Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(5): 1370-1375

Received: 19-07-2020
Accepted: 21-08-2020

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Physio-morphic basis of resistance in different aromatic rice varieties of Assam against rice stem borer, *Scirpophaga innotata* Walker

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Abstract
The present study was conducted to determine physio-morphic basis of resistance in 10 traditional and two recommended rice varieties against rice stem borer infestation at the Instructional-Cum-Research (ICR) farm, Assam Agricultural University, Jorhat during *Kharif* seasons of 2017-18 and 2018-19, respectively. The results of physio-morphic plant characters of different aromatic rice varieties revealed that plant height ranged from 112.40 to 135.17 cm, length of leaf blade 24.20 to 34.33 cm, width of leaf blade 0.80 -1.17 cm, number of leaves 60.0-98.0, stem diameter 0.87-1.10 cm, leaf trichome density 42.67-109.67/cm^2, number of tillers 9.0-20.33 and thousand grains weight 11.40-25.18 gm in the year 2017, whereas during 2018 that plant height ranged from 108.0 to 136.0 cm, length of leaf blade 24.60 to 34.17 cm, width of leaf blade 0.83 -1.16 cm, number of leaves 55.0-94.0, stem diameter 0.80-1.08 cm, leaf trichomes density 44.67-102.33/cm^2, number of tillers 9.0-19.0 and thousand grains weight 11.50-25.60 gm. From the correlation matrices of physio-morphic plant characters with stem borer infestation, it was noticed that greater plant height, longer leaf blade, narrower width of leaf blade, greater number of leaves, narrower stem diameter, high trichome density, more number of tillers and heavier thousand grain weight contributed for resistance against stem borer attack.

Keywords: Stem borer, rice, physio-morphic, resistance

1. Introduction
Aromatic rice or scented rice contributes a small but an important sub–group of rice. Aromatic rice varieties command a higher price in the international market. Owing to its pleasant aroma, fine and long grain, extreme grain elongation, soft texture on cooking, palatability and easy digestibility, it is highly regarded throughout Asia and are becoming popular in Europe [3] and USA including non-traditionl rice growing countries like Australia [4]. In Assam, total area under aromatic rice cultivation is around 20,000 ha producing 30,000 metric tons every year [18]. Aromatic rice enjoys a top position in terms of popularity. The aromatic rice of Assam is a unique class under *Sali* rice and traditionally known as "*Joha*". This class of rice has high demand in domestic market and is used mainly for preparation of special dishes like table rice, Kheer, Pulao and Payas. *Joha*, a cultivated aromatic rice in Assam, is known for its sweet aroma, superfine kernel, good cooking quality and excellent palatability and taste. Except elongation ratio, *Joha* rice of Assam is comparable to highly priced Basmati and other scented rice in India.

Rice crop is attacked by various biotic and abiotic factors. Among the biotic factors insect fauna is a dominant factor for decreasing the production of rice that resulted in 20-30% yield losses every year [15]. The rice plant is attacked by nearly 300 species of insect pests at specific growth stages and among them only 23 species cause notable damage [11] of which rice stem borer (*Scirpophaga innotata* Walker) is considered as one of the most destructive pests of rice worldwide and of regular occurrence from seedling to maturity stage. Their larvae bore in to stem, feed on the inner tissue and feeding of larvae cause 'dead heart' symptoms at the vegetative stage and 'white ear head' symptoms at reproductive stage.

Application of insecticides is the most common approach to manage insect pests, but overdependence on insecticides is usually not a preferred and sustainable pest control strategy as it leads to an exponential increase in the number of insect species resistant to insecticides, destruction of bio-control agents, resurgence of target pests, outbreak of secondary pests, environmental pollution and contamination of food products [14]. In such a back drop, a durable host plant resistance is identified as the most effective, least problematic and ecological

friendly approach for management of stem borer. Various morphological plant characters like plant height (cm), length of leaf blade (cm), width of leaf blade (cm), number of leaves, stem diameter (cm), tiller number, number of trichome and 1000 grain weight (g) are involved in imparting resistance against stem borers. Morphological structure has significant impact on herbivores and their natural enemies either positively or negatively [1]. Realizing the importance of mechanisms and bases of resistance in the host plant against insect control strategies, the present study is, therefore, planned to evaluate the morphological characters responsible for resistance against rice stem borer on11 different aromatic rice varieties.

