly, 1997; Beverton and Holt, 1966):

$$\frac{Y}{R} = EUm(1 - \frac{3U}{(1+m)} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)}$$

Where, $U=1-(L_c/L_\infty)$, $m=(1-E)/(M/K)=K/Z$, L_c=length of fish at first capture i.e. length at which 50 percent of the fish are retained by the gear (L_{50}) and E =F/Z.

Relative biomass-per-recruit (*B*/*R*) was estimated from the relationship *B*/*R*=(Y/R)/F (BOBP, 1985).

The value of E_{max}, $E_{0.1}$ and $E_{0.5}$ were estimated by using the first derivative of this function, where, E_{max} = maximum sustainable exploitation rate, $E_{0.1}$= exploitation rate at which the marginal increase of relative yield-per-recruit is $1/10^{th}$ and $E_{0.5}$= value of E under which the stock has been reduced to 50% of its unexploited biomass.

RESULTS AND DISCUSSION

Asymptotic Length (L_∞) and Growth Coefficient (*K*)

The minimum and maximum total lengths of *N. notopterus* (Pallas, 1769) were varied between 10.00 cm and 33.25 cm with the estimated value of asymptotic length ($L\infty$) 34.91cm which is higher than the value (33.8 cm) found by Kiran et al. (2004) and Sani et al. (2010); lower than the value (40 cm) found by Parameswaran and Sinha (1966). The value of Growth Coefficient (*K*) was 0.38 yr^{-1} for *N. notopterus* which were higher than the value (0.35 $year^{-1}$) found by Amin et al. (2006) and lower than the value (1.6 yr^{-1}) found by Zafar et al. (1998).

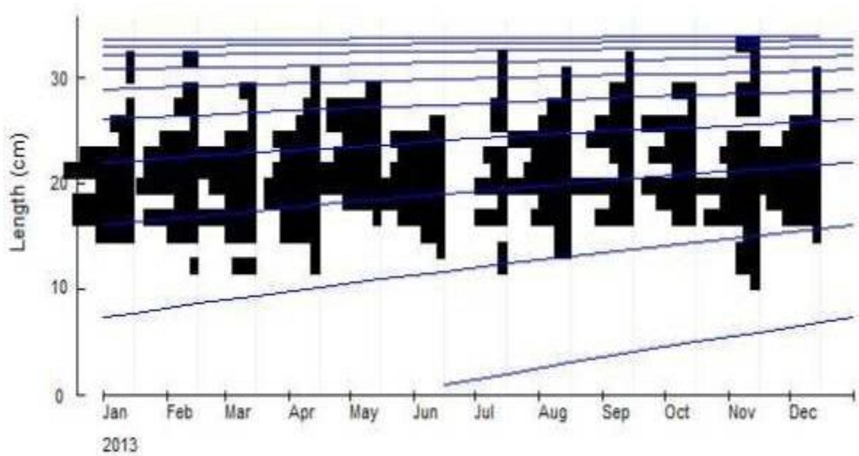

Figure1: Length-frequency distribution of *N. notopterus* in different months with superimposed growth curves as obtained from K-scan of FiSAT (n=555).

Mortality (Total, Natural and Fishing) and Exploitation Rate

The values of total mortality (*Z*), natural mortality (*M*) and fishing mortality (*F*) were 1.19 y^{-1}, 0.91 y^{-1} and 0.28 y^{-1} respectively (Figure 2); of which natural mortality was dominated over the fishing mortality which indicate that low fishing pressure is prevailing for *N. notopterus* in the Kaptai reservoir. The similar result was reported by Dinh, et al. (2007) for goby (*Pseudapocryptes elongates)* in the coastal mud flat areas of the Mekong Delta, Vietnam whereas different results were calculated by Nabi, et al. (2007) for *Polynemus paradiseus* and Rahman and Haque (2008) for *Gudusia chapra*. An exploitation level (E) of 0.24 was obtained for the *N. notopterus* fishery in Kaptai reservoir (Figure 2) which was relatively lower than the optimum fishing level (0.5) indicating lower level of exploitation rates of *N. notopterus* from this reservoir. The same phenomenon was reported by Azadi et al. (1997) for *Gudusia chapra and Gudusia manminna* of the Kaptai reservoir where lower level of exploitation rate was observed.

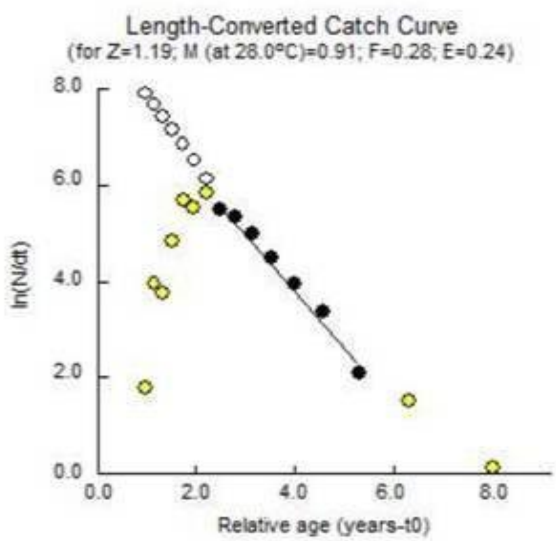

Figure 2: Length-converted catch curve for *N. notopterus*that was used for estimating different mortalities and exploitation rate (n=555).

Probability of Capture

The estimated length sizes for 25 % (L_{25}), 50 % (L_{50}) and 75 % (L_{75}) probabilities of capture would be 16.83 cm, 18.33 cm and 19.83 cm respectively for *N. notopterus* (Figure 3) indicating high catching probability of the juveniles to the reservoir. From the probability of capture analysis, it was found that about 75% fish are caught at the length of 19.83 cm for *N. notopterus* which indicated a higher catching probability of the pre-matured fish in Kaptai reservoir catches.

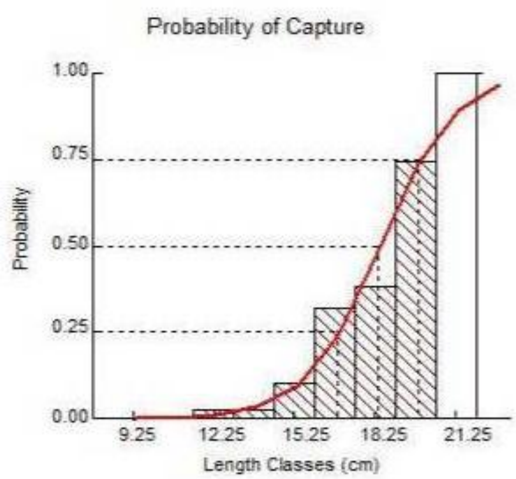

Figure 3: Probability of capture (n=555)

Recruitment Pattern

Two recruitment peaks were found for *N. notopterus,* one in March-April and another in May- June (Figure 4), with a continuous recruitment in almost every month in the reservoir . Two recruitment peaks for several fishes were reported by Rusell et al. (1977); Williams and Sale (1981); Fowler et al. (1992); Etim et al. (1994); Nabi et al. (2007).

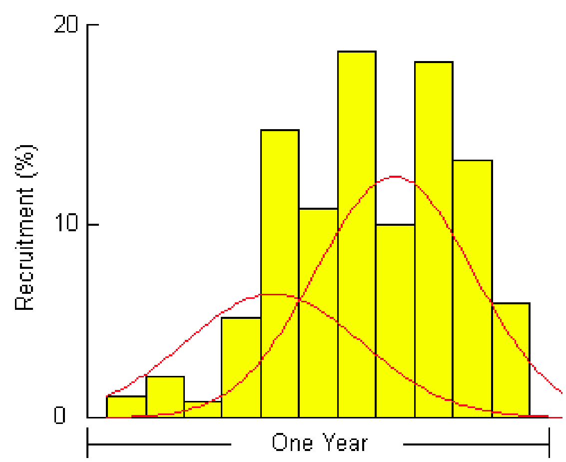

Figure 4: Recruitment patterns of *N. notopterus* for the investigated period (n=555).

Virtual Population Analysis

Total production in the year 2013 was 8537 MT (FRSS 2013) in Kaptai reservoir where 7310 MT (including *N. notopterus*) for other inland species excluding common available fishes.

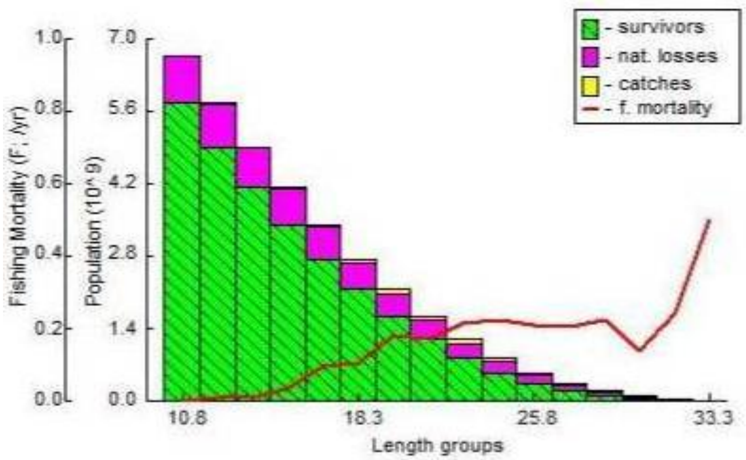

Figure 5: Population size and mortality Characteristics for *N. notopterus* (n=555) of Kaptai Lake based on length structured VPA.

The F at-length array showed (Figure 5) that the maximum fishing mortality is occurring in the length between 10.5cm to 30.5cm with a maximum value in the length of 33.25cm that repeatedly indicates high fishing mortality in the juvenile *N. notopterus* of Kaptai reservoir due to fishing operation.

The total steady state biomass was found to be 664.5 MT. Fishing mortality significantly increases with increasing of body length.

Relative Yield per Recruit and Biomass per Recruit

Beverton and Holt's relative yield per recruit and average biomass per recruit models, showing levels of yield indices in the Figure 6 for *N. notopterus* in the Kaptai Lake.

Plot in relative yield per recruit (Y'/R) and biomass per recruit (B'/R) were determined as a function of L_c/L_∞ and M/K (Figure 6) respectively. The $E_{0.1}$ and $E_{0.5}$ values were found to be 0.707 and 0.364 respectively. The exploitation rate at E = 0.24 (Figure 2) from the catch curve for *N. notopterus* was lower than that of generated 75% of B'/R ($E_{0.1}$ = 0.707) or maximum Y'/R (E_{max} = 0.828). This indicates that *(Y'/R)* could be increased slightly by increasing E. However, maximization of yields would lead to relatively low stock biomass, *i.e*. to low catch per effort.

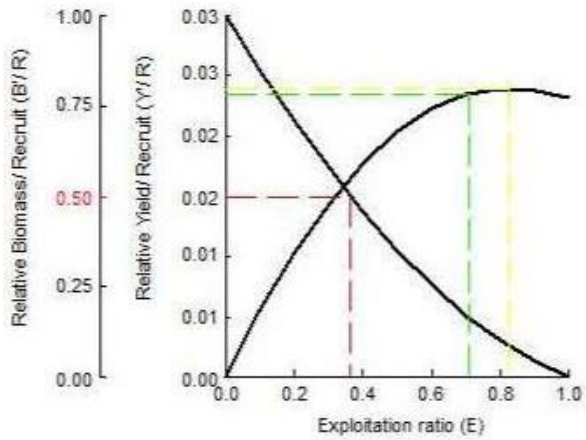

Figure 6: Relative yield per recruit and biomass per recruit for *N. notopterus* (n=555)

CONCLUSION

Kaptai reservoir is considered safe from human activities and it is capable of supporting various fish species including *N. notopterus*. From the findings of the present study it can be concluded that the stock of *N. notopterus is* more or less under optimum exploitation level. Any major change in the existing fishing level/exploitation will most likely result in a reduction in the yield per recruit and thereby hamper the MSY. Therefore, protection from any over exploitation, prohibition of indiscriminate fishing with non-allowable mesh size gears/nets, banning of fishing particularly during the spawning season of the studied species are recommended, which in turn will help to manage this fishery in a more sustainable way.

REFERENCES

Ahmed, K. K. and Hambrey, J. B. 1999.*Brush shelter: a recently introduced fishing method in the Kaptai reservoir fisheries in Bangladesh.* Naga, the ICLARM Quarterly, 22(4):20-23

Ahmed, K. K. U., Amin, S.M.N., Haldar, G. C. and Dewan, S. 2003. Population Dynamics and Stock Assessment of *Catla catla* (Hamilton) in the Kaptai reservoir, Bangladesh. *Asian Fisheries Science*, 16, pp. 121-131

Amin, S. M. N., Ara, R. and Zafar, M. 2006. Conservation of Marine and Coastal Shrimp Resources and Sustainable Aquaculture. *Research Journal of Fish & Hydro*:1(1):18-22

Azadi, M. A., Mustafa, M. G. and Rahman, A. S. M. S. 1997. ELEFAN based population dynamics of two clupeids, *Gudusia chapra* (Hamilton) and Gonia losa manmina (Hamilton) from Kaptai reservoir, Bangladesh. Chittagong University Student Part II Section, 21(2):125-132

Bertalanffy, L. V. 1983.A quantitative theory of organic growth. Human Biology, 10. pp.181-213

Beverton, R. J. H. and Holt, S. J. 1966.Manual of Methods for Fish Stock Assessment, Part 2. *In*: Tables of Yield Functions, Fisheries Technical Paper No. 38. Food and Agriculture Organization of the United Nations, Rome, Italy, pp.7-29

Beverton, R. J. H. and Holt, S. J. 1957.On the Dynamics of Exploited Fish Populations. *Fish. Invest. Ser. II*., 19, pp. 5 - 33

Bay of Bengal Program (BOBP). 1985. Marine Small Scale Fisheries of Bangladesh: a general description, BOBP, Madras, India.

