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Screening of indigenous Chak-hao rice (*Oryza sativa* L.) Genotypes of Manipur for Resistance Reactions against Yellow Stem Borer (YSB), *Scirpophaga incertulas* (Walker)

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ABSTRACT: Rice genotypes indigenous to Manipur were screened for resistance reactions against yellow stem borer at the research field of College of Agriculture, Central Agricultural University, Imphal, Manipur. The study was carried out keeping in mind the ever growing popularity and lack of research in the field of insect infestation in Chak-hao rice genotypes and to know its bio-chemical properties related to insect infestation. The experimental design followed was Randomized Bock Design, with three replications and 19 genotypes (treatments). Insect infestation was recorded at 30, 45, 60, 75 and 90 DAT. Analysis of variance was performed after appropriate transformation of mean values obtained from the various experiments. Considering the average of six observations *i.e.* at 30, 45, 60, 75 and 90 DAT, the lowest per cent dead heart was observed in Kota Chak-hao with 3.58 per cent. Wairi Chak-hao showed highest per cent dead heart with 5.37 per cent. For finding the resistance reactions, biochemical parameters such as total sugars, reducing sugars, total phenols and orthodihydroxy phenol were analysed. The result showed that sugar content and insect infestation were positively co-related and phenol content whereas insect infestation were negatively co-related. From the present study we were able to understand to some extent that the insect infestation is lesser as compared to that of common rice and the attributes such as phenolic contents play a major role in imparting resistance to the insect pest of Chak-hao rice genotypes.

Keywords: Screening, Yellow stem borer (YSB), Randomized Block Design (RBD), Biochemical Analysis.

INTRODUCTION

Rice genotypes known as chak-hao belong to the *Oryza sativa* L. species, and contain a high level of nutrients. They are mainly grown in Asia. In Manipur, a diverse array of these rice genotypes are available having a purplish grain colour mostly. The unique purple colour of chak-hao is due to high deposition of anthocyanins in the outer pericarp, seed coat and aleurone layer (Chaudhury, 2003). Chak-hao can be translated as delicious rice (Chak-rice; hao-delicious) (Roy *et al.,* 2014). They are sold in the local markets at a premium rate. Chak-hao cultivars can grow well on stressful condition such as poor soil nutrient and water, drought and stress condition. However, are poor yielding as compared to hybrid varieties and traditional varieties (Borah *et al.,* 2018). In recognition of its unique properties, the scope for its commercial cultivation and value addition for a profitable agro-business has been envisioned.

Only 20 species are important and occur regularly in tropical Asia (Grist and Lever, 1969). As of 2014, yellow stem borer (*Scirpopagha incertulas* Walker) was the dominant pest and caused a yield loss of 10-60% throughout the country. Hence, it necessitates evaluation of the reaction of the indigenous chak-hao rice genotypes against the changing pest status. Further, looking into the increasing market demand for chak-hao rice, it becomes necessary to identify the genotype which is resistant/ tolerant to the major insect pests and give higher yield for popularisation among farmers and also for use in the future genetic improvement programmes.

Due to the foregoing facts, the following objective has been set to screen indigenous chak-hao rice genotypes of Manipur for resistance reactions against major insect-pests of rice-

1. To ascertain the extent of yellow stem borer infestations in the indigenous chak-hao rice genotype in Manipur.
2. To study the mechanism of resistance reactions towards yellow stem borer in traditional chak-hao rice genotypes of Manipur.

MATERIALS AND METHODS

A field experiment was carried out during *Kharif*, 2017 at the Entomological Research Farm, College of Agriculture, CAU, Imphal located at 24°45´ N latitude and 93° 56 E´ longitude to evaluate 19 chak-hao rice genotypes (including the susceptible check) and find their resistance reaction against yellow stem borer of rice in present rice ecosystem of Manipur. Experimental design followed was Randomized Block Design, (RBD) each chak-hao rice genotypes were transplanted in 3 rows and each row consisted of 20 hills. After every 10 genotypes, three rows of susceptible check, Leimaphou was also transplanted. At the beginning and end of the plot, three rows of susceptible check were also transplanted to increase the pest pressure. The similar pattern was replicated three times. However, sequence of genotypes were randomised.

Table 1: Details of Chak-hao genotypes.

