GENETIC ANALYSIS OF RESISTANCE TO STEM ROT PATHOGEN (*MACROPHOMINA PHASEOLINA*) INFECTING JUTE[1]

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ABSTRACT - To study the inheritance as well as combining abilities for resistance to stem rot disease [*Macrophomina phaseolina* (Tassi) Goid.] in jute (*Corchorus olitorius* L.) the diallel crosses among seven varieties excluding the reciprocals were evaluated against this disease under 'sick plot' condition on the Gangetic plains of West Bengal, India during the months from May to September ('kharif' season) of 1989. Genetic analysis of the data showed that additive gene effect was predominant over nonadditive gene effect. General combining ability (gca) effect showed that the parents Russian red, Sudan green, Tanganyka and JRO-878 were the best general combiners towards desirable direction of resistance to this disease, while the specific combining ability (sca) effect was recorded to be highest in the cross Peking x JRO-7835 where both parents had undesirable gca effect. Some of the good general combiners also produced desirable sca effect in some of the cross combinations such as Russian red x JRO-878, Sudan green x JRO-878 and Tanganyka x Russian red. Average disease index of the parents and their F_1 progenies further showed that resistance to stem rot pathogen *M. phaseolina* was dominant over susceptibility.

Index terms: susceptibility, combining ability.

ANÁLISE GENÉTICA DA RESISTÊNCIA DA JUTA AO PATÓGENE DA PODRIDÃO-DO-CAULE (*MACROPHOMINA PHASEOLINA* L.)

RESUMO - Foram avaliados, durante os meses de maio a setembro (estação do 'Kharif') de 1989, nas planícies do Ganges, a oeste de Bengala, Índia, em condição de 'sick plot' (parcela infectada), os cruzamentos dialélicos - excluídos os recíprocos - entre sete variedades de juta (*Corchorus olitorius* L.), com o objetivo de estudar sua herança e sua capacidade de combinação, com vistas à resistência à podridão-do-caule (*Macrophomina phaseolina* (Tassi) Goid.). A análise genética dos dados mostrou que o efeito do gene aditivo predominou sobre o efeito do gene não-aditivo. A capacidade geral de combinação (cgc) mostrou que os pais Russian red, Sudan green, Tanganyka e JRO-878 foram os que melhor combinaram para obtenção de resistência a essa doença, enquanto o efeito da capacidade de combinação específica (cce) se mostrou maior no cruzamento Peking x JRO-7835, em que ambos os pais mostraram um efeito de capacidade geral de combinação (cgc) não desejado. Alguns dos combinantes gerais de boa qualidade também produziram um efeito desejável de capacidade geral de combinação em algumas das combinações, tais como na Russian red x JRO-878, Sudan green x JRO-878 e Tanganyka x Russian red. O índice médio da doença nos pais e sua progênies F_1 mostrou, além disso, que o grau de resistência ao patógeno *M. phaseolina* era maior que o da suscetibilidade.

Termos para indexação: susceptibilidade, capacidade de combinação.

INTRODUCTION

Stem rot of jute (*Corchorus capsularis* L. and *C. olitorius* L.) caused by *Macrophomina phaseolina* (Tassi) Goid. [= *Rhizoctonia bataticola* (Taub.) Butler] is a serious disease

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of this crop in different parts of India. The disease is particularly severe in eastern parts of the country including states of Assam, West Bengal, Bihar and Orissa as it causes significant reduction in yield and quality of the fibre under favourable climatic conditions. The same fungus may attack this crop at different stages of plant growth causing 'collar rot', 'seedling blight' and 'root rot' (Ghosh & Mukherjee, 1970). The pycnidial stage of the fungus is responsible for stem rot in mature plants (Ashby 1927). Characteristics symptoms of the disease are the formation of lesions on the stem as blackish brown depression which increase in size, and several such lesions may coalesce and finally girdle the stem. Where streaks run along the length of the stem the cortex becomes shredded exposing fibres. In case of severe infection pycnidia and sclerotia are formed on capsule and seed.

Lateritic and alluvial soils with low pH (5.6 to 6.5), high level of nitrogen, high rainfall, moderate temperature and high humidity favour infection on stem (Ghosh & Basak 1965). As the disease is both seed and soil borne (Varadarajan & Patel 1943) chemical control with organo mercuric compounds or systemic fungicides does not seem feasible. Cultural practices of control by increasing soil pH, and application of nitrogen coupled with potash (Ghosh & Basak 1965) are also not practicable to the farmers everywhere. Moreover, the sources of resistance to this disease are not properly identified except in a few varieties like D-154 and Fanduk of *C. capsularis*, and Chinsurah Green, R-26 and Dacca Local of *C. olitorius* (Kundu et al. 1959). The objective of this paper is to identify the sources of resistance and to study the inheritance of resistance to stem rot pathogen *M. phaseolina* for the development of resistant hybrids or synthetic varieties.

