B. N. Seal Journal of Science Volume 12, Issue 1, 2024

AGRICULTURE RESEARCH ARTICLE

Physico-chemical characters of some native rice cultivars and their relationship with infestation of key insect-pests under terai zone of West Bengal (India)

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Abstract: Studies with local scented, local non-scented and high yielding cultivars of rice were carried out in terai-zone of West Bengal (India) and the results revealed that leaf width and moisture content of the plants had positive co-relation with the infestation of yellow stem borer (*Scirpophaga incertulas* Walker), leaf folder (*Cnaphaloerocis medinals* (Guenee)) and Asian gall midge (*Orseolia oryzaee* (Wood Mason)). Leaf width showed distinct preference to the leaf folder. Total phenol and OD-phenol content were negatively correlated with the incidence of the three insect pests. Total phenol content had marked adverse effect on the incidence of the leaf folder whereas OD-phenol expressed its visible harmful effect on the infestation of stem borer. Local cultivars (both scented and non-scented) contained higher amount of the two phenolic compounds and experienced low level of insect attack than the high yielder. The two phenolic compounds increased after the pest attack and the percent increase was higher in local cultivars than the other types of rice.

Key words: Rice; Pest infestation; Leaf width; Moisture; Phenol; OD phenol

1. Introduction

Rice (*Oryza sativa* L.) is the 2nd most important crops in the world and Asia occupies the apex position in production and consumptions [1]. It serves as the staple food of majority of Indian population and also ½ of the world's population [2]. More than 90 % of the world's rice is produced and consumed in the Asia-Pacific Region. India ranks 2nd in rice production in the world next to China [3]. Besides providing protein and carbohydrates, it is also the source of calcium, iron, zinc, fibre, magnesium, manganese, selenium, B vitamins and other nutrients [4]. India possesses 43.39 million hectares of land under rice cultivation and rice alone supplies 689-780 kcal/capita/day in India and Asia [5].

Insect pests are considered to be one of the major hurdles of rice production in India. Year-round cultivation of high yielding, fertilizer responsive and photo-insensitive varieties has increased the production of paddy many folds but it has encouraged the incidence of various insect pests to

an alarming state. Rice stem borers, chiefly yellow stem borers, (*Scirpophaga incertulas* L.) are predominant in all the major rice-growing tracts of India and yield losses attributed to these pests may be as high as 30% [6]. However, Krishnaiah and Varma [7] reported that the yield loss due to dead heart and white ears, were in the range of 11.2% - 40.1% and 27.6 - 71.7%, respectively. Leaf folder, *Cnaphaloerocis medinals* (Guenee) has become a serious pest of rice over the years due to gradual and rapid change in rice ecosystem in South-East Asia [8-10], although it was observed to be a minor pest of rice in India [11-12]. The infestation reduces the photosynthetic area of leaves which in turn brings down the yield. Netam and Gupta [13] reported a yearly average of 15.2% infestation of leaves due to leaf folder whereas they recorded the maximum infestation of 25.3 % during 3rd week of September. The Asian rice gall midge *Orseolia oryzaee* (Wood Mason) is a serious pest of rice in South East Asia including India and in severe occasions the yield losses was estimated to be 60 - 100 % [14-15]. Annual yield loss of grains was estimated to be in the tune of 4,77, 00 tons worth eighty million US$. Asian rice gall midge has been reported almost from all the states of India except some few. In a recent study in terai zone of West Bengal, it was found that the maximum infestation was 6.01% during 43 Standard week [16]. Leaf moisture plays an important role in improving nutrient level of leaves, which in turn, improves the palatability of leaves to the larvae, enhance the feeding efficiency and increases the growth rate [17-18].