2. Materials and Method

The field experiment was conducted in field conditions adopting Latin Square Design (LSD) at the Instructional-Cum-Research (ICR) farm, Assam Agricultural University, Jorhat during *Kharif* seasons of 2017-18 and 2018-19, respectively. The experimental material comprised of 12 varieties of rice, among which 10 aromatic rice varieties *viz*., Kola Joha, Krishna Joha, Boga Joha, Kon Joha, Maniki Joha, Koni Joha, Sofguti Joha, Bokul Joha, Ronga Joha and Tulsi bhog Joha are traditionally cultivated in Assam and other varieties like Keteki Joha and Jaya are high yielding varieties. The traditional varieties were collected from farmers field, Serakapar, Sivasagar and high yielding varieties were collected from Regional Agricultural Research Station, Titabor, Jorhat, Assam. The seeds of different traditional and recommended varieties of rice were sown in nursery bed. One-month-old seedlings of each variety were transplanted in each plot during last week of July with half meter isolation distance between the varieties. The gross area for the whole experiment was 190 meter square which was divided into 12 sub-plots with an area of 10m×1.5m. The spacing between rows and between plant to plant was 20 cm and 20 cm, respectively. All recommended agronomic practices were adopted to maintain good crop stand in the field by following Package of Practices for *Kharif* Crops of Assam [2]. No plant protection coverage was provided in the experimental plot to build-up optimum condition for pest multiplication.

For physio-morphic studies, each rice variety was observed at weekly interval on 5 randomly selected plants per variety. Plant physical characters such as plant height (cm), length of leaf blade (cm), width of leaf blade (cm), number of leaves, stem diameter (cm), number of trichomes, tiller number, 1000 grain weight (g) for all the 12 varieties were recorded by adoption of [7] and [3]. Depending on the type of the characters, the observations were recorded at specific growth stage of the crop and and then correlated with stem borer infestation.

3. Statistical analysis

Each parameter's recorded data was statistically analyzed by one-way ANOVA using SPSS software and LSD range test to compare the mean differences at 5% level of significance.

