Tropical Agricultural Research Vol. 4 1992

Influence of Plant Nutrients and some Biochemical Plant Characteristics on Varietal Resistance to Yellow Stem Borer, *Scirpophaga incertulas* (Walker) of Rice

M. Shahjahan

Department of Entomology
Bangladesh Agricultural University
Bangladesh.

ABSTRACT. Varietal resistance has been considered to be the most economical, durable and nonhazardous to human and environmental health. Efforts to develop cultivars with levels of resistance higher than presently grown varieties will help in solving yellow stem borer (YSB) control problem in rice cultivars.

Thirty one Bangladeshi rice varieties were screened for resistance to YSB in the field in different seasons. Further study was conducted to evaluate the effect of nitrogen, silicon, zinc and sulphur on the percentage of infestation of YSB in the variety BR – 11 while identifying the major plant biochemical constituents of rice stem which may contribute to the resistance to YSB.

It was found that the infestation of YSB decreased with the increase of dosage of Zinc sulphate and Sodium silicate, whereas the infestation of YSB increased with the increasing dosage of Urea and Gypsum. Further, biochemical analysis of some selected rice varieties revealed that resistant cultivars BR1, DA26 and Kalizira contained higher percentage of dry matter, crude fibre and silicon and lower percentage of moisture, protein and fat than the susceptible cultivars BR14, BR2 and Pajam.

INTRODUCTION

Rice is the staple food of Bangladesh. Out of the total 145 million hectares of rice planted in the world, 7.3 percent of the area is found in Bangladesh (Chaudhary *et al.*, 1984). Poor plant protection programmes is one of the causes of low rice productivity in Bangladesh. About 175 insect pests infest rice in Bangladesh and stem borers are the most damaging pests (Alam *et al.*, 1981; Alam *et al.*, 1985).

Yellow stem borer (YSB), *Scirpophaga incertulas* (Walk.) is the most important stem borer species in Bangladesh. It is widely distributed in South and South East Asia (Heinrichs *et al.*, 1985). It causes 5 – 10% damage to the rice crop with about 60% damage in severe outbreaks (Jepson, 1954; Catling and Islam, 1982). YSB is active almost throughout the year except from December to February (Alam *et al.*, 1985). The pest is more abundant in multiple rice cropping areas (Heinrichs *et al.*, 1985). YSB develop inside the rice stems causing dead – hearts and white – heads. These symptoms, however, are not visible in all the damaged stems (Alam *et al.*, 1985). Larval feeding reduces stem elongation, plant vigour, tiller numbers and filled grains (Pathak, 1975).

Stem borers along with other insect species, are of major economic importance and have been the subject of numerous studies in the development of rice pest management systems. Of the various control methods, varietal resistance has received priority in integrated management of rice insect pests. Emphasis has therefore, been placed on the development of stem borer resistant rice varieties as this is considered to be the most economical, convenient, non – hazardous and built – in control measure. Screening of resistant rice varieties against stem borer has been done in India, Thailand, Indonesia, Sri Lanka, Malaysia and China. Some studies have also been made on morphological and anatomical characters, genetics of resistance, biochemical and physiological factors related to the borer resistance in Japan, Philippines and India (Chaudhary, *et al.*, 1984). In Bangladesh, some high yielding varieties (HYV), locally improved varieties (LIV) and local varieties (LV) have often been screened against stem borers, with very few studies on factors related to the stem borer infestation.

The present work was therefore, undertaken to achieve the following objectives:

i) To determine the level of resistance and susceptibility against YSB by screening twenty one rice cultivars.

ii) To study the effect of important nutrient elements on the reaction of BR11 (HYV) to the yellow stem borer infestation.

iii) To determine the major biochemical constituents influencing resistance to YSB of rice varieties.

MATERIALS AND METHODS

Field experiments were conducted in the Bangladesh Agricultural University farm (BAU farm) from April 1989 to June 1990 during *Aus*, *Aman* and *Boro* seasons. The topography of the lands was medium high belonging to the Brahmaputra Alluvium Soil Tract. The soil of the experimental area was sandy loam with pH value around 6.8. Analytical work was performed in the Department of Biochemistry, Bangladesh Agricultural University, Mymensingh.

