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The relation between certain host characters and bacterial blight incidence in rice*

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ABSTRACT

Amongst the different morphological features of rice varieties studied, no correlation was obtained between disease development and narrow or broad leaves, thick and thin leaves, pale and dark green leaves. However a strong correlation was observed between hairy and glabrous leaf texture and disease development. Hairy varieties suffered significantly more disease than glabrous varieties under natural field conditions though both were equally susceptible when pin-prick inoculated with the pathogen.

1. INTRODUCTION

VERY little information is available on the relation between morphological features of the host and its susceptibility to infection by bacterial blight organism.[1–3] Therefore, studies were undertaken to understand the relation between varietal reaction to bacterial blight in rice and certain morphological traits of the varieties.

2. MATERIALS AND METHODS

2.1. TESTING OF VARIETIES WITH DIFFERENT MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS

Twenty-five varieties with different morphological and physiological characters, *viz.*, broad and narrow, thick and thin, hairy and glabrous leaves and varieties with pale and dark green leaves, 'Zebra' and 'Cheetah' like speckled leaves, midribless and midrib present mutants, and varieties differing in amylose content of grain from 14–30 per cent were included in the study (table 1).

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Table 1. Reaction of 25 rice varieties to *X. oryzae* and the associated morphological characters, leaf colour and amylose content of grain of the host

Variety	Associated characters	Method of inoculation	
		Pin-prick	Spray
		Lesion length (cm)	% of leaf area infected in angular values
Broad vs. narrow, thick vs. *thin and hairy* vs. *glabrous leaves*			
R_{17} Tainan 3 mutant	Broad, hairy	1·53	36·73
R_5 Tainan 3 mutant	Narrow, hairy	3·16	36·84
352–2 Saturn mutant	Thick, hairy	7·50	67·57
299–1 Saturn mutant	Thin, hairy	7·86	56·67
R_1 Tainan 3 mutant	Broad, hairy	4·36	53·40
R_{30} Tainan 3 mutant	Broad, glabrous	2·26	26·86
Dark vs. *pale green, Zebra* vs. *Cheetah leaves*			
843–2 Saturn mutant	Dark green	10·93	60·93
863–2 Saturn mutant	Pale green	8·93	19·94
1–10 A Saturn mutant	Zebra leaves	6·86	67·93
PTB 10 Cheetah mutant	Cheetah-like speckled leaves	7·63	67·74
Saturn parent	Pale green	7·50	71·96
Midribless vs. *midrib present leaves*			
CR 75–93 mutant	Midribless	4·53	23·24
CR 75–93 parent	Midrib present	5·46	60·38
Amylose content of grain (%)			
Texas Patna	30	7·13	65·43
Rexoro	30	11·10	47·86
Taichung (Native) 1	27–29	7·93	61·21
GEB 24	27–29	2·73	52·74
IR 8	27	7·03	68·32
T 141	23·7	3·53	57·77
PTB 10	23·5	5·00	43·18
Jaya	20·6	6·40	58·73
Tainan 3	19·0	2·83	54·42
Early Prolific (AC 1768)	15–16	2·10	19·84
Century Patna	14–15	12·06	80·47
CR HP–8	No amylose but having only amylopectin	8·76	57·19
Mean		6·20	52·69
	C.D. at 5% =	2·12	17·14
	1% =	2·82	22·86

When the seedlings were 25 days old, they were transplanted at two seedlings per pot, into 22·5 cm diameter earthen pots which were filled with 4 kg of field soil. Nitrogen in the form of ammonium sulphate, phosphorus in the form of superphosphate and potassium in the form of muriate of potash were applied at N_{120} P_{60} K_{60} kg each/ha respectively in all the pots as a basal dose at the time of transplanting.

When the plants were 60 days old, they were inoculated by pin-prick and spray inoculation methods.[5] The first method would help in determining the inherent resistance of the host to the pathogen while the second would help in estimation of protective features of host morphology as entry of bacteria in the host was always through natural openings and wounds, etc.

Fourteen days after inoculation, the lesion length was measured[6] in the case of pin-prick inoculation method. The percentage of leaf area infected per plant was observed at 21 days after inoculation in the case of spray inoculation method.

2.2. INCIDENCE OF BACTERIAL BLIGHT ON HAIRY AND GLABROUS VARIETIES IN THE FIELD

Three hundred and twenty-two hairy and 191 glabrous fixed cultures, derived from several crosses and subjected to chemical mutagenesis, were grown in the field by the Rice Technologist of this Institute.

The plants were scored individually at the flag leaf stage for the percentage of leaf area infected per plant under natural heavy disease pressure.

