Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(6): 138-142

Received: 09-09-2019
Accepted: 13-10-2019

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# Effect of insect feeding on biochemical changes in rice plant

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**Abstract**

Rice crop is attacked by several insect pests from nursery to harvest. Investigation was carried out to determine the effect of feeding damages caused by the insect pests yellow stem borer (YSB), white backed plant hopper (WBPH), brown plant hopper (BPH) and leaf folder (LF) on the biochemical parameters of rice plant. Rice plants damaged by these insects were analyzed for the quantitative and qualitative changes in biochemical profile e.g. starch, nitrogen, soluble sugar, protein, total chlorophylls and carotenoids. The experiments have been conducted in a rice cultivar TN1 susceptible to all the insects. Standard biochemical procedures were followed to analyse different biochemical parameters. The concentration of starch in leaf was highest in the control, followed by YSB, WBPH, BPH and LF damaged plants in a sequence. Feeding by WBPH and BPH reduced the total nitrogen concentration of the leaf more compared to the other two insects. Total soluble sugar concentration in leaves of damaged plant was the maximum in the control plants exceeding the level of 20 (mg/g fresh weight) and insect feeding reduced it by more than half. YSB and BPH effects were more severe in comparison to the other two insects. Similar to the carbohydrates, leaf protein concentration (mg/g fresh weight) was also declined by insect feeding. In sharp contrast to the biochemicals, insect feeding did not have significant effect of chlorophyll a concentration of the leaf. Similar to chlorophyll a, the concentration of chlorophyll b was not influenced by insect feeding severely and the effects were marginal. The concentration of leaf carotenoids did not change much with insect feeding, but reduced marginally compared to the control plants. The level of reduction was maximum for BPH infestation.

**Keywords:** insect pest feeding, biochemical changes, rice plant

## Introduction

Pests are major biotic constraints to maximize yield. Rice crop is attacked by several insect pests from nursery to harvest, which cause severe yield loss in one region of the country or another [1]. The plants and herbivorous insects interact with each other in a physical manner and/or at biochemical level. Yellow stem borer (YSB) *Scirpophaga incertulas* (Walker) has emerged as one of the most important pests of rice during post green revolution years throughout the country [2]. It is one of the major pests in all rice producing areas of Asia, in south east Asia and India in particular [3]. Larval feeding and subsequent internodal penetration during vegetative and reproductive stage cause severing of the growing apical plant part [4]. Some of the most economically important other insects are the brown planthopper (BPH), *Nilaparvata lugens* (Stal.) and white backed planthopper (WBPH) *Sogatella furcifera* (Horvath) which can cause huge destruction of plants [5]. *N. lugens* is considered as the number one yield limiting factor in all rice growing countries both in tropics and temperate regions [6]. Amongst the sucking insect pests infesting rice, planthoppers especially the BPH, WBPH and leaf hoppers are of economic concern in India [7]. The white backed planthopper was first reported to cause very heavy damage in Punjab in 1966 [8]. Both the nymphs and adults feed on the stem and leaf sheath and remove plant sap, resulting in leaf yellowing, reduced tillering and plant height, and unfilled grains.

Since the mid-1960s, the rice leaf folder *Cnaphalocrocis medinalis* (Guenee) has increased in abundance in intensified rice growing areas in Asia; and in many countries they are now considered important pests [9] possessing enormous potential for economic losses. The leaf folder has been considered a miner pest of rice growing areas but after the existence, high yielding and Basmati rice varieties increasing the importance of these pests [10]. Leaf feeding insect have major importance because of their ability to defoliate or to remove the chlorophyll content of the leaves leading to considerable reduction in yield. Paddy leaf folder is one of the most important insect pests [11].

Compared to YSB, an internal feeder, the leaf folder (LF) *Cnaphalocrosis medinalis* is an external foliage feeder, whereas BPH and WBPH are sucking pests (phloem feeder). Investigation was carried out to determine the effect of feeding damages caused by a few selected insect pests on the biochemical parameters of rice plant. In the present study, LF, YSB, BPH and WBPH were selected as test insects. Rice plants damaged by these insects were analyzed for the quantitative and qualitative changes in biochemical profile e.g. starch, nitrogen, soluble sugar, protein, total chlorophylls and carotenoids. The experiments have been conducted in a rice cultivar TN1 sensitive to all the insects.