4. Results

Table 1 and Table 2 shows the physio-morphic plant characters of 11 different aromatic rice varieties including check variety (Jaya). The results showed that the highest plant height was recorded on variety Kola Joha with 135.17 cm which was closely followed by Krishna Joha (130.57cm), Kon Joha (128.50 cm), Bokul Joha (128.50 cm), with no any significant difference among those varieties. However, the lowest plant height of 112.40 cm was observed in Tulsi Bhog Joha which was found to be significantly different from rest of the different aromatic rice varieties except Koni Joha (115.0 cm) and Keteki Joha (116.0 cm), respectively. Similarly, during 2018, same trend of results in plant height was observed and the maximum plant height with 136.0 cm was observed in Kola Joha followed by Kon Joha (127.67 cm), Ronga Joha (127.50 cm), Bokul Joha (127.0 cm) and Krishna Joha (126.0 cm),whereas minimum was recorded on variety Tulsi Bhog Joha with 108.0 cm and statistically at par with Koni Joha (112.33 cm).With regards to length of leaf blade, the longest leaf blade length of 34.33cm was shown by Sofguti Joha which was found to be at par with Krishna Joha (33.50 cm) and Boga Joha (33.0cm),while the shortest leaf blade length was registered in variety Tulsi Bhog Joha with 24.40 cm followed by Ronga Joha (25.60 cm) and Kon Joha (25.63 cm) during 2017.Similarly, during 2018,the longest leaf blade length measuring 34.17 cm was found in variety Sofguti Joha followed by Krishna Joha (33.30 cm), Boga Joha (32.83 cm) and Kola Joha (32.73 cm).However, the shortest leaf blade length was recorded in variety Tulsi Bhog Joha (24.60 cm) and exhibited no difference with Kon Joha (25.33cm), Ronga Joha (25.50 cm) and Keteki Joha (26.0cm), respectively. The widest leaf blade measuring 1.17 and 1.16 cm were recorded in variety Tulsi Bhog Joha during 2017 and 2018, respectively. However, the narrowest leaf blade was recorded in Koni Joha (0.80 and 0.83cm) for both consecutive years. In respect of leaf numbers, maximum number of leaves (98.0 nos) were observed in variety Kola Joha followed by Sofguti Joha (97.0 nos),whereas minimum number was achieved in variety Tulsi Bhog Joha (60.0 nos) and Koni Joha (60 nos), which were at par with the variety Bokul Joha (65.0 nos) and Krishna Joha (69.0 nos) during 2017.Similarly, during 2018, Kola Joha showed maximum number of leaves (94.0 nos) followed by Sofguti Joha (91.0nos) and Boga Joha (90.0 nos) and minimum number of leaves were observed in Tulsi bhog Joha with 55.0 nos of leaves. Significantly maximum stem diameter was exhibited in Koni Joha (1.10cm) which did not differ significantly with Tulsi Bhog Joha, Krishna Joha, Bokul Joha and Ronga Joha and Kon Joha with 1.08 cm, 1.05 cm, 1.05 cm 1.04 cm and 1.04 cm, whereas minimum stem diameter was registered in Kola Joha (0.87 cm) and Sofguti Joha (0.87cm) which were at par with Maniki Joha (0.92 cm) during 2017. Similarly, during 2018, maximum stem diameter of 1.08 cm was shown by the variety Tulsi Bhog Joha followed by Bokul Joha (1.07 cm), Koni Joha (1.06 cm), Krishna Joha (1.05 cm) and Kon Joha (1.04 cm), while minimum was recorded in Kola Joha (0.80 cm) and exhibited no difference with Sofguti Joha (0.83 cm) and Maniki Joha. The mean data pertaining to number of trichomes showed a significant difference among different aromatic rice varieties. It was observed that Kola Joha possess maximum number of trichomes with 109.67/cm^2 leaf area which was closely followed by Sofguti Joha (101.67/cm^2 leaf area),whereas minimum number of trichomes were found in Tulsi Bhog Joha with 42.67/cm^2 leaf area followed by Koni Joha (44.33/cm^2 leaf area), Bokul Joha (46.67/cm^2 leaf area), Kon Joha (50.0/cm^2 leaf area), Ronga Joha (52.67/cm^2 leaf area) and Krishna Joha (54.33/cm^2 leaf area) in 2017.Similar trend results were also found for the year 2018, where maximum number of trichomes were found in variety Kola Joha (102.33/cm^2 leaf area) followed by Sofguti Joha (95.67/cm^2 leaf area) and minimum number was observed in Tulsi Bhog Joha (44.67/cm^2 leaf area) and exhibiting no

difference with Bokul Joha and Koni Joha with 46.67 number of trichomes per cm^2 leaf area. The data on number of tillers of different aromatic rice varieties indicated a significant variations among the varieties. In respect of number of tillers, the highest number of tillers with 20.33/plant and 19.0/plant was noticed in Kola Joha, while the lowest number was observed in variety Tulsi Bhog Joha with 9.0/plant, during 2017 and 2018, respectively. The data pertaining to weight of thousand grains of different aromatic rice varieties showed a significant difference among the varieties. Thousand fresh grains weighed significantly heavier in variety Kola Joha with 25.18 g/plant and was statistically at par with Sofguti Joha (24.80 g/plant) and Ronga Joha (23.73g/plant) during 2017 and this might be due to its larger grain size. Similarly, during 2018, the same variety Kola Joha showed the heaviest weight of thousand grains(25.60g/plant) and exhibited no significant difference with Sofguti Joha (24.14g/plant) and Ronga Joha (23.49g/plant). However, lighter weight was attained in Koni Joha with 11.40 g/plant followed by Tulsi Bhog Joha with 11.90g/plant during 2017, whereas during 2018, the lighter weight was recorded in Tulsi Bhog Joha (11.50 g/plant) followed by Koni Joha (11.75 g/plant)

