

Silica content of rice husk as determined by soil properties and varietal differences

MERVYN W. THENABADU

*Department of Agricultural Chemistry, Faculty of Agriculture,
University of Sri Lanka, Peradeniya*

(Received 21.02.78)

SUMMARY

THE contents of silica in the husk of four varieties of rice grown at seven locations distributed in the wet, intermediate and dry zones of the island in the Co-ordinated Rice Varietal Trials Project of *Maha* 1969/70 have been determined. It is found that the content of silica in the husk varied with location. Plants growing in the dry zone stations like Ambalantota, Paranthan and Maha Illuppallama had much more silica in their husk than those growing in the wet zone stations like Karapincha and Labuduwa (or Karadian Aru in the dry zone).

The relative contribution to grain weight by the husk is low in the variety I. R. 8 compared to varieties like H-4, LD 66 and Bg 11-11.

It was also found that in general the varieties H-4 and I. R. 8 had the lowest contents of silica in the husk compared to varieties like LD 66 and Bg 11-11. With the exception of Karadian Aru, plants grown at the dry zone locations had more silica in the husk than those grown in the wet zone. Plants from Bathalagoda in the intermediate zone contained the lowest amount of silica in the husk on an average.

INTRODUCTION

The compounds of silicon account for as much as 87 percent of the earth's crust, and silica is a major constituent of soil. A large percentage of the ash of some soil grown plants contains silica. Silica is important for the healthy growth of graminaceous plants such as rice and special organs of other plants like stinging hairs of nettle possibly contain large amounts of this element. In spite of the relatively large quantities of silica in tissues of some plants

Paper presented at the 31st Annual Session of the Sri Lanka Association for the Advancement of Science (Section B) on the 10th December, 1975.

This investigation was conducted at the Central Agricultural Research Institute, Gannoruwa, Peradeniya.

silicon is still not included among the elements essential for the growth of higher plants. According to Woolley, however, it is difficult to cultivate higher plants in the complete absence of silicon (16).

The importance of silica for the normal growth of rice has been reported by many (5, 6, 7, 8, 13). According to Matsubayashi *et al.* (4) 8 to 12 kg silica are absorbed by the rice plant from the top soil and from irrigation water. A crop producing 44 kg dry grain has been estimated to remove 16.48 kg of this compound, 3.43 kg of which is in the panicle (11).

One of the benefits of silica to rice is due to the fact that silification of epidermal cells makes the plant less susceptible to blast or *Helminthosporium* leaf spot disease. In addition rice grains of silica deficient plants get stained with brown spots due to fungal diseases. The presence of adequate silica in the plant also confers stiffness to stems and leaves of the rice plant; and according to Tanaka and Yoshida (14) one of the visible symptoms of silicon deficiency in rice is the softening and drooping of leaves which enhances mutual shading. Yoshida *et al.* (17) concluded that less than 5 percent of the element in the straw at maturity indicated a deficiency condition.

Silicon deficiency during the reproductive stage of growth has been reported to reduce panicle length, and a definite effect of this element on grain yield has been reported (9). Very high yield increases due to the presence of silicon in the nutrient medium even prompted investigators to consider this element essential for rice and some other crops.

This investigation was undertaken to study the effects of soil characteristics and varietal difference on the silica content in the husk of four varieties grown in different parts of the island in the Co-ordinated Rice Varietal Trials Project of *Maha* 1969-70 conducted by the Deputy Director of Agriculture (Research) and his staff at the C. A. R. I. and at various stations of the island (2).

MATERIALS AND METHODS

50 gm. samples of paddy (rough rice) at 14% moisture content collected from seven locations were hulled in a Satake Mill and the weights of the husk and grain were recorded.

The weighed husk samples were placed in a muffle furnace and heated gradually. On heating the husk began to char around 200°C as evidenced by the blackening. Further heating produced no apparent change until around 500°C when the black colour gradually changed to white and became completely white between 600° and 700°C.

