International Journal of Food, Agriculture and Veterinary Sciences ISSN: 2277-209X (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jfav.htm
2017 Vol.7 (3) September-December, pp.17-25/Sadat and Chakraborty
Research Article

SPATIAL VARIATION OF LEAF CHLOROPHYLL AND CONSEQUENCES OF LEAF DAMAGE BY *ANOMIS SABULIFERA* GUEN. IN JUTE FIELD

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ABSTRACT
Feeding of phytophagous insect pest is critically guided by plant nutrients. Defoliation due to insect pest attack has been shown to be related with increase in different primary metabolites and nitrogen which was both directly and indirectly associated with leaf chlorophyll content. Contemplating this principle present experiment is designed to understand the relation of spatial distribution of leaf chlorophyll in relation to insect pest herbivory. Observation from three adjacent administrative blocks of Uttar Dinajpur, West Bengal had shown that there was a significant positive correlation between feeding option of jute semilooper, *Anomis sabulifera* and laminar distribution of jute (*Corchorus olitorius*) leaf chlorophyll throughout the jute plant growth period. Distribution of chlorophyll along transects of jute leaf in relation to insect herbivory was observed.

Keywords: *Anomis Sabulifera, Corchorus Olitorius, Chlorophyll Content, Feeding Choice, Laminar Distribution*

INTRODUCTION
Changes in the leaf nutrient content have been related with both the survivorship and the quantity of defoliation by insect herbivores (Morrow, 1983). Nutritional value deviates with the amount of nitrogen, moisture, chlorophyll and fibre as well as the concentration of allelochemic compounds content of leaf (Mattson, 1980). Nitrogen, carbohydrate and other leaf nutrients modulate the growth rate of lepidopteran and coleopteran larvae (Feeny, 1970; Fox and Macauley, 1977). Leaf defoliation has also been shown to be associated with increases in the level of leaf total protein nitrogen and chlorophyll content (Wareing, 1970). Tuomi *et al.,* (1984) had reported that insect defoliation reduced the leaf nitrogen content in mountain birch, while increasing the levels of phenolic compounds. Spatial variation of chlorophyll within a leaf laminar was also observed (Holm-Hansen and Mitchell, 2004). Extent of damage due to insect pest attack is proportionally related to the leaf chlorophyll content (Santos *et al.,* 2011). Leaf area with higher chlorophyll content is thus more susceptible to herbivorous insects. Laminar map can therefore be prepared to point out the relatively more vulnerable leaf area and accordingly protective measure can be taken.
The SPAD-502 provided a unit less measure of leaf transmittance. The chlorophyll meter or SPAD (Soil Plant Analysis Development) meter is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves (Evans, 1983). Meter readings are given in Minolta Company-defined SPAD values. Strong linear relationship between SPAD values and leaf nitrogen concentration in relation to crop growth stage exists (Kariya *et al.,* 1982). Relationship between nitrogen and SPAD values explains the requirement of optimum nitrogen fertilizer (Takebe and Yoneyama, 1989). SPAD readings indicate the amount of nitrogen to be applied in the field at different crop growth stages.
Anomis sabulifera are the major phytophagous lepidopteran pest affecting growing jute leaf. Leaf laminar carbohydrate content is found to relate to the damage due to semilooper. Carbohydrates content depends on photosynthetic rate of the plant (Taiz and Zeiger, 2010). Correlation between jute leaf chlorophyll content and feeding preference of jute semilooper exists.
The present study conducted with an objective to evaluate laminar distribution of chlorophyll content in jute in SPAD unit and feeding preference of *Anomis sbulifera* in Uttar Dinajpur, West Bengal, India.

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MATERIALS AND METHODS

Study Site (Figure 1):

Villages of three jute-growing areas of the District Uttar Dinajpur, West Bengal, India were primarily considered in the study. The places belongs to Raiganj (25^o 36'46"N, 88^o 07'28"E), Hemtabad (25^o 41'00"N, 88^o 13'00"E) and Kaliyaganj (25^o 63'44"N, 88^o 32'66"E) blocks respectively. Average elevation of these three provinces is between 0.5 and 0.7 m above sea level. Mean annual rainfall ranges from 1200 mm to 1600 mm with the dry season lasting from October/November to April/May. Soil is alluvial with natural fertility and mostly neutral (pH 6.8) in nature. Soil EC value is 0.28mmhs/cm. N, P_2O_5 and K_2O contents were 280, 26 and 265 kg/ha respectively. During the period of experimentation temperature was 24.6–38.2^{o}C and RH was 38.2–96.4% respectively.

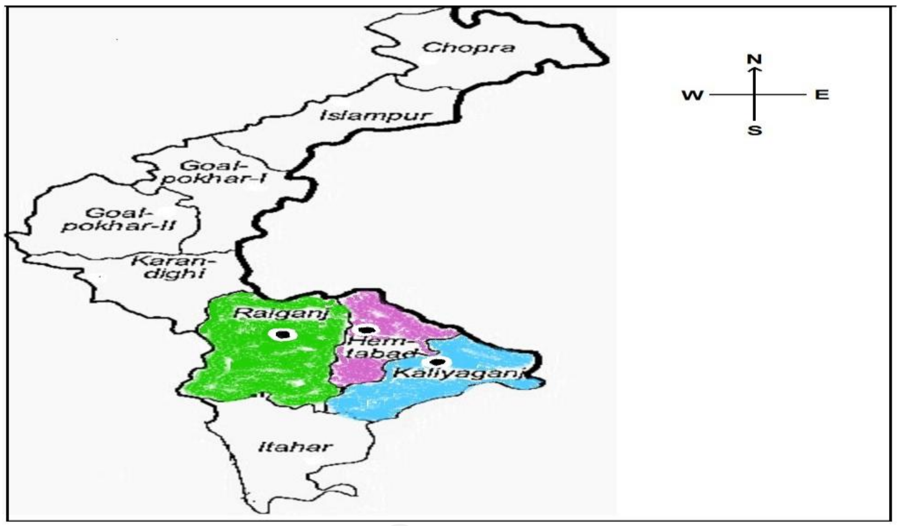

Figure 1: Place of Observation, (●) Indicates the Area of Experimentation

The Jute Plant and Jute Leaf (Figure 2):