The main approach for management of insect pests of rice has been through development of resistant varieties. Plant defense mechanism involves bio-physical characters and phytochemicals which exhibit resistance by means of accumulation in or near the tissues wounded or infested [19-23]. Polyphenols (tannins) are one of the most widely spread plant metabolites in nature and play an important role in plant defense mechanism. The role of phenols in conferring resistance has been identified in bhendi against *Amrasca devastans* Dist [24] and in melon against *Dacus curcurbitae* Cor. [25]. Cotton phenols and tannins had negative co-relation with while-fly population [26]. However, no notable study in rice has so far taken place in terai zone of West Bengal (India), a vast rice growing tract of the state. In view of the above some local native and high yielding cultivars of rice were evaluated against the key insect pests on the basis of some physico-chemical characters with a view that the emerged results will help formulating future pest management and breeding programmes in the region.

2. Materials and methods

Eight cultivars of rice belonging to local scented (LS), local non-scented (LNS) and high yielding (HY) groups were screened against rice stem borers, leaf folder and gall midge at the Research Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during Kharif 2005-2006. Twenty-eight days old seedlings were transplanted in 3M x 3M plots following a spacing of 15 x 20cm. The crop was raised with standard agronomic practices with

recommended dose of fertilizers. No plant protection measures were taken in the experiment. Observations on the incidence of the three insect pests were recorded at 7 days interval commencing from 15 days after transplanting. For physical character, leaf widths were measured from three leaves taken from middle, base and upper canopy selected randomly from each of five hills. Moisture percentage (%), total phenols and orthodihidroxy (OD) phenols of leaves were also estimated. Moisture percentage was estimated following the methods of Paul *et al*. (1992). Total phenols present in 1g of leaf sample were estimated using Folin-ciocalteau reagent following the method of Malick and Singh (1980). Orthodihidroxy (OD) phenol present in 1g of sample leaf was estimated using Arrow's Reagent following the method of Mahadevan and Sridhar (1986). The samples of fresh as well as infested leaves were collected at three different stages of the plant viz. active tillering stage, 50% heading stage and grain filling stage.

The infestation of the pests was recorded in terms of their damage symptoms viz. for stem borer as Dead Heart (DH) at early stages, white ear head (WEH) at late stages, for leaf folder as folded leaves and for gall midge as silver shoot. Data on the total number of leaves, infested leaves, tillers and infested tillers from 10 randomly selected hills from each replication were taken and mean percent infestation of individual insect pest was worked out. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Data thus obtained were analyzed statistically for better interpretation of the results. Besides, simple co-relations were worked out between physico-chemical parameters of the cultivars and percent infestation by the respective pests to establish the possible factors responsible for the resistance / susceptibility of the cultivar to the insects.

3. Results

3.1. Leaf width

Leaf width had significant variation among the cultivars (Table 1). The highest leaf width was noted from the HY cultivar Masuri (14.33 mm) which was followed by Swarna (12.58 mm), Hasansarai (LS) (11.57 mm), Doodhkalam(LNS) (11.29 mm), Tulaipanji (LS)(10.19 mm) and the lowest one was observed on Changa(LNS) (9.96 mm) which was statistically at par with Kalonunia (LS) (10.04 mm).

3.2. Moisture percentage

Significant variation in moisture content was observed among the cultivars (Table 1). Highest level of moisture content of the plant was recorded from HY cultivar Swarna (71.51%) which was at par with Masuri (71.36%) and Dudhkalam (LNS) (71.23%) while the lowest one was in Changa (69.30 %) a local non- scented cultivar.

3.3. Total phenol content (mg / g)

Significant difference existed among the cultivars in respect of total phenol content (Table 1). Highest level of total phenol was found in Changa (11.40 mg/g) followed by Malseera (10.85 mg/g) both being LNS cultivars while the lowest was observed in Masuri (HY) (9.01 mg/g) followed by Swarna (9.61 mg/g). The results revealed that the local non-scented and scented cultivars contained much higher level of total phenol content than the high yielder.

