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Distribution of Silica in Relation to Resistance to 'Blast' Disease in Rice

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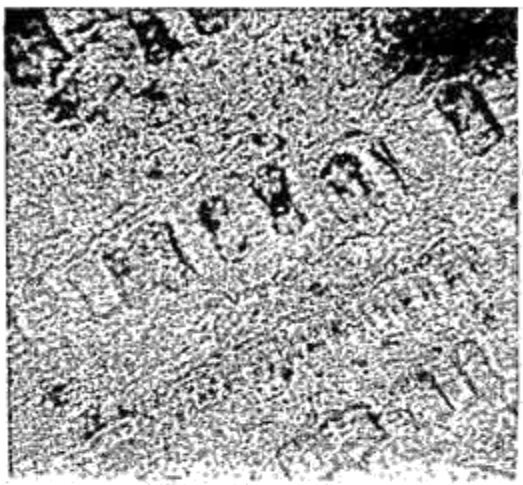
Introduction: 'Blast' disease of rice caused by *Piricularia oryzae* Cav. is known to occur in almost all the rice-growing countries of the world. It is by far the most important disease in the Madras State, causing severe losses to cultivators in the years when the seasonal conditions are favourable for the infection and spread of the disease. The only effective method of combating this disease so far known is by growing resistant varieties. The problem of disease-resistance in plants has aroused much interest among workers in the field of plant pathology and numerous investigations have been carried out on the morphological characters of the plant in relation to its resistance to diseases.

Cobb (1892) was the first to find that the resistance to rust of wheat varieties was correlated with morphological characters. Hursh (1924) found out that the resistance of wheat to *Puccinia graminis* was correlated with the relative proportion of sclerenchyma to collenchyma. Willaman and others (1925) reported that the varieties of plum that are resistant to disease have a higher crude fibre content, tougher skin and firmer flesh than the susceptible ones. Melhender and Craigie (1927) found that a correlation exists between the resistance of barberry leaves to stem rust and the thickness of the leaf as well as the resistance to puncture of the outer walls of the epidermal cells. Lutman (1919) found that the thickness of the skin determined the resistance of potato tubers to scab.

Studies on the relation of morphological characters to the susceptibility of the rice plant to disease have been made mostly by Japanese workers. Miyaki and Aachi (1922) found that the silica content of rice plant is correlated with the resistance of the plant to 'Blast' disease. This was confirmed by Kawashima (1927), Seki (1927), Ikari and Kubota (1930) and Miyake and Ikeda (1932). Onoder (1917) found that the silica content of healthy leaves of rice plants was larger than that of leaves affected by *Piricularia oryzae*. Nagai and Imamura (1930) found out that the varieties of rice plant that are susceptible to 'Blast' disease had a larger number of stomata on the epidermis of the pedicels of the spikes, than the resistant ones and that excessive nitrogen fertilization tends to lessen the amount of mechanical tissues in the pedicel thus enhancing susceptibility of the plant to the disease. Hashio Suzuki (1935) made exhaustive studies on the anatomical features of the rice plant and their reaction to 'Blast' and *Helminthosporium* diseases on dry and flooded soils in Japan with resistant and susceptible varieties and concluded that the thickness of the outer walls and the silicated outermost layer of the epidermal cells and the number of silicated bulliform cells, silicated long and short cells and silicated stomata are greater in resistant than in susceptible varieties and in the leaves of rice plants grown on the flooded than on the dry soil, while the number of stomata does not appear to be



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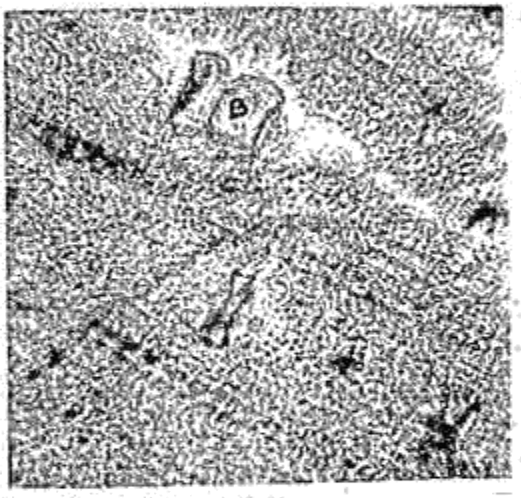