Field screening for resistance

Eleven, twenty one and nine varieties of rice were screened for stem borer resistance in *Boro, Aus* and *Aman* seasons respectively. The experiments were laid out in Randomized Block Design with three replications. Seedling were spaced at 25 x 15 cm in plots of 10 m^2. Thirty, forty and thirty days old rice seedlings were transplanted in *Boro, Aus* and *Aman* seasons respectively. The individual plots received 135 kg Urea, 90 kg Triple Super Phosphate (TSP), 70 kg Muriate of Potash (MP), 11 kg Zinc Sulphate ($ZnSO_4$) and 60 kg Gypsum per hectare. Data on the stem borer infestation were recorded 40, 70 and 100 days after transplanting (DAT). Percentage of stem borer infestation was calculated using the following formula:

$$\text{Percentage of dead heart (or white head)} = \frac{\text{No. of damaged hills in sample area}}{\text{Total no. of hills in sample area}} \times \frac{\text{No. of damaged tillers (or panicles)}}{\text{Total no. of tillers (or panicles in damaged hills)}} \times 100$$

Statistical analysis was carried out by F-test, Duncan's Multiple Range Test (DMRT) and Correlation Coefficient.

Fertilizer trial

Four different experiments were conducted in the field to study the effect of nutrient elements on YSB infestation during the *Aman* season of 1989. The selected cultivar was BR 11 as the variety is extensively cultivated by the Bangladeshi farmers. These experiments were laid out in Randomized Block Design with three replications. Seedlings were spaced at 25x15 cm in plots of 10 m^2. The age of the seedlings was 30 days. The doses of the nutrient elements which were used as different fertilizer are shown in tabular form:

Experiment I	Experiment II	Experiment III	Experiment IV
Levels of nitrogen (UreaKg/ha).	Levels of sulphur phur in the (Gypsum Kg/ha).	Levels of silicon (Sodium silicate Kg/ha).	Levels of zinc (Zinc sulphate Kg/ha).
N_0	S_0	Si_0	Zn_0
N_{50}	S_{30}	Si_{20}	Zn_5
N_{100}	S_{60}	Si_{40}	Zn_{10}
N_{150}	S_{90}	Si_{60}	Zn_{20}
N_{200}			
N_{250}			

The individual plots received 135 kg Urea, 90 kg TSP, 70 kg MP, 11 kg $ZnSO_4$ and 60 kg Gypsum excluding the fertilizers which were used as study material. Data on the stem borer infestation were recorded 40, 70, 100 days after transplanting (DAT) and the percentage of stem borer infestation was calculated. Statistical analysis was carried out using F – test, Duncan's Multiple Range Test (DMRT), Correlation – coefficient and Regression – coefficient.

Biochemical analysis

To ascertain some of the biochemical factors responsible for resistance in rice varieties to YSB a few known resistant and susceptible rice varieties (Table 3) were grown in the field with three replications. The individual plots were treated with 135 kg Urea, 90 kg TSP, 70 kg MP, 11 kg $ZnSO_4$ and 60 kg Gypsum per hectare. From each plot, plants from 10 randomly selected hills were taken at 40 and 75 DAT for

chemical analysis. The samples were washed thrice with distilled water to remove any adhering extraneous matter and oven-dried. The grounded materials were used for chemical analysis. The moisture, dry matter, protein, fat and crude fibre contents were determined following the methods outlined in the Association of Official Agricultural Chemists (AOAC, 1965). The silicon contents of the samples were determined following method used by Black (1965). Statistical analysis was carried out using F-test and Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Field screening for resistance

***Aus* season:** The percentage of YSB infestation in 21 varieties at 40 DAT ranged between 1.85 to 6.59 per cent and between 0.16 to 2.11 per cent at 70 DAT (Table 1a). On an average BR1 and DA26 were least infested and BR14 and BR2 were highly infested. The correlation coefficent of percentage of infestation between 40 and 70 DAT ($r=0.5250$) is significant at 0.05 level of probability. The present findings on BR1 and BR2 are in full agreement with those reported in Bangladesh Rice Research Institute (BRRI, 1975-76).

***Aman* season:** In *Aman* season the percentage of YSB infestation in commonly cultivated 9 varieties ranged from 0.20 to 3.63 per cent at 40 DAT and 0.01 to 0.37 per cent at 70 DAT (Table 1b). On an average *Pajam* was susceptible and *Kalizira* was resistant. The correlation coefficient of percentage of infestation between 40 and 70 DAT ($r=0.7737$) is significant at 0.05 level of probability. Alam *et al.*, (1985) reported that *Pajam* was susceptible.

