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The Intake of Silica by the Rice Plant with Reference to Blast Disease *

by

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Introduction: The blast disease caused by the fungus Piricularia Oryzae is the most serious disease of the rice crop, but is prevalent only on certain strains of paddy while others are immune to it. Hence the effective control of the disease at present is only through the use of resistant strains. Among the Madras strains, Co_4 (Coimbatore 4) is highly resistant even under worst conditions while the variety Adt_{10} (Aduthurai 10) is highly susceptiable to the disease. The latter strain is however a high yielder and hence very popular in the Tanjore Delta.

In modern times with the advancement of science many of the characters such as resistance and other factors which are indissoluble Mendelian factors of inheritance, located in the genes of chromosomes have been explained through enzymology in terms of certain set chemical reactions resulting in definite chemical compounds. Hence this inheritance of resistance to blast, located in specific strains were aimed to be studied in terms of possible chemical constituents in the strains which bestowed on the strains the disease resistance.

A perusal of literature on the subject of disease resistance in general and with special reference to paddy-blast revealed a considerable volume of experimental evidence in favour of a plausible relationship of silica in the plant to disease resistance. Thus Onodera (1), Miyake and Adachi (2), Kawashima (3), Ikari and Kubota (4), Miyake and Ikeda (5), Ito and Hyashi (6) have all correlated silica in the rice plant to blast resistance. Suzuki (7) examining through a microscope the cross sections of the leaves and pedicels of spikes of the rice plants recognised that the outermost layers of the epidermal cell walls contained great amounts of silica and that these silicated cells were greater in the resistant variety than in the susceptible one.

A preliminary study conducted on the anatomical and chemical aspects taking pre-harvest samples of plant material belonging to the varieties Co_4 and Adt_{10} growing under identical conditions revealed the following features:—

1. *Anatomical Studies:* A number of epidermal peelings of leaves and stems at the neck of earhead of the two varieties obtained by macerating the tissue with concentrated nitric acid and potassium chlorate (as bleaching agent) were examined under the microscope and were found

* Awarded Venkataswamy Naidu's Silver medal on the College Day 1954.

to exhibit extensive silication in the form of short and long cells. These silicated epidermal cells were easily detected under the microscope when stained with phenol or chloriodide of zinc and were found to be greater per unit area of Carl Ziess 7×10 in the resistant variety Co_4 than in the susceptible one Adt_{10}. Plates I to IV show the nature of silicated cells in the leaf and stem epidermis.

2. *Chemical Studies:* Chemical analysis of leaves and stems for silica content showed that the susceptible variety contained more silica than the resistant one.

Thus while the findings of the anatomical studies made on the leaves and stems were in line with those of the Japanese workers, the chemical analysis gave results of a contradictory nature. Hence it was decided to study in detail the intake and distribution of silica in the two varieties of rice plant.

Material and Method: The rice plants were raised in pots and the two series of pots viz., Co_4 and Adt_{10} were maintained under identical conditions of irrigation etc.,

Chemical Analysis: Samples of plant material viz., leaves, stems roots, panicles and whole plants, were collected at different stages of growth and were analysed for dry matter, ash and silica. Estimation of silica was done using hydrofluoric acid on the sulphated ash.

Discussion of results: The results of analysis of the plants and plant parts of the varieties Co_4 and Adt_{10} sampled at different stages of growth given in table I present the following features :-

1. *General:* There is a continuous absorption of silica during the life of the plant upto the grain formation stage after which the absorption ceases. The leaves and stems attain their maximum silica content by the time the flowering has taken place and the grains begin to set. The panicles show an increase in silica content even after grain formation stage and there is a coincidental fall in the silica content of leaves and stems. Thus there is a certain amount of evidence of movement of silica from one part of the plant to another. The results of analysis of roots are irregular especially in the case of Adt_{10} at flowering and this is reflected in the whole plant analysis.

2. *Silica content of leaves, stems etc, with reference to resistance to blast:* When the silica content of leaves and stems is expressed as percent of ash, dry matter or green matter, the resistant variety does not show higher value than the susceptible variety, especially after the plants have come to maturity as was also observed in the preliminary studies. The results of analysis of whole plant sample show that the plants sampled at tillering stage show greater silica content in the resistant

variety than the susceptible variety. Thus while there is an indication of the resistant variety having more silica than the susceptible variety when the plant as a whole is considered during the vegetative phase, the analysis of leaves and stems after the plants have come to maturity, do not show greater silica content in the resistant variety than in the susceptible one.