Chakma, I. L. 2007. *Fish Culture in Hill Tract Regions*, Desio Projatir Matshya Sakgrakkhon O Shamprasaran Ovijan 2007, Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, pp. 68

Dinh, T. D., Ambak, M. A., Hassan, A. and Phuong, N. T. 2007.Biology and population dynamics of the goby *Pseudapocryptes elongatus* in the coastal mud flat areas of the Mekong Delta, Vietnam. *Pakistan Journal of Biological Sciences*, 10(19): 3284-3294

Gayanilo, F. C. and Pauly, D. 1997. The FAO ICLARM Stock Assessment Tools (FiSAT): Reference Manual. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 15-42

Gayanilo, F.C., Sparre, P. and Pauly, D. 2005. FAO-ICLARM Stock Assessment Tools II (FiSAT II), User's Guide, Computerized Information Series (Fisheries) No. 8, (Revised Version), Food and Agriculture Organization of the United Nations, Rome, Italy

Jones, R. and Zalinge, N. P. V. 1981. Estimations of mortality rate and population size for shrimp in Kuwait Waters. *Kuwait Bull ofMarine Sci*ence, 2: 273-288

Khan, MD.G. and Mustafa, MD. G. 1989. Length-frequency based population analysis of the threadfin bream *Nemipterus japonicus* of the Bangladesh coast. *Indian Journal of Fisheries*, 36(2):163-166

King, M.1995. Fisheries biology, assessment and management fishing news books, London, pp. 22-115

Moreau, J. and Cuende, F. X.1991.On improving the resolution of the recruitment patterns of fishes. *Fishbyte*, 9(1): 45-46

Mustafa, M.G. and Graaf, G. de. 2008. Population parameters of important species in inland fisheries of Bangladesh. *Asian Fish Science*, 21:147-158

Nabi, M. R. and Ullah, M. H. 2012.Effects of Set Bagnet fisheries on the shallow coastal ecosystem of the Bay of Bengal, *Ocean & Coastal Mgt*, 67: 75-86

Nabi, M. R., Hoque, M. A., Rahman, R. A., Mustafa, S. and Kader, M. A. 2007. Population Dynamics of *Polynemus paradiseus* from Estuarine Set Bag Net Fishery of Bangladesh. *Chiang Mai Journal of Science*, 34(3): 355-365

Pallas, P. S. 1769. Spicilegia zoologica quibus novae imprimis et obscurae animalium species iconibus, descriptionibus atque commentariis illustrantur. 1(7):1-42 (Pls. 1-6)

Pauly D. 1984.Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators, Studies and Review No. 8, Manila, Philippines: International Center for Living Aquatic Resource Management

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Journal of the CIEM*, 39: 175-192

Pauly, D. A. 1987.Review of the ELEFAN System for Analysis of Length-Frequency Data in Fish and Aquatic Invertebrates. *In:* Pauly, D. and Morgan, G.R. eds., Length-Based Methods in Fisheries Research, Conference Proceedings, International Center for Living Aquatic Resource Management, Manila, Philippines, pp. 5-8

Pauly, D. and Gaschütz,G. 1979. A simple method for fitting oscillating length growth data, with a program for pocket calculators. International Council for the Exploration of the Sea, C.M. 1979/G: 24, pp. 26

Rahman, M. A. and Haque, M. M. 2008.Gonadal development of *Gudusia chapra* (Hamilton - Buchanan) from Rajdhala reservoir, Bangladesh. *Journal Inland Fish Society*, 40(1):10-15

Silvestre, G. T. and Garces, L. R. 2004. Population Parameters and Exploitation Rate of Demersal Fishes in Brunei Darussalam. *Fish Research*, 69:73-90

Wetherall,J. A.,Polovina, J. J. and Ralston, S. 1987. Estimating Growth and Mortality in Steady-State Fish Stocks from Length– Frequency Data. *In:* Pauly, D. and Morgan, G. R. eds., Length-Based Methods in Fisheries Research, Conference Proceedings, International Center for Living Aquatic Resource Management, Manila, Philippines, pp. 1-22

Zafar, M., Mustafa, M. G. and Amin, S. M. N. 1998. Population dynamics of *Acetes chinensis* in the Kutubdia channel of Bangladesh coastal waters. *Indian Journal of Fish*eries, 45:121-127

Sani, R., Gupta, B.K., Sarkar, U.K. Pandey, A., Dubey, V.K., and Lakra, W.S. 2010. Length-weight relationships of 14 Indian freshwater fish species from the Betwa (Yamuna River tributary) and Gomti (Ganga River tributary) rivers. *Journal of Applied Ichthyology*, pp.1-4

Etim, L., Uwe-Bassey, B.U. Brey, T. 1994. Population dynamics of the West African croaker *Pseudotolithus elongatus* in the Cross River Estuary, Nigeria. *Scientia Marina*, 58 (4):315-321

Russell, B.C., Anderson, G.R.V. and Talbot, F.H. 1977. Seasonality and recruitment of coral reef fishes. *Australian Journal of Marine and Freshwater Research*, 28: 521-528

Fowler, A. J., Doherty, P. J. and Williams, D. McB. 1992. Multiscale analysis of recruitment of a coral reef fish on the Great Barrier Reef. *Marine Ecology Progress Series*, 82:131-141

Williams, D. Mc. B., and Sale, P.F. 1981. Spatial and temporal patterns of recruitment of juvenile coral reef fishes to coral habitats within 'One-Tree Lagoon', Great Barrier Reef. *Marine Biology*, 65: 245-253

Kiran, B.R., Puttaiah, E.T. and Kumar, K. H. 2004. Length-weight relationship of Feather Back, *Notopterus notopterus* (Pallas) from Jannapura Pond, Karnataka, India. *Zoos' Print Journal*, 19(4):1449-1450

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EFFECT OF POTASSIUM ON BORO-FALLOW-T. AMAN CROPPING PATTERN IN OLD BRAHMAPUTRA FLOODPLAIN SOIL OF BANGLADESH

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ABSTRACT

Field experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh during 2010-11 to 2011-12 to investigate the effect of different levels of K on Boro-Fallow-T. Aman cropping pattern in Old Brahmaputra Floodplain Soil of Bangladesh. There were four treatments for the first crop (Boro rice): T_1 (Control), T_2 (50% NPKS), T_3 (75%NPKS) and T_4 (100% NPKS). The 100% NPKS rates were recommended on the basis of soil test values. T_4 treated plot of each block was further split into seven sub-plots to represent seven treatments ($T_{4.1}$ to $T_{4.7}$) for the second crop of T. Aman in the sequence. The results reveal that the grain yield of boro rice varied from 2.33 to 6.00 t ha^{-1} of which the highest yield was recorded with the application of 100% NPKS (T_4) and the lowest with T_1 (control). The effect of boro rice straw removal or incorporation was clearly visible on the following crop, T. Aman rice. The highest grain and straw yields of T. Aman were obtained with $T_{4.4}$ treatment, where 75% straw was removed and 25% straw incorporated with soil. The lowest yield was obtained with the control crop without fertilizer or straw residues. The NPKS uptake by T. Aman rice and benefit : cost ratio supported the dominant performances of $T_{4.2}$ (100% NPS + 50% K + 25% boro rice straw removed). The results suggested that it is possible to reduce K mining from soils as well as to reduce the rate of K fertilizer application, substituting by incorporation of rice straw residues in soil system.

Key words: Boro-T. aman sequence, Potassium levels & uptake, Old Brahmaputra Floodplain, Rice residues and Yield

INTRODUCTION

Potassium is often described as the "quality element" for crop production as is necessary for basic physiological formation of sugar and its subsequent movement

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among different parts, synthesis of protein, cell division and growth (Rao et al., 1990). Proper fertilization effectively improves quality and yield of crops, reduce cost, which augmenting farm income. On the contrary, improper fertilization not only reduces crop yield and quality, but also increases cost, reduce and effectiveness of fertilizer use.

The widespread problem of K deficiency as well as K mining due to intensive cropping with HYVs of rice and nutrient imbalance in soil, which can be minimized by judicial application of potassium fertilizer. Higher yield of rice with higher dose of K over the present recommended rate was reported by many workers (Mitra et al., 2001; Sairam et al., 2002; Singh et al., 2006 and Bahmaniar et al., 2007). In the BINA farm soil it is necessary to find out the optimum rate of potassium application for profitable rice production.

Potassium is considered to be the second element in uptake by most of the agricultural crops. On the other hand, there exists a gap between annual K removal by the crops and K addition through external sources. It would be very optimistic part to expect that this deficit of K will be balanced from the native and organic sources. If it is not being stress out the adequate use of potassium in crop production, this gap will widen further with increased target of food production. As evidenced by research findings, a large percentage of sterile or unfilled spikelets are caused by poor pollen viability and this retards carbohydrate translocation due to potassium deficiency (Dobermann and Fairhurst, 2000). Removal of potassium is higher by the modern varieties than the traditional ones. Removal of straw from the field is widespread in Bangladesh, which explains the depletion of soil K reserves at many sites. Straw is the only organic material available in significant quantities to the most rice farmers. Rice straw contains more K compared to other nutrients and therefore it can be used as a source of K supply to crops. Keeping with this in view, the present study designed with different levels of K along with rice straw of previous crop and with other recommended fertilizers to evaluate the incorporation of rice residues for supplying K as measured in terms of its effect on K uptake as well as rice yield.

MATERIALS AND METHODS

Field experiments were conducted at Bangladesh Institute of Nuclear agriculture (BINA) farm, Mymensingh, Bangladesh using the cropping pattern, Boro-Fallow-T. Aman during 2010-11 and 2011-12**.** The soil belongs to Sonatala series under the Agro Ecological Zone of Old Brahmaputra Floodplain of Bangladesh. The soil was silt loam in texture having soil pH 6.5, organic matter content 0.98 and total N 0.09% and available P 13, exchangeable K 0.10 and available S 8 ppm. There were four treatments for the first crop (Boro rice): T_1 - Control, T_2 -50% NPKS, T_3 -75% NPKS and T_4 -100% NPK, respectively and this 100% NPKS rates was recommended on the basis of soil test value. T_4 treated (100%NPKS) plot of each block was further splitted into seven plots to represent seven treatments ($T_{4.1}$ to $T_{4.2}$)

for the second crop of T. Aman rice. The treatments for T. Aman rice were T_1 -Control, T_2 -50% NPKS, T_3 -75%NPKS and $T_{4.1}$ -100% NPKS, $T_{4.2}$ -100% NPS + 50% K + 25% boro rice straw removed, $T_{4.3}$ -100% NPS + 50% K + 50% boro rice straw removed,$T_{4.4}$ -100% NPS + 50% K + 75% boro rice straw removed, $T_{4.5}$ -100% NPS + 75 % K + 25% boro rice straw removed, $T_{4.6}$ -100% NPS + 75% K + 50% boro rice straw removed and $T_{4.7}$ -100% NPS + 75% K + 75% boro rice straw removed, respectively. The experiment was laid out in a randomized complete block design (RCBD) with three replications (block) of each treatment. Each block was divided into ten unit plots for the selected cropping sequence. The unit plot size was 5m x 4m.

Rice cultivars for Boro and subsequent second crop T. Aman were used Binadhan-5 and Binadhan-7, developed in Bangladesh Institute of Nuclear agriculture. Forty and 25-day old seedlings for Boro and T. Aman rice were transplanted in the experimental plots maintaining 3 seedlings in each hill with a spacing of 20 cm x 20 cm. The recommended doses for N, P, K and S for Binadhan-5 were 140, 28, 48 and 22 kg ha^{-1}, respectively, and for Binadhan-7 the doses were 90, 12, 27 and 10 kg ha^{-1}, respectively. Fertilizers were applied as per treatment schedule. The full dose of each of triple superphosphate (TSP), muriate of potash (MoP), gypsum, zinc oxide and 1/3 of urea were applied at the time of final land preparation and rest of urea was applied equally splitted into two, equal splits, one after 15 and second at 35 days after transplanting (DAT). Intercultural operations such as irrigation and weeding were applied as and when required by the crop. Crop was harvested at full maturity. Grain yield was recorded on 14% moisture basis and straw yield on sun-dry basis. Five hills were randomly selected from each plot at maturity to record the yield contributing characters. Grain and straw samples were analyzed for the determination of K content (Knudsen et al., 1982). The K uptake by grain and straw was determined from K content and yield data. All the data were statistically analyzed by F-test and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

First crop: Boro rice (var. Binadhan -5)

Grain yield

The grain yield of boro rice (var. Binadhan-5) was significantly influenced by different treatments imposed in the experiment in both years (Table 1). In 2010-11 the grain yield of Binadhan-5 varied from 2.33 to 6.00 t ha^{-1}. The treatment T_4 (100% NPKS) produced the highest grain yield of 6.00 t ha^{-1} while the lowest grain yield (2.33 t ha^{-1}) was obtained in the treatment T_1 (Control) which was 89% increase over control. In producing grain yield the treatment may be ranked in the order of T_4> T_3> T_2> T_1. In 2011-12 the grain yield of Binadhan-5 varied from 2.25 to 6.24 t ha^{-1}. The treatment T_4 produced the highest grain yield while the lowest value was obtained from the treatment T_1 (control). These results are in agreement with Muangsri et al. (2008) who reported that application of rice straw and rice hull in combination with NPK fertilizer increased rice yield than that with NPK alone. Yield of rice grown on the soil amended with rice straw in combination with NPK fertilizers tended to be higher than that of rice grown on the soil amended with only NPK fertilizers.

Straw yield

Like grain yield, the straw yield of boro rice (var. Binadhan-5) responded significantly due to application of K (Table 1). In 2010-11 the straw yield varied from 2.43-6.75 t ha^{-1}. The highest straw yield (6.75 t ha^{-1}) was recorded in T_3 (75% NPKS) which was statistically similar to that of treatment T_2 (50% NPKS) and treatment T_4 (100% NPKS) and the lowest straw yield (2.43 t ha^{-1}) was observed in the T_1 (Control). In 2011-12 the straw yield of Binadhan-5 varied from 2.50 to 7.50 t ha^{-1} with the highest value in the treatment T_3. Again, the treatment T_1 produced the lowest straw yield. These results are in agreement with Bahmaniar et al. (2007) who found that different levels of potassium had positive effects on yield attributes, grain and straw yields of rice except harvest index and 1000-grain weight.

Potassium uptake by grain and straw of Binadhan-5

The K uptake by grain and straw as well as total K uptake by Binadhan-5 was also significantly influenced by different treatments (Table 2). During 2010-11 the K uptake by grain varied from 4.62 to 16.88 kg ha^{-1} while in straw it ranged from 30.30 to 106.09 kg ha^{-1}. The highest K uptake by grain (16.88 kg ha^{-1}) was recorded in T_3 (75% NPKS), which was statistically different from all other treatments while the lowest value (4.62 kg ha^{-1}) was observed in treatment T_1. On the other hand the highest K uptake by straw (106.09 kg ha^{-1}) as well as total K uptake (120.51 kg ha^{-1}) was found in T_4 (100% NPKS).

During 2011-12 the K uptake by grain varied from 4.28 to 13.73 kg ha^{-1} while by straw it ranged from 32.77 to 127.5 kg ha^{-1}. The highest K uptake by grain (13.77 kg ha^{-1}) was recorded in T_4 (100% NPKS), which was statistically similar to that of treatment T_3 (75%NPKS). On the other hand the highest K uptake by straw (127.5 kg ha^{-1}) as well as total K uptake (139.9 kg ha^{-1}) was found in T_3 (75%NPKS) which was statistically similar to that of treatment T_4 (100% NPKS). The lowest values were found in T_1 (control). These results are well corroborated with Mitra et al. (2001) who reported that the uptake of K was increased significantly with the increase in K levels for rice.

Second Crop: T. Aman (Var. Binadhan-7)

Grain yield

The grain yield of Binadhan-7 was also influenced significantly due to different treatments (Table 2). In 2010-11 the grain yield varied from 2.27 to 4.60 t ha^{-1}. The highest grain yield (4.60 t ha^{-1}) was obtained in $T_{4.4}$ (100% NPS + 50% K + 75% boro rice straw removed) while the lowest grain yield (2.27 t ha^{-1}) was found in T_1 (Control). The grain yield due to different treatments ranked in order of $T_{4.4} > T_{4.6} > T_{4.1} > T_{4.3} > T_{4.5} > T_{4.7} > T_3 > T_{4.2} > T_2 > T_1$. It was also shown that the grain yield of Binadhan-7 in 2011-12 ranged from 2.33 to 4.87 t ha^{-1}. The treatment $T_{4.7}$ (100% NPS + 75% K + 75% boro rice straw removed) gave the highest grain yield (4.87 t ha^{-1}) while the lowest value (2.33 t ha^{-1}) was obtained from the treatment T_1. This might be due to the release of additional K from rice straw left in the land. These results somehow support the findings of Bachkaiya et al. (2007) who reported that the grain yield of rice was influenced markedly with differently levels of K and 200 kg K ha^{-1} gave the highest grain yield.

Straw yield

The straw yield of T. Aman rice (var. Binadhan - 7) was significantly influenced by the different treatments (Table 5). The straw yield ranged from 3.87 to 7.60 t ha^{-1} in 2010-11 while in 2011-12 it varied from 3.53 to 6.93 t ha^{-1}. In 2010-11 the highest straw yield was observed in $T_{4.2}$ (100% NPS + 50% K + 25% boro rice straw removed) while in 2011-12 the highest straw yield was observed in $T_{4.7}$ (100% NPS + 75% K + 75% boro rice straw removed). In both years the treatment T_1 (Control) produced the lowest straw yield. This is supposed to be the addition of K from rice straw left in the land that exerted yield increase. Bahmaniar et al. (2007) also reported that K along with rice straw incorporation increased grain and straw yields of rice.

Potassium uptake by grain and straw of Binadhan -7

The K uptake by grain and straw as well as total K uptake of Binadhan-7 was also significantly influenced by the different treatments (Table 4). During 2010-11 the K uptake by grain varied from 4.52 to 16.52 kg ha^{-1} while in straw it ranged from 34.73 to 77.09 kg ha^{-1}. The highest k uptake by grain and straw was recorded in $T_{4.6}$ (100% NPS + 75% K + 50% boro rice straw removed), which was statistically different from all other treatments. The lowest K uptake was found in T_1 (Control). On the other hand, the total K uptake ranged from 39.25 to 93.61 kg ha-^{1} with the highest value in treatment $T_{4.6}$.