Out of sixteen medium aged (4-4½ months) varieties tested at each location only four (H 4, LD 66, Bg 11-11 and I. R. 8) were selected for this investigation. Some characteristics of the varieties reported are as follows :

SILICA CONTENT OF RICE HUSK

Varietal Characteristics

The variety H-4 has a light brown, long, slender grain and its milling out-turn percentage has been estimated at 72.4 percent. This variety is moderately susceptible to blast disease and susceptible to bacterial leaf blight.

The grain of the variety LD 66 is white, of medium size and intermediate shape. This variety is moderately susceptible to blast and bacterial leaf blight and has a milling out-turn of 69.7 percent.

The variety Bg 11-11 has a small white, bold grain. The susceptibility of this variety to blast varies from moderately susceptible to moderately resistant. It is moderately susceptible to bacterial leaf blight. It has a milling out-turn of 71.2 percent.

The variety I. R. 8 has a white, long grain with an intermediate shape. Its milling out-turn has been estimated at 74.6 percent. It is moderately susceptible to blast disease and susceptible to bacterial leaf blight.

Soil Characteristics

The characteristics of soils at the various locations were as follows:—

Wet Zone Locations

The soil at Karapincha was a strongly acid (pH 5) sandy loam with 0.21 percent total nitrogen and 5.4 percent organic matter. Its content of available P_2O_5 (Olsen's) was 65.2 lb per acre. The content of exchangeable potassium and cation exchange capacity of the soil were 0.02 in a 7.1 m.e. per 100 gm respectively.

At Labuduwa the soil was a moderately acid (pH 5.5) sandy loam (humic) containing 14.14 percent organic matter and 0.60 percent total nitrogen. The content of available phosphorus in the soil was very high (104.8 lb per acre) but the status of exchangeable potassium was low and the cation exchange capacity of this soil was high being 37.4 m.e. percent.

The soil at Bathalagoda was a moderate to slightly acidic (pH 5.9) sandy loam, low in total nitrogen and organic matter and medium in available phosphorus. It was very low in exchangeable potassium and low in cation exchange capacity (7.9 m.e. percent).

It was a slightly acidic (pH 6.1) sandy clay loam at Ambalantota which was fairly low in total nitrogen and low in organic matter content. It was well supplied with available phosphorus. The exchangeable potassium status of the soil was low while the cation exchange capacity was high being 26.2 m.e. percent.

The soil at Paranthan was a slightly acidic (pH 6.7) loamy fine sand which was low in total nitrogen and organic matter. The status of available phosphorus in this soil was very high, while that of exchangeable potassium and the cation exchange capacity were very low (3.8 m.e. percent).

At Maha Illuppallama the soil was a near neutral (pH 6.6) sandy clay loam which was fairly low in total nitrogen and very low in organic matter. The content of available phosphorus was medium while the status of exchangeable potassium was low. The cation exchange capacity of the soil was medium (15 m.e. percent).

At Karadian Aru the soil was a moderately acidic loamy fine sand, low in total nitrogen and very low in organic matter. The soil was high in available phosphorus and very low in exchangeable potassium and cation exchange capacity (5.5 m. e. percent).

RESULTS AND DISCUSSION

Grain Yields

Yield data of the four varieties of rice from the Report on the Co-ordinated Rice Varietal Trial Project, *Maha 1969/70* (2) are presented in Table I. Among these IR 8 yielded the highest and H4 the lowest.

Relative contribution of husk or hull to grain weight

The relative weight of husk in the grains, i.e. the percentage of husk over paddy on an oven dried basis is presented in Table 2. According to Lambers (3) the hull composes a part of the total weight which may vary between 16 and 24 percent depending on the variety. In this investigation the values ranged from 19 to 31 percent.