TABLE I. Showing the silica content in leaves, stems etc. of the varieties Co_4 and Adt_{10} at different stages of growth (Percentages)

Material analysed and stage of growth	SILICA CONTENT					
	Ash basis		Dry Matter basis		Green Matter basis	
	Co_4	Adt_{10}	Co_4	Adt_{10}	Co_4	Adt_{10}
1. *Leaves:*						
(a) Mature Plant Stage	55·02	54·46	10·86	10·70	3·14	2·77
(b) Flowering Stage	63·58	68·22	12·75	16·48	3·73	4·41
(c) Grain formation ,,	63 76	71 34	12·16	18·52	4·30	5·81
(d) Harvest ,,	57 11	60·16	11·24	12·12	4·11	4·32
2. *Stem:*						
(a) Mature Plant Stage	30 78	37·87	5·71	8 18	0·97	1·26
(b) Flowering ,,	48·09	50·22	8·99	12·45	1·55	2·05
(c) Grain formation ,,	48·84	50·19	8·32	13·33	2·02	2·93
(d) Harvest ,,	47·88	50·06	7·97	10·14	1·98	2·22
3. *Panicles:*						
(a) Flowering Stage ,,	53·09	65·72	4·19	8·19	1·13	2·14
(b) Grain Formation Stage	76·37	77 47	9·47	8·33	5·74	5·04
(c) Harvest ,,	82·81	79·73	17·17	11 32	12·28	9·06
4. *Roots:*						
(a) Mature Plant Stage	10 69	5·55	1·50	0·76	0·30	0·15
(b) Flowering ,,	29·20	30·40	3·95	4·37	0·66	0·83
(c) Grain Formation Stage	40·87	23 72	5·46	4·47	0·90	0·78
(d) Harvest Stage	35·75	38·68	5·23	5·79	0·82	0·91
5. *Whole Plants:*						
(a) Beginning to tiller	31·23	24·29	5·07	4 27	0·79	0·58
(b) Mature Plant Stage	37·82	43·69	6·20	8·99	1·23	1·54
(c) Flowering Stage	52·78	48·52	9·45	8 99	1·69	1·66
(d) Grain Formation Stage	53·83	59·54	9·84	13·07	2 80	2·95

TABLE II. Showing intake of silica during different periods of growth as percent of total intake

(Calculation based on silica on ash figures in table I)

	Leaves		Stems		Panicles	
	Co_4	Adt_{10}	Co_4	Adt_{10}	Co_4	Adt_{10}
1. Upto Maturity ..	*86·3*	*76·3*	63·0	75·4	—	—
2. Maturity to flowering ..	13·4	19·9	*35·4*	*24·6*	*64·1	82·4*
3. Flowering to grain formation ..	0·3	4·4	1·6	Nil	*28·1*	*14·7*
4. Grain formation to harvest ..	Nil	Nil	Nil	Nil	7·8	2·9

* Represents silica content at flowering as percent of total intake.

3. *Intake of silica during critical periods of vulnerability of the plant parts to fungus attack expressed as percent of total intake:* The critical periods of vulnerability to attack differ with the different parts of the plant. Thus during the early stages of growth of the plant the foliage is more exposed to fungus attack than the stems, the latter being covered by leaf sheaths. The time when the stem is really and badly exposed to attack is when it emerges through the flag leaf bearing the earhead i. e., at the time of flowering. At that time the stems are not only well exposed but are also very juicy conducting nutrients to panicle. Thus under actual field conditions we find that the stems mainly suffer the fungal attack at the neck of the earhead (portion below earhead) at flowering stage while the foliage are attacked much earlier, even from the nursery stage. Hence it would be but right to find out if there is any correlation of silica intake at these critical periods with the resistance of the plant to disease. Table II gives data pertaining to this. It is found from the data therein that a definite correlation does exist between the rate of intake during the critical periods of vulnerability to attack and the resistance. Thus we find during the vegetative stage when the leaves are more exposed to attack the intake of silica in leaves is greater in the resistant variety than in the susceptible one (86% of total in Co_4; 76% in Adt_{10}). The variety Co_4 is a longer duration one (180 days) than Adt_{10} (165 days) and the more rapid intake of silica is not a function of an enhanced rate of maturation processes. Again from maturity to flowering when as mentioned before the stem is more exposed to attack, the intake by this part of the plant is greater in the resistant variety than in the susceptible one (35% in Co_4; 25% in Adt_{10}). It is similarly high in the panicles of the resistant variety from the flowering stage to harvest. The panicles of the resistant variety show greater intake than the susceptible one (35 9% in Co_4; and 17·6% in Adt_{10}). Thus, while the silica in the plant when considered as mere total contents at a particular date does not give a correct indication of the role of silica in the resistance of the plant to disease, the representation of the intake during the critical periods of vulnerability to fungal attack expressed as percentage of total intake gives the correct picture.

TABLE III. Showing the dry matter percentage, in leaves, stems etc. at different stages of growth

Stages of growth	Leaf		Stem		Panicle		Root	
	Co_4	Adt_{10}	Co_4	Adt_{10}	Co_4	Adt_{10}	Co_4	Adt_{10}
1. Mature plants	28 98	25·84	16·92	15·38	—	—	20·20	19·80
2. Flowering	29·27	26·74	17·16	16·46	27 08	26·13	19·69	18·94
3. Grain formation	35·40	31·39	24·30	22·00	60·02	60 57	16 38	17·36
4. Harvest	30·58	35·73	24·84	21·84	71·56	79·99	15·63	15·63

4. *Presentation of silica on surface area basis in leaves:* Another interesting feature is presented by the data of dry matter contents of the parts analysed as given in table III. It is seen from the data in this table that at all stages of growth, the leaves, stems etc., show a greater dry matter percent in the resistant variety Co_4 than in the susceptible one Adt_{10}, exceptions being very few, noticed in roots and panicles only. The greater amount of dry matter in leaves, stems etc., of the variety Co_4, it was speculated would mask the results of analysis for silica when represented on the basis of weight. If this be acceded, the presentation of silica on the basis of the area of the surface on which it is distributed would give a better picture of silication, as silica is mostly confined to the epidermal regions. To confirm this, a study was made on the leaves of the two varieties collected at harvest stage.