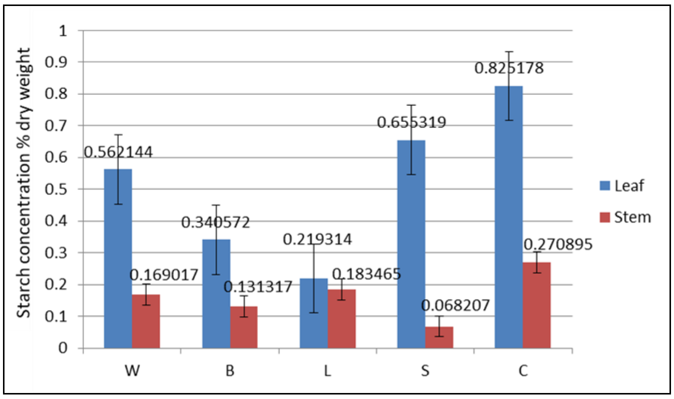
## Materials and Methods

It was studied on rice cv. TN 1 was studied in a pot experiment in the greenhouse. Seedlings were thinned to three plants/pot at 10 days after sowing (DAS). The experiment was carried out in completely randomized design and replicated 10 times. At 40 DAS 3/4$^{th}$ instar nymphs of BPH and WBPH were released separately @ 10 insects /plant. Freshly emerged YSB larvae @ 2/tiller were released with the help of a camel hair brush. Similarly 4$^{th}$ instar LF larvae @ 2/pot were released. Five days after infestation plant materials were collected and processed for analysis of biochemical parameters. Protein was Estimated by Lowry's Method [12], total soluble sugar by Anthrone method [13], Nitrogen by Kjeldahl method [14], Starch by Amyloglucosidase/ alpha amylase method [15], Chlorophyll by the procedure of Arnon [16].

## Results and Discussion

### Starch concentration of leaf and stem

In the present study, the leaf starch concentration was found higher than that of stem during the vegetative stage of rice plant. The concentration of starch in leaf was highest in the control, followed by YSB, WBPH, BPH and LF damaged plants in a sequence, suggesting that LF caused severe destruction to the carbohydrate synthesis of the leaf tissue. Although the insects slackened starch synthesis of stem, the effect was not identical to that of the leaf. Among the insects, YSB caused maximum damage to starch synthesis in the stem reducing it to one fifth of the concentration of the control (Fig. 1).

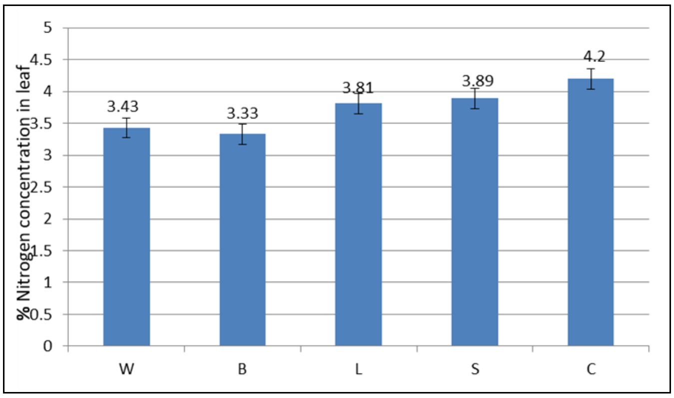



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 1:** Effects of insect damage on starch concentration (% of dry weight) of leaf and stem tissues of sensitive rice cultivar TN 1 during the vegetative stage

### Total nitrogen concentration of the leaf

The total nitrogen concentration of the leaf was highest in the control plants and insect feedings although reduced it significantly, it was not as high as that of the starch concentration. Both WBPH and BPH reduced the concentration more compared to the other two insects (Fig. 2).