MATERIAL AND METHODS

The study was undertaken at the Jute Research Station of Bidhan Chandra Krishi Viswavidyalaya, Kalyani (22.5°N, 88.2°E) located on the Gangetic plains of West Bengal during the months from May to September (kharif season) of 1989. The soil of the experimental field was alluvial in nature with pH 6.5. Cropping history of the previous seasons was only jute with normal agronomic practices. During the growing season at Kalyani the average weather data for a period of three successive years during the susceptible stage of plant growth show that the daily average maximum temperature varies from 31.4°C to 33.8°C, frequent rainfall occurs (total monthly 34.6 mm to 368.8 mm) and high humidity (70.0% to 91.2%) persist (Kaiser & Das 1988). Hence from ecological point of view, the existing soil type and weather conditions in the Gangetic plains at Kalyani during the growing season of jute are conducive for the development of stem rot disease.

In the experimental procedure, diallel crosses in all possible combinations among seven varieties of *C. olitorius*, namely JRO-632, JRO-7835, JRO-878, Peking, Russian red, Sudan green and Tanganyka excluding the reciprocals were made on the basis of disease reaction at different locations of All India Coordinated Research Project on Jute and Allied Fibre Crops. The resultant 21 F_1 hybrids and their parents were then evaluated for resistance to stem rot pathogen *M. phaseolina* under 'sick plot' condition. Previous test in the 'sick plot' showed that the variety JRO-7835 exhibited uniform susceptible reaction to this stem rot pathogen for three successive years 1985, 1986 and 1987. Seeds of F_1 hybrids and their parents were planted during middle of May in 2-row plots with three replications. Each row was 5 m long and contained about 70 plants. About 45 days prior to planting finely chopped *M. phaseolina* infected jute stem of previous season and 3 cm thick layer of farm yard manure and compost were thoroughly mixed to the soil by ploughing for increasing the inoculum density following the method adopted by Kaiser & Das (1983). Normal agronomic practice was followed and no plant protection measure was undertaken during the entire growing season.

Disease symptoms appeared as the plants approached maturity and the disease severity was rated on individual plant basis seven days prior to harvesting with the help of a one (very slight infection) to ten (very heavy infection) disease index rating scale. After calculating the average disease index per plant the type of reaction in a testing variety was determined as described below:

Average disease index	Intensity of infection	Reaction
1.0 to 2.0	**Very slight to slight infection,** very few to few scattered lesions on stem.	Resistant
2.1 to 4.0	**Light infection,** moderate number of lesions on stem, some of them are larger in size, a very few lesions coalesce.	Moderately resistant
4.1 to 6.0	**Moderate infection,** lesions abundant and larger in size, some of them coalesce.	Moderately susceptible
6.1 to 8.0	**Heavy infection,** lesions abundant, most of them coalesce to girdle the stem or form streaks.	Susceptible
8.1 to 10.0	**Very heavy infection,** lesions abundant, most of them coalesce to girdle the stem or form streaks, infection extending upto capsule and seed.	Highly susceptible

The statistical analysis II of Gardner & Eberhert (1966) for variety cross diallel was adopted to estimate the general combining ability (gca) and specific combining ability (sca). The gca effect and sca effect were further studied after analysing the data following Griffing's (1956) method 2 or Model I. In the present case gca is equivalent to variety effect of Gardner & Eberhert (1966).

RESULTS AND DISCUSSION

The average disease index of F_1 hybrids and their parents on reacting with the stem rot pathogen *M. phaseolina* are sinificantly different as evidence by the general analysis of variance, and hence the analysis of variance for combining ability was followed as presented in Table 1. The table shows that the variance for both gca and sca are highly sinificant, which indicates the presence of both additive and nonadditive genes in controlling resistance to this diseases. It is also evident from the table that the estimated variance for gca as exhibited by the combining ability is much higher than that of sca, there by indicating the predominance of additive genetic effects in controlling resistance to this disease. A study by Boling & Grogan (1965) to determine the genetics of host reaction to *Fusarium* ear rot (*F. moniliforme*) of corn revealed that the estimates of additive genetic effects proved to be important in the inheritance of host resistance. Kappleman & Thompson (1966) found that additive genetic effects were significant for eight populations studied in case of *Diplodia* stalk rot (*D. maydis*) of corn. Kulkarni & Sinde (1985) also reported the importance of both additive and nonadditive genetic effects in determining the *Striga* resistance in sorghum. The results of the present study, therefore, suggest that the pedigree method of selection can be also used for the improvement of resistance in jute to stem rot pathogen *M. phaseolina* due to predominance of additive genetic effects in controlling resistance to this disease.

The average disease index, gca effect, sca effect and the respective standard error are presented in Table 2. From the average disease index it appears that all the parents, except JRO-7835 and Peking, and the F_1 progenies are resistant to moderately resistant in disease reaction. The parents JRO-7835 and Peking

TABLE 1. Analysis of variance for combining ability of 7 x 7 cross diallel of jute for resistance to stem rot pathogen *Macrophomina phaseolina*.