Table 4 also shows that the k uptake by grain, straw as well as total K uptake by Binadhan–7 during 2011-12 responded significantly due to different treatments. The highest K uptake by grain (12.11 kg ha^{-1}) was found in $T_{4.6}$ (100% NPS + 75% K + 50% boro rice straw removed), while the lowest value (3.50 kg ha^{-1}) was observed in absolute control treatment. The total K uptake varied from 57.50-131.1 kg ha^{-1}. The highest total K uptake (131.1 kg ha^{-1}) was found in $T_{4.3}$ (100% NPS + 50% K + 50% boro rice straw removed). The lowest total K uptake (57.50 kg ha^{-1}) was observed in T_1. These results are well corroborated with Muangsri et al. (2008) who reported that the K uptake of rice without fertilizer was the lowest and application of rice hull in combination with NPK fertilizer increased K absorption and uptake than with NPK alone.

ECONOMIC ANALYSIS

For economic analysis, the variable costs were considered and the fixed costs were ignored. Variable costs included variable money costs and variable opportunity costs. Variable money cost was the purchasing price of fertilizers and variable opportunity cost included the amount of money paid for carrying and broadcasting of fertilizers. Gross return was calculated as the total value of grain and straw. Table 5 shows the cost and benefit of different treatments used in the experiment. Among the treatments, $T_{4.6}$ gave the highest benefit-cost ratio (4.38). The second highest benefit-cost ratio was found in treatment $T_{4.4}$ (4.32). The minimum benefit-cost ratio was observed in treatment $T_{4.1}$ (3.49). Thus the use of 100% NPS + 75% K + 50% Boro rice straw was found to be more effective and beneficial for T. Aman rice production.

CONCLUSION

Rice straw in combination with K fertilizer could be a good option for supplying K for rice production in Bangladesh. The use of 100 kg N ha^{-1}, 27 kg of P ha^{-1}, 48 kg of K ha^{-1}, 22kg of S ha^{-1} for Boro rice and 90 kg N ha^{-1}, 27 kg of P ha^{-1}, 36 kg of K ha^{-1}, 10 kg of S ha^{-1} and 50% rice straw removed from previous crop for T. Aman can be the best treatment combination for the Boro-Fallow-T. Aman cropping pattern. However, similar study needs to be done in other areas of Bangladesh for location specific recommendation.

REFERENCES

Bachkaiya, V., Patil, S.K., Sarwgi, S.K. and Choudhary, V.K. 2007. Effect of potassium application on yield and potassium content and uptake in vertisols of chhattisgarh under rice- wheat cropping sequence. *Environmental Ecology*, 25(1): 89-91

Bahmaniar, M.A., Ranjbar, G.A. and Ahamafian, S.H. 2007. Effects of N and K applications on agronomic characteristics of two Iranian and landrace rice (*Oryza sativa* L.) cultivars. *Journal of Biological Science*, 10 (6): 880-886

Dobermann, A. and Fairhurst, T. 2000. Rice: nutrient disorders and nutrient management. Singapore and Los Banos (Phillipines): Potash and Phosphate Institute (PPI), Potash and Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI), pp.191

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. John Wilely and Sons. New York

Knudsen, D., Peterson, G.A. and Pratt, P.F. 1982. Lithium, Sodium and Potassium. In methods of Soil Analysis Part 2 edited by Page *et al.*, American Society of Agronomy, Inc. Publisher, USA, pp. 225-245

Mitra, G. N., Sahoo, D., and Rout, K.K. 2001. Effect of N-K interaction on yield, nutrient uptake and grain quality of rice- groundnut cropping sequence in the alluvial soil of Orissa. *Journal of Potassium Research*, 17 (1-4): 71-78

Muangsri, M., Chanchareonsook, J. and Sarobol, E. 2008. Effect of rice straw and rice hull in combination with nitrogen phosphorus and potassium fertilizer on yield of rice grown on phimai soil series. *Proceeding of the 46th Kasetsart University Annual Conference*, Kasetsart 29 Jan 1 Feb 2008 Subject: Plant, 82-89

Rao, Y. Jan, L.Y. and Jan, Y.N. 1990. Similarity of the product of the Drosophila neurogenic gene big brain to transmembrane channel proteins. *Nature,*345 (6271): 163-167

Sairam, R.K. Rao, K.V. and Srivastava, G.C. 2002. Differential response of wheat genotypes to long term salinity stress in relation to oxidative stress, antioxidant activity and osmolyte concentration. *Plant Science,* 163: 1037-1046

Singh, G.R., Dixit, R.S. and Dwivedi, A.P. 2006. Effect of nitrogen, phosphorus and potassium levels on growth, yield and quality of hybrid rice (*Oryza sativa* L.) *Agronomy*, 43(1): 64-66

Table 1: Grain and straw yield of Boro rice (var. Binadhan-5) as influenced by different levels of K

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2010-11	2011-12	2010-11	2011-12
T_1 (Control)	2.33c	2.25c	2.43b	2.50c
T_2 (50% NPKS)	4.40b	4.13b	6.38a	6.25b
T_3 (75% NPKS)	4.87b	4.95ab	6.75a	7.50a
T_4 (100% NPKS)	6.00a	6.24a	6.53a	7.17ab
CV (%)	9.29	10.67	9.85	9.16
SE (±)	0.41	0.27	0.54	0.308

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 2: Effect of K on the potassium uptake by grain and straw of Boro rice

Treatment	K uptake (kg ha^{-1})					
	2010-11			2011-12		
	Grain	Straw	Total	Grain	Straw	Total
T_1 (Control)	4.62c	30.30b	34.92b	4.28c	32.77c	37.03c
T_2 (50% NPKS)	12.73b	72.11c	84.84c	8.26b	102.5b	110.7b
T_3 (75% NPKS)	16.88a	82.47b	99.35b	12.38a	127.5a	139.9a
T_4 (100% NPKS)	14.42b	106.09a	120.51a	13.73a	125.1a	138.9a
CV (%)	2.67	4.71	7.71	8.71	4.50	4.29
SE (±)	1.42	8.36	9.59	0.482	2.52	2.64

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 3: Grain and straw yield of T. Aman (var. Binadhan-7) as influenced by different levels of K

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2010-11	2011-12	2010-11	2011-12
T_1	2.27d	2.33c	3.87f	3.53c
T_2	3.80c	3.50b	5.90de	5.25a
T_3	4.33ab	4.10ab	5.70e	6.48a
$T_{4.1}$	4.40ab	4.37ab	6.30cde	6.73a
$T_{4.2}$	4.10bc	4.27ab	7.60a	6.51a
$T_{4.3}$	4.37ab	4.33ab	7.20ab	7.30a
$T_{4.4}$	4.60a	4.53ab	6.70bcd	6.75a
$T_{4.5}$	4.33ab	4.20ab	6.70bcd	6.42a
$T_{4.6}$	4.47ab	4.60ab	6.60bcd	6.28a
$T_{4.7}$	4.33ab	4.87a	7.10abc	6.93a
CV (%)	6.31	9.71	6.92	8.48
SE (±)	0.13	0.325	0.20	0.304

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 4: Effect of K on the potassium uptake by grain and straw of T. Aman rice

Treatment	K uptake (kg ha^{-1})					
	2010-11			2011-12		
	Grain	Straw	Total	Grain	Straw	Total
T_1	4.52g	34.73d	39.25d	3.50f	54.0e	57.50f
T_2	10.54ef	62.08c	72.62c	7.00e	85.54d	92.54e
T_3	11.38de	70.31abc	81.69bc	8.01cde	105.0c	113.2d
$T_{4.1}$	9.18f	71.67ab	80.85bc	7.42de	109.6bc	116.2cd
$T_{4.2}$	14.59b	67.63bc	82.22b	9.46bc	107.5bc	115.6cd
$T_{4.3}$	12.62cd	73.90ab	86.52ab	9.01cd	123.3a	131.1a
$T_{4.4}$	13.54bc	75.92ab	89.46ab	11.15ab	111.4b	120.5bc
$T_{4.5}$	11.33de	72.39ab	83.72b	7.95cde	107.2bc	114.3d
$T_{4.6}$	16.52a	77.09a	93.61a	12.11a	108.8bc	120.3bc
$T_{4.7}$	9.60f	74.04ab	83.64b	7.84cde	118.6a	126.4b
CV (%)	5.28	3.40	5.29	8.24	2.82	2.80
SE (±)	0.60	2.31	2.78	0.58	1.67	1.78

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 5: Production economic analysis of Boro-Fallow-T. Aman cropping pattern

Treatment	Economic Yield ($kg\ ha^{-1}$)		Gross return (Tk)	Added cost over control (Tk)	Added benefit over control (Tk)	Gross margin over control (Tk)	MBCR
	Grain	Straw					
T_1	4590	6165	75015	-	-	-	-
T_2	6915	8862	112587	8887	37572	28685	4.23
T_3	8025	12213	132588	13331	57573	44242	4.30
$T_{4.1}$	8270	13030	137080	17775	62065	44290	3.49
$T_{4.2}$	8370	14100	139650	17025	64635	47610	3.80
$T_{4.3}$	8700	14500	145000	17025	69985	52960	4.11
$T_{4.4}$	9013	13450	148645	17025	73630	56605	4.32
$T_{4.5}$	8530	13120	141070	17400	66055	48655	3.80
$T_{4.6}$	9200	14030	152030	17600	77015	59415	4.38
$T_{4.7}$	9070	12880	148930	17400	73915	56515	4.25

Grain - 15 Tk. kg^{-1}, Straw - 1.00 Tk. kg^{-1}, N -12 Tk. kg^{-1}, P- 22 Tk. kg^{-1}, K - 25 Tk. kg^{-1}, S - 10 Tk. kg^{-1}, MBCR - Marginal benefit cost ratio

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CONTRIBUTION OF GREEN MANURE INCORPORATION IN COMBINATION WITH NITROGEN FERTILIZER IN RICE PRODUCTION

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ABSTRACT

An experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during April to November, 2012 to study the combined effects of *Sesbania* green manure incorporation with different levels of nitrogen fertilizer on the growth and yield of BINA dhan7. There were five treatments for using *Sesbania* as pre-rice green manure (GM): Fallow (No GM), GM for incorporation at 40, 50, 60, and 70 days after sowing (DAS). T. Aman was planted after chopping the GM. For T. aman there were 9 treatments: Fallow plot received full dose (180 kg urea ha^{-1}) of N fertilizer while plots with GM received 50 and 75% of recommended N fertilizer. The experiment was laid out in a Randomized Complete Block Design with three replications. The highest grain yield of 5752 kg ha^{-1} and straw yield of 6654 kg ha^{-1} were observed in the plot treated with 75%recommended dose of nitrogen (RDN) and green manure incorporated at 50 DAS. The lowest grain yield (4783 kg ha^{-1}) and straw yield (5154 kg ha^{-1}) were recorded with GM incorporated at 40 DAS + 50% RDN. The N content and uptake by the grain and straw were differed significantly due to different treatments and maximum uptake was recorded with the application of 75% recommended dose of nitrogen (RDN) and green manure incorporated at 50 DAS. The overall results indicate that application of Sesbania green manure incorporated at 50 DAS in combination with 75% recommended dose of nitrogen could be considered more effective for BINA dhan7 production.

Key words: Rice, Green manure, *Sesbania*, Nitrogen, BINA dhan7

INTRODUCTION

Low soil fertility due to organic matter depletion is a major constraint severely affecting higher crop production in Bangladesh (BARC, 2012). Organic matter contributes to soil fertility and productivity through its positive effect on the physical,

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chemical and biological properties of the soil. But the organic matter content in many parts of Bangladesh soils has been seriously depleted due to intensive cropping with modern varieties, very little use of crop residues, little or no use of organic manures, absence of green manure etc. As a result, soil productivity, in general, has been degraded and stagnation in yield has occurred even with high dose of chemical fertilizers under rice based cropping patterns.

Adding inorganic fertilizers is a good way of correcting the deficiency of nutritional elements, but they not only add to the cost of production but often are not available to meet the demands of farmers. Although the fertilizers are very effective in increasing yield, they may deteriorate the soil structure and pollute the groundwater. In addition, chemical fertilizers are expensive due to the energy crisis and are unavailable to many farmers, particularly in developing countries like Bangladesh. In this situation, green manure can serve as a cheaper source of plant nutrition and has become popular with farmers. Green manuring is the process of growing leguminous crops and ploughing the same in soil. On decomposition, it results in increased soil fertility. At the same time, improving the organic matter content of soil also improves its water holding capacity, aeration, colloidal complex, and hence its ability to retain nutrients.

Although many green manure crops are available (Kerala Agricultural University, 2002), the N_2-fixing leguminous crop Dhaincha (*Sesbania aculeata*) is particularly important because it can fix 56.2-150 kg ha^{-1} of nitrogen (Bin, 1983). Studies with *Sesbania* green manuring at Bangladesh Agricultural University have shown very promising contribution of *S. aculeata* in supplementing N requirement of the following T. Aman rice and also recycling of S and P for the next crops. Many workers suggested green manuring along with N fertilizer application for slow release of nutrient elements during the entire period of crop growth (Singh et al., 1990). It has also been reported that green manuring provides a substantial amount of nutrients for the next crop (BRRI, 1998; Elahi, 1991). It is evident that the application of *Sesbania aculeata* along with the recommended chemical fertilizers may ensure adequate supply of nutrients especially nitrogen to the transplanted rice over the entire growing season for better plant growth with higher grain production (Pervin et al., 1995)

Although *S. aculeata* is known for long as a GM crop but there is a lack of adequate knowledge regarding the time and method of chopping and mixing the GM crop with the soil. Therefore, the present study was undertaken to find out the appropriate time for chopping and mixing *Sesbania* as a pre-rice green manure and to determine the optimum doses of N to be applied in combination with *Sesbania* green manure incorporated at different times for the production of BINA dhan7.

MATERIALS AND METHODS

The experiment was carried out at Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh during April to November, 2012. The soil belongs to Sonatala series under the AEZ of the Old Brahmaputra Floodplain. The experimental soil was silt loam in texture. BINA Dhan7, a high yielding variety of rice was used in this experiment as test crop. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment comprised of 9 treatments: T_0 (No GM + 100%RDN), T_1 (GM incorporated at 40 DAS + 50%RDN), T_2 (GM incorporated at 40 DAS + 75%RDN), T_3 (GM incorporated at 50 DAS + 50%RDN), T_4 (GM incorporated at 50 DAS + 75%RDN), T_5 (GM incorporated at 60 DAS + 50%RDN), T_6 (GM incorporated at 60 DAS + 75%RDN), T_7 (GM incorporated at 70 DAS + 50%RDN) and T_8 (GM incorporated at 70 DAS + 75%RDN). Here, RDN = Recommended dose of nitrogen (180 kg urea ha^{-1}) as per BARC Guide (BARC, 2005); GM = Green manure.