***Boro* season:** The percentage of YSB infestation in 11 varieties at 70 DAT ranged between 1.24 to 6.78 per cent and between 1.79 to 6.53 percent at 100 DAT (Table 1c). Percentage of infestation at 40 DAT was nil. On an average BR1 and BR12 were least infested and BR14 and BR20 were highly infested. The correlation coefficent of percentage of infestation between 70 and 100 DAT ($r=0.3141$) is not significant at 0.05 level of probability.

Table 1a. Percentage of Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation in Aus Season, 1989.

Variety	Percentage of (YSB) infestation	
	40 DAT	70 DAT
BR14 (Gazi)	6.59	2.11
BR2 (Mala)	5.28	1.93
BR9 (Sufala)	5.21	0.66
BR16 (Shahi balam)	5.11	1.15
BR3 (Biplob)	4.17	1.92
IR8	3.99	1.93
Horinmuda	3.90	1.21
BR8 (Asha)	3.88	0.62
BR7 (Brri balam)	3.87	1.27
BR15 (Mohini)	3.85	1.28
BR12 (Niyamat)	3.70	0.80
BR12 (Moyna)	3.67	0.65
BR20 (Nizami)	3.52	1.18
DA22 (Dular)	3.44	1.16
DA2 (Kataktara)	3.43	1.24
2052	3.42	1.27
DA14 (Dharial)	3.18	1.93
BR6	2.78	1.90
Purbachi	2.29	0.33
DA26 (Hashikalmi)	2.02	0.27
BR1 (Chandina)	1.85	0.16
F value	NS	NS

NS = Not significant at 5% level of significance.
DAT = Date after transplantation.

Table 1b. Percentage of Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation in Aman Season, 1989.

Variety	Percentage of (YSB) infestation	
	40 DAT	70 DAT
BR4 (Brisail)	1.96 b	0.17 b
BR5 (Dulhabhog)	0.81 c	0.14 bc
BR10 (Progoti)	0.43 cd	0.18 b
BR11 (Mukta)	3.62 a	0.16 bc
Pajam	3.63 a	0.37 a
Nizersail	0.22 d	0.02 d
Biroi	0.21 d	0.03 cd
Kalizira	0.20 d	0.01 d
Tulsimala	0.82 c	0.05 bcd
F value	**	**
Sx	0.159	0.040

** $P < 0.01$

In a column, the figures having common letter(s) do not differ significantly.

Table 1c. Percentage of Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation in Boro Season, 1990.

Variety	Percentage of (YSB) infestation	
	70 DAT	100 DAT
BR1 (Chandina)	1.24 c	1.79 e
BR2 (Mala)	3.17 bc	3.65 bcde
BR3 (Biplob)	3.35 bc	5.11 abcd
BR8 (Asha)	4.19 abc	4.14 abcde
BR9 (Sufala)	4.06 abc	6.03 ab
BR12 (Moyna)	2.30 c	2.66 de
BR14 (Gazi)	2.45 c	6.53 a
BR15 (Mohini)	5.71 ab	3.75 bcde
BR20 (Nizami)	6.78 a	4.99 abcd
IR24	3.46 bc	5.39 abc
Purbachi	3.55 bc	2.79 cde
F value	*	*
Sx	0.885	0.806

* $P < 0.05$

In a column, the figures having common letter(s) do not differ significantly.

Fertilizer trial

Nitrogen: The percentage of YSB infestation with different doses of nitrogen ranged from 1.23 to 3.62 at 40 DAT, 2.50 to 4.55 at 70 DAT and 1.17 to 4.00 at 100 DAT (Table 2a). In general the pest infestation increased with the increase of doses of nitrogen upto 150 kg/ha. The regression coefficient between doses of nitrogen and percentage of infestation at 40 DAT ($b=0.0083$) is insignificant. The correlation coefficient of percentage of infestation between 40 and 70 DAT ($r=0.8204$), 40 and 100 DAT ($r=0.9034$) and 70 and 100 DAT ($r=0.8300$) is significant at 0.05 level of probability. The result of the

present experiment agreed with the findings of Ishii and Hirano (1959), Saroja and Raju (1981) and Sasamoto (1960).