The varieties were grouped into four grades by adopting the following 0–4 grade system: 0 = no disease; 1 = 0·1–25 per cent leaf area infected; 2 = 25·1–50 per cent leaf area infected; 3 = 50·1–75 per cent leaf area infected; 4 = 75·1–100 per cent leaf area infected.

2.3. EFFECT OF RANDOM PLANTING OF HAIRY AND GLABROUS VARIETIES ON THE DISEASE OCCURRENCE UNDER NATURAL FIELD CONDITIONS

(i) Ten seedlings of the hairy variety, CR 75–83 15Kr Mut 13–5 were randomly planted amongst 90 plants of the glabrous variety, CR 75–83 LT 15Kr 38–41 at one seedling per hill. Care was taken to see that the seedlings of the hairy variety were not transplanted in the border rows. The spacing between the plants and rows was 20 cm. The unit plot size was 2·2 m × 2·2 m. Each plot was separated from another by a gap of 1 m all-round. The plants were fertilised with N_{80} P_{60} K_{60} kg/ha as a basal dose and another dose of N_{40} kg/ha was applied at boot leaf stage. There were four replications.

All ten hairy plants and ten plants of the glabrous variety randomly selected, leaving the border rows, were observed individually for the percentage of leaf area infected at the flag leaf stage.

(ii) In another experiment, ten seedlings of the glabrous variety CR 75–83LT 15Kr 38–41 were randomly planted amongst 90 plants of the

hairy variety, CR 75–83 15Kr Mut 13–5. The experimental details were the same as mentioned in the previous experiment. All ten glabrous plants and ten plants of the hairy variety randomly selected, leaving the border rows, were observed individually for the percentage of leaf area infected at the flag leaf stage.

2.4. REACTION OF TWO HAIRY AND TWO GLABROUS VARIETIES UNDER ARTIFICIAL INOCULATION METHODS

Two hairy (CR 75–83 25Kr Mut 11 and CR 75–83 15Kr Mut 13–5) and two glabrous (CR 75–83 LT 25Kr 4–31 and CR 75–83 LT 15Kr 38–41) varieties derived from the same cross Rexoro × Chainan 8 were grown in pots. They were inoculated by pin-prick and spray inoculation methods. Another set of plants were spray inoculated after injury. In this case, the plants were disturbed to cause mechanical injury by subjecting them to a gust without breaking the leaves followed by spraying the plants with the inoculum and the percentage of leaf area infected per plant was recorded 21 days after inoculation.

2.5. MORPHOLOGICAL AND HISTOLOGICAL FEATURES OF THE LEAVES OF HAIRY AND GLABROUS VARIETIES

The hairy and glabrous varieties used in the previous experiment were grown in pots. The morphological features were studied by direct observation of the leaves under the microscope to observe the surface structures and the histological characteristics were studied by cutting microtome sections to observe internal anatomical features of the leaves.

3. RESULTS

3.1. TESTING OF VARIETIES WITH DIFFERENT MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS

No relation between leaf width and leaf thickness and disease development was observed either with respect to lesion length or the percentage of leaf area infected (table 1).

There was no significant difference between hairy and glabrous varieties in the lesion length when inoculated by pin-prick method. However, they varied significantly when inoculated by spray method. The hairy variety showed more percentage of leaf area infected than the glabrous variety.

The intensity of green colour of the leaves did not seem to play any role in the disease development. The pathogen could infect the apparently

chlorophyll lacking areas in 'Zebra' and 'Cheetah' mutants. The dark and pale green leaved Saturn mutants also did not differ significantly with each other.

There was also no significant difference between the midribless mutant and midrib present parent when inoculated by pin-prick method. But they varied significantly when they were spray inoculated. The midrib present parent showed more percentage of leaf area infected than the midribless mutant.

Neither did amylose nor amylopectin content of grain seem to influence the disease development irrespective of the method of inoculation employed.

3.2. INCIDENCE OF BACTERIAL BLIGHT ON HAIRY AND GLABROUS VARIETIES IN THE FIELD

Amongst the hairy varieties, 0·9, 8·4, 16·8, 30·2 and 40·7 per cent of the varieties fell under grades 0, 1, 2, 3 and 4 respectively. Amongst glabrous varieties, 60·8, 34·0, 3·7, 0·5 and 1·0 were in grades 0, 1, 2, 3 and 4 respectively (figure 1). The percentage of hairy varieties showing the highest infection grade (4) was 40·7 while it was only 1·0 per cent in the case of glabrous varieties. On the other hand, 60·8 per cent of the glabrous varieties were in '0' grade while the hairy varieties were only 0·9 per cent in this grade.