Green manuring crop, *Sesbania aculeata* was sown at a time on the same day but incorporated into the soil at different time interval i.e.40, 50, 60 and 70 DAS. Nitrogen, phosphorus, potassium and sulphur were supplied through urea, TSP, MoP and gypsum, respectively. The recommended fertilizer doses applied for the experiment were 180 kg urea ha^{-1}, 120 kg TSP ha^{-1}, 70 kg MoP ha^{-1}, 50 kg gypsum ha^{-1}. TSP, MoP and gypsum were applied as basal dose during final land preparation. Urea was applied in three instalments (the first instalment at 15 DAT, the second at 30 DAT and the third at 45 DAT). The seedlings of 25 day old were transplanted at a time in all the experimental plots maintaining a spacing of 20 cm x 20 cm although the green manure was incorporated into the soil at different time interval as per treatments. Intercultural operations such as irrigation and weeding were done as and when necessary. The crop was harvested at full maturity. Ten hills were randomly selected from each plot to record the yield contributing characters. Grain and straw yields were recorded plot wise and converted to kg ha^{-1}. Grain and straw samples were collected, dried, grounded, sieved and used for chemical analysis. Grain and straw samples were analysed for total nitrogen concentration following semi-micro Kjeldahl method (Bremner and Mulvaney, 1982). The N uptake by grain and straw was determined from the N content and yield data. All the data were statistically analyzed following F-test and mean comparison was made by Duncan's New Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Yield contributing characters

Yield contributing characters such as plant height, effective tillers hill^{-1}, panicle length, grains panicle^{-1} and 1000-grain weight were influenced significantly due to application of green manure in combination with different levels of N fertilizer (Table 1). The tallest plant (94.21 cm), maximum number of effective tillers hill^{-}

^{1}(14.73), longest panicle (24.42 cm), maximum grains panicle^{-1} (84.80) and maximum 1000-grain weight (23.08 g) were recorded in the treatment GM incorporated at 50 DAS + 75% RDN which was statistically similar to all other treatments except where no green manure was incorporated, GM incorporated at 40 DAS + 50%RDN and GM incorporated at 70 DAS + 75% RDN.. Many research workers reported that combined application of *Sesbania* green manure and nitrogen fertilizer increased the plant height (Deshpande et al., 2011), effective tillers hill^{-1} (Paramanik et al., 2004), grains panicle^{-1} (Shrivastava et al., 2005; Deshpande et al., 2011 and Vaiyapuri et al., 2002) and1000-grain weight (Vaiyapuri et al., 2002).

Grain yield

The highest grain yield of BINA dhan7 (5752 kg ha^{-1}) was obtained in the treatment GM incorporated at 50 DAS + 75% RDN which was statistically similar to those observed in GM incorporated at 40 DAS + 75% RDN, GM incorporated at 60 DAS + 75%RDN and GM incorporated at 70 DAS + 75%RDN with the values of 5519, 5512 and 5448 kg ha^{-1}, respectively (Table 2). The increase of grain yield might be due to more availability of nitrogen to rice crop released by incorporation of green manure and due to other beneficial effects of GM. The lowest grain yield (4783 kg ha^{-1}) was obtained in the treatment GM incorporated at 40 DAS + 50% RDN which was at par with No GM + 100% RDN, GM incorporated at 50 DAS + 50% RDN, GM incorporated at 60 DAS + 50% RDN and GM incorporated at 70 DAS + 50% RDN were identical with T_1 with grain yield of 5115, 5222, 5127 and 4875 kg ha^{-1}, respectively. Dekamedhi and Medhi (2000) reported that grain yield of rice was significantly increased due to application of green manure in combination with N fertilizer. These results are also in agreement with Miah et al. (2001), Paramanik et al. (2004), Sarkar et al. (2004) and Chaudhary et al. (2011).

Straw yield

The highest straw yield (6654 kg ha^{-1}) was recorded in the treatment GM incorporated at 50 DAS + 75% RDN which was statistically similar to that recorded in GM incorporated at 60 DAS + 75% RDN) (6461 kg ha^{-1}). The lowest straw yield (5154 kg ha^{-1}) was recorded in the treatment GM incorporated at 40 DAS + 50% RDN (Table 2). Dekamedhi and Medhi (2000) found that straw yield of rice increased with the addition of green manure and urea-N.

Biological yield

The highest biological yield (12410 kg h^{-1}) was recorded in the treatment GM incorporated at 50 DAS + 75% RDN which was statistically similar to those recorded in GM incorporated at 40 DAS + 75% RDN, GM incorporated at 50 DAS + 50% RDN, GM incorporated at 60 DAS + 75%RDN and GM incorporated at 70 DAS + 75% RDN (Table 2). The lowest biological yield (9937 kg ha^{-1}) was noted in the treatment GM incorporated at 40 DAS + 50% RDN Which was on par with the treatments No GM + 100% RDN, GM incorporated at 60 DAS + 50% RDN and GM incorporated at 70 DAS + 50% RDN

Nitrogen content and uptake by rice grain and straw

N content and uptake both by grain and straw of BINA Dhan7 varied significantly due to application of green manure and N fertilizer. The N content in rice grain ranged from 1.037 to 1.430% and in rice straw from 0.532 to 0.644%. (Table 3).The highest N content both in rice grain (1.430%) and straw (0.644%) was observed in the treatment GM incorporated at 50 DAS + 75% RDN and the lowest value was noted in the treatment GM incorporated at 40 DAS + 50% RDN.

Nitrogen uptake by rice grain ranged from 49.54 to 81.54 kg ha^{-1}. The maximum N uptake 82.24 kg ha^{-1} by rice grain was observed in GM incorporated at 50 DAS + 75% RDN. The minimum N uptake of 49.54 kg ha^{-1} was observed in T_1 GM incorporated at 40 DAS + 50% RDN. The results are in agreement with Medhi et al. (1996) and Dekamedhi and Medhi (2000) who found that with the combined application of green manure and N fertilizer, N uptake by rice grain was increased. In case of rice straw, N uptake ranged from 27.39 to 42.86 kg ha^{-1}. The maximum N uptake 42.86 kg ha^{-1} by straw was observed in GM incorporated at 50 DAS + 75% RDN. The minimum N uptake by rice straw 27.39 kg ha^{-1} was recorded in GM incorporated at 40 DAS + 50% RDN. The results reveal that N uptake in rice grain was higher than that of straw. The total N uptake was the highest in GM incorporated at 50 DAS + 75% RDN and the lowest in GM incorporated at 40 DAS + 50% RDN which was statistically similar to that of GM incorporated at 70 DAS + 50% RDN. The results support the findings of Duhan et al. (2002) who found increased N uptake of rice with application of green manure along with N fertilizer.

CONCLUSION

On the basis of one year experimentation it can be concluded that incorporation of *Sesbania* green manure at 50 DAS along with the application of 75% of recommended N fertilizer is best for cultivation of BINA dhan7.

REFERENCE

BARC (Bangladesh Agricultural Research Council). 2005. Fertilizer Recommendation GUIDE-2005 Soils Pub. No. 45, Bangladesh Agricultural Research Council, Farmgate, Dhaka

BARC (Bangladesh Agricultural Research Council). 2012. Fertilizer Recommendation GUIDE-2012 Soils Pub. No. 45, Bangladesh Agricultural Research Council, Farmgate, Dhaka

Bremner, J.M. and Mulvaney, C.S. 1982. Nitrogen-Total. In Methods of Soil Analysis Part 2. Edited by A.L. Page, R.H. Miller and D.R. Keeney. pp. 595-624. Amer. Soc. Agron. Inc. and Soil Sci. Soc. Amer. Inc., Madison, Wisconsin.

BRRI (Bangladesh Rice Research Institute). 1998. Proceedings of the Annual Internal Review for 1997. Rice Farming Systems, BRRI Joydebpur, Gazipur. Pub. No. 1701. p. 60

Chaudhary, S.K., Singh, J.P. and Jhair, S. 2011. Effect of integrated nitrogen management on yield, quality and nutrient uptak of rice (*Oryza sativa*) under different dates of planting. *Indian Journal of Agronomy,* 56(3): 228-231

Dekamedhi, D. and Medhi, D.N. 2000. Effect of green manures and urea on nitrogen mineralization in relation to growth of rice under upper Brahmaputra valley zone of Assam. *Indian Journal of Agricultural Science*, 70(5): 829-830

Deshpande, H.H. and Devasenapathy, P. 2011. Effect of different organic sources of nutrients and green manure on growth and yield parameters of rice (*Oryza sativa* L.) grown under lowland condition. *Crop Research Hisar,* 41(1): 1-5

Duhan, B.S., Mahendera, S. and Singh, M. 2002. Effect of green manuring and nitrogen on yield and uptake of micronutrients by rice. *Journal of Indian Society of Soil Science,* 50 (2): 178-180

Elahi, M. 1991. Intercropping forage green manure with a grain legume in the pre rice dry wet period for food, feed and organic nitrogen across irrigated and rainfed rice ecosystems. *Rice Abstract*, 15(2): 92

KAU (Kerala Agricultural University Thrissur). 2002. Package of Practices Recommendations: Crops, 12th ed. Directorate of Extension. Kerala Agricultural University Thrissur, p. 278

Medhi, B.D., Barthakur, H.P., Barthakur, S.N. 1996. Effect of organic and inorganic source of nitrogen in the nutrients in soil and soil solution and growth of rice. *Journal of Indian Society of Soil Science*, 44(2): 263- 266

Miah, M.G., Bari, M.N., Islam, M.R. and Hirota, O. 2001. Green manuring with *Sesbania* spp. for maintaining rice productivity and soil environment. *International Tropical Agriculture,* 24: 29-42

Paramanik, M.Y.A., Sarkar, M.A.R., Islam, M.A. and Samad, M.A. 2004. Effect of green manures and different levels of nitrogen on the yield and yield components of transplant aman rice. *Journal of Agronomy,* 3(2): 122-125

Pervin, S., Hoque, M.S., Jahiruddin, M. and Mian, M.H. 1999. Effects of urea, *Azolla* and *Sesbania* incorporation on the concentration and uptake of N, P, K and S in rice (*Oryza sativa*). *Pakistan Journal of Scientific and Industrial Research*, 42(3): 145-149

Sarkar, M.A.R., Paramanik, M.Y.A., Faruk, G.M. and Ali, M.Y. 2004. Effect of green manures and levels of nitrogen on some growth attributes of transplant aman rice. *Pakistan Journal of Biological Science,* 7(5): 739-742

Shrivastava, A., Shrivastava, G.K., Gayen, S.K. and Rajput, R.S. 2005. Effect of integrated nutrient management on rice production. *Bhartiya Krishi Anusandhan Patrika,* 20(1): 19-24

Singh, Y., Singh, B., Meelu, O.Y. and Maskina, M.S. 1990. Nitrogen equivalence of green manure for wetland rice on course textural soils. *International Rice Research Notes,* 15 (2): 25

Viyapuri, V. and Sriramachandrasekaran, M.V. 2002. Effect of green manures on growth and yield of lowland rice. *Journal of Ecology and Biology*, 14(4): 295-298

Table 1: Effects of green manure and different levels of nitrogen on yield components of BINA dhan7

Treatments	Plant height (cm)	Effective tillers hill^{-1} (No.)	Panicle length (cm)	Grains panicle^{-1} (No.)	1000-grain weight (g)
T_0 (No GM + 100% RDN)	89.05c	13.33abc	23.19cd	78.33d	22.06bc
T_1 (GM incorporated at 40 DAS + 50% RDN)	88.55c	12.07bc	22.97d	71.67e	21.80c
T_2 (GM incorporated at 40 DAS + 75% RDN)	93.82ab	13.80ab	24.20ab	83.47ab	22.79ab
T_3 (GM incorporated at 50 DAS + 50% RDN)	92.13abc	13.03abc	23.88abc	82.67abc	22.17bc
T_4 (GM incorporated at 50 DAS + 75% RDN)	94.21a	14.73a	24.42a	84.80a	23.08a
T_5 (GM incorporated at 60 DAS + 50%RDN)	93.58ab	12.27bc	23.73abc	79.00cd	21.83c
T_6 (GM incorporated at 60 DAS + 75% RDN)	93.80ab	13.79ab	24.01ab	83.07abc	22.47abc
T_7 (GM incorporated at 70 DAS + 50% RDN)	90.23bc	11.93c	23.54bcd	77.00d	22.34bc
T_8 (GM incorporated at 70 DAS + 75% RDN)	91.13abc	12.67bc	23.77abc	80.47bcd	22.44abc
SE m (±)	0.727	0.312	0.154	1.36	0.141
CV%	2.04	6.99	1.57	2.84	2.00

Figure (s) in a column having common letters does not differ significantly.

GM = Green manure; RDN = Recommended dose of nitrogen; DAS = Day after sowing; SEm = Standard error of means; CV=Coefficient of variation

Table 2: Grain, straw and biological yields of BINA dhan7 as influenced by green manure and different levels of nitrogen

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
T_0 (NO GM + 100% RDN)	5115cde	5666c	10780bcd
T_1 (GM incorporated at 40 DAS + 50% RDN)	4783e	5154d	9937d
T_2 (GM incorporated at 40 DAS + 75% RDN)	5519ab	6003bc	11520abc
T_3 (GM incorporated at 50 DAS + 50% RDN)	5222bcd	5938c	11160abcd
T_4 (GM incorporated at 50 DAS + 75% RDN)	5752a	6654a	12410a
T_5 (GM incorporated at 60 DAS + 50% RDN)	5127cde	5779c	10910bcd
T_6 (GM incorporated at 60 DAS + 75%RDN)	5512ab	6461ab	11970ab
T_7 (GM incorporated at 70 DAS + 50% RDN)	4875de	5641c	10520cd
T_8 (GM incorporated at 70 DAS + 75% RDN)	5448abc	6084bc	11530abc
SEm (±)	106.94	149.72	252.53
CV%	3.78	4.52	6.10

Figure (s) in a column having common letters does not differ significantly.

GM = Green manure; RDN = Recommended dose of nitrogen; DAS = Day after sowing; SEm = Standard error of means; CV = Coefficient of variation

Table 3: Effects of green manure and different levels of nitrogen on N contents and uptake of BINA dhan7

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_0 (NO GM + 100% RDN)	1.317b	0.560bc	67.30c	31.72cd	99.02cd
T_1 (GM incorporated at 40 DAS + 50% RDN)	1.317b	0.532c	49.54f	27.39d	76.93f
T_2 (GM incorporated at 40 DAS + 75% RDN)	1.340b	0.560bc	74.06b	33.71c	107.8bc
T_3 (GM incorporated at 50 DAS + 50% RDN)	1.150c	0.588abc	59.90d	34.85bc	94.75de
T_4 (GM incorporated at 50 DAS + 75% RDN)	1.430a	0.644a	81.54a	42.86a	124.4a
T_5 (GM incorporated at 60 DAS + 50% RDN)	1.123c	0.588abc	57.40de	34.04bc	91.43de
T_6 (GM incorporated at 60 DAS + 75% RDN)	1.287b	0.616ab	70.98bc	39.80ab	110.8b
T_7 (GM incorporated at 70 DAS + 50% RDN)	1.090cd	0.560bc	53.21ef	31.59cd	84.80ef
T_8 (GM incorporated at 70 DAS + 75% RDN)	1.287b	0.616ab	70.16bc	37.42abc	107.6bc
SEm (±)	0.044	0.012	3.51	1.55	4.85
CV (%)	3.81	4.00	3.89	9.09	5.77

Figure (s) in a column having common letters does not differ significantly.

GM = Green manure; RDN = Recommended dose of nitrogen; DAS = Day after sowing; SEm= Standard error of means; CV = Coefficient of variation

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COMBINING ABILITY OF DIFFERENT YIELD RELATED CHARACTERS IN RICE

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ABSTRACT

Combining ability for yield and yield contributing character of rice was studied using five lines IR79156A, BRRI7A, BRRI33A, BRRI21A and IR75608A and four testers BRRI20R, BRRI31R, BRRI26R and BAU521R to produce 20 F_1 in line × tester fashion. The variances due to SCA were larger than the variance due to GCA for all the characters which indicate the prevalence of non-additive gene action. BRRI7A/BRRI31R cross combination was the best specific combiner for grain yield/plant. The predominance of non-additive genetic components was observed for all the traits which indicated that the improvement of the characters with greater non-additive genetic component could be contemplated for the exploitation of heterosis. Estimates of GCA effects showed that maternal line BRRI33A and paternal tester BRRI31R was an excellent general combiner for improving yield contributing traits. The cross IR79156A/BRRI20R was found as good specific combiner for most of the yield contributing traits viz., panicle length, panicle weight, number of spikelet/panicle, spikelet fertility, 1000 grain weight, harvest index and grain yield/plant. The cross between good general combiners did not always produce the best specific crosses. Moreover, the predominance of the production of the best specific crosses from high × low and low × low combiners indicated the influence of non-additive and over dominant gene actions on the yield and yield contributing traits.

Key words: GCA, SCA, Line, Tester.