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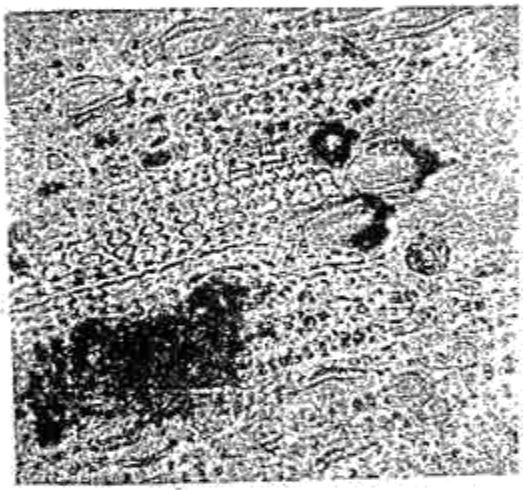

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correlated with the susceptibility to disease. He also reported that the number of silicated epidermal cells per unit area of the leaf could safely be used as a criterion in comparing the degree of silicification of the epidermal tissues of the plant. Akai (1939) concluded from a comparison of the ash figures for leaves of rice plants from humid and arid nursery beds that the number of silicated bulliform cells per unit area was greater in plants from the humid beds than in those from the arid beds and also that the bulliform cells are more easily penetrated by the fungus than the long and short cells and it is possibly significant that the number of silicated bulliform cells varies in accordance with these different conditions in the seedling stage.

There is thus considerable evidence to show that the resistance of the rice plant to 'Blast' disease is correlated with the silicification of epidermal tissues. Studies on varietal resistance of rice to 'Blast' disease was started in Madras in the year 1930 and Thomas and Krishnaswami (1947) have reported on the wide range of susceptibility to 'Blast' disease of different varieties of paddy evolved by the Madras Agricultural Department. Studies relating to the estimation of silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of 20 cultures of paddy of varying grades of susceptibility to the 'Blast' disease were made by the authors and also the effect of graded doses of nitrogenous fertiliser on the number of silicated epidermal long cells and the silicated epidermal bulliform cells per unit area of the leaf in the three established highly resistant varieties and one known highly susceptible variety was studied and the results obtained are reported in this paper.

Material and Method: *Material:* Twenty cultures of paddy of varying grades of susceptibility to 'Blast' disease were selected for the study and seedlings were raised in pots in paddy soil. The third leaf, counted from the top, from each variety was cut on the 15th day and on the 30th day after sowing and preserved in Formalin - acetic - alcohol. The leaf was divided into three equal parts and only the middle one-third of the leaf was selected for the purpose of estimation.

To estimate the effect of nitrogenous fertiliser on the number of silicated long and bulliform cells per unit area of the leaf, material was collected from the field manurial experimental plots laid out in 'O' Block, Central Farm Wetlands, Coimbatore. The material comprised four varieties (Co. 4, Co. 26, Co 25 and Adt. 10) and 4 treatments (Ammonium sulphate to supply 40 lb., 80 lb., and 120 lb. of Nitrogen per acre and control – no manure). The leaf material required for the estimation was selected at random from each of the treatments on 14—12—1950 i. e., 112 days after sowing and 60 days after application of the fertiliser. The third leaf from the top was cut, the middle third portion of the leaf was selected as before and preserved in the Formalin - acetic - alcohol.

Method: (1) *Silicated epidermal long cells:* - The leaf was cut into small bits of about half an inch in length and kept in test tubes and macerated by Schulze's maceration method *. Concentrated nitric acid was poured into the tubes to cover the leaf bits and a few crystals of potassium

*Chamberlain, C. J. (1921) Method in Plant Histology P. 137. The University of Chicago, Illinois.

chlorate added and then gently heated until bubbles were evolved and the reagents acted to make the material white. The contents of the tube were then poured into a dish of cold water and thoroughly washed. The peels were selected and stained with Safranin when only the non-silicated structures took the stain and the silicated cells were seen bright. Counts of the silicated long cells were made under the microscope. (Leitz - eyepiece 4 and objective 8). Twenty fields were counted for each variety and the mean number of silicated epidermal long cells per unit area was calculated.