Treatments	Name of Chak-hao rice genotypes
T_1	Pong chak-hao
T_2	Komchak-hao
T_3	Kothachak-hao
T_4	Chettamochak-hao
T_5	Chak-haoPoireiton
T_6	Wahongchak-hao
T_7	Chingchak-haoAngangba
T_8	Chak-haoSempak
T_9	Chak-haoAmubi
T_{10}	Chak-haoTatha
T_{11}	Chak-haoAngangbi
T_{12}	Chak-haoHeimang
T_{13}	Komchak-haoMacha
T_{14}	Chak-haoManamNungshibi
T_{15}	Chak-haoNapduina
T_{16}	WairiChak-hao
T_{17}	Chak-haoMongkhangi
T_{18}	Chak-haoTaniangban
T_{19}	Leimaphou (KD 2-6-3)

At 30, 45, 60, 75, and 90 DAT, random selections of 10 hills per replication were observed for Yellow stem borer infestation. From 10 randomly selected hills at the vegetative stage of the crop, the number of tillers per hill and the number of dead hearts were counted. A slight pull on the dead heart confirmed the yellow stem borer infestations. The white ear head incidence was very low and calculated from 75 and 90 DAT. The following formula was used to determine the percent infestation:

Number of dead heart per hill

$$\text{Per cent dead hearts} = \frac{\text{Number of dead heart per hill}}{\text{Total number of tillers}} \times 100$$

$$\text{Per cent white ears} = \frac{\text{Number of white ears per hill}}{\text{Total number of tillers per hill}} \times 100$$

Biochemical basis of resistance. Based on leaf samples collected from 60 days old plants of resistant and susceptible gene pools, the following biochemical constituents were determined: total sugars, reducing sugars, total phenols, and ortho-dihydroxy phenols. The procedures followed are discussed as under.

Alcohol extraction of plant tissues. A sample of uninfested leaves was collected from a 60-days-old plant of the chak-hao rice genotype. Each sample was washed and dried in the shade. One gram each of plant samples of all genotypes were taken in separate conical flasks and 15 ml of 80 per cent ethanol was added. These were refluxed on a hot water bath for 30 minutes before being analyzed. The extracts were cooled after boiling. After decanting the supernatants into new flasks, the residues were again re-extracted with hot ethanol and decanted. Extracts were filtered through Whatman No.1 filter paper and then made up to a known volume with 80 percent ethanol. Samples were prepared from the extracts after they were stored in refrigerator at 4°C.

Preparation of aliquot samples. For estimating total sugars, reducing sugars, total phenols, and ortho-dihydroxyphenols, the samples (supernatant solution) should be alcohol free extract which are known as aliquot samples. So, 2 ml of supernatant solution were taken in a test tube with the help of micropipette and placed in a water bath to evaporate the alcohol (ethanol) till the samples were completely dry. After complete dryness, they were prepared into 1 ml alcohol free extract (aliquot solution) by adding 1 ml water to the test tubes and placed them in small test tubes.

Total soluble sugars estimation. According to the Anthrone method for determining total soluble sugars (Sadasivan and Manickam, 1996), working standard solutions were prepared by dissolving 10 ml glucose stock solution in 100 ml water. Working standard solutions of 0.2, 0.4, 0.6, 0.8 and 1 ml, along with 0.1 ml aliquot samples (alcoholic free extracts), were pipetted out into test tubes and the volume was made up to 1 ml with distilled water. In each sample, Anthronereagent was added in a volume of 4 ml, followed by adding water to make a total volume of 25 ml. After 1 minute in a boiling bath, they were cooled and colour developments were measured at 630 nm using spectrophotometer. Total soluble sugars were calculated by drawing standard graph with glucose as standard.

Estimation of reducing sugars by DNS method. The working standard glucose solutions were prepared by dissolving 10 ml glucose stock solution in 100 ml water. Standard solutions of 0.2, 0.4, 0.6, 0.8 and 1 ml, as well as 0.1 ml aliquot samples (ethanol free extract) of selected genotypes were pipetted into test tubes, which were subsequently filled with distilled water to a volume of 1 ml. In addition to 3 ml of DNS, 25 ml of distilled water was added to each sample. After boiling for 1 minute, they were cooled and the colour developed was measured using a spectrophotometer at 510 nm. Reducing sugars content was calculated by drawing a standard graph with glucose as standard.