4.1 Correlation of stem borer infestation with different morphological characters

Table 3 and Table 4 reveals the correlation matrix between plant physio-morphic characters with stem borer infestation. The correlation study of plant height was recorded negatively significant with stem borer infestation in terms of per cent dead heart (DH) and white ear head (WEH) (r = -0.732** and r = -0.784** and r = -0.606* and r = -0.598*). The correlation matrix of leaf blade showed a non-significant negative relationship ($r= - 0.378^{NS}$) in terms of dead heart during 2017, but a highly significant negative correlation ($r= - 0.677^{*}$) was achieved during 2018.Similarly, white ear head (WEH) showed a non- significant negative correlation ($r= -0.225^{NS}$ and $r = -0.221^{NS}$) with leaf blade length for both the years, 2017 and 2018. Positive and non-significant was observed between the width of leaf blade with dead heart (DH) percentage ($r = 0.461^{NS}$ and $r = 0.555^{NS}$), whereas in case of white ear head (WEH), it was found to be positive and significant (r = 0.608* and r = 0.678**) for both the years, 2017 and 2018, respectively. Negative and significant correlation existed between number of leaves with stem borer (*S. innotata*) infestation at vegetative ($r = - 0 .962^{**}$ and r = -0.891**) and reproductive stage ($r = - 0 .655^{*}$ and $r = -0.577^{*}$) respectively, during both the years, 2017 and 2018. Moreover, stem diameter exerted a highly significant positive correlation ($r = 0.829^{**}$ and $r = 0.816^{**}$) at vegetative stage, whereas non-significant positive correlation ($r = 0.555^{NS}$ and $r = 0.504^{NS}$) at reproductive stage. Number of trichomes were noticed a significant negative correlation ($r = -0.860^{**}$ and $r = -0.870^{**}$) at vegetative stage and non-significant negative correlation ($r = 0.566^{NS}$ and $r = 0.553^{NS}$) at reproductive stage, during 2017 and 2018, respectively. A negative significant correlation ($r = -0.806^{**}$ and $r = -0.739^{**}$) was observed in between number of tillers and stem borer infestation at vegetative stage during 2017 and 2018, respectively. However, the correlation was very weak and negatively associated ($r = -0.476^{NS}$ and $r = -0.413^{NS}$) at reproductive stage. Thousand grain weight was recorded significant and negatively correlated with (r = -0.650) with dead heart (DH) and non significant negative correlation with white ear head (WEH) ($r = -0.424^{NS}$) in the year 2017. However, a negative non significant association was achieved with dead heart (DH) and white ear head (WEH) ($r = -0.570^{NS}$ and $r = -0.423^{NS}$) during 2018.

Table 1: Physio-morphic characters of different aromatic rice varieties during *Kharif* 2017

Variety	Plant height (cm)	Length of leaf blade (cm)	Width of leaf blade (cm)	No. of leaves	Stem diameter (cm)	No. of trichomes/ cm^2 leaf area	No. of tillers	Length of panicle	No. of grains per panicle	1000 Grain weight (g)
1. Keteki Joha	116.0^{b}	26.50^{abcd}	1.05^{cdef}	80.20^{cde}	1.00^{bcd}	60.67^{bc}	12.67^{cde}	23.83^{a}	124.0^{ab}	18.08^{d}
2. Kola Joha	135.17^{d}	32.33^{cde}	1.06^{cdef}	98.0^{e}	0.87^{a}	109.67^{d}	20.33^{g}	27.0^{ab}	286.67^{d}	25.18^{g}
3. Krishna Joha	130.57^{cd}	33.50^{de}	1.02^{bcde}	69.0^{bc}	1.05^{cd}	54.33^{b}	10.00^{abc}	27.67^{ab}	118.0^{ab}	16.35^{c}
4. Boga Joha	124.5^{bcd}	33.0^{de}	1.08^{def}	90.0^{de}	0.98^{bc}	78.33^{c}	15.33^{ef}	25.87^{a}	129.33^{b}	20.60^{ef}
5. Kon Joha	128.50^{cd}	25.63^{abc}	0.90^{ab}	75.20^{bcd}	1.04^{cd}	50.0^{b}	10.33^{abc}	25.33^{a}	122.0^{ab}	21.81^{f}
6. Maniki Joha	122.0^{bc}	27.40^{abcde}	0.93^{abc}	88.0^{de}	0.92^{ab}	79.0^{c}	14.00^{def}	27.83^{ab}	214.33^{c}	21.50^{f}
7. Koni Joha	115.0^{b}	29.70^{bcde}	0.80^{a}	60.0^{ab}	1.10^{d}	44.33^{ab}	9.67^{ab}	28.47^{ab}	115.0^{ab}	11.40^{a}
8. Sofguti Joha	123.43^{bcd}	34.33^{e}	1.15^{ef}	97.0^{be}	0.87^{a}	101.67^{d}	15.67^{f}	25.73^{a}	260.0^{d}	24.80^{g}
9. Bokul Joha	128.50^{cd}	29.56^{bcde}	1.03^{bcdef}	65.0^{bc}	1.05^{cd}	46.67^{b}	9.33^{ab}	31.0^{b}	120.0^{ab}	14.40^{b}
10. Ronga Joha	123.50^{bcd}	25.60^{abc}	1.00^{bcd}	77.0^{bcd}	1.04^{cd}	52.67^{b}	11.33^{bcd}	24.40^{a}	123.67^{ab}	23.73^{g}
11. Tulsi Bhog Joha	112.40^{b}	24.20^{ab}	1.17^{f}	60.0^{ab}	1.08^{cd}	42.67^{ab}	9.00^{ab}	27.50^{ab}	110.33^{ab}	11.90^{a}
12. Jaya	51.0^{a}	22.0^{a}	1.54^{g}	46.0^{a}	1.10^{d}	24.33^{a}	8.67^{a}	24.57^{a}	94.67^{a}	19.50^{de}
P< value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
F value	68.93	7.16	39.24	19.02	15.45	35.23	40.20	4.11	109.41	199.18