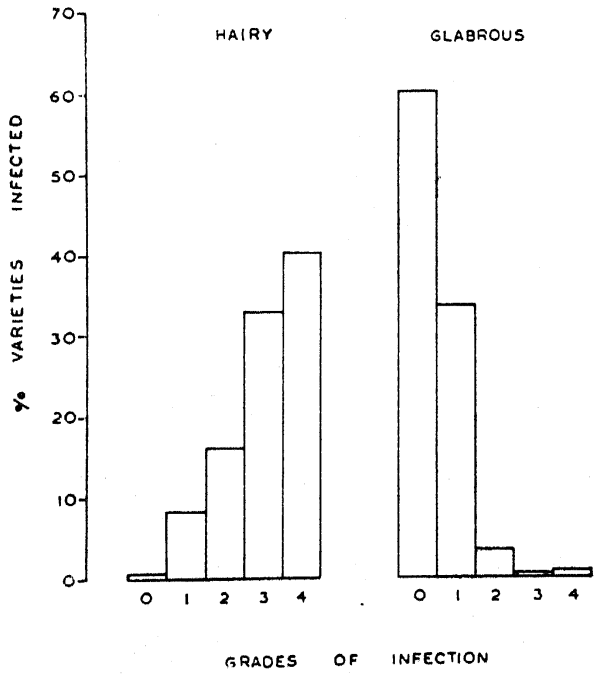

Figure 1. Incidence of bacterial blight on hairy and glabrous varieties.

3.3. EFFECT OF RANDOM PLANTING OF HAIRY AND GLABROUS VARIETIES ON THE DISEASE OCCURRENCE UNDER NATURAL FIELD CONDITIONS

(i) Ten plants of the hairy variety showed maximum disease development (68·4 per cent leaf area infected per plant) while the plants of glabrous variety showed only traces of infection (5·7 per cent leaf area infected). The hairy plants first caught the infection and showed maximum disease whereas the glabrous plants developed infection at a later stage.

(ii) In another experiment also where ten plants of the glabrous variety were randomly distributed in the background of the hairy variety, the glabrous plants again showed only 4·2 per cent infection per plant while the background hairy plants showed 71·3 per cent of infection.

3.4. REACTION OF TWO HAIRY AND TWO GLABROUS VARIETIES UNDER ARTIFICIAL INOCULATION METHODS

The two hairy and glabrous varieties showed almost the same lesion length when inoculated by pin-prick indicating that they were all equally inherently susceptible (figure 2). However, the hairy varieties had more infection than glabrous varieties when they were spray inoculated without causing injury to the foliage. Even when these varieties were subjected to a gust and then inoculated, both the hairy varieties showed higher infection than the glabrous ones. Inoculation after exposure to gust resulted comparatively higher infection in glabrous varieties when compared to infection which developed without spray injury.

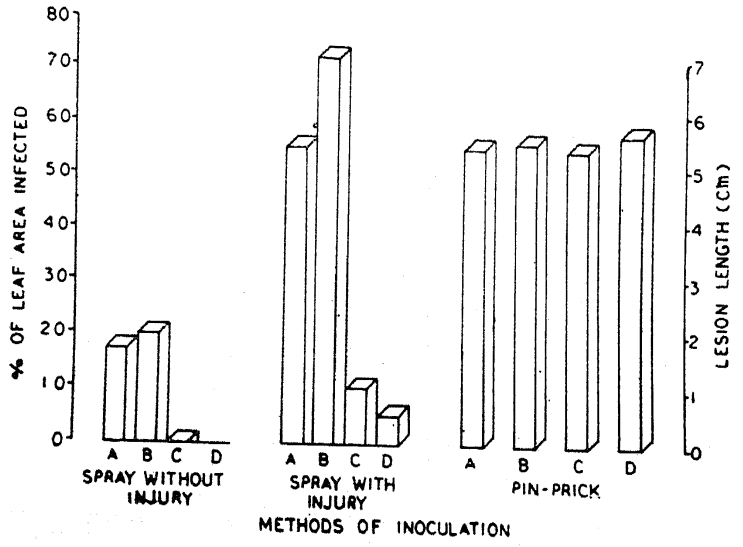

Figure 2. Reaction of hairy and glabrous varieties under different methods of inoculation. A. CR 75–83 25Kr Mut 11 (Hairy); B. CR 75–83 15Kr Mut 13–5 (Hairy); C. CR 75–83 LT 25Kr 4–31 (Glabrous); D. CR 75–83 LT 15Kr 38–41 (Glabrous).

3.5. MORPHOLOGICAL AND HISTOLOGICAL FEATURES OF THE LEAVES OF HAIRY AND GLABROUS VARIETIES

Large number of different types of hairs arising over the veins and also in the inter-veinal zones were found on the surface of the lamina of the hairy varieties and they were totally lacking in the case of glabrous varieties.