(2) *Silicated epidermal bulliform cells:* The silicated epidermal bulliform cells were estimated by the 'Spodogram' method *. Pieces of the leaf material of approximately 2 x 5 m.m. were cut from the sides of the midrib and placed in porcelain dishes. They were then subject to slow continuous heat over rosette burner for 4 to 6 hours i. e., until the leaf bits turned to ash. The dishes were allowed to cool and the leaf bits removed carefully with a camel hair brush dipped in xylol and mounted on glass slides in pure xylol . The silicated bulliform cells in unit area were counted under the microscope. Twenty readings were taken in each case and mean number per unit area was calculated.

RESULTS

I. Silicification of epidermal cells in resistant and susceptible varieties: The results of the estimation of the silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of twenty cultures of paddy of varying grades of susceptibility to the disease are given in Table I along with their maximum neck infection percentages recorded in the fields so far since 1943 in order to give a comparative idea of their degree of resistance or susceptibility to the disease with their relative silicification of the epidermal cells. It can be seen from the table that most of the varieties which have shown high degree of susceptibility to the disease contain comparatively lesser number of silicated epidermal long cells and silicated epidermal bulliform cells per unit area of the leaf. The varieties Co. 4 and Co. 26 which are noted for their high degree of resistance have shown a significantly greater number of silicated cells per unit area.

II. The effect of nitrogenous fertilizer on the silicification of epidermal cells. It is generally observed that the application of increased doses of nitrogen to the soil tends to increase the incidence of 'Blast' disease in the paddy plant. In order to find out whether there is any change in the degree of silicification of epidermal long cells and epidermal bulliform cells due to application of nitrogenous fertilizer, leaf material was collected from different treatments in the manurial experimental plots as described already and the silicated epidermal cells were estimated as before and the results obtained are given in Table II. The average percentage of neck infections of the plants due to the disease in different treatments as recorded in the same field during the season are also given against each treatment.

* Warner, O. (1928) Biologia generalis IV, 403—446.

TABLE I- Silicification of epidermal cells in twenty cultures of rice of varying grades of susceptibility to 'Blast' disease.

S. No.	Variety or culture.	Percentage of Neck infection	Mean No. of silicated epidermal long cells per unit area.		Mean no. of silicated epidermal bulliform cells per unit are.	
			15 days old	30 days old	15 days old	30 days old
1.	Co. 4	0·0	6 35	15·45	19·20	19·95
2.	Co. 26	1·5	5.65	8·25	19·40	18·50
3.	3185	2·2	3·70	6·20	8·15	13·90
4.	8036	2·2	2·40	8·70	5·70	15·80
5.	3273	2·4	1·70	6 00	4·00	13·55
6.	2554	2·9	4·10	4·85	12·95	13·45
7.	2552	3 0	4·55	5·70	18·50	13 05
8.	2380	3·10	1·50	7·30	14 50	14·65
9.	2744	3·60	4·50	4·45	15·95	17·55
10.	Co. 25	4·5	3 00	6·00	14·60	15·85
11.	GEB· 24	14·9	5 05	5 05	18·15	10·00
12.	Adt. 4	17 9	0 95	2·45	6·05	5·95
13.	Co. 2	20·7	1·70	2·65	1·35	4·90
14.	Adt. 6	23·1	1·90	3·20	5·50	7·50
15.	Co. 20	31·9	1·15	3·45	9·65	3·95
16.	Co. 10	34·3	2·50	1·70	4·85	3·75
17.	Ptb. 10	45·1	1·30	2·95	10·30	7 00
18.	Co. 13	53·1	1·85	1·65	5·90	4·10
19.	Co. 19	82·5	3·10	2·95	7·70	5·10
20.	Adt. 10	100·00	1·40	1·70	3·55	3·90

TABLE II—The effect of nitrogenous fertilizer on the silicification of epidermal cells.