Data based on mean of 10 observations.(10 plants/plot)

In column mean followed by same letter do not differ significantly ($P<0.05$) at LSD range test.

Table 2: Physio-morphic characters of different aromatic rice varieties during *Kharif* 2018

Variety	Plant height (cm)	Length of leaf blade (cm)	Width of leaf blade (cm)	No. of leaves	Stem diameter (cm)	No. of trichomes/ cm^2 leaf area	No. of tillers	Length of panicle	No. of grains per panicle	1000 Grain weight (g)
1.Keteki Joha	121.0^{cd}	26.0^{ab}	1.04^{abc}	80.0^{abcd}	1.00^{bcd}	59.33^{d}	12.00^{abcde}	24.23^{ab}	159.67^{b}	18.48^{bcd}
2.Kola Joha	136.0^{e}	32.73^{cde}	1.05^{bc}	94.0^{d}	0.80^{a}	102.33^{f}	19.00^{f}	29.33^{c}	265.0^{d}	25.60^{f}
3.Krishna Joha	126.0^{de}	33.30^{de}	1.02^{abc}	74.0^{abcd}	1.05^{cd}	58.67^{cd}	9.40^{ab}	24.67^{ab}	116.67^{a}	16.41^{bc}
4.Boga Joha	122.0^{cd}	32.83^{cde}	1.06^{bc}	90.0^{cd}	0.92^{abc}	76.67^{e}	14.33^{de}	25.33^{abc}	191.67^{c}	20.38^{de}
5.Kon Joha	127.67^{de}	25.33^{ab}	0.92^{ab}	82.0^{bcd}	1.04^{cd}	52.67^{bcd}	10.33^{abcd}	25.6^{abc}	121.33^{a}	21.60^{de}
6.Maniki Joha	120.67^{cd}	27.60^{bc}	0.94^{ab}	85.0^{bcd}	0.88^{ab}	76.33^{e}	12.33^{bcde}	24.33^{ab}	174.67^{bc}	21.46^{de}
7.Koni Joha	112.33^{bc}	28.40^{bcd}	0.83^{a}	65.0^{abc}	1.06^{cd}	46.67^{bc}	9.67^{abc}	24.67^{ab}	110.0^{a}	11.75^{a}
8.Sofguti Joha	124.33^{cde}	34.17^{e}	1.11^{bc}	91.0^{cd}	0.83^{a}	95.67^{f}	14.67^{e}	28.0^{bc}	248.0^{d}	24.14^{ef}
9.Bokul Joha	127.0^{de}	29.90^{bcde}	1.03^{abc}	70.0^{abcd}	1.07^{cd}	46.67^{bc}	9.33^{ab}	27.40^{bc}	112.33^{a}	14.92^{ab}
10.Ronga Joha	127.5^{de}	25.50^{ab}	1.00^{abc}	85.0^{bcd}	1.00^{bcd}	50.67^{bcd}	13.67^{cde}	25.0^{ab}	120.67^{a}	23.49^{ef}
11.Tulsi Bhog Joha	108.0^{b}	24.60^{ab}	1.16^{c}	55.0^{a}	1.08^{d}	44.67^{b}	9.00^{ab}	27.0^{abc}	102.33^{a}	11.50^{a}
12.Jaya	49.67^{a}	21.0^{a}	1.50^{d}	60.0^{ab}	1.10^{d}	26.0^{a}	8.33^{a}	23.17^{a}	98.0^{a}	19.26^{cd}
P< value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
F value	75.37	12.69	14.61	5.55	10.74	81.44	13.98	4.77	109.48	36.03