Estimation of total phenols. Total phenol was estimated using the method as given by Malik and Singh (1980). The working standard catechol solution was prepared by dissolving 10 ml catechol stock solution in 100 ml water. Working standard solutions of 0.1, 0.2, 0.3, 0.4 and 1 ml were pipetted out in a series of test tubes, along with 0.1 ml aliquot samples (alcoholic free extract) of selected genotypes, and the volume was made up to 1 ml with distilled water. To 1 ml of sample extract, 0.2 ml FCR reagent and 2 ml 20% Na_2CO_3 and distilled water were added making the volume upto 25 ml. It was kept in a boiling water bath for 1 minute, cooled and the colour developed was measured at 650 nm using spectrophotometer. Total phenol content was calculated by drawing a standard graph with catechol as standard.

Estimation of ortho-dihydroxy phenol. According to Arnow method (Arnow, 1937) for determining ortho-dihydroxy phenolworking standard catechol solution were prepared by dissolving 10 ml catechol stock solution in 100 ml water. Working solutions of 0.1, 0.2, 0.3, 0.4 and 1 ml each along with 0.1 ml aliquot sample (alcoholic free extract) of the selected genotypes were pipetted out in a series of test tubes and the volume was made up to 1 ml with distilled water. To 1 ml of sample extract, 1 ml of Arnowreagent, 2 ml NaOH and 1 ml of 0.05 N HCl and volume was made upto 25 ml by adding distilled water. It was kept in a boiling water bath for 1 minute, cooled and colour developed was measured at 515 nm using spectrophotometer. Ortho-dihydroxy phenol content was calculated by drawing standard graph with glucose as standard

Statistical analysis. Statistical test of significance through analysis of variance was performed after appropriate transformation of mean values obtained from the various experiments.

RESULT AND DISCUSSION

Based on the average of five observations *i.e.* at 30, 45, 60, 75 and 90 DAT, the lowest incidence was observed in Wahongchak-hao with 3.58 per cent, the standard check (Leimaphou) had an average infestation of 8.4%. Chak-hao Amubi suffered highest infestation with 5.37 per cent infestation apart from the standard check (Table 2).

Basis of resistance against major insect pest of chak-haorice genotypes

Total soluble sugars content in yellow stem borer resistant and susceptible genotypes. The total soluble sugars are presented in table 3 for each selected susceptible genotype (plus the susceptible check) and five resistant genotypes. The soluble sugar content in susceptible genotypes ranged from 4.77 to 6.38 per cent whereas that in resistant genotypes ranged from 3.12 to 3.82 per cent. The total soluble sugar content of 6.38 percent was recorded in chak-haoPoireiton, while 3.12 percent was recorded in Komchak-hao.

Reducing sugars concentration in resistant and susceptible genotypes. The reducing sugar content ranged from 2.08 to 2.71 percent in the susceptible genotypes. A total of 2.06 per cent was recorded in Kothachak-hao, whereas 4.29 per cent was recorded in Liemaphou. Chak-hao Taniang ban (1.75 percent) recorded the lowest level of resistance, followed by Chak-hao Sempak (1.99 percent), Kothachak-hao (2.06 percent), Komchak-hao (2.24 percent) and Chak-hao Manam Nungshibi (2.27 percent) in ascending order.

Total phenols content in yellow stem borer resistant and susceptible genotypes. The total phenols content were relatively high in resistant genotypes. The highest phenol content was recorded in Kothachak-hao (4.61 per cent) followed by Chak-hao Sempak (4.24 per cent), Komchak-hao (4.20 per cent), Chak-hao Manam Nungshibi (4.08 per cent) and Chak-hao Taniang Ban (4.01 per cent) in descending order. The total phenols content was lowest in standard check, Leimaphou (1.93 per cent).

Ortho-dihydroxy phenol content in yellow stem borer resistant and susceptible genotypes. In the susceptible genotypes, the ortho-dihydroxy phenol content were relatively lower when compared with resistant genotypes. The susceptible genotypes *viz.*, Leimaphou (1.11 per cent), Chak-haoAmubi (1.26 per cent), Wairi Chak-hao (1.27 per cent), Chak-haoTatha (1.28 per cent) and Chak-hao Poireiton (1.61 per cent) recorded lower ortho-dihydroxy phenol content in ascending order. Whereas the resistant genotypes *viz.*, Kotha chak-hao (2.70 per cent), Chak-hao Sempak (2.20 per cent), Chak-hao Taniang Ban (2.17 per cent), Chak-hao Manam Nungshibi (2.07 per cent) and Komchak- hao (1.88 per cent) in descending order recorded higher ortho-dihydroxy phenol content.