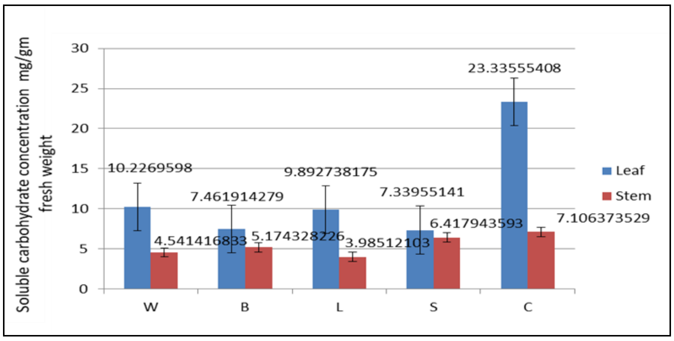



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 2:** Effect of insect damage on nitrogen concentration (% of dry weight), of leaf of sensitive rice cultivar TN 1 during the vegetative stage.

### Soluble carbohydrate concentration of leaf and stem

Similar to starch, the effect of insect feeding was very severe on soluble carbohydrate concentration of leaf and stem of the sensitive rice cultivars TN1. Total soluble sugar concentration in leaves of damaged plant was the maximum in the control plants exceeding the level of 20 (mg/g fresh weight) and insect feeding reduced it by more than half. YSB and BPH effects were more severe in comparison to the other two insects. Compared to the leaf, the effect of insect feeding on stem soluble carbohydrates was much lower. The concentration was marginally reduced by YSB compared to the control. In contrast, the other three insects lowered the concentration significantly; the maximum reduction was caused by LF infection. (Fig. 3)

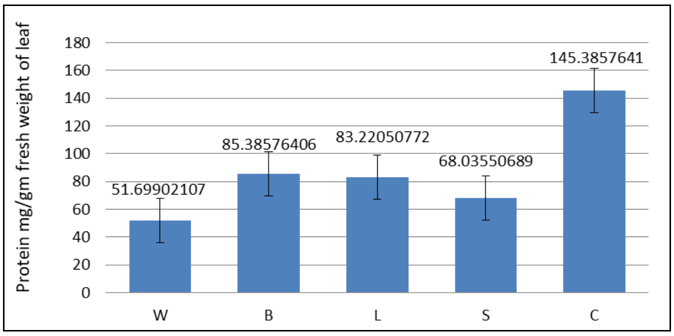



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 3:** Effect of insect damage on soluble carbohydrate concentration (mg/g fresh weight), of leaf and stem of sensitive rice cultivar TN 1 during the vegetative stage of development.

### Protein concentration of leaf

Similar to the carbohydrates, leaf protein concentration (mg/FW g) was also declined by insect feeding. The leaf protein concentration was high in the control plants and insect feeding reduced it by 40-60 %. Although, both WBPH and BPH are sap feeders, the leaf protein value was very less in WBPH (51.69902107 mg/g fresh wt.) damaged plants compared to BPH damaged plants (85.38576406 mg/g fresh wt.) (Fig.4). LF and YSB also reduced the leaf protein concentration effectively.

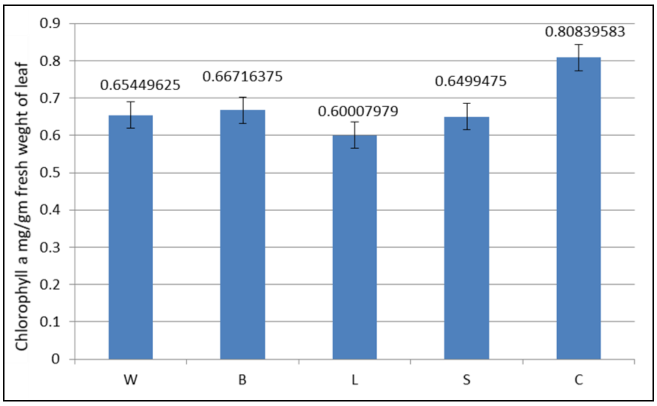



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 4:** Effect of insect damage on protein concentration (mg/g fresh weight), of leaf of sensitive rice cultivar TN 1 during the vegetative stage of development.

### Chlorophyll a concentration

In sharp contrast to the biochemicals insect feeding did not have significant effect of chlorophyll a concentration of the leaf, although the level of the material reduced in all insect infested conditions compared to the control. The level of reduction was maximum for LF.

