Tropical Agricultural Research Vol. 4 1992

Biochemical Constituents Influencing the Infestation Rate of Yellow Stem Borer of Rice

M. Shahjahan

Department of Entomology
Bangladesh Agricultural University
Bangladesh.

ABSTRACT. A field experiment, with nine varieties of rice, was conducted to determine the influence of some biochemical constituents on the infestation rate of rice yellow stem borer. Higher plant moisture, protein and fat induced a higher infestation, where as higher plant crude fibre and silica content significantly reduced the infestation rate. Borer infestation rate was positively correlated with moisture, protein and fat but negatively correlated with crude fibre and silica. Path coefficients revealed highest positive role of protein and a negative role of silica in borer infestation. Regression equations showed highest contribution of protein (52.00%).

INTRODUCTION

Rice stem borers have been recognized as important rice pests. They are endemic to Southern Asia and the monophagous yellow rice stem borer (YSB), *Scirpophaga incertulas* (Walk) is the most important borer species in Bangladesh. It causes 5 – 10% damage to the rice crop with about 60% damage in case of a severe outbreak (Jepson, 1954; Catling and Islam, 1981). The larval stage of YSB feeds on sheaths and bore into the rice stem causing deadhearts and whiteheads.

The growth and development of yellow stem borers has been reported to be affected by different biochemical constituents of rice plants. Chaudhary *et al.*, (1984), Marwat and Baloch (1985) and Subbarao and Perraju (1976) observed the relationship of plant moisture with the infestation rate. Chandramohan and Chelliah (1984), Chaudhary *et al.*, (1984), Manwan and Vega (1975) and Sasamoto (1960 and 1961) reported that resistant varieties contained a higher amount of silica and susceptible varieties contained a higher amount of nitrogen.

In Bangladesh, several modern varieties, locally improved varieties and local varieties have been screened against stem borers, but very little emphasis has been given to the biochemical constituents of plants that impart host resistance.

Work on determination of correlation matrix, regression equations and path coefficient analysis among rice pests and affecting constituents is absent in Bangladesh. Such types of large approaches are practiced on a large scale by agronomists and plant breeders (Khaleque *et al.*, 1978; Amin, 1979).

This experiment was, therefore, undertaken to find out the inter-relationship between rice stem borer infestation and the biochemical plant constituents affecting the borer infestation.

MATERIALS AND METHODS

A field experiment was conducted in the Bangladesh Agricultural University farm during 1989 with nine rice varieties namely, BR1, BR2, BR5, BR14, BR15, DA22, DA26, Pajam, and Kalizira. The experiment was laid out in a factorial randomized block design with three replications. The unit plot size was 4.0 m x 2.5 m and rice plants were spaced at 25 cm between rows and 15 cm within the rows. The individual plots were treated with 135 kg Urea, 90 kg Triple Super Phosphate (TSP), 70 kg Muriate of Potash (MP), 11 kg $ZnSO_4$ and 60 kg Gypsum per hectare. Stem borer infestation percentages were assessed by using Onate's formula (1965). Two different observations were made first one at 40 days after transplantation (40 DAT) and other at 75 DAT. From each plot plants from ten randomly selected hills were taken at 40 and 75 DAT for laboratory analysis of moisture, protein, fat, crude fibre and silica. Plant samples collected were washed, oven-dried and then ground by an electric grinder. The moisture, protein, fat and crude fibre contents were determined following the methods outlined in the Association of Official Agricultural Chemists (AOAC, 1965) and the silica content was determined following the method used by Black (1965). The mean data of two dates were analyzed statistically maintaining factorial RBD for field data and factorial CRD for Laboratory data by using a micro computer. The mean differences were adjudged with Duncan's New Multiple Range Test (DMRT). To determine the extent of inter-relationship among the borer infestations and rice plant constituents, correlation matrix for all possible data combinations was worked out by the method described by Hayes *et al.*, (1955). Correlation coefficients were further partitioned into constituents of direct and indirect effects by path coefficient analysis originally developed by Wright (1923) and later described by Dewey and Lu (1959) taking all the characters into consideration. Borer infestation was considered as a resultant variable. The relative importance of each independent variable generated by the step-wise regression programme including the test of significance of this incremental contribution of each variable were accomplished by employing the "F-test" (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

The data on the different plant constituents influencing YSB infestation in different rice varieties at different ages are presented in Table 1. Inter-relationships among borer infestations and rice plant constituents are presented in Tables 2, 3 and 4.