Data based on mean of 10 observations.(10 plants/plot)
In column mean followed by same letter do not differ significantly (P<0.05) at LSD range test.

Table 3: Simple correlation coefficient (r) and regression equation between physio-morphic characters of different aromatic rice varieties and per cent infestation of stem borer during *Kharif* 2017

SI. No.	Parameters	% Dead heart (DH)	% White ear head(WEH)
1.	Plant height	r = -0.732** y = 47.38 –0.232x	r = -0.606* y = 27.12 – 0.139x
2.	Length of leaf blade	r= - 0.378^{NS}	r = -0.225^{NS}
3.	Width of leaf blade	r = 0.461^{NS}	r =0 .608* y = -7.07+ 16.81x
4.	No. of leaves	r = -0.962** y = 51.45 – 0.415x	r = - 0 .655* y = 26.23 – 0.205x
5.	Stem diameter	r = 0.829** y = -50.81+70.32x	r = 0.555^{NS}
6.	No. of trichomes	r = -0.860** y = 34.80-0.237x	r = -0.566^{NS}
7.	No. of tillers	r = -0.806** y = 39.45-1.59x	r = -0.476^{NS}
8.	1000Grain weight	r = -0.650* y = 38.32- 0.954x	r = -0.424^{NS}

NS = Non-significant
*Corelation is significant at 0.05 level
**Corelation is significant at 0.01 level

Table 4: Simple correlation coefficient (r) and regression equation between physio-morphic characters of different aromatic rice varieties and per cent infestation of stem borer and leaf folder during *Kharif* 2018

SI. No.	Parameters	% Dead heart (DH)	% White ear head(WEH)
1.	Plant height	r = -0.784** y = 44.33 – 0.221x	r = -0.598* y = 24.46– 0.116x
2.	Length of leaf blade	r= - 0.677* y = 44.67 – 1.03x	r = -0.221^{NS}
3.	Width of leaf blade	r = 0.555^{NS}	r =0 .678** y = -7.90 + 17.83x
4.	No. of leaves	r = -0.891** y = 52.76 – 0.442x	r = - 0.577* y = 26.15– 0.196x
5.	Stem diameter	r = 0.816** y = -30.93+50.14x	r = 0.504^{NS}
6.	No. of trichomes	r = -0.870** y = 33.62-0.246x	r = -0.553^{NS}
7.	No. of tillers	r = -0.739** y = 36.07-1.48x	r = -0.413^{NS}
8.	1000Grain weight	r = -0.570^{NS}	r = -0.423^{NS}

NS = Non-significant
*Corelation is significant at 0.05 level
**Corelation is significant at 0.01 level