INTRODUCTION

Rice occupies 77% of total cropped area (BBS, 2011). At present rice alone constitutes about 92% of the total food grain produced annually in the country. It provides 75% of the calories and 55% of the proteins in the average daily diet of the people (Bhuiyan et al., 2002). Further estimate is rather more precise to feed the

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population by the year 2025, which is about 21% higher than the population of 2000 (Bhuiyan et al., 2002). In this way breeding programs are effective and essential for improving the present varieties and increasing of yield (Nematzade and Valizade, 2002). Reduced plant height, more effective tiller, large and compact panicles, increased spikelet number/panicle, increased 1000 grain weight and higher yield are the most important rice characters to be improved in breeding programs (Paterson et al., 2005). Selection is an important technique in plant breeding and breeders use this method for improving the architecture of a crop by management of available genetic variability (Eidi Kohnaki et al., 2013). Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability. Combining ability analysis is one of the useful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis. Line × tester technique (Kempthorne et al., 1957) is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations. It also provides information on genetic components and enables the breeders to choose appropriate breeding methods for hybrid variety or cultivar development programs (Mirarab and Ahmadikhah 2010). Keeping this in view, the present investigation was carried out to study the combining ability in order to identify good combiners and superior hybrid combinations.

MATERIALS AND METHODS

The experimental material consists of nine rice genotypes viz.,IR79156A, BRRI7A, BRRI33A, BRRI21A and IR75608A were used as female (designated as lines) and four genotypes (BRRI20R, BRRI31R, BRRI26R and BAU521R) designated as tester were used as male. These parents were crossed to produce 20 F_1 hybrids according to line × tester mating design (Kempthorne, 1957). This study was conducted in consecutive two years comprising of T. Aman 2011 and Boro season 2011-12 at Research station of Bangladesh Rice Research Institute, Gazipur. In T. Aman season of 2011 Line and Tester materials were grown separately in stagger fashion with an interval of 5 days so as to synchronize flowering. At flowering stage crossing was made in Line × Tester fashion to raise 20 F_1 test hybrids. Single seedlings of each entry were transplanted at 15×20 cm spacing in 3×5 m^2 plots in a RCBD (randomized complete block design) with three replications. In this study including traits are plant height, days to 50% flowering, days to maturity, panicle length, panicle weight, number of panicle/m^2, number of spikelet/panicle, spikelet fertility, 1000 grain weight, harvest index and grain yield/plant were evaluated based on standard evaluation rice system (Scshu, 1988). Collected data were subjected to statistical analysis using line × tester analysis following Kempthorne (1957).

RESULTS AND DISCUSSION

Result of ANOVA (Table 1) showed that there was high significant difference among treatments, crosses and parents for all the traits indicating adequate genetic variations among parental varieties and crosses. Analysis of crosses effect to its components (lines, tester and parents vs crosses) showed highly significant difference (at 1% level) among tester for all trait except panicle/m^2, among lines most of the traits except panicle length, panicle weight, spikelet fertility, harvest index and grain yield/plant and in parents vs. crosses all trait except panicle length. There was highly significant difference (at 1%) level among line × testers for all traits except number of spikelet/panicle. The significant differences among the lines, tester and lines × testers indicated that the genotypes had wide genetic diversity among themselves for all traits. Significant mean squares due to lines and tester for a particular trait indicate the prevalence of additive variance. However, significant difference due to interactions of line × tester for some of the characters suggested the importance of both additive and non-additive variance for these traits (Bagheri and Babaeian 2010). Thus both additive and non additive gene actions should be studied for improving yield related traits.

The variance due to SCA was larger than the variance due to GCA for all the characters which were reflected in σ^2g:σ^2s ratio being less than unity. From this result, predominance of non-additive genetic components over the additive genetic components was revealed in the inheritance of all the traits. It could be concluded that the improvement of the characters with greater non additive genetic component could be contemplated for the exploitation of heterosis and with bi-parental mating.

Table 1: Analysis of variance (MS) for different characters in rice under line × tester method

Sources of variation	df	PH	DF	DM	PL	PW	PPM	SPP	SF	TGW	HI	GYP
Treatment	28	375.97**	31.29**	41.85**	5.42**	2.44**	2894.04**	811.17**	1353.97**	14.45**	695.83**	764.17**
Replication	2	17.17**	16.77**	11.60**	0.59	0.08	928.49**	167.71	37.70	0.01	23.19	9.20
Parents	8	801.07**	73.92**	96.70**	9.34**	4.66**	1108.37**	984.27**	2740.88**	23.41**	932.81**	1027.93**
Crosses	19	209.26**	12.09**	19.33**	3.99**	1.39**	2374.14**	667.75**	712.13**	11.35**	404.20**	475.33**
Parents vs Crosses	1	142.61**	55.23**	30.85**	1.18	4.77**	27057.58**	2151.36**	2453.66**	1.65**	4340.91**	4142.13**
Lines	4	178.29**	36.21**	58.71**	3.35	0.69	4973.55*	2061.14**	261.86	31.04**	227.31	384.08
Testers	3	741.44**	21.98**	30.37**	13.98**	4.46**	1710.08	819.45**	2646.10**	19.15**	1680.93**	1494.15**
Lines × Testers	12	86.54**	1.58**	3.44**	1.71**	0.85**	1673.69**	165.36	378.73**	2.84**	143.98**	251.04**
Error	56	3.35	0.33	0.22	0.38	0.06	136.55	103.91	27.28	0.15	8.72	9.493
Variance Component												
σ^2 gca		3.582	0.31	0.46	0.07	0.02	20.44	14.66	9.73	0.25	7.60	6.55
σ^2 sca		27.729	0.42	1.07	0.44	0.26	512.38	20.49	117.15	0.90	45.08	80.52
σ^2 gca/σ^2 sca		0.13	0.74	0.43	0.16	0.08	0.04	0.72	0.08	0.28	0.18	0.08

PH=Plant height, DF=Days to 50% flowering, DM=Days to maturity, PL=Panicle length, PW=Panicle weight, PPM=Number of panicle/m^2, SPP=Number of spikelet/panicle, SF= Spikelet fertility, TGW= 1000 grain weight, HI=Harvest index, GYP= grain yield/plant

Table 2: Proportional contribution of line, tester and their interaction to total variance for different characters in rice

Proportional contribution	PH	DF	DM	PL	PW	PPM	SPP	SF	TGW	HI	GYP
Lines	17.94	63.06	63.94	17.67	10.53	44.10	64.98	7.74	57.56	11.84	17.01
Tester	55.95	28.71	24.81	55.26	50.86	11.37	19.38	58.67	26.63	65.66	49.63
Line × tester	26.12	8.23	11.25	27.07	38.60	44.52	15.64	33.59	15.80	22.50	33.36

PH=Plant height, DF=Days to 50% flowering, DM=Days to maturity, PL=Panicle length, PW=Panicle weight, PPM=Number of panicle/m^2, SPP=Number of spikelet/panicle, SF= Spikelet fertility, TGW= 1000 grain weight, HI=Harvest index, GYP= grain yield/plant

The proportional contribution of lines, testers and their interaction for yield and yield contributing characters are presented in table 2. It is evident from the table that testers played an important role toward for plant height (55.95%), panicle length (55.26%), panicle weight (50.86), spikelet fertility (58.76%), harvest index (65.66%) and grain yield/plant (49.63%) indicating predominant parental influence for these traits. The lines contributed 63.06%, 63.94%, 44.10%, 64.98% and 57.56% towards days to 50% flowering, days to maturity, number of panicle/m^2, number of spikelet/panicle and 1000 grain weight respectively. The smaller contribution of interactions of the line × tester than tester for all traits except for number of panicle/m^2 indicated higher estimates of variances due to general combining ability Contribution of interactions of line × tester was higher than lines for plant height (26.12%), panicle length (27.07), panicle weight (38.60), spikelet fertility (33.59), harvest index (22.50) and grain yield (33.36), exhibiting higher estimates of GCA variances for interaction. Rissi et al. (1991) observed higher estimates of GCA variance due to tester in rice.

General Combining Ability Effects

Among the female parent BRRI33A and BRRI21A showed significant positive GCA effect while IR75608A had significant negative effects for plant height (Table 3). Among male parent BRRI20R and BRRI26R showed positive GCA effect while, BRRI31R and BAU521R showed negative GCA effect. BRRI21A had positive significant effect on days to flowering while IR75608A had significant negative significant effect for days to 50% flowering. In case of days to maturity IR79156A, BRRI7A and BRRI33A exhibited positive significant effect while BRRI21A and IR75608A showed significant negative effect. Paternal line BRRI20R and BRRI31R exerted significant negative effect and on the other hand BRRI26R and BAU521R showed significant positive effect for this trait. BRRI20R and BRRI31R showed significant negative effect while BRRI26R showed significant positive effect for days to maturity. Significant negative GCA effects on plant height and growth duration are useful for the development of early dwarf variety. From above result it is evident that IR75608A and BRRI31R was the good general combiner for plant height and growth duration. The result suggested that IR75608A and BRRI31R could be used to contribute for shorter plant height and growth duration (Table 3).

For panicle length BRRI7A and BRRI26R exhibited good combining ability effect due to their positive significant effect. BRRI33A and BRRI20R showed positive significant GCA value 0.23 and 0.75 respectively on panicle weight. The line BRRI33A had significant positive effect on number of panicles/m^2 while BRRI7A and BRRI21A showed significant negative effect. In case of tester BRRI31R showed significant positive effect and BAU521R showed significant negative effect for same trait. For the number of spikelet/panicle BRRI33A exhibited good combining ability effects. In case of spikelet fertility BRRI33A and BRRI21A showed good GCA effect but paternal effect of BRRI20R and BRRI31R was also significantly positive. All the parental line showed poor GCA effect for 1000 grain weight except BRRI7A which was a good combiner for that trait. Among the testers BRRI20R and BRRI31R are good general combiner and the other two are poor combiner for this trait.

Table 3: Estimate of general combining ability (GCA effects of parents for different traits in rice

Designation	PH	DF	DM	PL	PW	PPM	SPP	SF	TGW	HI	GYP
A lines (line)											
IR79156A	-0.01	0.33	2.00**	0.24	0.07	0.41	-2.02	-1.42	0.18	-0.77	1.93**
BRRI7A	-0.04	0.33	0.33*	0.57**	0.09	-13.68**	1.91	-5.88**	2.62**	-4.22**	-2.96**
BRRI33A	4.80**	1.42**	1.58**	0.08	0.23*	33.89**	20.88**	5.23**	-1.67**	7.37**	9.10**
BRRI21A	1.17*	0.92**	-0.33*	-0.03	0.02	-17.72**	-6.67*	4.29**	-0.58**	-0.92	-3.92**
IR75608A	-5.92*	-3.00**	-3.58**	-0.86**	-0.41**	-2.90	-14.11**	-2.22	-0.55**	-1.47	-4.16**
SE(gi)	0.53	0.17	0.13	0.18	0.07	3.37	2.94	1.51	0.11	0.85	0.89
SE(gi-gj)	0.75	0.23	0.19	0.25	0.10	4.77	4.16	2.13	0.16	1.20	1.26
R lines (tester)											
BRRI20R	3.55**	-1.10**	-1.42**	0.24	0.75**	0.31	4.91	11.80**	1.23**	9.95**	11.02**
BRRI31R	-3.64**	-0.90**	-0.88**	-0.20	0.06	14.71**	-10.96**	10.62**	-0.54**	8.26**	5.80**
BRRI26R	7.87**	1.43**	1.72**	1.14**	-0.48**	-4.97	3.82	-14.82**	0.60**	-10.37**	-9.47**
BAU521R	-7.78**	0.57**	0.58	-1.18**	-0.33**	-10.04**	2.22	-7.59**	-1.29**	-7.84**	-7.35**
SE (gi)	0.47	0.15	0.12	0.16	0.06	3.01	2.63	1.35	0.10	0.76	0.80
SE (gi-gj)	0.66	0.21	0.17	0.23	0.09	4.27	3.72	1.91	0.14	1.08	1.13

PH=Plant height, DF=Days to 50% flowering, DM=Days to maturity, PL=Panicle length, PW=Panicle weight, PPM=Number of panicle/m^2, SPP=Number of spikelet/panicle, SF= Spikelet fertility, TGW= 1000 grain weight, HI=Harvest index, GYP= grain yield/plant

In case of harvest index, the line BRRI33A and tester BRRI20R and BRRI31R exhibited significant positive GCA effects while BRRI7A, BRRI26R and BAU521 had significant negative effects. BRRI33A, IR79156A, BRRI20R and BRRI31R were identified as good combiners for grain yield/plant because for most of the traits of these genotypes showed desirable combining ability effects. On the contrary BRRI7A, BRRI21A, IR75608A, BRRI26R and BAU521R had poor combining ability effects for grain yield.

Specific Combining Ability Effects

Out of 20 crosses, 13 crosses showed significant SCA effects for plant height composed of one high × high, ten high × low and four low × low GCA effects (Table 5). The cross combination IR79156A/ BRRI31R, IR79156A/BAU521R, BRRI7A/BAU521R, BRRI33A/BRRI20R, BRRI21A/BRRI20R and IR75608A/ BRRI26R exhibited highly significant negative SCA effects for Plant height indicating them as good specific combiner crosses for dwarfness (Table4). These crosses involved positive general combiners for plant height. Biswas (2003) found high negative effect for a cross in which both parents were positive combiners for plant height. The superiority of low × low general combiners might be due to presence of over dominance effect.

For earliness (days to flower) the best cross combinations were IR79156A/BRRI31R (0.93), BRRI7A/BAU521R (0.73) and BRRI33A/BRRI20R (0.82) which showed significant negative SCA effect and these were considered as the best specific combiners for earliness. Whereas BRRI7A/BRRI20R (0.93), BRRI33A/BAU521R (0.85) and BRRI21A/ BRRI31R (0.82) identified as the poor specific combiner for this trait. This result was also in agreement with the findings of Hossain (2008).

The negative significant SCA effect estimated for days to maturity in IR79156A/BRRI26R (-1.13). BRRI7A/BAU521R (-0.67), BRRI33A/BRRI31R (-0.78), BRRI21A/BRRI20R (-1.67), BRRI21A/BAU521R (-0.67) and IR75608A/BRRI20R (-1.08) indicate the hybrids had good specific combining ability for earliness. The cross combination BRRI21A/BRRI20R and IR75608/BRRI20R showed negative significant SCA effects due to having low × low parental GCA effect. Generally, low × low general combiner parents produced the best and early hybrids with highly significant negative SCA effects (Table 5). This result indicated that dominant × dominant type of gene action was responsible for the cross combination for earliness. Bashar (2002) reported the similar result in rice.

For panicle length the cross combination BRRI7A/BRRI26R (1.12) and IR79156A/BRRI20R (1.03) showed significant positive SCA effects due to evolved from high × high and medium × medium parental GCA effects indicating additive and over dominant gene action for this trait (Table 4 & 5). For panicle weight, the cross combinations IR79156A/BRRI20R, BRRI7A/ BRRI31R, BRRI33A/BRRI26R and BRRI21A/BRRI26R showed significant positive SCA effects while IR79156A/BRRI31R, IR79156A/BRRI26R, BRRI7A/BRRI26R, BRRI21A/ BRRI20R and IR75608A/BRRI26R had significant negative SCA effects.