Source	DF	SS	MS
gca	6	15.087	2.154**
sca	21	24.289	1.157**
Error	54	2.357	0.044NS

** Significant at 1% level of probability

NS = Not significant.

TABLE 2. Average disease index (above diagonal), general combing ability (gca) effect (gi), specific combining ability (sca) effect (sij) (below diagonal) and the respective standard error.

	JRO-632	JRO-7835	JRO-878	Peking	Russian Red	Sudan Green	Tanganyka	gca effect
JRO-632	4.00	3.67	1.33	2.00	2.00	1.00	1.00	0.143**
JRO-7835	0.356*	6.33	3.33	1.33	1.00	3.33	3.00	0.957**
JRO-878	-0.725**	0.462**	2.00	1.67	1.33	1.33	2.00	-0.302**
Peking	-0.759**	-2.420**	-0.643*	5.00	3.33	1.33	1.67	0.402**
Russian Red	0.093NS	-1.720**	-0.131NS	1.164**	2.00	1.00	1.00	-0.450**
Sudan Green	-0.943**	0.573**	-0.168NS	-0.872**	0.350*	2.00	2.00	-0.413**
Tanganyka	-1.019**	0.167NS	0.426**	-0.608**	-0.426**	0.537**	2.00	-0.337**

SE (gi) = ±0.065; SE (sii) = ±0.188; SE (gi-gj) = ±0.100; SE (sij) = ±0.160; SE (sii-sjj) = ±0.221; SE (sij-sik) = ±0.280; & SE (sij-skl) = ±0.262

** Significant at 1% level of probability

* Significant at 5% level of probability

NS = Not significant.

are, however, suceptible (average disease index 6.33) and moderately susceptible (average disease index 5.00), respectively. When any one of these two parents were crossed with a resistant or a moderately resistant parent the resultant F_1 progenies always reacted towards resistance. Further, when two resistant parents with an average disease index 2.0 were used in the cross combinations the resultant F_1 progenies show an average disease index always less than 2.0. Therefore from the average disease index of the parents and their respective crosses it is clear that resistance to stem rot of jute is dominant over susceptibility. Similar phenomenon was observed by different workers in a number of plant diseases, for example, in cases of (i) *Diplodia* stalk rot of corn (Kappleman & Thompson 1966), (ii) *Fusarium* ear rot of corn (Boling & Grogan 1965), (iii) *Cephalosporium* stalk rot (*C. acremonium*) of corn (Khan & Paliwal 1980) and (iv) oval leaf spot (*Ramulispora sorghiwala*) in sorghum (Grewal et al. 1987).

Table 2 further shows that among the seven parents studied four parents, namely JRO-878, Russian red, Sudan green and Tanganyka are the best general combiners for resistance to *M. phaseolina*. It is also clear that some of the crosses exhibit negative sca effects with the involvement of a good general combiner and a poor general combiner as in the cases of JRO-878 x JRO-632, Peking x JRO-878, Russian red x JRO-7835, Sudan green x JRO-632, Sudan green x Peking, Tanganyke x JRO-632 and Tanganyka x Peking. Therefore these crosses may produce desirable transgressive seggregation in F_2 generation. Among the 21 sca effects the best specific combiners were recorded in the cross Peking x JRO-7835 where both parents have undesirable gca effect. Some of the good general combiners also produced desirable sca effect in some of the cross combinations such as Russian red x JRO-878, Sudan green x JRO-878 and Tanganyka x Russian red. Intra and inter-specific crosses of jute made by Haque et al. (1979) also revealed that moderately resistant to moderately susceptible progenies against the stem rot pathogen *M. phaseolina* could be developed in B_3F_6. However, in the crossing programme those workers used both cultivars and wild type disease resistant parents.

CONCLUSIONS

1. The variance for both gca and sca are highly significant, which indicates the importance of both additive and nonadditive genetic effects in controlling resistance to stem rot of jute.

2. The nature of variance may be understood by studying the gca/sca ratio. This ratio is higher than unity, which indicates the predominance of additive genetic variance.

3. When a susceptible or a moderately susceptible parent was crossed with a resistant or a moderately resistant parent the resultant F_1 progenies always reacted towards resistance. The result indicates that resistance is dominant over susceptibility.

4. The gca effect shows that some of the parents (JRO-878, Russian red, Sudan green and Tanganyka) are better general combiners than others (JRO-7835 and Peking) towards desirable direction for resistance to this disease. Although these better general combiners produced desirable sca effect in the crosses Russian red x JRO-878, Sudan green x JRO-878 and Tanganyka x Russian red, but it was recorded to be highest in the cross JRO-7835 x Peking. Thus a better general combiner may not always be a better specific combiner.

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