Biochemical constituents and YSB infestation of rice varieties at different ages

The rice varieties varied significantly in respect to their moisture, protein, fat, crude fibre and silica content as well as borer infestation rate (Table 1). Experimental results showed that local varieties (*Kalizira* and DA26) were less susceptible to rice stem borer than the modern varieties. Among the tested varieties, BR1 and *Kalizira* showed the least susceptibility to rice stem borer which contained a lower amount of moisture (75.105 and 74.905), protein (8.136 and 8.325) and fat (5.490 and 4.905) but a higher amount of silica (7.195 and 5.055) and a higher amount of crude fibre (38.405 and 38.935 respectively). On the other hand, highly susceptible varieties BR2 and BR14 contained higher amounts of moisture (78.105 and 77.740), protein (9.655 and 9.806), fat (6.060 and 6.125) and lower amounts of crude fibre (37.098 and 37.085) and silica (5.000 and 4.690 respectively). The present findings are in agreement with the reports of Chandramohan and Chelliah (1984), Chaudhary *et al.*, (1984), Marwat and Baloch (1985), Panda *et al.*, (1975) and Subbarao and Perraju (1976) who found that low moisture and nitrogen containing varieties were more resistant to rice stem borer.

Table 1. Relationship Between Different Plant Constituents and on the Borer Infestation in Different Rice Varieties at Different Ages.

Variety and date of rice	Moisture (%)	Protein (%)	Fat (%)	Crude Fibre (%)	Silica (%)	Borer infestation (%)
Variety:						
BR1	75.105 e	8.136 f	5.490 e	38.405 b	7.195 a	1.005 ef
BR2	78.105 b	9.655 b	6.060 b	37.098 e	5.000 f	3.605 b
BR5	77.400 cd	8.475 e	5.080 g	37.950 c	4.475 h	2.000 d
BR14	77.740 bc	9.806 a	6.125 a	37.085 e	4.690 g	4.350 a
BR15	77.305 cd	8.905 c	5.865 c	37.723 d	5.500 d	2.565 c
DA22	77.100 d	8.813 d	5.870 c	37.702 d	6.200 c	2.300 cd
DA26	75.300 e	8.328 f	5.545 d	38.318 b	6.790 b	1.145 ef
Pajam	79.175 a	8.780 d	5.255 f	36.750 f	4.300 i	0.475 fg
Kalizira	74.905 e	8.325 f	4.905 h	38.935 a	5.055 e	0.105 g
Date:						
40 DAT	79.747 a	11.377 a	7.483 a	35.780 a	5.144 b	3.074 a
75 DAT	74.061 b	6.286 b	3.671 b	39.769 b	5.790 a	0.826 b

Significant at 5% level.

In a column, the figures having common letter(s) do not differ significantly at 5% level of probability.
DAT = Date after transplantation.

Table 2. Correlation Matrix between Rice Plant Constituents and YSB infestation Rate.

Variable	Protein	Fat	Crude Fibre	Silica	Borer Infestation
Moisture	0.9174**	0.8930**	-0.9202**	-0.5683**	0.6757**
Protein		0.9888**	-0.9564**	-0.3920**	0.7214**
Fat			-0.9353**	-0.2784*	0.7056**
Crude Fibre				0.4436**	-0.6847**
Silica					-0.3516*

*, ** Significant at 5% and 1% level of probability, respectively.

Table 3. Path coefficient analysis of plant constituents influencing YSB infestation.

Characters	Indirect effects through					Total Correlation with borer Infestation
	Moisture	Protein	Fat	Crude Fibre	Silica	
Moisture	-0.0143	0.6179	0.1261	-0.1185	0.0645	0.6757**
Protein	-0.0131	0.6735	0.1397	-0.1232	0.0450	0.7214**
Fat	-0.0128	0.6660	0.1413	-0.1205	0.0316	0.7056**
Crude Fibre	0.0131	-0.6441	-0.1321	0.1288	-0.0503	-0.6847**
Silica	0.0081	-0.2640	-0.0393	0.0571	-0.1135	-0.3516*

Residual effect = 0.6873

N.B. Underlined figure denotes the direct effect of the character on the borer infestation.

