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Full Length Research Paper

Disease index construction against prevalence of major diseases in fine rice

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An experiment was carried out to study the covariance and co-heritability against prevalence of major diseases in 30 fine rice cultivars. The results revealed varying degrees of resistance against the major diseases. The cultivar, Ranjit was the top most yielder with 5.037 t/ha. Among the three major diseases, yield versus brown spot revealed the highest co-heritability (3.350) and yield versus disease index also showed the highest value (0.889). Except lodging percentage high heritability was measured for other selected characters. The growing condition was favorable for the incidence of brown spot that was predicted by the maximum environmental covariance (1.550) between yield versus brown spot. The yield potentials of Paijum, Kalozira and Begunbichi did not significantly differ from the highest yield of Ranjit and among them only Kalozira scored zero disease index. Cultivars, such as Zirashail, Nazirshail, Kaloshoru, Sadakatari, Binnipakri, Lalfota, Suman sorna, Moulata, Zaithakatari, Chinigura, Rajshahi sorna, Uknimodhu and Katari were in general poor yielder as compared to other cultivars but interestingly observed that the cultivars Nazirshail, Sadakatari and Sumon sorna scored zero disease indices against the three major diseases. Therefore, simultaneous consideration on yield and disease incidence in every cultivar was paid due attention during the investigation.

Key words: Covariance, co-heritability, disease incidence, fine rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for the people of Bangladesh as well as for three billion people of the world and playing an important role in the national economy of many developing countries (Faruq et al., 2010; Trans, 2001). About 40% of the world's population consumes rice as a major source of calorie (Banik, 1999). Globally rice is the second important cereal crop after wheat in terms of area, production and consumption. The agricultural land of Bangladesh is being decreased by about 1% per annum (Husain et al., 2006) while the population is increasing at an alarming rate of 1.43% per year (Anon, 2006). There are many causes of low yield of rice in Bangladesh. Diseases and pests are considered as major constraints for rice production (Fakir, 1982). Tropical and subtropical climate not only favors rice production but also favors the development of diseases. Among the major diseases, bacterial leaf blight (BLB), sheath rot, sheath blight, blast and brown spot cause a substantial loss in quality and quality of rice. Bacterial leaf blight is caused by X*anthomonus oryzae;* attacks leave and leaf sheath of rice plant at tillering and booting stages (Ou, 1972). It even enhances development of symptoms such as sheath blight and stem rot (Horino, 1986) and may cause an average of 20 to 30% yield loss (Ou, 1985). Sheath blight of rice is caused by *Rhizoctonia solani* which affects grain filling and panicle emergence and about 28 to 30% yield reduction was estimated in susceptible cultivars (Shahjahan et al., 1986a) due to attack by this pest. A disease occurring in plant serves as

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a host for the causative pathogen. Conversely, disease can seldom develop if the plant cannot act as host for the pathogen; the later situation points to immunity, while the former to susceptibility of the host. Immunity is the rule and susceptibility the exception as there are far more non-hosts than hosts to any given pathogen (Van der plank, 1975). Immunity is the complete as well as absolute expression there is no grade of it. On the other hand, the susceptibility of a plant results disease with varying degrees of infection. Therefore, resistance is the counterpart of susceptibility and extreme or complete resistance is analogous to immunity (Russell, 1978). To manage diseases of rice, several techniques such as agronomic modifications, resistant varieties, application of pesticides and biological control have been practiced to some extent. Very few resistant cultivars are available for practical use and the present intensive rice cultivation practices offer a favorable condition for disease development. Under the circumstances, disease is difficult to control by cultural practices alone or in combination with chemicals. For that matter, the resistant sources (genes) can be used to develop a rice cultivar which is resistant to diseases. In the present investigation it was tried to estimate different genetic parameters for yield and other yield related characters, to assess disease severity in fine rice cultivars under field condition; to find out covariance and co-heritability of major diseases and finally to identify the source of resistance against major diseases of fine rice.

MATERIALS AND METHODS

The experiment was carried out at the experimental field laboratory of the Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh with the technical assistance of Institute of Biological Science, university of Malaya, Malaysia during the period from June to December 2009 to study the covariance and co-heritability of different traits against the prevalence of major diseases in fine rice. A total of 30 varieties of fine rice were taken in the investigation. The lists of the cultivars are presented in Table 2. The experiment was laid out in randomized complete block design with three replications. Each replication accommodated 150 plants of 30 cultivars having 20 cm × 20 cm spacing. The plot size was 3 m × 2 m. The spaces between replications and between plots were 1 m and 50 cm, respectively. Disease index was calculated according to the modified infection index, recommended by All India millet Worker's Conference (India), March, 1976.