It will be observed that at all locations the variety Bg 11-11 had the highest value of husk over paddy, being significantly higher than all varieties at Kara pincha, Bathalagoda, Ambalantota, Maha Illuppallama and Karadian Aru. At Labuduwa the differences were not significant although the relative weight of husk was highest in the variety Bg 11-11. The absence of statistical significance at Labuduwa is most probably due to the relatively high coefficient of variation.

At Paranthan the relative contribution of husk to total weight of grain in Bg 11-11 was not different from that of LD 66 and H4 although Bg 11-11 had the highest weight of husk. This was significantly different to only that of IR 8. The mean values of the relative weight of husk in the grain also show Bg 11-11 to have the highest value.

SILICA CONTENT OF RICE HUSK

The data in Table 2 shows that contribution to total grain weight from the hull may range between approximately 19 to 31 percent, with mean values ranging from approximately 21 to 26 percent. Thus generally, 1/5 th or more of the weight of the grain is due to that of the hull. The fact that the husk or hull contributes appreciably to the weight of the grain, and that this could vary from variety to variety is often overlooked when grain yields of varieties per unit of land are most usually determined in field investigations; where weight of grain is converted to bushels per acre.

Variations in the relative weight of husk in the grains of the four varieties depend also on the weight per 1000 grains. Taking the extreme cases in this investigation Bg 11-11 weighed 13.96 gm while IR 8 weighed 31.35 gm per 1000 grains. It is also reported that Indica varieties have relatively low amounts of silica in their tissue compared to Japonica varieties.

Silica content in rice husk

The data on the content of silica (expressed on dry weight basis) for the four varieties at the seven locations are presented in Table 3.

In the Wet Zone station of Labuduwa it is seen that the varieties H4 and LD 66 had very much more silica in the husk than IR 8. These differences were very highly significant. The silica content in Bg 11-11 too was significantly greater than that of IR 8. At Karapincha the differences in silica content of rice husk were not significant.

The results from Bathalagoda, the single location in the Intermediate Zone were not significant.

In three of the Dry Zone stations Ambalantota, Paranthan and Karadian Aru, the variety Bg 11-11 had the highest content of silica in the husk.

On the whole the highest content of silica in the rice husk was in the variety LD 66 which was followed by the variety Bg 11-11. The variety IR 8 had the least amount of silica in its husk.

The content of silica in the husk has a direct bearing on the content of available silica in the soil. It will be observed that plants grown in the wet zone locations had less of this constituent than those grown in the dry zone (with the exception of Karadian Aru). According to Panabokke and Nagarajah (9) rice growing soils in the districts of Galle and Ratnapura contain between 300 to 450 lb available silica per acre compared to those in the Hambantota district which contain 450-600 lb per acre, and the Jaffna and Anuradhapura districts which both contain more than 600 lb silica per acre. The Batticaloa district in which Karadian Aru is situated has the relatively low value of 100-200 lb per acre of available silica.

The rice growing soils of the Kurunegala district contain between 450-600 lb available silica per acre, although the content of silica in husk from plants grown at Batalagoda in the same district was relatively low, being of the same magnitude as that at Labuduwa of the wet zone. This may probably be due to local soil conditions at Bathalagoda. These results are in agreement with those of Ueda *et al.* (15) who reported that silica content of rice is related to the silica-sesquioxide ratio of soils.

It has been reported, as stated earlier, that silicon is necessary for the normal growth of the rice plant, the stems and leaves of which generally contain 10 to 20 percent of the element, and the response of rice to silica in field experiments has been reported in Sri Lanka (1, 12).

Rice husk and straw are two of the cheap and easily available sources of silica which can be used for preplant application to rice fields. In most areas these are just not made use of for any useful purpose. Rice husk contains generally about 70 percent fibre (carbonaceous material) and between 10 to 20 percent silica. In addition it contains between 0.5 to 1.0 percent nitrogen and about 0.5 percent K_2O , 0.2 percent manganese and 0.5 percent calcium. On the other hand when rice husk is burnt the silica content in the ash could range between 67 to 84 percent, and that of K_2O could be between 0.6 and 1.3 percent.