Table 4: Estimate of specific combining ability (SCA) effects of hybrids for different traits in rice

Designation	PH	DF	DM	PL	PW	PPM	SPP	SF	TGW	HI	GYP
IR79156A/BRRI20R	3.73^{**}	0.60	1.33^{**}	1.03^{**}	0.87^{**}	-25.47^{**}	13.92^{*}	10.28^{**}	0.91^{**}	4.05^{*}	6.65^{**}
IR79156A/ BRRI31R	-3.31^{**}	-0.93^{**}	-0.53	-0.33	-0.38^{**}	-18.13^{**}	-7.93	-10.44^{**}	0.57	-4.42^{*}	-8.44^{**}
IR79156A/BRRI26R	3.52^{**}	-0.27	-1.13^{**}	-0.14	-0.42^{**}	7.56	-3.98	-4.04	-1.45^{**}	-4.08^{*}	-4.53^{*}
IR79156A/BAU521R	-3.94^{**}	0.60	0.33	-0.56	-0.07	36.04^{**}	-2.01	4.19	-0.02	4.45^{*}	6.31^{**}
BRRI7A/BRRI20R	2.76^{*}	0.93^{**}	1.00^{**}	-0.93^{*}	-0.10	12.77	-7.21	-0.11	0.23	3.16	0.29
BRRI7A/ BRRI31R	5.29^{**}	0.07	0.13	0.73	0.57^{**}	13.54	-0.35	16.31^{**}	-0.36	9.68^{**}	11.97^{**}
BRRI7A/BRRI26R	-1.85	-0.27	-0.47	1.12^{**}	-0.40^{**}	-1.44	1.94	-8.60^{**}	-0.26	-6.82^{**}	-5.02^{**}
BRRI7A/BAU521R	-6.20^{**}	-0.73^{*}	-0.67^{*}	-0.93^{*}	-0.06	-24.87^{**}	5.62	-7.60^{*}	0.38	-6.02^{**}	-7.24^{**}
BRRI33A/BRRI20R	-3.48^{**}	-0.82^{*}	0.42	0.02	-0.16	-12.29	-2.68	-5.61	0.01	-4.98^{**}	-5.87^{**}
BRRI33A/ BRRI31R	0.12	-0.35	-0.78^{**}	-0.22	-0.23	-20.77^{**}	-7.61	-6.61^{*}	0.32	-5.21^{**}	-8.45^{**}
BRRI33A/BRRI26R	3.01^{**}	0.32	-0.05	0.15	0.58^{**}	26.91^{**}	5.67	8.85^{**}	0.45	7.49^{**}	8.60^{**}
BRRI33A/BAU521R	0.36	0.85^{*}	0.42	0.05	-0.18	6.15	4.61	3.37	-0.78^{**}	2.70	5.71^{**}
BRRI21A/BRRI20R	-5.82^{**}	-0.32	-1.67^{**}	-0.08	-0.76^{**}	-2.00	-0.85	-13.57^{**}	-1.24^{**}	-4.68^{**}	-10.00^{**}
BRRI21A BRRI31R	-1.56	0.82^{*}	1.13^{**}	-0.20	-0.14	13.83^{*}	7.14	0.43	-0.31	-0.95	3.33
BRRI21A/BRRI26R	4.20^{**}	0.15	1.20^{**}	-0.47	0.67^{**}	-15.07^{*}	-2.10	16.24^{**}	1.95^{**}	9.98^{**}	10.16^{**}
BRRI21A/BAU521R	3.18^{**}	-0.65	-0.67^{*}	0.76	0.23	3.33	-4.17	-3.10	-0.40	-4.35^{*}	-3.48
IR75608A/BRRI20R	2.81^{*}	-0.40	-1.08^{**}	-0.03	0.15	27.09^{**}	-3.16	8.99^{**}	0.10	2.45	8.92^{**}
IR75608A/ BRRI31R	-0.53	0.40	0.05	0.01	0.19	11.52	8.75	0.32	-0.23	0.90	1.59
IR75608A/BRRI26R	-8.87^{**}	0.07	0.45	-0.66	-0.42^{**}	-17.96^{*}	-1.53	-12.45^{**}	-0.68^{**}	-6.57^{**}	-9.21^{**}
IR75608A/BAU521R	6.60^{**}	-0.07	0.58^{*}	0.69	0.08	-20.65^{**}	-4.06	3.14	0.81^{**}	3.22	-1.31
SE (sij)	1.06	0.33	0.27	0.36	0.14	6.74	5.88	3.01	0.22	1.71	1.77
SE (sij-skl)	1.49	0.50	0.38	0.50	0.20	9.54	8.32	4.26	0.31	2.41	2.52

PH=Plant height, DF=Days to 50% flowering, DM=Days to maturity, PL=Panicle length, PW=Panicle weight, PPM=Number of panicle/m^2, SPP=Number of spikelet/panicle, SF= Spikelet fertility, TGW= 1000 grain weight, HI=Harvest index, GYP= grain yield/plant

For number of panicle/m^2 out of 20 cross combinations four crosses, IR79156A/BAU521R (36.04), BRRI33A/BRRI26R (26.91), BRRI21A/ BRRI31R (13.83) and IR75608A/BRRI20R (27.09) showed positive significant effect and those were considered as good specific combiners. The poorest specific combiners were IR79156A/BRRI20R (-25.47), IR79156A/BRRI31R (-18.13), BRRI7A/BAU521R (-24.87), BRRI33A/BRRI31R (-20.77), BRRI21A/BRRI26R (-15.07), IR75608A/ BRRI26R (-17.96), and IR75608A/BAU521R (-20.65) for this trait. Generally, high × medium, high × low and medium × medium general combiner parents produced good specific combination crosses with positive SCA effects for panicle/m^2. It indicated additive ×additive and additive × dominant type of gene action for the crosses (Table 5). Parental GCA effects for individual traits and its expression in SCA hybrid combinations determine high, medium and low status of cross combinations. For the number of spikelet/panicle, only one IR79108A/BRRI20R combination (13.92) showed specific good combining ability. Spikelet fertility exhibited significant SCA effects for eleven crosses in which near about to half of the crosses showed positive effects and the rest half showed negative effects (Table 4).

Based on parental GCA effects specific cross combinations are divided into three types of interactions viz., high × high, high × medium and low × low interactions (Table 5).

Table 5: Distribution of crosses in relation to GCA effects of parents and SCA effects of crosses for yield and yield contributing characters in rice

Characters	SCA status of cross	GCA status of parent						
		H×H	H×M	H×L	M×M	M×L	L×L	Total
PH	+	2	3	2	0	1	1	9
	0	0	1	3	0	0	1	5
	-	2	0	1	0	3	0	6
DF	+	1	0	0	0	1	0	2
	0	3	3	5	0	2	2	15
	-	0	1	1	0	1	0	3
DM	+	0	0	3	0	1	1	5
	0	2	2	4	0	0	1	9
	-	1	1	1	0	1	2	6
PL	+	1	0	0	1	0	0	2
	0	0	4	1	5	5	1	16
	-	0	1	1	0	0	0	2
PW	+	0	1	1	1	1	0	4
	0	1	2	2	1	4	1	11
	-	0	1	0	1	2	1	5
PPM	+	0	1	1	1	1	0	4
	0	0	2	2	1	3	1	9
	-	1	1	0	2	2	1	7
SPP	+	0	0	0	1	0	0	1
	0	0	3	1	5	8	2	19
	-	0	0	0	0	0	0	0
SF	+	0	2	3	0	0	0	5
	0	2	1	3	0	3	0	9

	-	2	1	0	0	1	2	6
TGW	+	0	1	1	0	0	1	3
	0	2	0	5	0	2	4	13
	-	0	1	2	0	0	1	4
HI	+	0	1	2	0	2	0	5
	0	0	3	2	0	1	0	6
	-	2	2	0	0	3	2	9
GYPP	+	1	0	5	0	0	1	7
	0	0	0	3	0	0	2	5
	-	3	0	2	0	0	3	8
Total	+	5	9	18	4	7	4	47
	0	10	21	31	12	28	15	117
	-	11	9	8	3	13	12	56

H= High GCA, L= Low GCA, M= Medium GCA

‘+’= significant positive SCA, ‘0’= non-significant SCA, ‘-’= significant negative SCA

PH=Plant height, DF=Days to 50% flowering, DM=Days to maturity, PL=Panicle length, PW=Panicle weight, PPM=Number of panicle/m^2, SPP=Number of spikelet/panicle, SF= Spikelet fertility, TGW= 1000 grain weight, HI=Harvest index, GYP= grain yield/plant

Seven cross combinations found to have significant SCA effects in which three were IR79156A/BRRI20R (0.91), BRRI21A/BRRI26R (1.95) and IR75608A/BAU521R (0.81) positive which were considered as the best specific combiners and rest four were IR79156A/BRRI26R (-1.45), BRRI33A/BAU521R (-0.78), BRRI21A/BRRI20R (-1.24) and IR75608A/BRRI26R (-0.68) considered as the poorest specific combiners for thousand grain weight (Table 4). Generally, the above crosses involving high × medium, high × low and low × low general combiner parents produced good or best specific combination of crosses with positive SCA effects for 1000 grain weight (Table 5). It indicated that additive × additive, additive × dominant and dominant × dominant types of gene actions were involved for the crosses. Similar finding was also reported by Pradhan and Singh (2008).

Fourteen crosses showed significant SCA effects for harvest index in which IR79156A/BRRI20R (4.05) (medium × high), IR79156A/BAU521R (4.45) (medium × low), BRRI7A/ BRRI31R (9.68) (low × high), BRRI33A/BRR26R (7.49) (high × low) and BRRI21A/BRRI26R (9.98) (medium × low). IR75608A/BRRI31R (-4.42) (medium ×high), IR75608A/BRRI26R (-4.08) (medium × low), BRRI7A/BRRI26R (-6.82) (low ×low), BRRI7A/BAU521R (-6.02) (low × low), BRRI33A/BRRI20R (-4.98) (high × high), BRRI33A/ BRRI31R (-5.21) (high × high), BRRI21A/BRRI20R (-4.68) (medium × high) and BRRI21A/BAU521R(-4.35) (medium × low) , IR75608A/BRRI26R (-6.57) (medium × low) produced significant negative SCA effects for harvest index (Table 4). The predominance of best specific crosses from high × low and low ×low general combiners indicated the non-additive and over dominant gene actions in improving the harvest index for high grain yield.

Out of 20 cross combinations 7 crosses expressed significant positive SCA effects and 8 crosses showed significant negative SCA effect for grain yield/plant. Out of seven crosses best performing crosses was IR79156A/BRRI20R (6.65) (was high × high for grain yield/plant and the rest were either with high × low or low × low combination. Petchiammal and Kumar (2007) and Hossain (2008) also obtained high SCA effects for grain yield from high × low and low ×low general combiners in rice (Table 5). The superiority of low × low general combiner might be due to over dominance effect. Such crosses were expected to generate transgressive segregation for exploiting super high yielding genotypes. Importantly, BRRI7A/ BRRI31R cross combination was the best specific combiner for grain yield/plant (highest positive SCA value of 11.97).

CONCLUSION

From above results predominance of non-additive genetic components over the additive genetic components was revealed in the inheritance of all the traits. It could be concluded that the improvement of the characters with possess greater non-additive genetic components could be contemplated for the exploitation of heterosis and with bi-parental mating. BRRI33A and BRRI31R was an excellent general combiner for improving yield contributing traits. The cross IR79156A/BRRI20R was the good specific combiner for most of the yield contributing characters. BRRI7A/ BRRI31R cross combination was the best specific combiner for grain yield/plant.

REFERENCES

BBS, 2011. Year Book of Agricultural Statistics of Bangladesh, Planning Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka. pp 23-27

Bagheri N.A., Babaeian-Jelodar N.A. 2010. Heterosis and combining ability Analysis for yield and related-yield traits in hybrid rice. *International Journal of Biology,* 2:2

Bashar, M.K. 2002. Genetic and morpho-physiological bases of heterosis in rice (*Oryza sativa* L.). *Ph.D. Dissertation*. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh. 147p

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

Biswas, P.S. 2003. Heterosis and combining ability analysis in rice using cytoplasmic genetic male sterile lines. *M.S. Thesis*. Dept. of Genetics and Plant Breeding. Bangladesh Agricultural University, Mymensingh. 133p

Eidi Kohnaki M, Kiani G.H. and Nematzadeh G.H. 2013. Relationship between morphological traits in rice restorer lines at F3 generation using multivariate analysis. *International Journal of Advanced Biology and Biomedical Research,* (IJABBR), 1, 6: 572-577

Hossain, M. K. 2008. Heterosis and its association with genetic attributes using line x tester mating in rice (*oryza sativa* L.). *M.S. Thesis* in Genetics and Plant Breeding. Sher-e-Bangla Agricultural University, Dhaka. 131p

Kempthorne, O. 1957. An introduction to genetic statistics. *John Wiley and Sons, Inc*., New York. pp. 453-471

Mirarab M, Ahmadikhah A. 2010. Study on genetics of some important phonological traits in rice using line × tester analysis. *Annals of Biological Research,* 4: 119-125

Nematzade Gh A, Valizade A. 2002. Hybrid rice improvement. *Mazandaran University prining office*. 202 p

Paterson A.H., Freeling M., Sasaki T. 2005. Grains of knowledge: genomics of model cereals. Genome Res. 15: 1643-1650

Petchiammal K.I. and Kumar C.R.A. 2007. Combining ability studies for yield and yield associated traits in rice (*Oryza sativa* L.) involving Assam rice cultivars. *International Journal of Agricultural Science,* 3(2): 234-236

Pradhan S.K., Singh S. 2008. Combining ability and gene action analysis for morphological and quality traits in basmati rice. *Oryza,* 45(3): 193-197

Rissi R.D., Hallauer A.R., De R.R. 1991. Evaluation of four tester for evaluating maize lines in a hybrid development program. *Revista Brasllelia de Genetica*, 14:467-481

Scshu D.V. 1988. Standard evaluation system for rice. *The International Rice Testing Program*. The International Rice Research Institute. Los Banos. Philippines. pp. 1-54

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PHENOTYPIC AND MORPHOMETRIC CHARACTERIZATION OF INDIGENOUS CHICKENS AT JHENAIGATI UPAZILA OF SHERPUR DISTRICT IN BANGLADESH

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ABSTRACT

The study was conducted at Rangtia, Shalchura and Dudhnoi villages under Jhenigati upazilla of Sherpur district in Bangladesh for phenotypic and morphometric characterization of indigenous chickens. Among three types of indigenous chickens, Non-descript Deshi were prominent (86%), compared to Cap Headed (10%) and Naked Neck (4%) and the overall mean body weight, back length, body circumference and pelvis width were 961.50 ± 17.79 gm, 152.70 ± 1.29 mm, 219.20 ± 1.89 mm and 25.57 ± .62 mm respectively. The prominent colors of plumage, shank, skin, earlobe and eggshell were multiple (24%), white (52%), white (89%), white & red (47%) and white (48%), respectively while 99% chicken's had single comb. The highest correlation (0.70) was observed between body weight & body circumference followed by (0.36) between body weight & back length and (0.27) between body weight & pelvis width while eggshell color was significantly correlated with body weight (-0.48), body circumference (-0.41) and pelvis width (-0.26). However, comb type was significantly ($p<0.05$) affected body weight and pelvis width. But bird type had significant ($p<0.05$) effect on pelvis width only. Present study reveals that variations in some phenotypic characteristics have significant influence on the pelvis width and body weight while a little change in some morphometric traits may affect body weight of indigenous chickens in Bangladesh which may serve as important indicator trait(s) for future research on the conservation and development of indigenous chicken ecotypes *in- situ.*

Keywords: Indigenous chicken, Body measurement, Correlation, Conservation.

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INTRODUCTION

Bangladesh Economic Review (2009) showed the highest growth rate of livestock sub-sector in GDP at constant rates (base year 1995-‘96) in the years 2004-‘05 (7.23%) and 2005-‘06 (6.15%) compared to crops, vegetables (0.15%) and fisheries (3.91%) (MOFL, 2009). According to BBS (2010), the number of chickens and ducks were 228.04 million and 42.68 million, respectively but the national share of commercial and family poultry in terms of egg production is probably almost equal and that of meat production is 60:40 (Bhuiyan, 2011). Identification and characterization of the chicken genetic resources generally requires information on their population, adaptation to a specific environment, possession of traits of current or future value and socio cultural importance (Weigend and Romanov, 2001). Indigenous Guangua and Mecha chicken are crest/cap and plain headed, pea combed, have no shank feather (Halima, 2007). Shahjahan et al. (2011) in Bangladesh reported that traditionally local chicken perform a variety of functions, e.g. laying eggs, hatching chicks, brooding and caring of them. However, chicken types (full feathered, naked neck and cap headed indigenous chickens) have no significant effect ($P > 0.05$) on eggs per clutch (Shahjahan, 2010). High demand of indigenous (Deshi) cockerel for their tenderness and special taste was observed (Ahmed and Ali, 2007) and indigenous chickens were popular to rural, peri-urban and urban people (Chowdhury, 2012). There are a number of breeds/types of indigenous chickens such as: Non-descript Deshi, Aseel, Naked Neck, Hilly and Dwarf in Bangladesh and these are undergoing genetic erosion due to continuous indiscriminate crossing with exotic stock but no attempts have been made to improve and conserve these valued genetic resources (Bhuiyan et al., 2005). For this perspective, characterization of indigenous chicken both phenotypically & morphometrically is important. However, objectively taken data pertaining to phenotypic & morphometric characteristics of Indigenous chicken *in-situ* are limited in Bangladesh. So, this study was designed to evaluate the phenotypic and morphometric traits of indigenous chickens and to reveal the relationship among them.