According to this scheme, each hill was assigned a severity scale/score as under:

1 = No symptoms.
2 = Symptoms on nodal tillers only (5% infection).
3 = Symptoms on main tillers but still productive panicles only (10% infection).
4 = Symptoms on the most main tillers so that there is a very few productive panicles (30% infection).
5 = Symptoms on all tillers; no productive panicles (35% infection)

The scoring system required a special scoring sheet where a mark was put in an appropriate severity box for each hill examined. A disease index was then developed:

$$\text{Disease Index} = \frac{\sum(\text{No. of hills X grade})}{\text{Total no. of plant estimated X Highest grade}} \times 100$$

Genotypic and phenotypic co-variances were estimated by using the following formulae of Singh and Chaudhury (1985):

$$\text{Genotypic covariance } (\sigma g_i g_i) = \frac{MSP_v - MSP_e}{r}$$

Where, MSP_v = Mean sum of products of characters X and Y; MSP_e = Mean sum of products due to error of characters X and Y; and r = Number of replications.

$$\text{Phenotypic covariance } (\sigma p_i p_i) = \sigma g_i g_i + \sigma e_i e_i$$

Where, $\sigma g_i g_i$ = Genotypic covariance; and $\sigma e_i e_i$ = Mean sum of products due to error of characters X and Y

Co-heritability values were estimated according to the following formulae:

$$\text{Co-heritability} = \frac{\text{Genotype Covariance}}{\text{Phenotypic Covariance}}$$

RESULTS AND DISCUSSION

Genetic parameters for different characters

The results from 30 fine rice cultivars relating to different genetic parameters are presented in Table 1. The wider difference between GCV and PCV for yield (t/ha) and lodging percentage proclaimed remarkable influence by environment for their expression. All the characters showed high heritability except lodging percentage (59.28 %) and the maximum heritability value (99.69) was estimated both for plant height and sterility percentage, whereas Raisheed et al. (2002) observed moderate heritability for most of the yield contributing characters in fine rice.

Disease incidence and affected yield potential

The extent of variation among the cultivars in respect of yield, disease incidence and disease index are presented in Table 2. The mean yields of 30 cultivars ranged from 2.033 to 5.037 (t/ha) with an average performance of 3.309 (t/ha). The significant variation was supported by DMRT (Gomez and Gomez, 1984). The highest yield was obtained from Ranjit and the lowest from Binnipakri. Components of covariance like genotypic covariance ($\sigma g_i g_i$), phenotypic covariance ($\sigma p_i p_i$) and environmental covariance ($\sigma e_i e_i$) and co-heritability are presented in Table 3. Analysis of variance revealed significant genetic differences between the lines while taking 30 cultivars of

Table 1. Genetic parameters for different morpho physiological characters in fine rice.

Characters	Genotypic variance ($\sigma^2 g$)	Phenotypic variance ($\sigma^2 p$)	Environmental variance ($\sigma^2 e$)	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (at 5% selection intensity)	Genetic advance (as % of mean)
Plant height (cm)	145.2	145.65	0.365	9.106	9.120	99.69	24.78	18.73
Tillers/hill(at vegetative stage)	3.796	3.989	0.193	10.57	10.84	95.16	3.92	21.25
Effective tillers/hill	6.754	7.10	0.347	18.94	19.42	95.13	5.22	38.05
Panicle length (cm)	10.94	11.20	0.264	12.54	12.68	97.67	6.733	25.53
Spikelets/panicle(no.)	3.664	3.8	0.136	16.50	16.80	96.42	1.95	16.81
Sterility (%)	20.38	20.45	0.062	33.32	33.37	99.69	5.70	25.87
1000-grain weight (g)	25.48	25.50	0.020	28.86	28.87	82.92	10.39	59.43
Yield/ha(t)	0.343	0.742	0.398	21.26	31.27	87.23	10.82	29.78
Days to maturity	55.578	57.90	2.324	5.935	6.05	95.98	15.05	11.98
Days to 50% flowering	50.60	51.18	0.570	0.077	0.078	98.86	14.92	15.73
Leaf angle just below the flag leaf (0°)	25.08	28.83	3.746	20.67	22.15	87.00	9.623	39.72
Lodging percentage	238.25	401.86	163.611	79.399	103.12	59.28	24.48	25.93

Table 2. Disease indices along with phenotypic acceptability of fine rice cultivars.