3.4. OD-Phenol (mg / g)

OD-Phenol content varied significantly among the cultivars as depicted from Table 1. Hasansarai (LS) ranked the top with 3.74 mg/g fresh tissue followed by Malseera (3.23 mg/g). Significantly lowest OD-Phenol content was obtained in Swarna (1.89 mg/g) and Masuri (1.94 mg/g) and both were statistically at per with each other. Like total phenol content, high yielding varieties had the lowest OD-Phenol level while local scented and local non-scented cultivars contained much greater amount of the phenolic compound.

3.5. *Stem Borer infestation*

Infestation due to stem borers showed significant variation among the cultivars (Table 1). The most heavily infested variety was HY Swarna with 3.61 % damaged tillers which was followed by Masuri (3.22 %) (HY) and Kalonunia (3.20 %) a local scented cultivar. Changa (LNS) was the least damaged cultivar with only 1.83 % infested tillers. A perusal of the results reveals that except Kalonunia all local cultivars recorded markedly lower level of attack than the high yielder.

3.6. Leaf folder infestation

The cultivars differed significantly with respect to leaf folder infestation (Table 1). Highest level of infestation was recorded from HY Swarna (7.62%) followed by Masuri (7.07%). Significantly lowest infestation was recorded from Changa and Malseera both being LNS cultivars where both had registered 3.76 % leaf damage. It was found that high yielders were heavily damaged than the local ones.

3.7. Gall midge infestation

A marked variation in gall midge infestation in all the cultivars was observed (Table 1). Highest silver shoot was recorded from Swarna (HY) (1.82%) while the significantly lowest from Tulaipanji (0.75%) a local scented cultivar. Among the local non-scented cultivars notable difference was observed and Malseera (0.88%) was the least damaged cultivar. Similarly, the local scented cultivars differed markedly and Tulaipanji recorded the lowest level of damage (0.75%). Between the high yielding varieties, Masuri was the least infested (0.99%).

Table 1: Physico-chemical parameters and percent infestation by insect pests of different rice cultivars

Cultivars		Physico-chemical properties of rice leaf				% infestation due to		
		Leaf width (mm)	**Moisture (%) ***	**Total Phenol (mg/g)**	**OD Phenol (mg/g)**	**Stem borer (DH/WEH)**	**Leaf folder (damaged leaf)**	**Gall midge (silver shoot)**
Local non-scented	Doodhkalam	11.29 ^{d†} (3.36) *	71.23^{a} (60.05)	10.80 ^{b} (3.29)	2.16 ^{e} (1.61)	2.63 ^{d} (1.74)	4.91 ^{d} (2.28)	1.01 ^{b} (1.22)
	Changa	9.96 ^{f} (3.17)	69.30 ^{c} (59.45)	11.40 ^{a} (3.38)	2.82 ^{c} (1.79)	1.83 ^{g} (1.51)	3.76 ^{f} (2.03)	1.02 ^{b} (1.22)
	Malseera	10.05 ^{f} (3.18)	70.30 ^{b} (59.76)	10.85 ^{b} (3.30)	3.23 ^{b} (1.90)	2.02 ^{f} (1.57)	3.76 ^{f} (2.03)	0.88 ^{c} (1.16)
Local scented	Tulaipanji	10.19 ^{e} (3.20)	69.31^{c} (59.46)	10.16 ^{d} (3.20)	2.40 ^{d} (1.68)	2.79 ^{c} (1.79)	4.32 ^{e} (2.16)	0.75 ^{d} (1.11)
	Hasansarai	11.57 ^{c} (3.40)	70.31^{b} (59.76)	10.69 ^{c} (3.28)	3.74 ^{a} (2.02)	2.15 ^{e} (1.60)	4.19 ^{e} (2.13)	0.84 ^{c} (1.15)
	Kalonunia	10.04 ^{f} (3.18)	70.05 ^{b} (59.68)	9.73 ^{e} (3.13)	2.37 ^{d} (1.67)	3.20 ^{b} (1.90)	5.36 ^{c} (2.37)	1.02 ^{b} (1.22)
High yielding	Swarna	12.58 ^{b} (3.54)	71.51^{a} (60.14)	9.61 ^{f} (3.11)	1.89 ^{f} (1.52)	3.61 ^{a} (1.99)	7.62 ^{a} (2.79)	1.82 ^{a} (1.50)
	Masuri	14.33 ^{a} (3.77)	71.36^{a} (60.09)	9.01 ^{g} (3.02)	1.94 ^{f} (1.54)	3.22 ^{b} (1.90)	7.07 ^{b} (2.70)	0.99 ^{b} (1.21)