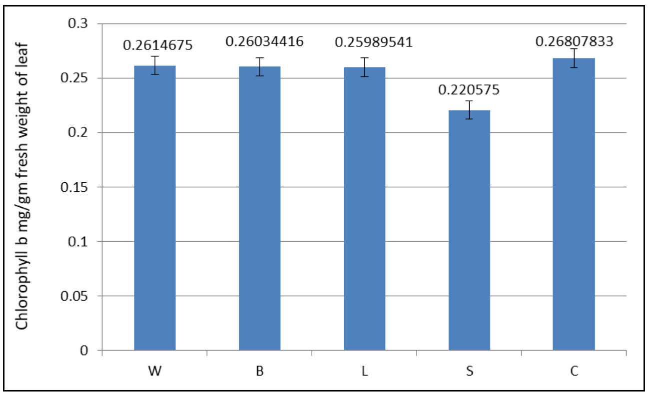



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 5:** Effect of insect damage on total chlorophyll a concentration (mg/g fresh weight), of leaf of sensitive rice cultivar TN 1 during the vegetative stage of development.

### Chlorophyll b concentration

Similar to chlorophyll a, the concentration of chlorophyll b was not influenced by insect feeding severely and the effects were marginal compared to the control (Fig. 6). Among the insects YSB reduced chlorophyll b concentration more than the others.

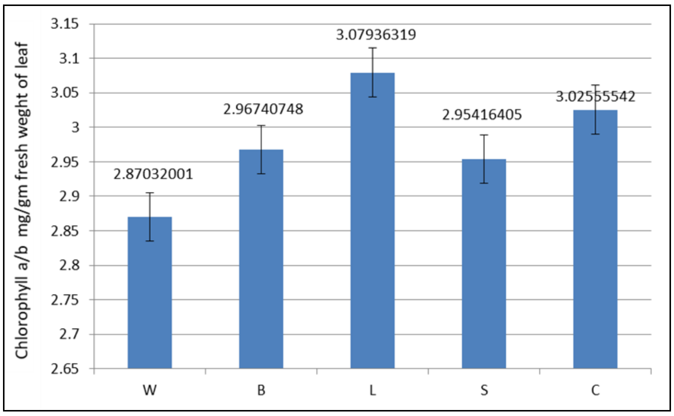



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 6:** Effect of insect damage on total chlorophyll b concentration (mg/g fresh weight), of leaf of sensitive rice cultivar TN 1 during the vegetative stage of development.

### Chlorophyll a /b ratio

Although both categories of chlorophylls a and b are individually not affected significantly by the insect feeding, there is a dramatic effect on the ratio between them. Compared to the control plants the ratio increased in case of LF and decreased in the other three, the maximum being in WBPH.

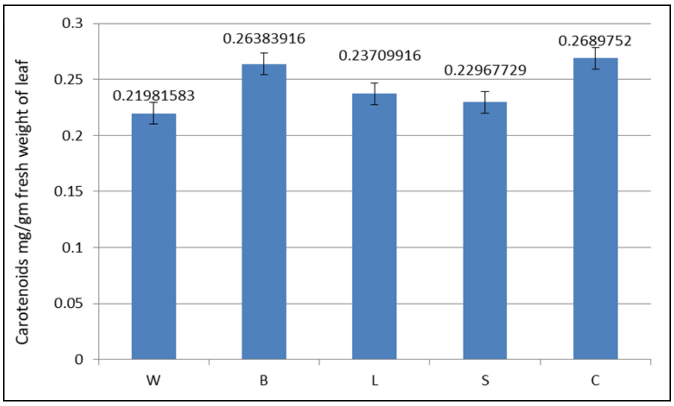



W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 7:** Effect of insect damage on total chlorophyll a/b ratio of leaf of sensitive rice cultivar TN 1 during the vegetative stage of development.

### Carotenoid concentration of leaf

Similar to chlorophylls, the concentration of leaf carotenoids did not change much with insect feeding, but reduced marginally compared to the control plants. The level of reduction was maximum for the BPH infestation (Fig. 8).




W- WBPH, B- BPH, L- LF, S- YSB, C- Control

**Fig 8:** Effect of insect damage on total carotenoid concentration (mg/g fresh weight), of leaf of sensitive rice cultivar TN 1 during the vegetative stage of development.