Sulphur: The percentage of YSB infestation with different levels of sulphur ranged from 0.54 to 4.22 at 40 DAT, 2.21 to 6.86 at 70 DAT and 0.80 to 2.23 at 100 DAT (Table 2b). The differences in the YSB incidence due to treatments were found significant only at 100 DAT. In general, the degree of infestation increased with the increase of doses of sulphur (as Gypsum). The regression coefficient between doses of sulphur and percentage of infestation at 40 DAT ($b=0.0205$), 70 DAT ($b=0.0401$) and 100 DAT ($b=0.0060$) was not significant. The correlation coefficient of percentage of infestation between 40 and 70 DAT ($r=0.4828$), 40 and 100 DAT ($r=0.0342$) and 70 and 100 DAT ($r=0.7984$) was not significant at 0.05 level of probability.

Silicon: The percentage of YSB infestation with different doses of silicon ranged from 2.98 to 0.65 percent at 40 DAT, 12.19 to 3.27 per cent at 70 DAT and 0.95 to 0.35 per cent at 100 DAT (Table 2c). The degree of infestation decreased with increasing doses of silicon (as Sodium silicate) upto 40 kg/ha of silicon. At 70 DAT the differences in the YSB incidence were found statistically significant. The regression coefficient between doses of silicon and percentage of infestation at 40 DAT ($b=0.0137$), 70 DAT ($b=0.0481$) and 100 DAT ($b=0.0039$) were not significant. The correlation coefficient of percentage of infestation between 40 and 70 DAT ($r=0.7533$), 40 and 100 DAT ($r=0.8677$) and 70 and 100 DAT ($r=0.7369$) were not significant at 0.05 level of probability. The silica content of the plant has been considered to impart resistance to pests. Sasamoto (1961), Djamin and Pathak (1967) and Subbarao and Perraju (1976) recorded a highly significant negative correlation between silicacontent of the stem and susceptibility to the rice stem borer.

Table 2a. Effect of Different Levels of Nitrogen on the Reaction of Rice Variety BR11 to the Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation during Aman Season 1989.

Dose (kg/ha)	Percentage of YSB infestation at		
	40 DAT	70 DAT	100 DAT
	1.23	2.50	1.17
N_{50}	1.54	3.06	1.43
N_{100}	2.67	3.95	1.93
N_{150}	3.62	4.36	4.00
N_{200}	2.72	4.55	2.87
N_{250}	3.23	3.58	2.56
F value	NS	NS	NS

NS = Not significant

Table 2b. Effect of Different Levels of Sulphur on the Reaction of Rice Variety BR11 to the Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation during Aman Season 1989.

Table 2b. Effect of Different Levels of Sulphur on the Reaction of Rice Variety BR11 to the Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation during Aman Season 1989.

Dose (kg/ha)	Percentage of YSB infestation at		
	40 DAT	70 DAT	100 DAT
S_0	0.53	2.21	0.97 b
S_{30}	4.22	3.87	0.79 b
S_{60}	2.74	6.85	2.23 a
S_{90}	3.07	5.31	1.09 b
F value	NS	NS	*

NS = Not significant
* = Significant at 5% level of probability
Means followed by different letters are significantly different.

Table 2c. Effect of Different Levels of Silicon on the Reaction of Rice Variety BR11 to the Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation during Aman Season 1989.

Dose (kg/ha)	Percentage of YSB infestation at		
	40 DAT	70 DAT	100 DAT
Si_0	2.98	8.60 ab	0.95
Si_{20}	0.65	4.42 bc	0.65
Si_{40}	0.68	3.27 c	0.35
Si_{60}	2.06	12.19 a	0.79
F value	NS	*	NS

NS = Not significant
* = Significant at 5% level of probability
Means followed by different letters are significantly different.

Zinc: The percentage of YSB infestation with different doses of zinc ranged from 3.20 to 1.14 per cent at 40 DAT, 5.84 to 4.12 per cent at 70 DAT and 2.29 to 0.68 per cent at 100 DAT (Table 2d). It was observed that the infestation of stem borers decreased with the increase of zinc (as Zinc sulphate) but the results were statistically not significant. The regression coefficient between doses of zinc and percentage of infestation at 40 DAT (b=0.0903), 70 DAT (b=0.0456), 100 DAT (b=0.0717) were not significant. The correlation coefficient of percentage of infestation between 40 and 70 DAT (r=0.7825), 40 and 100 DAT (r=0.7295), and 70 and 100 DAT (r=0.7272) were not significant.