*, Significant at 5% level. **, Significant at 1% level.

Table 4. Step-wise regression from each step for the determination of relative importance of plant constituents to borer infestation.

Step/Regression equation	R^2	F value computed
Step I: $Y = -2.697 + \underset{(0.070)}{0.527^{**}} X1$	0.520	56.434 **
Step II: $Y = -3.012 + \underset{(0.473)}{0.777} X1 - \underset{(0.634)}{0.339} X2$	0.723	27.970 **
Step III: $Y = -5.344 + \underset{(0.556)}{0.709} X1 - \underset{(0.659)}{0.301} X2 + \underset{(0.148)}{0.035} X3$	0.724	18.332 **
Step IV: $Y = 1.271 + \underset{(0.850)}{0.363} X1 + \underset{(1.177)}{0.224} X2 - \underset{(0.196)}{0.033} X3 - \underset{(0.424)}{0.229} X4$	0.726	13.620 **
Step V: $Y = -5.719 + \underset{(0.935)}{0.492} X1 + \underset{(1.214)}{0.138} X2 - \underset{(0.210)}{0.008} X3 - \underset{(0.432)}{0.209} X4 + \underset{(0.334)}{0.115} X5$	0.727	10.724 **

Figures in parentheses below the regression coefficients show the standard errors of the estimated value

**, significant at 1% level

Y = Borer infestation. X1 = Protein. X2 = Fat. X3 = Moisture,

X4 = Silica, X5 = Crude fibre.

They also showed that the susceptible varieties contained lower amount of silica. Marwat and Baloch (1985), Sasamoto (1960 and 1961) and Subbarao and Perraju (1976) observed that the changes in plant moisture were positively correlated to infestation as against the changes in silica contents which were negatively correlated to it.

All the plant component except silica and borer infestation rate were found to decrease with the increases of plant ages from 40 DAT to 75 DAT (Table 1). Percentage of silica contents increased with plant ages, possibly due to cumulative absorption effect of silica by rice plants.

Quantitative relationships

Information on correlation coefficient is particularly useful for indirect selection. Borer infestation rate was found to be significant and positively correlated with moisture content (0.6757, $P<0.01$), protein (0.7214, $P<0.01$) and fat (0.7056, $P<0.01$) in rice plants but negatively correlated with crude fibre (−0.6847, $P<0.01$) and silica content (−0.3516, $P<0.05$) (Table 2). These results indicate that the presence of higher plant moisture, protein and fat content may induce higher stem borer infestation where as higher crude fibre and silica may reduce the infestation rate. Sasamoto (1960 and 1961) and Subbarao and Perraju (1976) have recorded high negative correlations between silica content of stems and stem borer infestation.

The estimated correlation coefficient among rice stem borer infestation and plant constituents tested were partitioned into direct and indirect effects and have been presented by path−coefficient analysis in Table 3. The direct effect of plant moisture on infestation of rice stem borer was negative and was relatively low (−0.0143). Its indirect effects via protein, fat and silica were positive but via crude fibre were negative. The plant protein showed a positive and the highest direct effect (0.6735) on infestation. Its indirect effects via fat and silica were positive but via moisture and crude fibre its indirect effects were negative. Plant fat also showed a positive direct effect (0.1413) and indirect positive effects via protein and silica but negative effects via moisture and crude fibre. Crude fibre showed the lowest direct positive correlation effect (0.1288) on YSB infestation. It produced an indirect positive effect only via moisture but negative effects via protein, fat and silica. Silica exerted the maximum negative direct influence (−0.1135) on infestation and indirect effects via protein and fat but positive indirect effects via moisture and crude fibre. These results of path-coefficient analysis indicated a high direct negative effect of plant silica on borer infestation. These findings are in agreement with the view of Sasamoto (1961), Panda *et al.*, (1975) and Marwat and Baloch (1985). The high residual factor (0.6873) suggests that many parameters which influence borer infestation were not included in this study.