Carotenoids serve two key roles in plants as they absorb light energy for use in photosynthesis, and they protect chlorophyll from photo damage. Between the two sap feeders the level of carotenoids was more in leaves of plants damaged by BPH compared to WBPH (Fig. 8). Field observations in BPH and WBPH infestation it is observed that in BPH damage there is apparently not much yellowing of plants and plant succumb all of a sudden without much warning to the famers. Whereas in WBPH damage, extended yellowing of plants similar to that of rice tungro disease is observed. Thus chlorophyll a and carotenoids possibly play a role in expression of damage symptoms in plant hopper infestation.

Watanabe and Kitagawa [17], studied the effect of BPH infestation on japonica rice plant and observed that photosynthesis rate, leaf nitrogen concentration in infested plants was lower than that in control plants. The chlorophyll content and total plant dry weight were also reduced by BPH which is also observed in the present investigation. Similarly, Jayasimha [18] also observed that total soluble protein and soluble sugar content were reduced after BPH damage. However, based on a laboratory study on effect of BPH, YSB, LF infestation on biochemical parameters of rice plant Usha Rani. and Jyothsna [19] concluded that the quantity of bio-chemicals, such as proteins, phenols and carbohydrates were enhanced, although there was no valid physiological explanation. In the present study, information on the effect of infestation of rice plant by white backed plant hopper (WBPH), *Sogatella furcifera* (Horvath) was generated for the first time. This information is strongly supported by the influence of the attack on biochemical parameters.

A laboratory study was undertaken by Usha Rani. and Jyothsna [19] to ascertain the impact and the extent of feeding by different pests on biochemical constituents in rice plants. The borer pest-yellow stem borer (YSB), surface feeder-leaf roller (LR), and a sucking pest, brown plant hopper (BPH), fed rice plants were analyzed for the quantitative and qualitative changes in biochemical profile that occur as plant's defensive responses were analyzed. The quantity of bio-chemicals such as proteins, phenols and carbohydrates has been enhanced. It was demonstrated that the elevated levels of bio-chemicals may play a major role in plant defense.

Laboratory estimation of chemical constituents such as soluble protein, soluble sugar and free amino acid in both healthy and BPH damaged leaf sheath of test varieties revealed that there were significant differences in total soluble protein, soluble sugar and free amino acid in healthy and BPH damaged plant of all test varieties. The total soluble protein and soluble sugar content were reduced and total free amino acid increased after BPH damage [18].

Experiments were conducted to measure the effect of feeding by BPH on photosynthesis and the translocation of assimilates in rice plants [17]. They used mature japonica rice plants. Photosynthesis rate, leaf nitrogen concentration in infested plants was lower than that in control plants. After flowering, the chlorophyll content and total plant dry weight were reduced by BPH. Results suggested that removal of assimilates and reduction in photosynthesis by BPH have the greatest effect on growth and yield of rice plants.

Rice planthoppers including BPH and WBPH are the most economically important insect pests attacking rice crop. Both the nymphs and adults of these hoppers suck the sap from phloem and xylem resulting in wilting and drying up of plant [20]. Information on the effect of sap feeding by hoppers on rice plant is very limited.

The leaf blades of rice plants TN 1, infested with adults of the BPH, declined in chlorophyll, moisture, soluble protein, and protease activity, but increased in level of free amino-N, and amino acid incorporation compared with leaf blades of un-infested plants. The leaf sheaths of the infested plants showed similar effects. They also had lower level of sugars, than leaf sheaths of un-infested plants.

## Conclusion

The value of all biochemical parameters studied in the plants infested by different insect pests was reduced compared to the control or healthy plants. This inference points to the herbivore attribute of insects causing severe damage to the plant growth by limiting different metabolic processes involved with carbon assimilation and development. The insect work like parasites and dwell on the primary production of photosynthesis. It is noteworthy that the photosynthesis of the leaf, although was reduced by the insect feeding is not as much affected as that of the products like starch and soluble carbohydrates, on which the insect sustain for growth. Because the insects are primarily sap feeders they had preference for the soluble carbohydrates produced in primary production, whereas they do not have significant preference for the pigments, like chlorophylls and carotenes. Continuous consumption of soluble carbohydrates might have reduced supply of soluble carbohydrates as substrates for starch synthesis. Protein concentration was also affected due to limited resource for biological energy. Between the two sap feeders the level of carotenoids was more in leaves of plants damaged by BPH compared to WBPH. Chlorophyll a and carotenoids possibly play a role in expression of yellowing damage symptoms in plant hopper infestation.

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