MATERIALS AND METHODS

Location of study area

Data were collected from the villages named, Rangtia (25°22′ N & 90°09′ E), Shalchura (25°21′ N & 90°08′ E) and Dudhnoi (25°18′ N & 90°09′ E) of Jhenaigati upazila under Sherpur district in Bangladesh.

Data collection

An elaborate household survey (called In-depth Household Survey) was conducted at April 2011 and August 2011 on 59 randomly selected households at Jhenaigati upazila of Sherpur district in Bangladesh under the UNEP-GEF-ILRI FAnGR Asia Project. The birds reared in these households were wing banded and in-depth survey data were collected on bird and comb type, plumage, shank, skin, earlobe and egg shell color, body weight, back length, body circumference and pelvis width. Individual birds were measured and to have the live body weight a 5 kg weighing balance (CAMRY, CHINA.) was used while different body organs were measured following the instruction narrated in figure 1 using a 150 cm plastic tailoring tape (Butterfly Brand, Shanghai, China).

Experimental design and data analysis

The statistical design of the study was unbalanced factorial in nature because the numbers of observations in different traits were unequal. Analyses were performed by analysis of variance (ANOVA) method using the General Linear Model (GLM) procedure under Statistical Package for the Social Sciences (SPSS 1998) version 11.5 with the option uni-variate. In addition, for significant variables, pair wise comparisons of treatment means were made using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Phenotypic characteristics and morphometric measurements

Non-descript Deshi were prominent (86%), compared to Cap Headed (10%) and Naked Neck (4%) among three types of indigenous chickens at Jhenigati upazilla of Sherpur district in Bangladesh (Table 1) while in Ethiopia, Duguma (2006) documented three ecotypes of chicken namely Horro, Tepi and Jarso. Comb size is associated with gonadal development and intensity of light but comb type is the consequence of gene interaction (Bell, 2002). However, at present study high proportion of (99%) single comb and lower proportion of (1%) pea comb were found (Table 1) and similarly reported by Bhuiyan et al. (2005) in Bangladesh (97% single comb), Apuno et al. (2011) in Nigeria (96.45% single comb and 0.44% pea comb) and Badubi et al. (2006) in Botswana (90% single comb and 1% pea comb).Thus the results of the present study and published reports from others research works suggested that the single comb is dominant over any comb type . We observed variation in plumage colors of indigenous chickens in Bangladesh, where multiple plumage color (24%) was prominent followed by others, black, black & white, red brown, red, white, yellow, grayish and white & red (table 1) and this finding was in line of the research work of Melesse and Negesse (2011) in indigenous chickens in southern region of Ethiopia (Kei, Tikur, Gebsima, Netch, Kokima, Wosera, Zagolima and Zigrima) and Daikwo et al. (2011) in chicken of Dekina (Brown/Black 35.5%, Black 10.25%, Black/White 6.5%, Brown/Black/White 3.25%, & White 2.75%). However these birds possessed shanks with different colors (Table 1) like white (52%), black (36%), yellow (10%) and white with red (2%) and among these, white color was prominent to others and this finding was supported by Faruque et al. (2010) in Bangladesh. Similarly, Youssao et al. (2010) reported the most predominant shank colors were white in forest ecotypes than that of Savannah though there were birds with grey, black & yellow colored shanks but dissimilarly Daikwo et al. (2011) found yellow colored shanks dominant over black/yellow, black and white in chickens of Dekina. Complete absences of black pigments in dermis and yellow pigments in epidermis of shanks, results the colors are white (Bell, 2002). White (89%) skin colored birds were prominent over yellow skin in indigenous chickens of Bangladesh (table 1) and this finding was supported by Bhuiyan et al. (2005) in Bangladesh and Dana et al. (2010) in Ethiopia. Most of the birds had white with red earlobe color (47%) but there were birds with black (32%), red (16%), others (3%) and red brown (2%) colored earlobe in indigenous chickens (Table 1) while Biswas (2005) observed the red earlobe color (58 %) was prominent over white (45.8%) but Ahmed and Ali (2007) found 80.55% white earlobe color of Deshi chicken. Indigenous chickens laid mainly eggs with (48%) white shell and (20%) red brown shell (Table 1) while Bhuiyan et al. (2005) documented light brown (67%) and white (27%) shelled eggs of the indigenous chickens in Bangladesh. However, Biswas (2005) reported that the hens of Non-descript Deshi, Hilly and Naked Neck laid light brown (62.42%) to cream or off white (30.28%) colored eggs. The highest mean body weights were (table 5.1) observed in Cap Headed bird (972±37.02gm) followed by Non-descript Deshi (966.4±19.73gm) and Naked Neck (830±86.6gm) and mean body weight of over all indigenous chickens under study was 961.50 ± 17.79gm and which was very close to the findings of Islam et al. (2012) but lower than Semakula et al. (2011), Ssewannyana et al. (2003) and Kyarisiima et al. (2004). Mean back length (table 5.1), body circumference and pelvis width of over all indigenous chickens under study were 152.70 ± 1.29, 219.20 ± 1.89 and 25.57 ±0.62mm respectively in indigenous chickens of Bangladesh while Semakula et al. (2011) found back length and chest circumference of male birds (215 and 292.3mm respectively) higher than female birds (194 and 257mm respectively) at the age of 10 months and above.

Correlation among phenotypic traits

Bird and comb type, shank, eggshell, earlobe, skin and plumage color had no significant correlation between each other. So bird type, plumage color, shank color or eggshell color did not affect each other significantly (Table 2). However, Guni et al. (2013) reported that plumage color was closely associated with shank and earlobe color, shank color was associated with skin and earlobe color while, earlobe color was associated with comb type in Tanzanian chicken.

Correlation among morphometric traits

The highest correlation (0.70) between body weight & body circumference followed by correlation (0.36) between body weight & back length and correlation (0.27) between body weight & pelvis width were observed but there were no significant correlation between back length & body circumference, back length & pelvis width and body circumference & pelvis width (Table 3). However Gueye et al. (1998) reported that, the correlations between body length and live weight ($r = 0.33$) was positive and significant ($p<0.01$) in Senegalese chicken but according to Alabi et al. (2012) body weight was highly correlated with linear body measurements in Naked

Neck and Venda chickens and it was non-significant (p> 0.01) in Koekoek chicken of South Africa. Apuno et al. (2011) also found significant correlation between body weight, back length and body circumference in Nigerian indigenous chicken. On the other hand Faruque et al. (2007) reported high degree of correlation between body weight and linear body measurements and they observed the best correlation in Naked Neck chicken while Daikwo et al. (2011) found body weight of chicken in Dekina highly correlated with back length and body circumference. So, results of the present study and findings of other scientists suggested that selection for any of these linear body measurements will cause direct improvement in body weight.

Correlation among morphometric & phenotypic characters

There was no significant correlation between phenotypic traits and morphometric traits except correlation of eggshell color with body weight, body circumference and pelvis width (Table 4). However, eggshell color was significantly correlated with body weight (-0.48), body circumference (-0.41) and pelvis width (-0.26) and this study is suggesting the possibility in the reduction of specific eggshell color with the increase of body weight, body circumference and pelvis width. On the contrary, Buvanendran and Merritt (2011) observed a consistent trend towards a darker egg shell color with increasing body weight in meat type chicken.

Effects of phenotype on morphometric traits

Bird type had significant (p<0.05) effect on pelvis width (table 5.1) while there was no significant effect of plumage (Table 5.2) shank, skin (table 5.3), earlobe and eggshell (table 5.4) color on body weight, back length, body circumference and pelvis width. While Faruque et al. *(*2010) reported significant differences of body weight among Indigenous Naked Neck, Hilly & Non-descript Deshi chicken. However, comb type significantly (p<0.05) affected body weight and pelvis width (table 5.1)

Effect of bird type

Bird types had no significant effect on body weight and back length and similar findings were reported by Faruque et al. (2007) but Alabi et al. (2012) found significant effect in South Africa. Bird type also had no effect on body circumference and similar observation was reported by Youssao et al. (2010) in Benin between two ecotypes namely Savannah & Forest while bird types had the significant effect on pelvis width in indigenous chickens of Bangladesh. On the other hand bird types (full feathered, naked neck and cap headed indigenous chicken) had no significant effect (p>0.05) on eggs per clutch (Shahjahan, 2010). However, among three types of indigenous chickens in present study, Naked Neck had comparatively lower body weight, back length, body circumference and pelvis width than Non-descript Deshi and Cap headed chicken and this findings was in line with the research work of Sarker et al. (2014).

Effect of comb type

Comb type had no significant effect on back length and body circumference but body weight and pelvis width of indigenous chickens in Bangladesh were significantly affected but Apuno et al. (2011) found no significant ($p>0.05$ %) effect in Senegalese chicken. However, Comb size of dam had non significant influence on day old chick weight, 6th week chick weight and 11th week chick weight (Haq et al., 2003).

Effect of plumage color

Plumage colors did not affect body weight, back length, body circumference and pelvis width significantly but Sarker et al. (2014) found significant effect of plumage color on body weight of Indigenous chicken in Bangladesh. On the other hand, Apuno et al. *(*2011) found significant effect of plumage colors on back length and body circumference in Senegalese chicken. However, Shahjahan et al. (2011) found significant effect of specific plumage colors and age groups ($p<0.05$ and $p<0.01$, respectively) on egg production.

Effect of shank color

Shank colors had no significant effect on body weight, back length, body circumference and pelvis width similarly, Apuno et al. (2011) found no significant effect on body weight and back length in Senegalese chickens.

Effect of skin, earlobe and eggshell color

Skin, earlobe and eggshell colors had no significant effect on body weight, back length, body circumference and pelvis width. However, Older hens lay lighter colored eggs (Odabasi et al., 2007) and in respect to medium and heavy birds, light broilers produced breast meat with higher values of redness (Bianchi et al., 2007).

CONCLUSION

Present study reveals that variations in some phenotypic characteristics had significant influence on the pelvis width and body weight while selection for some linear body measurements will cause direct improvement in body weight of Indigenous chickens in Bangladesh. The results of this work may therefore serve as an important base for future research on the conservation and development of Indigenous chicken ecotypes *in- situ.*

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REFERENCES

Ahmed, S.T. and Ali, M.A. 2007. Performance of Synthetic, Desi, Synthetic x Desi and Synthetic x Star cross brown chicken at marketing. Proceedings of the 5th International Poultry Show and Seminar. Organized by World's Poultry Science Association, Bangladesh Branch. 01-03 March, 2007, pp. 18-25

Alabi, O. J., Norris, D. and Egena, S. S. A. 2012. Comparative Study of Three Indigenous Breeds of South Africa: Body Weight & Linear Body Measurements. *Agricultural Journal*, 3: 220-225

Apuno, A. A., Mbap, S.T. and Ibrahim, T. 2011. Characterization of local chickens (Gallus gallus domesticus) in Shelleng and Song Local Government Areas of Adamawa State, Nigeria. *Agriculture and Biology Journal of North America*, 2(1): 6-14.

Badubi, S.S., Rakereng, M. and Marumo, M. 2006. Morphological characteristics and feed resources available for Indigenous chickens in Botswana. *Livestock Research for Rural Development*, 18(1)

Bianchi, M., Petracci, M., Sirri. F., Folegatti, E., Franchini, A. and Meluzzi, A. 2007. The influence of the season and market class of broiler chickens on breast meat quality traits. *Poultry Scince*, 86(5):959-63

Biswas, S.R. 2005. Genetic Dilution of of Indigenous Chicken in Selected Villages. MS Thesis. Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh

BBS, 2010. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka

Bell, D.D. 2002. Anatomy of the chicken. In D.D. Bell and W. D. Weaver eds. Commercial chicken meat and egg production, 5th edition. pn., pp. 45–46. USA, Springer Science + Business Media, Inc

Bhuiyan, A. K. F. H. 2011. Implementation of National Livestock Development Policy (2007) and National Poultry Development Policy (2008): Impact on smalholder livestock rearers. Keynote paper presented at the South Asia Pro Poor Livestock Policy Programme (SAPPLP)-BRAC workshop held at BRAC Centre Inn, Dhaka

Bhuiyan, A.K.F.H., Bhuiyan, M. S. A. and Deb, G.K. 2005. Indigenous chicken genetic resources in Bangladesh: Current status and future outlook. *Animal Genetic Resources Information (AGRI)*, FAO, Italy, 36: 73-84

Buvanendran, V. and Merritt, E.S. 2011. Correlated responses in egg quality traits to selection for early body weight in meat type chicken. *Canadian Journal of Genetics and Cytology*, 14 (3):477-482

Chowdhury, S. D. 2012. Keynote Paper on Indigenous poultry: Need for policy intervention and sustainable approaches to higher productivity. Proceedings of a Seminar, 28 January, 2012, Animal Husbandry Faculty Gallery, Bangladesh Agricultural University, Mymensingh 2202. pp. 8-20

Dana, N., Dessie, T., van der Waaij, H.L. and van Arendonk, A.M.J. 2010. Morphological features of indigenous chicken populations of Ethiopia. *Animal Genetic Resources*, 46: 11–23

Daikwo, I. S., Okpe, A. A. and Ocheja, J.O. 2011.Phenotypic Characterization of Local Chickens in Dekina. *International Journal of Poultry Science,* 10 (6):444-447

Duguma, R. 2006. Phenotypic characterization of some Indigenous chicken ecotypes of Ethiopia. Ethiopian Institute of Agricultural Research, P.O. Box 32, Debre Zeit, Ethiopia. *Livestock Research for Rural Development*, 18(9)

Faruque, S., Sarker, N.R., Islam, M.N. and Sarker, M.S.K. 2007. Performance of native chicken under intensive system. *Journal of the Bangladesh Agricultural University*, 5(2): 283-288

Faruque, S., Siddiquee, N. U., Afroz, M. A. and Islam, M. S. 2010. Phenotypic characterization of Native Chicken reared under intensive management system. *Journal of the Bangladesh Agricultural University,* 8(1): 79–82

Guni, F. S. and Katule, A. M. 2013. Characterization of local chickens in selected districts of the Southern Highlands of Tanzania: I. Qualitative characters. *Livestock Reseaech for Rural Development*, 25(9)

Gueye, E.F. Ndiaye, A. and Branckaert, R. D. S.1998. Prediction of body weight on the basis of body measurements in mature indigenous chickens in Senegal. *Livestock Research for Rural Development,* 10(3)

Haq, A., Akram, M., Mukhtar, N.,Rehman, S. and Ramzan, M. 2003. Effect of Parental Comb Size and Body Weight on Subsequent Performance in Lyallpur Silver Black Layers. *Pakistan Journal of Life and Social Science*, 1(2): 98-101

Halima, H.M. 2007. Phenotypic and genetic characterization of indigenous chicken populations in Northwest Ethiopia. Ph.D. Thesis, University of Free State, Bloemfontein, South Africa

Islam, F., Sarker, S. C., Bhuiyan, A. K. F. H., Akteruzzaman, M., Bett, R.C., Baltenweck, I., Poole, J., Ibrahim, M.N.M. and Okeyo, A. M. 2012. The status of indigenous chicken farming and options for improvement in Bangladesh. Proceedings of a Seminar, 28 January, 2012, Animal Husbandry Faculty Gallery, Bangladesh Agricultural University, Mymensingh. p. 21

Kyarisiima, C. C., Kugonza, D. R. and Twesigye, C. K. 2004. The Potential Role of Uganda Indigenous Chicken in Poverty Alleviation. *The Uganda Journal*, 50: 85-90.