** Figures in the parenthesis are square root and arc sine transformed values.*

† Alphabets used beside indicate Duncan's Test results, where means followed by the same letters in the column does not differ at 5% level of significance.

3.8. Correlation between physico-chemical parameters and pest infestation

Results of co-relation studies furnished in table 2 revealed that leaf width and leaf moisture content were positively correlated with the infestation of leaf folder, stem borer and gall midge. However, the incidence of the pests was negatively correlated with total phenol and OD – Phenol content as well. Correlation co-efficient between leaf folder and leaf width was highly significant. Total phenol content showed pronounced adverse effect on the infestation on the leaf folder while in case of stem borer it was OD-phenol.

Table 2: Correlation co-efficient between physico-chemical parameters and the incidence of stem borer, leaf folder and gall midge

Physical and bio-chemical parameters	Values of correlation co-efficient (r)		
	Stem borer	**Leaf folder**	**Gall midge**
Leaf Width	0.13	0.86*	0.38
Moisture %	0.57	0.37	0.49
Total phenol	-0.39	-0.89**	-0.34
OD-phenol	-0.85*	-0.01	-0.42

**Significant at 5% level of confidence; **Significant at 10% level of confidence*

Table 3: Impact of pest injury on phenolic compounds in tissues of rice leaf

Cultivars		**Phenolic contents of leaf**					
		Total phenol (mg/g)			**Ortho Di-hydroxy phenol (mg/g)**		
		Fresh tissue	**Infested tissue**	**% increase after infestation**	**Fresh tissue**	**Infested tissue**	**% increase after infestation**
Local non-scented	Doodhkalam	9.79[a†] (3.14) *	11.92 [c] (3.45)	21.76	1.66 [f] (1.45)	2.13 [g] (1.60)	28.31
	Changa	8.94 [c] (3.01)	10.54 [f] (3.25)	17.90	2.20 [d] (1.62)	2.56 [e] (1.72)	16.36
	Malseera	7.54 [f] (2.78)	10.49 [f] (3.25)	39.12	1.65 [f] (1.45)	2.68 [d] (1.76)	62.40
Local scented	Tulaipanji	8.34 [e] (2.91)	10.89 [e] (3.31)	30.58	2.38 [c] (1.67)	3.26 [c] (1.91)	36.97
	Hasansarai	9.77 [a] (3.14)	13.05 [a] (3.60)	33.57	2.56 [b] (1.72)	3.91 [b] (2.06)	52.73
	Kalonunia	8.62 [d] (2.96)	11.71 [d] (3.42)	35.85	1.50 [g] (1.40)	2.38 [f] (1.67)	59.00
High yielding	Swarna	9.70 [b] (3.13)	12.40 [b] (3.52)	27.84	3.24 [a] (1.90)	4.24 [a] (2.14)	30.86
	Masuri	7.30 [g] (2.74)	9.51 [g] (3.09)	30.27	2.05 [e] (1.57)	2.76 [d] (1.78)	34.63

** Figures in the parenthesis are square root and arc sine (*) transformed values.*

†Alphabets used beside indicate Duncan's Test results, where means followed by the same letters in the column does not differ at 5% level of significance.