C. Biochemical analysis

The lowest moisture, protein and fat contents were found in the resistant varieties BR1 and DA26 and the highest moisture, protein and fat contents were found in the susceptible varieties BR14 and BR2 at both 40 and 75 DAT in *Aus* season. In *Aman* season the lowest percentage of moisture, protein and fat contents was found in the *Kalizira* variety and the highest percentage was found in the *Pajam* variety (Table 3). Subbarao and Perraju (1976) reported that in rice varieties the degree of resistance was high when moisture content was low. Panda *et al.*, (1975) and Padhi and Chatterji (1986) found that the susceptible varieties had significantly higher nitrogen content than the resistant varieties. The present findings are in agreement with the above reports.

The highest dry matter, crude fibre and silicon contents were found in resistant varieties BR1 and DA26 and the lowest dry matter, crude fibre and silicon contents were found in the susceptible varieties BR14 and BR2 at both 40 DAT and 75 DAT in *Aus* season. In *Aman* season the highest percentage of dry matter, crude fibre and silicon contents was found in the *Kalizira* variety and the lowest percentage was found in the *Pajam* variety. Subbarao and Perraju (1976) reported that in the rice varieties the degree of resistance was increased by high content of dry matter. Sasamoto (1961), Djamin and Pathak (1967) and Panda *et al.*, (1975) found that resistant varieties had higher silica contents than susceptible varieties. The variety with higher crude fibre content apparently caused lesser infestation.

Table 2d. Effect of Different Levels of Zinc on the Reaction of Rice Variety BR11 to the Yellow Stem Borer (YSB), *Scirpophaga incertulas* Infestation during Aman Season 1989.

Dose (kg/ha)	Percentage of YSB infestation at		
	40 DAT	70 DAT	100 DAT
Zn_0	3.20	5.84	2.29
Zn_5	2.74	4.55	1.32
Zn_{10}	1.14	4.12	1.32
Zn_{20}	1.52	4.71	0.68
F value	NS	NS	NS

NS = Not significant

Table 3. Biochemical constituents of selected rice cultivars at different ages, resistant and susceptible to Yellow rice Stem Borer (YSB), Scirpophaga incertulas (1989).

Variety of rice	Moisture		Dry Matter		Protein		Fat		Crude Fibre		Silica	
	40 DAT	75 DAT	40 DAT	75 DAT	40 DAT	75 DAT	40 DAT	75 DAT	40 DAT	75 DAT	40 DAT	75 DAT
Aus Season:												
BR14	81.44a	74.04abc	18.56	24.96	12.81a	6.80	8.15a	4.10	34.97d	39.20	4.38f	5.00f
BR2	81.21a	75.00a	18.79	25.00	12.56b	6.75	8.11a	4.01	35.00d	39.21	4.65e	5.35e
BR15	80.01b	74.60ab	19.99	25.40	11.50c	6.31	7.81b	3.92	35.50c	39.95	5.00d	6.00d
DA22	80.10b	74.10abc	19.90	25.90	11.37d	6.25	7.75c	3.99	35.52bc	39.99	5.70c	6.70c
DA26	77.40c	73.20cd	22.60	26.80	10.64e	6.01	7.21d	3.88	35.93ab	40.71	6.60b	6.98b
BR1	77.21c	73.00d	22.79	27.00	10.63e	6.00	7.19d	3.79	35.96a	40.85	7.03a	7.36a
Value	**	**	NS	NS	**	NS	**	NS	**	NS	**	**
Sx	0.197	0.285	-	-	0.011	-	0.011	-	0.121	-	0.010	0.010
Aman Season:												
Pajam	83.35a	75.00a	19.65b	25.00b	11.25a	6.31a	7.31a	3.20a	35.50c	38.00c	3.90c	4.70c
BR5	80.00b	74.80a	20.00	25.20	10.93b	6.02b	7.02b	3.14b	36.40b	39.50b	4.03b	4.92a
Kalizara	77.00c	72.81c	23.00a	27.19a	16.69b	5.96c	6.80c	3.01c	37.35a	40.52a	5.01a	5.10a
F Value	**	**	**	**	**	**	**	**	**	**	**	**
Sx	0.310	0.144	0.310	0.144	0.057	0.013	0.019	0.008	0.015	0.017	0.008	0.013

** P < 0.01
In a column, the figures having common letter(s) do not differ significantly.
DAT = Dates after Transplanting.
NS = Not significant.