In addition to its use as a soil amendment for agronomic purposes rice husk also serves as a valuable, easily available industrial raw material.

Rice husk constitutes the largest by-product of the rice milling industry. About 345 thousand tons of rice husk would be available per year in this country on the basis of 23 percent husk in the grain, and on production figures for 1969/70 (ie. Maha 1969/70=49.49, and Yala = 27.95 million bushels of paddy). If all this is burnt completely it would amount to approximately 56 thousand tons of ash.

Some husk is used as fuel for boiling tanks in rice mills and thus reduces the fuel bill of mill owners.

Rice husk has been used for other purposes too. For example it is used in the manufacture of furfural by steam-acid digestion of husks, and for the manufacture of active carbon by destructive distillation of the husks. Active carbon is used in sugar and oil refining, in the purification of certain chemicals, and for the preparation of gas masks. Two important by products of destructive distillation of paddy husk are methyl alcohol and acetic acid.

Rice husk finds use as a loose insulating material in buildings and for cold storage due to its thermal insulating properties. It is also used for the preparation of water glass.

SILICA CONTENT OF RICE HUSK

Burnt ash is used in the manufacture of ceramicware and mechanics' soap; and as a sweeping material for garage floors etc. due to its property of absorbing oil. It is also used in the manufacture of abrasive powders and local tooth powders.

The finely ground husk is used as a filler in the manufacture of plastics and plywood glues, as an anti-caking agent in commercial fertilizer mixtures and in the manufacture of hard-boards.

REFERENCES

- (1) Administration Report of the Director of Agriculture, Part II 1968-1969, page C 177
- (2) Co-ordinated Rice Varietal Trial Project, Volume III, Report for Maha 1969-1970, Research Division, Department of Agriculture, Peradeniya
- (3) LAMBERS, D. H. R. (1970) Varietal improvement in rice. In Aspects of Rice Growing in Asia and the American. Miscellaneous Paper 7. Landbouwhogeschool Wageningen. The Netherlands
- (4) MATSUBAYASHI, M., ITO R., NOMOTO, T. TAKASE, T. and YAMADA N. (1968). Theory and Practice of Rice Growing. Fuji Publishing Co. Ltd. Nishigahara, Kita-ku. Tokyo.
- (5) MITSUI, S. and TAKATOR, H. (1963). Nutritional study of silicon in graminaceous crops. *Soil Sci. Plant Nutr.* 9: 49-58
- (6) OKAWA, K. (1936). Investigation on the physiological action of silicic acid for plants. *J. Sci. Soil and Manure, Japan.* 10: 95-110; 216-243; 414-423
- (7) OKAWA, K. (1937). Investigation on the physiological action of silicic acid for plants. *J. Sci. Soil and Manure, Japan* 11: 23-36
- (8) OKAMOTO, Y. (1959). Physiological studies on the effects of silicic acid upon rice plants, IV-VI. *Proc. Crop Sci. Soc. Japan* 28(1): 35-40
- (9) OKUDA, A. and TAKAHASHI, E. (1964). The role of silicon. In: Mineral Nutrition of the Rice Plant. John Hopkins Press. Baltimore, Md. U. S. A. pp. 123-146
- (10) PANABOKKE, C. R. and NAGARAJAH, S. (1964). The fertility characteristics of ricegrowing soils of Ceylon. *Trop. Agrist.* 120: 3-30
- (11) Rice Information Co-operative Effect (1966). Rice Production Manual. University of the Philippines.
- (12) RODRIGO, D. M. (1964). Response of rice to silica. *Trop. Agrist.* 120: 219-226
- (13) SOMMER, A. L. (1926). Studies concerning the essential nature of aluminum and silicon for plant growth. *Univ. of California. Publ. Agric. Sci.* 5(2): 57-81
- (14) TANAKA, A. and YOSHIDA, S. (1970). Nutritional Disorders of the Rice Plant in Asia. The International Rice Research Institute. Philippines.
- (15) UEDA, K., YAMAOKA, M. and NISHIMURA, S. (1957). NIPPON DOJO NIROYOGAKU ZASSHI, 27. 401-402 Quoted by Jones, L. H. P. and Handreck, K. A. Advances in Agronomy Vol. 19, pp 107-149, 1967
- (16) WOOLLEY, J. T. (1957). Sodium and silicon as nutrients for the tomato plant. *Plant Physiol.* 32: 317-321
- (17) YOSHIDA, S., NAVASERO, S. A., and RAMIREZ, E. (1969). Effects of silica and nitrogen supply on some leaf characters of the rice plant. *Plant Soil* 31: 48-56.