3.9. Impact of pest injury on the phenolic compounds of rice leaf

Table 3 represents the effect of insect pest attack on the occurrence of two phenolic compounds in the host plants. It was observed that in all the cultivars, the amounts of phenolic compounds were

elevated to higher extent in infested tissues than that of fresh ones. Highest percent increase of total phenol content was found in Malseera (39.12%) followed by Kalonunia (35.85%), Hasansarai (33.57%) and Tulaipanji (30.58%). The lowest percentage increase was obtained in Changa (17.90%). Identical results were observed in case of OD-Phenol content. Maximum increase was found in Malseera (62.40%) while the minimum was in Changa (16.36%).

4. Discussion

High yielding cultivars possessed broader leaves than local ones and experienced much greater damage by the three key pests. Higher fecundity of stem borers of rice is observed in varieties with longer and broader leaves and higher larval population are seen in varieties with wider parenchymatous areas [27]. Broader leaves facilitate easy folding and provide better shelter and enhanced the amount of food to the larvae of leaf folder. However, studies with susceptible and resistant varieties revealed that morphological characters have no effect on the incidence of gall midge [28]. Cultivars with higher moisture content had greater degree of pest infestation. Increased amount of moisture content makes the plant more succulent and improves nutrient level of leaves, which the pests prefer due to its higher palatability. Hanifa and Subramanian (1973) observed that enhanced nutrient level of leaves as a result of higher moisture content improves the palatability of the leaves to the larvae. Availability of moisture content in leaves enhanced feeding efficiency of silkworm larvae and increased their growth rate (Paul *et al.* 1992). The results under the present study are in conformity with the findings of Rao *et al.* (2002) and Bose and Bindroo (2001).

Total phenol and OD – Phenol content had adverse effect on the incidence of stem borer, leaf folder and gall midge. Local cultivars (both scented and non-scented) experienced low level of damage by the insect pests and they contained higher level of phenols than high yielder. That is, higher the total Phenol and OD – Phenol content more was the tolerance / resistance to the pests. Phenolic compounds play a vital role in imparting resistance of germplasms (Levin,1971). Polyphenols react through hydrogen bonding with protein [29] forming a protein-tannin complex [30] thereby reducing the nutritive value of the ingested foods through chemical degradation of essential amino acids [31]. High level of phenol was found in resistant varieties of rice against BPH than susceptible one [32]. Thayumanavan *et al.* [33] and Veeravel and Parthivan (1994) [34] observed that rice varieties resistant to thrips contained high amount of phenolic compounds. Sahayaraj *et al*. [23] reported that phenols present in okra had adverse effect on mite population. It was observed by Kalpana *et al*. [35] that total phenol content was negatively correlated with rice whorl maggot infestation. The results lend further support from Butter *et al*. [26] who observed that cotton phenols and tannins had negative correlation with white fly population.

Total phenol and OD-phenol content increased after pest injury. The percentage increase of total phenol and OD-phenol content was highest in local native cultivars (39.12% and 62.40%

respectively in Malseera). This indicates that local cultivars possess inherent capacity to withstand pest attack because of accumulation of high level of phenolic compounds following pest injury. Following herbivory many changes occur in plants which ultimately result in accumulation of phenolic compounds [36]. Amudhan *et al*. [37] observed the increased accumulation of total phenol content in rice plants following the infestation of gall midge. Praveen *et al*. [38] reported that phenol production in cotton plant increased with insect attack. Similar results were also obtained by Daniel *et al*. [39] in cotton. The results are in conformity with the findings of Jayanthi and Goud [40].

From the above it may be concluded that the broader leaved cultivars are very much susceptible to leaf folders. Moisture content is positively related to attack by all the insects. Total phenol content is markedly deleterious to the leaf folder while OD-phenol has pronounced adverse effect on the incidence of the stem borer. Phenolic compounds increased after pest attack and the maximum increment occurs in local cultivars. Many native cultivars of scented and non-scented type are generally cultivated and maintained by the farmers in this region and no information was available regarding the aspect reported in this paper. This finding may be useful in formulating the future pest management and breeding programme of rice in this region.

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