Yellow stem borer incidence during the study period was low. Due to the low incidence, a damage score could not be calculated using the standard rice evaluation system. Hence as a result, comparisons were made between the different genotypes using the C.D. at 5%. Yellow stem borer damage was more severe in the early stage of the crop than in the advanced stage. The larvae of yellow stem borer can damage more tillers at an early stage of the crop, but as the crop grew up, they concentrated in a single tiller. Bandong and Litsinger (2005) reported an almost similar finding. Additionally, they revealed that resistance could be caused by the following: (1) Lignin and cellulose deposits on the cell walls, (2) tight wrapping of the leaf sheath, and (3) silica deposition.

A comparison of selected resistant and susceptible rice genotypes revealed that the total soluble sugar content of selected resistant genotypes was significantly lesser. In addition, the total sugars and the reducing sugar content of susceptible genotypes was higher than that of resistant genotypes. Ahmad *et al*. (2006) reported similar findings. They revealed that high amount of total and bound phenols contain were found to be imparting resistance against rice leaf folder and rice stem borer. The total soluble sugars and reducing sugars content in present investigation is supported by Singh (2010), where they reported that the total soluble sugars and reducing sugars contain was higher in susceptible genotypes in comparison to resistant genotypes.

In contrast to sugar content, total phenol content and ortho-dihydroxyphenol content were significantly lower in selected susceptible genotypes than in selected resistant genotypes. Elanchezhyam *et al*. (2017) also reported similar observations in their study. Asem *et. al.* (2015) reported that the reason for its resistance may be attributed by its high phenolic and anthocyanin content.

Table 2: Per cent Yellow stem borer damage in Chak-hao rice genotypes during *Kharif*, 2017.

List of Chak-hao rice genotypes	Mean Per cent dead hearts/white earheads recorded at					***Mean per cent dead hearts/white earheads
	*30 DAT	*45 DAT	*60 DAT	**75 DAT	**90 DAT	
Pong Chak-hao	4.62 (2.26)	3.82 (2.08)	4.54 (2.24)	4.56 (2.24)	3.06 (1.18)	4.12 (2.14)
KomChak-hao	4.35 (2.20)	3.99 (2.12)	3.99 (2.11)	3.6 (2.02)	2.84 (1.83)	3.75 (2.06)
KothaChak-hao	4.15 (2.16)	3.47 (1.19)	4.15 (2.16)	3.73 (2.06)	2.78 (1.18)	3.66 (2.03)
ChettamoChak-hao	4.8 (2.32)	4.63 (2.26)	4.97 (2.33)	5.69 (2.46)	3.28 (1.94)	4.69 (2.26)
Chak-haoPoireiton	5.9 (2.53)	5.14 (2.37)	5.59 (2.47)	5.1 (2.37)	3.41 (1.98)	5.03 (2.34)
WahongChak-hao	2.42 (1.17)	3.48 (1.19)	4.37 (2.12)	4.21 (2.17)	3.43 (1.98)	3.58 (2.01)
ChingChak-haoAngangba	5.32 (2.39)	6.14 (2.85)	6.07 (2.56)	5.33 (2.39)	3.89 (2.09)	5.35 (2.40)
Chak-haoSempak	4.17 (2.14)	4.3 (2.19)	4.07 (2.12)	3.44 (1.98)	2.84 (1.83)	3.76 (2.05)
Chak-haoAmubi	6.98 (2.37)	5.46 (2.44)	5.83 (2.15)	4.92 (2.33)	3.66 (2.04)	5.37 (2.41)
Chak-haoTatha	5.6 (2.47)	5.69 (2.49)	5.69 (2.49)	5.27 (2.40)	3.9 (2.10)	5.23 (2.39)
Chak-haoAngangbi	3.95 (2.08)	4.08 (2.14)	4.63 (2.26)	4.16 (2.15)	3.27 (1.94)	4.02 (2.11)
Chak-haoHeimang	4.76 (2.28)	4.52 (2.24)	4.75 (2.28)	4.75 (2.28)	3.39 (1.97)	4.43 (2.21)
Komchak-haoMacha	4.73 (2.26)	4.25 (2.17)	4.87 (2.32)	4.46 (2.22)	3.44 (1.98)	4.35 (2.19)
Chak-haoManamNungshibi	3.6 (2.02)	4.16 (2.16)	3.62 (2.02)	3.59 (2.02)	3.27 (1.94)	3.65 (2.03)
Chak-haoNapduina	4.9 (2.30)	4.17 (2.16)	4.98 (2.34)	5.34 (2.42)	3.43 (1.98)	4.56 (2.24)
WairiChak-hao.	5.35 (2.42)	5.64 (2.48)	5.53 (2.45)	5.42 (2.43)	4.55 (2.24)	5.30 (2.40)
Chak-haoMongkhangi	3.91 (2.10)	4.63 (2.26)	4.41 (2.21)	4.18 (2.16)	3.29 (1.95)	4.08 (2.14)
Chak-haoTaniang Ban	4.61 (2.25)	3.85 (2.08)	3.73 (2.05)	3.93 (2.10)	3.24 (1.92)	3.87 (2.08)
Leimaphou	9.55 (3.17)	8.77 (3.04)	8.67 (3.03)	8.61 (3.02)	6.4 (2.63)	8.4 (2.98)
S.Ed(±)	0.18	0.10	0.14	0.15	0.09	0.29
CD	0.37	0.21	0.29	0.31	0.19	0.57