Table 1.—Yield Data of Four Varieties from Report on Co-ordinated Rice Varietal Trials—Project at Seven Locations (Mana 1969/70)

Variety	Intermediate Zone				Dry Zone			Mean
	West Zone		Zone		Dry Zone			
	Karapincha	Labuansa	Bakalagoda	Ambalan-tota	Fareenthan	Mahaillup-pattana	Karachi	Arx
H 4	43.0	44.1	77.9	70.1	70.0	69.4	58.9	61.9
LD 66	65.2	78.3	101.2	85.7	72.6	100.0	89.4	86.4
Bg 11-11	69.1	77.6	97.4	92.0	70.2	79.2	80.0	79.8
IR 8	74.0	80.3	101.4	97.6	84.2	108.2	107.6	90.5
L.S.D. 1%	22.6	19.4	14.0	17.3	9.1	21.2	13.9	—
L.S.D. 5%	18.9	14.7	10.5	13.0	6.8	15.9	9.6	—
C.V. %	21.8	15.9	8.2	10.8	6.7	13.0	7.7	—

SILICA CONTENT OF RICE HUSK

Table 2—Relative Weight of Husk in the Grains at Seven Localities (% over Dried Weight)

Variety	Locations							Mean
	Wet Zone		Intermediate Zone		Dry Zone			
	Karapincha	Labudanas	Botalagoda	Ambalanota	Feranthon	Maha Illup-pallama	Keravon Aru	
H 4	22.0	20.4	21.8	22.7	22.0	22.8	21.6	21.9
LD 66	22.4	22.3	21.4	23.0	24.3	24.9	20.8	22.7
Bg-11-11	24.7	24.0	31.1	25.9	25.3	29.5	24.6	26.4
IR 8	20.5	19.2	26.5	22.5	19.2	23.4	22.6	21.9
L. S. D. 5%	1.8	N.S.	2.7	1.5	3.8	1.7	1.2	—
L. S. D. 1%	2.5	N.S.	3.8	2.2	—	2.6	1.8	—
C. V. %	1.1	11.5	6.6	4.1	10.5	4.1	3.3	—

Table 3.—Silica Content in Rice Husk in Four Varieties at Seven Locations (% of SiO₂, Dry Weight)

Variety	Wet Zone		Inter-mediate Zone			Dry Zone			Mean
	Karepincha	Labuduwa	Batalagoda	Ambalan-tota	Paranthan	Maaha Illup-palloga	Kavathen Ara		
H 4	9.78	17.26	8.62	22.84	19.60	19.64	11.71	15.64	
LD 66	11.83	17.07	11.02	24.06	21.78	23.22	13.76	17.53	
Bg 11-11	9.90	15.56	11.60	26.29	22.95	21.65	13.89	17.41	
IR 8	9.94	12.11	9.45	20.98	20.74	19.92	13.10	15.18	
Mean	10.36	15.50	10.17	23.54	21.27	21.20	13.12	—	
L. S. D. 1%	N.S.	3.66	N.S.	2.32	N.S.	2.05	1.38	—	
L. S. D. 5%	N.S.	2.54	N.S.	1.62	1.92	1.41	0.95	—	
C. V. %	11.98	10.26	21.31	4.29	5.64	4.98	4.44	—	