5. Discussion

The present results regarding plant height showed a close conformity with the findings of [6] where they reported a significant negative relationship (r = -0.211*) between plant height and white ear head (WEH). The number of egg masses deposited by yellow stem borer (*S. incertulas* Walker) was

negatively correlated with plant height as suggested by [16]. Significant correlation between pink stem borer (*Sesamia inferens* Walker) infestation with the plant height [9]. The present results were also in accordance with the findings of [17] and according to them, greater plant height, increased tiller number and leaf macro hairs resulted in reduction of infestation rate of yellow stem borer. In respect of leaf blade length, the result of the present investigation was in confirmation with [6] and according to them, the correlation in between length of leaf blade with white ear head (WEH) caused by *Chilo suppressalis* had a non-significant negative relationship. Moreover, the number of egg masses deposited by the female yellow stem borer (*S. incertulas*) was negatively correlated with second leaf length as reported by [16]. The results indicated that rice varieties with wide leaf was more susceptible to the borer infestation. Oviposition preference in the wide leaf rice varieties by the female moth might be one reason for which more infestation occurred in such varieties. The present results were supported by [19] who investigated that resistant varieties caused mortality or inhibited the growth of stem borers and therefore, resistance was highly correlated with larger width of the leaf sheath ridge. These findings were also in accordance with that of [10], who found that in wild rice, non-preference was attributed to very narrow pith, slender, hard and tough stems. Highly significant positive correlation was also recorded between Asiatic rice borer (*Chilo suppressalis*) and width of flag-leaf [12]. However, the results were also in confirmation with the findings of [6] and they recorded a significant positive correlation between *C. suppressalis* infestation with leaf width. The current results demonstrated that stem borer, *S. innotata* preferred variety comparatively with less number of leaves and the findings of [16] was in agreement with the present findings and according to him, the number of egg masses deposited by *S. incertulas* was negatively correlated with number of leaves/plant.

As the pest remained most of its life inside the stem, therefore, they preferred rice varieties with larger stem diameter which facilitated their easy movement as well as to make their life processes more comfortable. The results of the present investigation were in conformity with [9] and they also reported a significant positive correlation between pink stem borer (*S. inferens*) infestation with the stem diameter for two consecutive years. They also stated that boarder stem facilitated larval development and movement. Therefore, varieties with large stem diameter encountered high borer infestation. Significant positive correlation between striped stem borer (*C. suppressalis*) infestation with stem diameter as reported by [6]. Wild rice varieties appeared to be more resistant to stem borer due to narrow stems [10]. Some other researchers also reported that thin stem diameter characters did not allow stem borer larva to feed on rice plant [8]. The tolerant genotypes against stem borer, should have high number of tillers, narrow stem diameter and flag leaf angle [5]. The present findings pertaining to number of trichomes with stem borer attack were in agreement with the results of [17], where they confirmed that higher number of trichomes decreased the incidence of stem borer and therefore contributed resistance against the insect pest attack.

6. Conclusion and Recommendations

Study of various physio-morphic plant characters in 11 different aromatic rice revealed that plant height ranged from 112.40 to 135.17 cm, length of leaf blade 24.20 to 34.33 cm, wide of leaf blade 0.80 -1.17 cm, number of leaves 60.0-98.0,stem diameter 0.87-1.10 cm, leaf trichomes density 42.67-109.67/cm^2, number of tillers 9.0-20.33 and thousand grains weight 11.40-25.18 gm in the year 2017, whereas during 2018 that plant height ranged from 108.0 to 136.0 cm, length of leaf blade 24.60 to 34.17 cm, width of leaf blade 0.83 -1.16 cm, number of leaves 55.0-94.0, stem diameter 0.80-1.08 cm, leaf trichome density 44.67-102.33/cm^2, number of tillers 9.0-19.0 and thousand grains weight 11.50-25.60 gm. From the correlation matrices of physio-morphic plant characters with stem borer infestation, it was noticed that greater plant height, longer leaf blade, greater number of leaves, narrower stem diameter, high trichome density, more number of tillers and heavier thousand grain weight contributed for resistance against stem borer attack. On the basis of above characters, Kola Joha, Sofguti Joha, Boga Joha and Maniki Joha are recommended for cultivation during *Sali* season. Further study is needed to diversify new resistance basis in aromatic rice.

7. Acknowledgements

The authors are grateful to Board of Research in Nuclear Sciences, Trombay, Mumbai for providing financial assistance during the tenure of the work. Sincerest thanks and gratefulness are due to Dr. A.Rahman, Professor & Head, Department of Entomology, Faculty of Agriculture, Assam Agricultural University, Jorhat for his fruitful suggestions and guidance in the execution of this work.

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