Figures in parentheses are square root transformed values; *Mean per cent dead heart; **Mean per cent white earheads; ***Mean of five replications

Gurjar *et al.* (2012) reported that simple phenols act on the membrane disruption and deprive the substrate, phenolic acids and flavonoids bind to adhesions complex with cell wall and inactivate enzymes, thus, protect from the bacteria, fungus and insect pest attacks. Lev-Yadun and Gould (2008) also confirmed that anthocyanins have also been observed to function in a diverse array of plant/animal interactions which include the repellence of herbivores and parasites. They suggested that the optical properties of anthocyanin may serve as visual signals to potential herbivores, indicating a strong metabolic investment in toxic or unpalatable chemicals and they have also been implicated in the camouflage of plant parts against their backgrounds, in the undermining of insect crypsis and in the mimicry of defensive structures.

Singh and Sharma (1998), reported the chak-hao in common are resistant to many rice diseases (sheath rot, foot rot, stem rot, narrow brown spot, false smut, bacterial leaf blight and bacterial leaf streak) and rice insect pests (stem borer, case worm, thrips, rice skipper, green horned caterpillar, green semi looper and rice bug). The resistance may be due to the presence of high phenolic and anthocyanin contents. Harborne (1989) reported that certain phenolic compounds and flavonoid such as the anthocyanin has been demonstrated to act as anti-feedants, toxins, warning signals or precursors to physical defense systems.

The present study coincides with the reports of Enyiukwu *et al.* (2014) where they reported that plant extracts which are rich in phenolic compounds are being used as phytochemicals to protect against several insect pest such as rice stem borers, leaf folders and diseases like bacterial blight, stem rot, brown rot, root rot and brown spot Thus, there is no wrong to suggest that the high phenolic and the antioxidant of the black scented rice act as a plant defensive mechanism which protect themselves from certain disease and pests which perhaps is the reason for low incidence of diseases and insect pests.

Amsagowri *et al.* (2018) found in their study that the rice accessions with lower levels of total sugars, reducing sugar and non-reducing sugar; and higher levels of total phenol and ortho-dihydroxy phenol were resistant and moderately resistant. These defensive biochemical compounds might have reduced the YSB incidence. The also reported that among the rice accessions, ortho-dihydroxy phenol content varied from 0.10 to 0.33 mg/g and 0.12 to 0.53 mg/g of stem in healthy and infested plants, respectively.

The findings of the present study also corroborated with earlier findings of Padhi (2004) who reported that rice varieties TKM-6 and PTB-18 recorded lower borer incidence, larval survival and sugar content, but higher amount of total phenols, ortho-dihydroxy phenol and silica indicating their resistance to YSB as against the susceptible check, Jaya. The amount of phenolic compounds and silica increased significantly with the age of the plant, but the survival of the larvae decreased as crop age advanced. So, the degree of resistance in rice varieties to *S. incertulas* was influenced by the presence of high phenolic compounds (Carbonari and Martins, 1998).

Table 3: Biochemical constituents in yellow stem borer resistant and susceptible Chak-hao rice genotypes of Manipur.