The distribution of marginal hairs in the hairy and glabrous varieties was somewhat interesting. In both types, the hairs were more abundant towards the apex of the leaf than towards the middle portion. Further, they were more in one margin than the other margin of the leaf in glabrous varieties. As far as the basal portion of the leaf blade was concerned, marginal hairs were absent in all the four varieties.

Though both the hairy and glabrous varieties possessed marginal hairs towards the apex of the leaf blade, there were more number of marginal hairs, big in size and also closely placed in the case of hairy varieties. But in the case of both the glabrous varieties, the marginal hairs were small in size, less in number and were widely placed.

No clear-cut differences in the internal anatomical features was noted between the hairy and glabrous varieties.

4. DISCUSSION

Narrow leaf character was reported to be associated with the resistance of the host by Kiryu and Mizuta[1,2] and Singh and Rao.[3] In the present study, however, no such association was observed. According to Sulaiman and Ahamed,[4] broad-leaved types resulted in an increase of the disease. But, no relationship between broad-leaved and narrow-leaved varieties included in this study were found either in lesion length or the percentage of leaf area infected. Similarly, there was no difference in the spread of infection between thick and thin leaves.

Under natural field conditions, the total leaf area exposed to infection might be less in narrow leaves as compared to broad leaved varieties as observed by Kiryu and Mizuta.[2] Since these varieties were artificially spray inoculated till run-off level, the area of exposure might not have played any role in the present study. Therefore, testing of large number of varieties with distinct characters under both natural field conditions and artificial inoculation tests might help to clarify such discrepancies.

While screening 6,000 Assam Rice collections for their resistance to bacterial blight under natural and artificial clip inoculation conditions, Devadath

and Seshagiri Rao (unpublished) observed that, in general, the narrow-leaved varieties were more tolerant than the broad-leaved varieties under natural disease pressure in the field but the disease ratings in the clip inoculation failed to indicate such differences and all of them were found to be equally susceptible. Their observations thus confirmed the idea that the leaf width was not associated with genetic resistance, but helped as an escape mechanism. Moreover, the narrow-leaved BJ_1 variety and the broad-leaved varieties like Malagkit Sungsong, Nagakayat and Lacrosse × Zenith-Nira were all equally resistant (Devadath, personal communication). The view expressed by Kiryu and Mizuta[2] and Sulaiman and Ahamed[4] could not be confirmed by the present data under artificial inoculation wherein the foliage was covered uniformly with the bacterial suspension.

The intensity of green colour of the leaves did not seem to play any definite role in the disease development. This is in contrast to the findings of Singh and Rao[3] wherein they observed that mutants with dark green leaves were more resistant. It might be surmised that the colour of the leaf had no relation with the disease development because bacterial blight was a vascular disease.

The percentage of leaf area infected was less in midribless mutant than its prominent midrib possessing parent, thus indicating a close affinity of the bacterium towards the vascular tissue since it was a xylem-borne pathogen. Therefore, the midribless character, though seemed to be of some use in reducing the disease intensity under field conditions, midribless nature of the leaf was considered to be agronomically an undesirable character in rice.

In the present study, no relationship was found to exist between amylose and amylopectin content of the grain and the disease development thus agreeing with the findings of Singh and Rao.[3]

Contrary to the findings of Singh and Rao,[3] there was no difference in lesion length produced between hairy and glabrous varieties when they were pin-prick inoculated. But, observations recorded on the natural incidence of the disease in field conditions consistently showed that the glabrous varieties suffered less disease than hairy varieties. Even when a hairy variety was planted randomly in the background of a glabrous variety and *vice versa*, only the hairy variety suffered more blight than the glabrous one. Thus, there seems to be a very close association between the leaf hairiness and the natural occurrence of bacterial blight.

Microscopic examination of the leaves of those varieties showed large number of hairs on the surface and also the margins of the leaves in hairy varieties whereas the surface hairs were totally lacking in glabrous varieties. Therefore, such morphological characters indicate that the hairs help in

the successful entry of the pathogen either by providing more entry points to the pathogen when the hairs break due to mechanical injury or by providing congenial micro-climate over the leaf surface against the sunlight, dry weather or other adverse climatic conditions. The fact that some of the surface hairs also occurred above the veins in hairy varieties indicated their positive role in hastening up of the infection.

These findings have some practical significance in bringing down the disease in the field. For instance, breeding of glabrous rice varieties and cultivation of such varieties in large areas might reduce the disease intensity thereby arresting the disease build-up. However, this might not help in cyclone proned areas where the plants could be injured easily. Therefore, genetical tolerance coupled with glabrous leaf texture would be a suitable combination for reducing the secondary spread of bacterial blight.

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B5 —May 77