Melesse, A. and Negesse, T. 2011. Phenotypic and morphological characterization of indigenous chicken populations in southern region of Ethiopia. *Animal Genetic Resources,* 49:19–31

MOF. 2009. Bangladesh Economic Review, Ministry of Finance, Government of the People’s Republic of Bangladesh.

Odabasi, A.Z., Miles, R.D., Balabn, M. O. and Portier, K. M. 2007. Changes in brown eggshell color as the hen ages. *Poultry Scinece*, 86(2):356-63

Sarker, N. R., Hoque, A., Faruque, S.,Islam, N. and Bhuiyan, F. H. 2014. An ex situ study on body characteristics and effect of plumage color on body weight of indigenous chicken (Gallus domesticus) in Bangladesh. *Animal Sciences,* 36: 79-84

Semakula, J., Lusembo, P., Kugonza, D. R., Mutetikka, D., Ssennyonjo, J. and Mwesigwa, M. 2011. Estimation of live body weight using zoometrical measurements for improved marketing of indigenous chicken in the Lake Victoria basin of Uganda. *Livestock Research for Rural Development*, 23: (8)

Ssewannyana, E., Onyait, A. O., Ogwal, J., Mukasa, B., Nsamba, P and Masaba, J. 2003. Characteristics of Rural Chicken in Apac and Kumi districts of Uganda. *Uganda Journal of Agricultural Sciences*, 8:159-164

Shahjahan, M. 2010. Diversity in performance of Indigenous Chicken in some selected areas of Bangladesh In-Situ. A Thesis for M. S. degree, Submitted to the Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh-2202

Shahjahan, M., Amin, M.R. and Bhuiyan, A.K.F.H. 2011. Diversity in performance of indigenous chicken in some selected areas of Bangladesh in-situ. Proceedings of 9th Asia Pacific Poultry Conference, the World's Poultry Science Association Taiwan Branch, 20-23 March, 2011. Taipei, Taiwan. Mon-S4-08. CD

SPSS, 1998. Statistical Package for the Social Sciences. SPSS Inc. an IBM Company Headquarters, 233 S.WAckes Drive,11 th floor Chicago,Illinois 60606

Weigend, S. and Romanov, M.N. 2001. Current strategies for the assessment and evaluation of genetic diversity in chicken resources. *World Poultry Science Journal*, 57: 275-287

Youssao, I. A. K., Tobadal, P. C., Koutinhouinl, B. G., Dahouda, M., Idrissou, N. D., Bonou, G. A., Tougan, U. P., Ahounou, S., Yapi-Gnaoré, V., Kayang, Rognon, B., X. and Tixier-Boichard, M. 2010. Phenotypic Characterization and Molecular Polymorphism of Indigenous Poultry Population of the species *Gallus gallus* of Savannah and Forest ecotypes of Benin. *African Journal of Biotechnology*, 9(3): 369-381

Table 1: Frequencies of bird and comb type, plumage, shank, comb, skin, earlobe and eggshell colors in indigenous chickens

Phenotypic Parameter		Percentage (%)	Total	Phenotypic Parameter		Percentage (%)	Total
Bird Type	Naked Neck	4	100	Comb Type	Single	99	100
	Non-descript Deshi	86			Pea	1	
	Cap Headed	10		Skin Color	White	89	100
Plumage Color	Black	15	100		Yellow	9	
	White	5			Not Definite	2	
	Yellow	4		Earlobe Color	Black	32	100
	Red	8			Red	16	
	Grayish	3			Red Brown	2	
	Multicolor	24			White and Red	47	
	Black and White	12			Others	3	
	Red Brown	10		Egg shell Color	White	48	100
	White and Red	2			Red	2	
	Others	17			Red Brown	20	
Shank Color	Black	36	100		Others	24	
	White	52			Not Definite	6	
	Yellow	10					
	White and Red	2					

Table 2: Correlation among phenotypic characters

Parameter	Bird Type	Comb Type	Plumage Color	Shank Color	Skin Color	Earlobe Color	Eggshell Color
Bird Type	1	-0.03	-0.00	0.05	-0.04	-0.08	-0.13
Comb Type	-0.03	1	0.14	0.01	-0.02	-0.04	0.00
Plumage Color	-0.00	0.14	1	0.15	0.10	-0.10	0.01
Shank Color	0.05	0.01	0.15	1	0.06	-0.04	-0.01
Skin Color	-0.04	-0.02	0.10	0.06	1	-0.02	0.00
Earlobe Color	-0.08	-0.04	-0.10	-0.04	-0.02	1	0.04
Eggshell Color	-0.13	0.00	0.01	-0.01	0.00	0.04	1

Table 3: Correlation among morphometric traits

Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width (mm)
Body Weight (gm)	1.00	0.36**	0.70**	0.27**
Back Length (mm)	0.36**	1.00	0.04	-0.12
Body Circumference (mm)	0.70**	0.04	1.00	0.08
Pelvis Width (mm)	0.27**	-0.12	0.08	1.00

** Correlation is significant at 0.01% level

Table 4: Correlation among morphometric & phenotypic characters

Phenotypic Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width(mm)
Bird Type	0.06	-0.04	0.13	-0.01
Comb Type	0.01	-0.10	0.11	-0.01
Plumage color	-0.09	-0.15	0.04	-0.13
Shank color	-0.01	0.09	-0.08	-0.12
Skin color	-0.07	-0.14	-0.14	0.10
Earlobe color	-0.11	0.05	-0.18	-0.03
Eggshell color	-0.48**	0.09	-0.41**	-0.26**

**Correlation is significant at 0.01% level

Table 5.1: Effects of bird and comb type on morphometric traits

Phenotypic Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width(mm)
Bird Type	NS	NS	NS	*
Non-descript Deshi	966.40±19.73 (86)	153.26 ±1.33 (86)	218.96 ±2.07 (86)	25.63 ±0.68 (86)
Naked Neck	830.00 ±86.60 (4)	147.50 ±9.46 (4)	210.00 ±10.8 (4)	25.00 ±2.89 (4)
Cap Headed	972.00 ±37.02 (10)	150.00 ±4.94 (10)	225.00 ±4.78 (10)	25.25± 1.68 (10)
Total	961.50±17.8 (100)	152.70±1.29 (100)	219.20±1.89 (100)	25.57±.62 (100)
Comb Type	*	NS	NS	*
Single	961.30±17.98 (99)	961.30±17.98 (99)	961.30±17.98 (99)	961.30±17.98 (99)
Pea	980.00 (1)	980.00 (1)	980.00 (1)	980.00 (1)
Total	961.5±17.82 (100)	961.5±17.82 (100)	961.5±17.82 (100)	961.5±17.82 (100)

* Significant at 0.05 % level of probability ($p<0.05$), NS=Non Significant,

Figure in the parentheses indicate the number of observation.

Table 5.2: Effects of plumage color on morphometric traits

Phenotypic Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width(mm)
Plumage Color	NS	NS	NS	NS
Black	965.33±40.50 (15)	152.00 ±2.96 (15)	218.00 ±5.27 (15)	27.33 ±1.28 (15)
White	932.00±134.85 (5)	160.00 ±10.00 (5)	216.00 ±12.88 (5)	23.50±2.69 (5)
Yellow	952.50±54.98 (4)	152.50 ±6.29 (4)	210.00 ±4.08 (4)	27.51 ±4.78 (4)
Red	1062.50±69.94 (8)	160.00 ±3.78 (8)	221.25 ±6.39 (8)	28.75 ±2.45 (8)
Grayish	1026.67 ±63.60 (3)	153.33±12.012 (3)	223.33 ±6.67 (3)	21.67 ±1.67 (3)
Multiple color	970.42±34.16 (24)	155.2 ±3.03 (24)	222.08 ±3.71 (24)	23.33±1.23 (24)
Black & White	950.83±43.61 (12)	152.50 ±2.17 (12)	210.83 ±4.34 (12)	29.59±1.79 (12)
Red Brown	981.00±57.22 (10)	144.50 ±2.17 (10)	230.00 ±6.32 (10)	26.50 ±1.67 (10)
White & Red	750.00±170.00 (2)	160.00 (2)	205.00±25.00 (2)	17.50±2.50 (2)
Others	918.23±47.29 (17)	148.23 ±2.90 (17)	218.82 ±4.44 (17)	24.11±1.23 (17)
Total	961.50±17.80 (100)	152.70±1.30 (100)	219.20±1.89 (100)	25.57± 0.62 (100)

NS=Non Significant, Figure in the parentheses indicate the number of observation.

Table 5.3: Effects of shank and skin color on morphometric traits

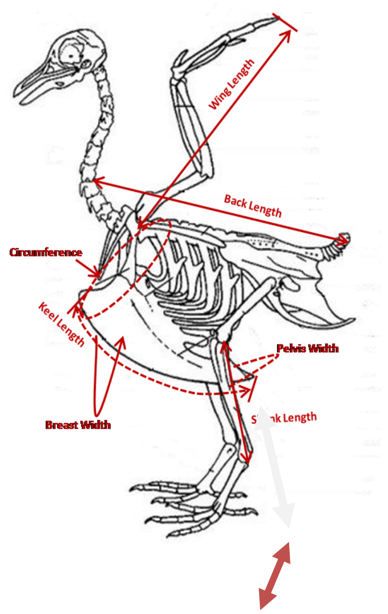
Phenotypic Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width(mm)
Shank Color	NS	NS	NS	NS
Black	948.33±31.33 (36)	151.67 ±1.67 (36)	220.28 ±3.68 (36)	25.28 ±0.87 (36)
White	974.23 ±25.30 (52)	153.07 ±1.90 (52)	220.57 ±2.41 (52)	26.34 ±0.95 (52)
Yellow	949.00 ±44.63 (10)	153.00 ±5.78 (10)	209.00 ±4.06 (10)	23.75 ±1.71 (10)
White & Red	930.00 ±30.00 (2)	160.00 ±10.00 (2)	215.00 ±5.00 (2)	20.00 (2)
Total	961.50±17.80 (100)	152.71±1.31 (100)	219.00±1.89 (100)	25.57±0.61 (100)
Skin Color	NS	NS	NS	NS
White	957.53 ±19.03 (89)	153.3 ± 1.38 (89)	218.76 ±1.98 (89)	25.59± 0.67 (89)
Yellow	1020.00 ± 65.60 (8)	148.12 ± 4.42 (8)	226.25 ± 7.05 (8)	23.75 ± 1.83 (8)
Not Definite	865.00 ± 35.00 (2)	140.00 (2)	200.00±10.00 (2)	30.00 (2)
Total	960.70± 17.90 (100)	152.62± 1.30 (100)	218.99± 1.90 (100)	25.53±0 .62 (100)

NS=Non Significant, Figure in the parentheses indicate the number of observation.

Table 5.4: Effects of earlobe and eggshell color on morphometric traits

Phenotypic Parameter	Body Weight (gm)	Back Length (mm)	Body Circumference (mm)	Pelvis Width(mm)
Earlobe Color	NS	NS	NS	NS
White	981.56 ± 29.12 (32)	152.03 ±2.24 (32)	221.56 ± 3.60 (32)	25.85± 0.90 (32)
Red	968.12 ± 40.23 (16)	149.69 ±3.55 (16)	226.25 ± 4.73 (16)	23.12± 1.50 (16)
Red Brown	1050.00±170.00 (2)	165.00±5.00 (2)	220.00±10.00 (2)	40.00±5.00 (2)
White & Red	931.49 ± 26.96 (47)	153.40 ± 1.80 (47)	214.47 ± 2.58 (47)	25.53± 0.90 (47)
Others	1123.30 ±144.02 (3)	156.67 ±12.01 (3)	230.00 ± 5.78 (3)	26.67± 3.33 (3)
Total	961.50± 17.80 (100)	152.70± 1.29 (100)	219.20± 1.89 (100)	25.57± 0.61 (100)
Eggshell Color	NS	NS	NS	NS
White	1010.20 ±18.39 (48)	151.04 ±1.60 (48)	223.12 ±2.25 (48)	26.77±0.79 (48)
Red	1050.00±270.00 (2)	165.00±5.00 (2)	220.00±10.00 (2)	40.00±5.00 (2)
Red Brown	1012.50 ±41.22 (20)	157.00 ±2.41 (20)	224.00 ±3.28 (20)	25.00±1.36 (20)
Others	892.08 ±34.48 (24)	150.40 ±3.21 (24)	214.58 ±4.34 (24)	23.85±1.06 (24)
Not Definite	650.00±66.28 (6)	156.67 ±7.61 (6)	190.00±8.94 (6)	20.00±2.58 (6)
Total	962.32±17.95 (99)	152.63±1.30 (99)	219.30±1.90 (99)	25.48±.61.00 (99)

NS=Non Significant, Figure in the parentheses indicate the number of observation.



Pelvis width
Width of the pelvis is measured when the chicken is standing. The calipers rested on the back and measured the distance between the outer edges of the thighs.

Circumference
Circumference is measured with the tape at the anterior end of the keel bone. The tape is passed under the wings and anterior to the legs

Back length
When the chicken is standing, the neck curves so that the neck is almost perpendicular to the back. The back is measured from the nadir of the curve to the base of the tail.

Breast width
Measured at the anterior end of the keel while the chicken is held on its back. Use a caliper.

Keel length
Keel length is measured with the tape as the chicken is held on its back.

Shank length
Distance from the shank joint (s)

Shank circumference
Circumference of the "drum stick" taken at the uppermost part of the shank.

Wing Length
Taken from the shoulder joint to the extremity of the terminal phalanx, digit III.

Figure 1: Linear measurements of a chicken showing Back Length, Circumference, Pelvis Width, Shank Length, Keel Length, Wing Length and Breast Width

Source: Blood sampling procedure and in-depth monitoring survey manual for indigenous chicken, goats and pigs of UNEP-GEF-ILRI FAnGR Asia Project on 2010 (BSPIMSM , 2010).

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De Datta, S. K. 1981. Principles and practices of rice production. Los Banos, Manila.

International Rice Research Institute. 2000. International rice trade: a review of 1999 and prospects for 2000. *International Rice Commission Newsletter*, IRRI, Manila.

Steel, R.G.D. and Torrie, J.H. 1980. Principles and procedures of statistics: A biometrical approach. 2nd ed. McGraw-Hill, New York.

Westerman, R.L. (ed.) 1990. Soil testing and plant analysis. 3rd ed. SSSA Book Ser. 3. SSSA, Madison, WI.

Chapter in a Book

David, H. and Easwaramoorthy. 1988. Physical resistance mechanisms in insect plant interactions. p. 45-70. In T.N. Ananthakrishnan and A. Rahman (ed.), *Dynamics of insect plant interactions: Recent advances and future trends*. Oxford and IBH Publication, New Delhi.

Johnson, D.W. and D.E. Todd. 1998. Effects of harvesting intensity on forest productivity and soil carbon storage. p. 351–363. In R. Lal et al. (ed.) *Management of carbon sequestration in soils*. Advances in Soil Science. CRC Press, Boca Raton, FL.

Conference/Symposium/ Proceedings

Joshi, B.K. 2004. Crossing frequency and ancestors used in developing Nepalese mid and high hill rice cultivars: Possible criteria for yield improvement and rice genes conservation. p. 502-523. In Proc. *National Conference on Science and Technology*, 4th, Vol. 1. 23-26 Mar., 2004. NAST, Kathmandu, Nepal.

Ramanujam, S. (ed.) 1979. *Proceedings of International Wheat Genet Symposia*, 5th, New Delhi, India. 23–28 Feb. 1978. Indian Soc. Genet. Plant Breeding, Indian Agric. Res. Inst., New Delhi.

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Software and Software Documentation

Minitab. 1998. MINITAB 12. Minitab, State College, PA.

Online publication

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