Accession No.	Cultivar	Phenotypic acceptability	No. of tillers infected by brown spot/hill	Affected leaf area by bacterial leaf blight/hill (%)	Affected tillers by sheath blight/hill (%)	Disease index (%)	Yield (t/ha)
FR1	Zirashail	5	9.100B	86.00B	75.00AB	82.67BC	2.283 JK
FR2	Nazirshail	9	0.0000O	0.0000O	0.000R	0.0000Q	2.540 H-K
FR3	Philippine katari	7	5.633K	59.00K	41.33N	58.00LM	3.567 C-G
FR4	Kaloshoru	7	8.633CD	82.00CD	70.67CD	81.00C	2.483 I-K
FR5	Sanla	5	6.000J	62.67J	43.00MN	62.33JK	3.480 D-G
FR6	Ranjit	7	3.733N	48.33N	27.67Q	67.00F-H	5.037 A
FR7	Chikon sorna	5	6.600HI	70.00GH	67.00E-G	68.00FG	3.053 F-J
FR8	Sadakatari	9	0.0000O	0.0000O	0.000R	0.0000Q	2.320JK
FR9	Shilkumul	9	0.0000O	0.0000O	0.0000R	0.0000Q	4.160 B-D
FR10	Binnipakri	5	10.20A	89.00A	77.33A	88.33A	2.033 K
FR11	Paijum	7	9.033B	88.00AB	75.00AB	85.33B	4.350 A-C
FR12	Shitabhog	5	7.067G	68.00HI	59.00I	70.00EF	3.563 C-G
FR13	Zira	5	6.300IJ	63.00J	47.00KL	65.67G-I	3.497 D-G
FR14	Kalozira	9	0.0000O	0.0000O	0.000R	0.0000Q	4.627AB
FR15	Lalfota	5	8.300D	80.67CDE	69.00C-F	82.67BC	2.367 I-K

Table 2. Contd.

FR16	Dairkashail	9	0.0000O	0.0000O	0.0000R	0.0000Q	4.267 B-D
FR17	Badshabhog	9	0.0000O	0.0000O	0.000R	0.0000Q	3.330 E-H
FR18	BR 34	9	0.0000O	0.0000O	0.000R	0.0000Q	3.827 B-F
FR19	Dudhsar	9	0.0000O	0.0000O	0.000R	0.0000Q	3.553 C-G
FR20	Begunbichi	5	6.867GH	67.67HI	67.67D-G	60.00KL	4.440 AB
FR21	Sumon sorna	9	0.0000O	0.0000O	0.000R	0.0000Q	2.467 I-K
FR22	Moulota	5	8.933BC	82.67C	72.00BC	82.67BC	2.503 I-K
FR23	Zaithakatari	7	8.400D	73.67F	62.33H	63.00I-K	2.663H-K
FR24	Lalchikon	5	6.733GH	68.33HI	57.00I	68.67FG	3.163F-I
FR25	Malshira	9	0.0000O	0.0000O	0.0000R	0.0000Q	4.233 B-D
FR26	Chinigura	7	8.433D	79.67DE	66.33FG	71.67DE	2.820 G-K
FR27	Rajshahi sorna	5	6.900GH	71.00G	70.00C-E	64.33H-J	2.627 H-K
FR28	Uknimodhu	5	7.50F	79.00E	64.67GH	73.33D	2.843 H-K
FR29	Radhunipagal	9	0.0000O	0.0000O	0.000R	0.0000Q	4.100 B-E
FR30	Katari	7	7.900E	71.67FG	70.33CD	67.67FG	2.793 G-K
	LSD		0.3350	2.300	2.871	2.802	0.6896
	Mean		5.972	59.956	49.044	58.056	3.309

Values with same letter did not differ significantly at 1% level.

Table 3. Co-variance and co-heritability of major diseases in fine rice.

Yield vs. Disease	Genotypic covariance	Environmental covariance	Phenotypic covariance	Co-heritability
Yield (t/ha) vs. Bacterial leaf blight/hill	-8.930	0.314	-7.025	2.005
Yield (t/ha) vs. Sheath blight/hill	-9.252	0.543	-7.807	1.026
Yield (t/ha) vs. Brown spot/hill	-2.290	1.550	-0.482	3.350
Yield (t/ha) vs. Disease index (%)	-6.821	-0.296	-5.817	0.889

fine rice for yield and yield contributing characters. Rao et al. (1997) alsoobserved such type of variation during estimation of cause and effect relations of yield and yield components in rice.