Two sets of 50 leaves were collected for each of the two varieties from the bulk sample used for chemical studies. Every 10th or 15th leaf from the bulk was taken according to the size of bulk. The surface area was measured by using a planimeter on the outlines of leaves traced on tissue paper. Silica was estimated as usual after drying the material and the results expressed on area basis. The results are given in table IV.

TABLE IV. Showing silica in leaves represented on area basis

No.	Particulars	Experiment I		Experiment II	
		Co_4	Adt_{10}	Co_4	Adt_{10}
1.	Green weight of 50 leaves in grams	23·1390	18 1630	22·9550	17·6310
2.	Dry weight ,, ,,	8·4650	6.4950	8·4404	6·1240
3.	Ash weight ,, ,,	1·5810	1·3780	1·5770	1·2990
4.	Silica in 50 leaves in milligrams	952 0	784 0	949 0	712 0
5.	Total surface area in sq. cm.	2742 -	2472	2534·4	2420
6.	Silica per 100 sq. cm. of leaf surface in milli grams	34.85	31·85	36·60	30·70
7.	Silica as percent of dry matter	11·25	12·12	11·25	12·12

It is seen from the data given in table IV that the differences in green weight, dry weight and ash weight is considerable in the two varieties, Co_4 showing higher value than Adt_{10}. It is also seen that the silica content per unit area is greater in Co_4 than in Adt_{10}.

Conclusion: 1. Chemical analysis of leaves and stems sampled at different stages of growth show that the silica content when represented on the basis of dry weight, green weight or ash weight bears no correlation to the resistance of the plant to blast i. e., the resistant variety Co_4 does not show higher silica content than the susceptible one Adt_{10}. However, when the silica intake in leaves, stems and panicles during the critical period of vulnerability to fungal attack is expressed as percent of total intake, there is a direct correlation between silica and resistance, the resistant variety Co_4 showing greater intake than the susceptible variety Adt_{10}.

2. The computation of silica on the basis of surface area, based on chemical analysis, gives a better picture of the silica distribution in the different parts of plant than when represented on the basis of weight and this is in line with the observation made in the anatomical studies in which the resistant variety showed more silicated cells.

3. Hence it is evident that consideration of total silica does not give the correct picture of the rôle of silica in the resistance of the rice plant to blast disease. But from this study it was established that the rate of absorption of silica by the plant parts during the critical period of vulnerability to fungal attack is the factor which decides resistance or susceptibility of a rice variety.

Summary: The blast disease on paddy caused by the fungus Piricularia Oryzae though the most serious disease of the rice crop is not prevalent on all strains of paddy. Paddy strains like Co_4 are completely immune to it. It was sought to find out criteria of a chemical nature that would indicate resistance or susceptibility. A perusal of literature on the subject showed all evidence in favour of silica as the factor responsible for resistance. However, preliminary chemical analysis of plants of the resistant variety Co_4 and a susceptible one Adt_{10} showed no greater silica content in Co_4 than in Adt_{10}, though the anatomical studies on the epidermal peelings of leaves and stems showed greater number of silicated cells in Co_4 than in Adt_{10}. Hence, a detailed study on the intake of silica by the two varieties was taken up. Plants were raised in pots. Chemical analysis for silica content was done on leaves, stems, etc. at different stages of growth and the results expressed as (i) total intake at different stages on the basis of dry matter weight etc., (ii) intake during critical periods of vulnerability to fungal attack as percent of total intake and (iii) silica content on the basis of surface area of leaves. The following conclusions were drawn:

1. The total intake of silica by leaves and stems is not correlated with the resistance to disease.

2. The intake of silica during the critical period of vulnerability of the plant to fungal attack is directly correlated with the resistance to disease, the resistant variety showing more of intake than the susceptible one.

3. Silica as assessed on the basis of area instead of on dry matter basis gives a better picture of the distribution of silica in the leaves and confirms the findings made by the anatomical studies in which greater number of silicated cells per unit area was observed in the resistant variety than in the susceptible one.

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Recent Advances in Agriculture with Special Reference to Weed Control

by

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Introduction: Taking "recent" to mean within the past ten years, a number of new developments can be enumerated as constituting advances in the field of agriculture. But from the view-point of plant physiology, these developments can be narrowed down to just three or four, viz., in the field of plant nutrition with special reference to micro-nutrients, photoperiodism, hydroponics, dormancy and growth-hormones. The last one is perhaps the most outstanding, but within the scope of this paper it is proposed to discuss only a single aspect of growth hormones, namely their* potentialities as weedicides.

* Paper read at the 1954 College Day and Conference Symposium on "Recent Advances in Agriculture."