S. No.	Treatments.	Co. 4			Co. 26			Co. 25			Adt. 10.		
		A	B	C	A	B	C	A	B	C	A	B	C
1.	No manure (Control)	0·00	19·20	21·80	0·00	14·90	17·00	0·00	13 10	20·40	63·4	2·30	3·70
2.	Ammonium sulphate 40 lb. N per acre	0·00	14·40	19·40	0·00	12·75	18 90	0·00	11·95	15·00	82·4	1·60	2·50
3.	Ammonium sulphate 80 lb. N per acre	0·00	12·05	18·00	0 01	10·30	15·00	0·00	10·95	13·90	87·5	1·70	2·10
4.	Ammonium sulphate 120 lb. N per acre	0·00	10·80	15·10	0·00	9·65	12·70	0·02	9·60	13·50	90·3	1·70	2·30

A — Percentage of neck infection due to the disease as recorded in the field.
B — Mean number of silicated epidermal long cells per unit area of the leaf.
C — Mean number of silicated epidermal bulliform cells per unit area of the leaf.

The results obtained indicate that there is a tendency for reduction in the silicification of epidermal long and bulliform cells in both resistant and susceptible varieties due to the application of nitrogenous fertilizer. There was a significant reduction in the degree of silicification in all the three resistant varieties when higher doses of ammonium sulphate was applied, However in the susceptible variety Adt. 10 the average number of silicated epidermal long and bulliform cells per unit area was so small that the reductions due to application of manures were found to be insignificant even at higher manure levels.

Discussion. The data obtained in the above studies indicate that a correlation exists between the degree of disease resistance in the rice plant and the distribution of silica in its epidermal tissues. Except in a few cases, in all varieties there was a corresponding decrease in the degree of silicification with an increase in the susceptibility to the disease, the decrease in the number of silicated epidermal long cells and silicated epidermal bulliform cells running parallel to each other. Maximum silicification was observed in the varieties Co. 4 and Co. 26, which are noted for their high degree of resistance to the disease, the most susceptible varieties like Co. 10, Co. 13 and Adt. 10 showing the minimum amount and the rest ranging between these two levels. The lessening in the degree of silicification due to the application of nitrogenous fertilizer may be due to profuse vegetative growth of the plant and want of corresponding increase in the intake of silica to maintain the original level of silicification.

It is generally observed that the leaf infection is correlated with the neck infection of the plant due to the disease. Leaf infection takes place both through the stomata and by piercing the cuticle, Yoshi (1933). Whether the resistance is due to the physical obstruction offered by the silicated cells or to the chemical composition of the sap is a point to be investigated by further studies.

Summary and Conclusion. Studies relating to the estimation of silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of twenty cultures of rice of varying grades of susceptibility to 'Blast' disease were made to find out whether there is any correlation between the number of silicated cells in unit area of the leaf and the susceptibility of the seedlings to the disease. The effect of application of nitrogenous fertilizer on the silicification of the epidermal cells in the leaves of three known resistant and one known susceptible variety of rice was also studied.

(i) It was observed that in the leaves of all known susceptible varieties there were fewer silicated epidermal long cells and silicated epidermal bulliform cells than in the resistant varieties.

(ii) In two highly resistant varieties, Co. 4 and Co. 26, maximum number of silicated cells were recorded,

(iii) There was a tendency for reduction in the number of silicated epidermal long cells and silicated epidermal bulliform cells per unit area in both resistant and susceptible varieties when higher doses of nitrogenous fertilizer was supplied.

(iv) In the susceptible variety Adt 10, the number of silicated cells per unit area of the leaf was so small that the reduction due to the application of manure was found to be insignificant even at higher manure levels.

The results obtained confirm the findings of other workers elsewhere, and may be helpful to the breeder in selection of the material for 'Blast' resistance.

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PLATES

1. Photomicrograph of spodogram material of Co. 4 showing silicated epidermal bulliform cells.
2. ,, ,, of epidermal peelings of Co. 4 showing silicated epidermal long cells.
3. ,, ,, of spodogram material of Adt. 10 showing silicated epidermal bulliform cells.
4. ,, ,, of epidermal peelings of Adt. 10 showing silicated epidermal long cells.
5. ,, ,, of spodogram material of Co. 26 showing silicated epidermal bulliform cells.
6. ,, ,, of spodogram material of Co. 25 showing silicated epidermal bulliform cells.

Note: B: Silicated epidermal Bulliform Cell.
L: Silicated epidermal Long Cell.

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