Percentage of diseased leaf area by bacterial leaf blight/hill

The mean values for percentage of diseased leaf area by bacterial leaf blight/hill against the cultivars showed a wide range of variation from 0.00 to 89.00% with a mean performance of 59.956% (Table 2). The highest percentage of blight/hill was observed in Binnipakri and the infection of Binnipakri was significantly higher than other cultivars, except Paijum. Muralidharan et al. (2004) reported that unknown genes showed bacterial leaf blight resistance in rice cultivars when tested at several locations. The minimum difference between phenotypic covariance (-7.025) and genotypic covariance (-8.930) revealed that there was minimum genetic contribution for the development of this disease. The mean of co-heritability percentage of diseased leaf area by bacterial leaf blight/hill versus yield was 2.005(Table 3). The results suggested that percentage of leaf area infected by bacterial leaf blight/hill and yield potential of the tested cultivars was co-related in their expression.

Percentage of affected tillers by sheath blight/hill

The highest percentage of affected tillers by sheath blight/hill was observed in Binnipakri (79.07) and it was significantly different from other cultivars except, Zirashail and Paijum (Table 2). The phenotypic covariance (-7.807) was lower than that of genotypic covariance as presented in Table 3. This difference indicated of the influence environment for the development of the disease. The co-heritability of percentage of affected tillers by sheath blight/hill versus yield was 1.026. Miah et al. (1985) opined that the incidence of sheath blight had increased in Bangladesh.

Number of tillers infected by brown spots/hill

The mean values for number of tillers infected by brown spots/ hill ranged from 0.00 to 10.20, with a mean performance of 5.972. According to DMRT, the highest number of affected tillers by brown spots/hill was observed in Binnipakri and ten cultivars did not infect by any pathogen. Goel et al. (2003) stated the effects of 14 different inorganic and/or organic fertilizer treatments on the natural occurrence of brown spot caused by *Drechslera oryzae* and *Cochliobolus miyabeanus* in high yielding rice cultivar PR114 in the irrigated agro-ecosystem of Panjab, India and reported that integrated disease management could minimize the occurrence of brown spot in such agro-ecosystem. The components of variation for number of affected tillers by brown spots/hill showed considerable phenotypic covariance (-0.482) in comparison to genotypic covariance (-2.290). The mean of co-heritability for the number of affected tillers by brown spots/hill versus yield was 3.350. The positive environmental co-variance (1.550) indicated a great influence of environment upon the infection of tillers by brown spot causing pathogen.

Development of disease index

Disease index (%) showed a highly significant mean sum of square due to cultivars. The mean values ranged from 0.00 to 88.33%, with a mean performance of 58.056 (Table 2). The highest disease index was obtained from Binnipakri (88.33%) and it was significantly different from all other cultivars. The phenotypic covariance (-6.937) was higher than the genotypic covariance (-6.556) as presented in Table 3. The considerable difference between genotypic and phenotypic co-variances indicated that the environment had favored remarkably for the development of diseases. The value of co-heritability of disease index (%) versus yield was 0.889.

The highest yield (5.037 t/ha) was obtained from the cultivar Ranjit but it was not significantly different from the yields of Paijum, Kalozira and Begunbichi. Among these higher yielding cultivars, disease index scored zero only against the cultivar Kalozira. The lowest yield (2.033t/ha) was recorded from the cultivar Binnipakri and its yield potential did not differ from the yields of Zirashail, Nazirshail, Kaloshoru, Sadakatari, Lalfota, Sumon sorna, Moulata, Zaithakatari, Chinigura, Rajshahi sorna, Uknimodhu and Katari cultivars. In these thirteen lower yield potentials disease index was scored zero against the cultivars, Nazirshail, Sadakatari and Sumon sorna. The inherent yield potentials did not remarkably affect by these three major diseases but the development of these diseases could not be checked without application of pesticides which were hazardous for environment. Besides, the farmers are not conscious about the judicious application of the toxic chemicals in controlling these diseases during crop management. Therefore, disease index score along with yield potential of a particular cultivar could be simultaneously considered during selection of cultivars for the improvement of fine rice.

Conclusion

The observed covariance and co-heritability indicated that degrees of resistance against the major diseases are varying in 30 fine rice cultivars. Within the highest yielders Kalozira scored zero disease index, where as in poor yielders Nazirshail, Sadakatari and Sumon sorna scored zero disease indices against the three major diseases. Among these major diseases, yield versus brown spot revealed the highest co-heritability, yield versus disease index showed the highest value and between yield versus brown spot, brown spot was predicted by the maximum environmental covariance. This study of major disease of rice along with yield and yield contributing characters and its finding will be useful for the selection of fine rice genotypes with better disease resistant and high yielding potential.

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