REFERENCES

Alam, S., Catling, H.D., Karim, A.N.R.R., Alam, M.S. and Quraishi, N. (1981). Check list of rice insects in Bangladesh. Bangladesh J. Zool. 9(2): 91 – 96.

Alam, S, Karim, A.N.R.M. and Ahmed, M.S. (1985). Researches on rice stem borers at Bangladesh Rice Research Institute (BRRI), Entomology Division, BRRI, Joydevpur, Gazipur, Bangladesh. pp. 163.

AOAC. (1965). Official Methods of Analysis, Association of Official Agricultural Chemists. 10th ed. Washington, D.C. pp. 600.

Black, C.A. (1965). Methods of Soil Analysis (Part II). American Society of Agronomy, Inc. Publisher, Madison, Wisconsin, U.S.A. pp. 959 – 962.

BRRI. (1975 – 76). Annual Report. Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur, Bangladesh. pp. 68.

Catling, H.D. and Islam, Z. (1982). The Problem of Yellow Rice Borer in Asian Deep Water Rice. pp. 451 – 458. *In*: Proceeding of the 1981 International Deep Water Rice Workshop, International Rice Research Institute, Los Banos, Philippines. pp. 508.

Chaudhary, R.C., Khush, G.S. and Heinrichs, E.A. (1984). Mini – review: Varietal resistance to rice stem borers in Asia. Insect Sci. Applic. 5(6): 447 – 463.

Djamin, A. and Pathak, M.D. (1967). The role of silica in resistance to Asiatic rice borer, *Chili suppressalis* (Walker) in rice varieties. J. Econ. Ent. 60: 347 – 351.

Heinrichs, E.A., Medrano, F.G. and Rapusas, H.R. (1985). Genetic Evaluation for Insect Resistance in Rice, Int. Rice Res. Inst., Los Banos, Laguna, Philippines. pp. 356.

Ishii, S. and Hirano, C. (1959). Effect Fertilizers on the Growth of Larvae of the Rice Stem Borer, *Chili suppressalis* Walker. II. Growth of the larvae on the rice plants cultured in nutrients solutions of different nitrogen level. Jap. J. Appl. Ent. Zool. 3(1): 16 – 22.

Jepson, W.P. (1954). A critical review of the World Literature on the Lepidopterous Stalk borers of Tropical Graminaceous Crops. Commonwealth Institute of Entomology, London. pp. 127.

Padhi, G. and Chatterji, S.M. (1986). Influence of nitrogen in rice varieties on the yellow stem borer (*Scirpophaga incertulas* Walk.) infestation. J. Entomol. Res. 10(2): 171 – 173.

Panda, N., Pradhan, B. Samato, A.P. and Prakasa Rao, P.S. (1975). Note on the relationship of some biochemical factors with the resistance in rice varieties to yellow rice borer. Indian J. Agric. Sci. 45(10): 499 – 501.

Pathak, M.D. (1975). Insect Pests of Rice. International Rice Research Institute, Los banos, Philippines. pp. 68.

Saroja, R. and Raju, N. (1981). Varietal reaction to rice stem borer under different nitrogen levels. Int. Rice Res. Newsl. 6: 7.

Sasamoto, K. (1960). Studies on the Relation between the Silica content in the Rice Plant and Insect Pests. VIII. Feeding Preference of the Rice Stem Borer Larvae for the Rice Plants Cultured in Soils of Different Nitrogen Levels. Jap. J. Appl. Ent. Zool. 4(2): 115 – 118.

Sasamoto, K. (1961). Resistance of the rice plant applied with silicate and nitrogenous fertilizers to the stem borer, *Chili suppressalis* (in Japanese, with English summary). Proc. Fac. Liberal Arts Educ. Japan. 3: 3 – 48.

Subbarao, D.V. and Perraju, A. (1976). Resistance in some rice strains to first instar larvae of *Tryporyza incertulas* (Walker) in relation to plant nutrients and anatomical structure of the plants. Int. Rice Res. Newsl. 1: 14 – 15.