Chak-hao rice Genotypes	***Per cent infestation of stem borer**				**Biochemical constituents (per cent)**
	***Per cent infestation of stem borer**	****Total soluble sugars**	****Reducing sugars**	****Total phenols**	****Ortho dihydroxy phenols**
Kothachak-hao	3.66 (2.03)	3.33 (1.96)	2.06 (1.60)	4.61 (2.26)	2.70 (1.79)
Chak-haoManamNungshibi	3.65 (2.03)	3.29 (1.95)	2.27 (1.66)	4.08 (2.14)	2.07 (1.60)
ChakhaoTaniang Ban	3.87 (2.08)	3.18 (1.92)	1.75 (1.50)	4.01 (2.12)	2.17 (1.63)
Komchak-hao	3.75 (2.06)	3.12 (1.90)	2.24 (1.65)	4.20 (2.17)	1.88 (1.54)
Chak-haoSempak	3.76 (2.05)	3.82 (2.08)	1.99 (1.58)	4.24 (2.18)	2.20 (1.64)
Wairichak-hao	5.30 (2.40)	5.75 (2.50)	2.71 (1.78)	2.75 (1.80)	1.27 (1.33)
Chak-haoPoireiton	5.03 (2.34)	6.38 (2.62)	2.59 (1.78)	2.07 (1.60)	1.61 (1.45)
Chak-haoAmubi	5.37 (2.41)	5.16 (2.38)	2.41 (1.67)	2.18 (1.64)	1.26 (1.33)
Chak-haoTatha	5.23 (2.39)	4.77 (2.29)	2.08 (1.62)	2.13 (1.62)	1.28 (1.33)
Ching Ch. Angangba	5.35 (2.40)	5.29 (2.41)	2.79 (1.83)	2.98 (1.86)	1.27 (1.33)
Leimaphou	8.40 (2.98)	5.77 (2.50)	4.29 (2.19)	1.93 (1.56)	1.11 (1.27)
S.Ed(±)	0.22	0.05	0.06	0.03	0.07
CD	0.32	0.11	0.12	0.06	0.15

The values in parentheses are square root transformed values; *Mean of five replications; **Mean of three replications

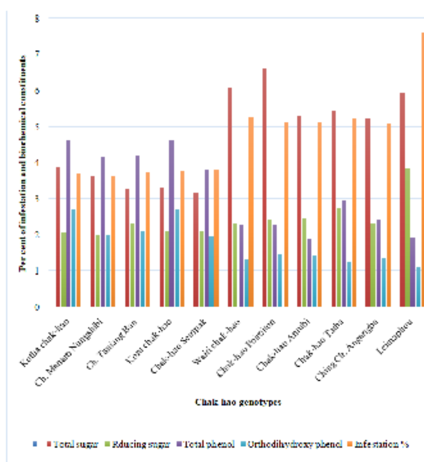

Fig. 1. Graphical representation between per cent yellow stem borer infestation and biochemical constituents.

The present study also concurs with that of Vijay Kumar *et al.* (2012), they reported that total sugars present in susceptible genotypes were 10.13-15.84 mg/g, and in gall midge resistant genotypes the sugar content varied from 6.81 to 10.24 mg/g. The amount of reducing sugars in susceptible and resistant genotypes varied from 6.22 to 10.21 mg/g, and 3.80 to 6.22 mg/g respectively. But in resistant genotypes lower amounts of sugars, and reducing were recorded compared to gall midge susceptible genotypes. These findings are in accordance with the susceptible variety Jaya, which contributed significantly more amount of total and reducing sugars than TKM-6 and PTB-18 against YSB (Padhi, 2004).

CONCLUSION AND FUTURE SCOPE

In conclusion, we screened the infestation percent of rice yellow stem borer and analysed the basis of resistance and susceptibility in the comparatively selected susceptible and resistant chak-hao rice genotypes of Manipur. The present study documented that the rice stem borer infestation and total sugars were found to be highest in chak-hao Poireiton demonstrating that sugar content may be one of the factors for making the plants vulnerable to insect pest infestation while rice stem borer infestation and phenolic content were exhibited to be highest in Kothachak-hao. The supplementation of chak-hao rice in the diet has positive impacts on human health. In addition, it can be concluded that chak-hao has a defensive mechanism which can protect it against some of the diseases and pests as a result of the high anthocyanin and phenolic content. The anthocyanin pigment benefit the human health and are involved in the defensive mechanisms of plants. The current research on the importance of these cultivars should encourage the agricultural scientists to include them in the crop improvement programmes, research could increase productivity without losing grain quality characteristics and result in pharmaceutical applications as well as improving our knowledge of defense mechanisms of plants

There is a vast scope for exploration of chak-haoin terms of exploring insect infestation and its resistance mechanism so that breeding methods can be exercised in depth to transfer resistance trait of chak-hao rice to common rice and to transfer high yielding traits to the chak-hao genotypes since it has been reported that the former is a poor yielder despite of lesser infestation of insects pests and diseases besides having anti-oxidant properties.

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Conflict of Interest: None.

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