Relative contribution of plant constituents

Following the step-wise regression programme, borer infestation was regressed with each plant component. Selection of the first component was then accomplished by employing the criteria of coefficient of determination (R^2) and F-test (Table 4). The relative importance of the influencing component was plant protein (X1) as per step I. Its relative contribution towards borer infestation was 52.00%. According to step II, plant fat (X2) was the next important component influencing the infestation rate in the presence of protein. According to step III, plant moisture (X3) entered as the third important plant component among the components tested in the presence of protein and fat. Plant silica (X4) was the fourth plant component according to step IV in presence of protein, fat and moisture where as crude fibre (X5) was the last in order of importance, as revealed by step V. F-test showed that the contributions of plant protein, fat, moisture, silica and crude fibre were significant at 1% level. Results revealed that the maximum influence on borer infestation were contributed by plant protein (52.00%) followed by fat (22.30%), moisture (0.10%), silica (0.20%) and crude fibre (0.10%). These results confirmed the reports of Sasamoto (1961), Panda *et al.*, (1975) and Marwat and Baloch (1985).

From these results, it may be concluded that plant protein was the most important and enhancing factor for borer infestation, which made the highest positive correlation association (0.7214, $P<0.01$) with borer infestation and the maximum positive direct effect (0.6735) and maximum influences (52.00%) on infestation rate followed by plant fat and moisture. It is interesting to note that though crude fibre and silica showed significant negative correlations (-0.6847, $P<0.01$ and -0.3516, $P<0.05$, respectively) with borer infestation, they failed to prove their supremacy in path-coefficient analysis or step-wise-regression.

REFERENCES

Amin, E.A. (1979). Correlation and path coefficient analysis in some short-statured rice cultivars and strains. Intern. Rice Comm. Newsl.. 28(1): 19-21.

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.

Catling, W.D. and Islam, Z. (1981). The problem of yellow borer in Asian deep-water rice. Paper presented at Deep-water Rice Workshop, Bangkok. 2-6 November, 1981.

Chandramohan, N. and Chelliah, S. (1984). Relationship between biochemical characteristics of rice and establishment of yellow stem borer (YSB) larvae. Int. Rice Res Newsl. 9(6): 16.

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.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51: 515-518.

Hayes, H.K., Immer, F.R. and Smith, D.C. (1955). Methods of plant breeding. Mc-Graw Hill Book Co. Inc., New York. pp. 551.

Jepson, W.P. (1954). A critical review of the world Literature on the lepidoterous Stalk borers of Tropical Graminaecous crops. Commonwealth Institute of Entomology, London. pp. 127.

Khaleque, M.A., Joarder, O.I. and Eunus, M.A. (1978). Inter-relationship and path coefficient for agronomic traits in rice. Cereal Res. Comm. 6(2): 205-214.

Manwan, I. and Vega, C.R. (1975). Resistance of rice varieties to yellow borer, *Tryporyza incertulas* (Walker). Saturday Seminar, May 10, 1975. Int. Rice Res. Int., Los Banos, Philippines. pp. 12.

Marwat, N.K. and Baloch, U.K. (1985). Varietal resistance in rice to *Tryporyza* species of stem borers and its association with plant moisture, total ashes and silica contents. Pakistan J. Agric. Res.. 6(4): 278 - 281.

Onate, B.T. (1965). Estimation of stem borer damage in rice field. Phil. Statistician. 14: 201 - 221.

Panda, N., Pradhan, B., Samato, A.P. and Prakasa Rao, P.S. (1975). Notes 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.

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 rice stem borer, *Chilo suppressalis* (Walker). Proc. Fac. Liberal Arts and Educ. Yamanasaki Univ., Japan. 3: 1 - 73.

Snedecor, G.W. and Cochran, W.G. (1968). Multiple Regression in Statistical Methods. The Iowa State University Press, Iowa, U.S.A.. pp. 381 - 416.

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

Wright, S. (1923). Theory of path coefficients. Genetics. 8: 239 - 255.