Jute is a flowering plants belongs the family Malvaceae with 40-100 species (Islam, 2012). The plants are tall, unbranched or with only a few side branches usually annual herbs which reaches a height of about 4mt. The leaves are simple and arranged in alternate fashion (Dicke, 2000). Flowers are yellow, 2-3cm diameter with five petals. Fruits encapsulate many seeds. It thrives almost anywhere and can be grown year-around (Islam, 2013).

Jute leaves are simple in nature and are arranged in alternate fashion. Leaves are 6-10 cm long and 3.5-5 cm broad. Its shape is elliptic-lanceolate and its apical part is acute or acuminates (Figure 2). Jute leaves show characteristics of glabrous and serrate margin. The lower serratures on each side of leaf prolonged into a filiform appendage over 6 mm long and which is rounded at the base. The stipules are subulate, pubescent, glabrous or ciliated. Each leaf contains 3-5 nerves for water and food transportation (Osawaru *et al.*, 2012; Islam, 2013).

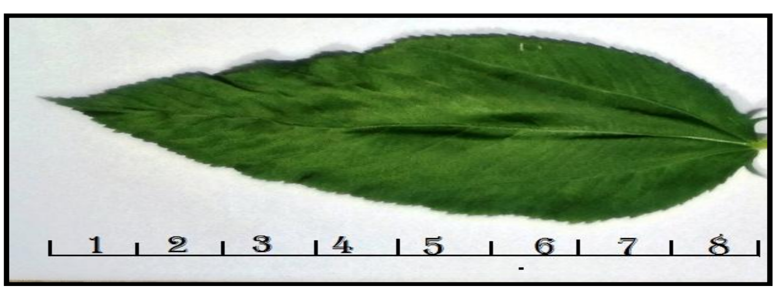

Figure 2: Laminar Area Numbers in Jute Leaf from Tip to Base

Experimental Design

The experiment was conducted in 2017 covering the calendar month of April to August in randomized block design with three replications adopting standard cultivation practices. Before sowing N, P_2O_5 and K_2O at the rate of 20kg/ha were applied as basal application. The jute seeds were sown in a row spacing of 25 cm in small plots of 4 m ×4 m with a gap of 1 m between each plot. At completely grown condition, plant to plant distance was maintained at 6–8 cm apart after thinning.

***Estimation of Affected Leaf Laminar Area*:**

Thirty Pest affected leaves were collected from each study site and brought to the laboratory. Pest affected areas were calculated by placing these leaves on graph paper and measuring each squares covered by the leaf. Total length of a leaf was divided in to eight segments to understand laminar distribution of food preference.

Estimation of Leaf Chlorophyll Content:

Chlorophyll content of jute leaves were measured by chlorophyll meter, SPAD 502 (Soil and Plant Analysis Development) of Minolta Co. Ltd., Osaka, Japan (1989). Each chlorophyll reading was taken after 7-days of field N treatment to understand full effect of N on chlorophyll content.

The SPAD chlorophyll meter possess two LED at the tip, which emits light in the range of 600-700 nm and 860-1060 nm range, in sequence when closed (Godoy, 2002). The light passes by the emitter and the part crosses the sheet of leaf reaches a receiver (photodiode silicon). Then, the light signals converts into electrical signals, amplified and again converted into digital signals. This signals used by microprocessor to calculate the SPAD value which are shown in display monitor. The obtained values of chlorophyll in SPAD value are proportionate to the amount of chlorophyll present in leaf because the wavelength used in SPAD chlorophyll meter were based on two absorbance peaks of chlorophyll in vitro (Godoy, 2002).

Chlorophyll reading of jute leaves was taken at early morning to avoid effect of direct sunlight on measurement. Chlorophyll reading of leaf was taken at the area between leaf midrib and margin of each laminar area produced by subdividing total length of the leaf into eight equal parts (Godoy, 2002).

Observation on the Rate of Herbivory:

The rate of insect herbivory was defined as any area lost within, or on the outer perimeter of the leaf over a monthly period. Ten healthy leaves, commencing with the youngest fully emerged leaf from the previous year, were tagged on three branches of each tree. The rate of herbivory on each leaf was monitored over an 8 month period, by tracing the outline of any area missing within the leaf onto transparent plastic sheets. A planimeter was then used to measure the area of each leaf and a loss in leaf area between samples was assumed to be caused by herbivory. The amount of leaf area lost was not adjusted for leaf expansion because the growth of these leaves was found to be minimal using suitable statistical model.

Statistical Analysis:

Statistical analysis of observed data were conducted by following analysis of variance model, through KyPlot version 2.0 beta 15 (32 bit) using 5% level of significance. The relation between chlorophyll and used nitrogen fertilizer was compared by using simple linear correlation analysis.

RESULTS AND DISCUSSION

Study in relation to the laminar distribution of chlorophyll content of jute leaf and damage to jute leaf by *A. Sabulifera* in jute crop field was assessed by randomized block design during the year 2017 at three different fields from three adjacent administrative blocks of the District Uttar Dinajpur, West Bengal. The result is delineated below:

Observation on the Variation of Distribution of Laminar Chlorophyll along the Leaf Transects (Table 1 and Figure 3):

Grossly jute farmers had sown jute seed at 15 (SMW) Standard Meteorological Week. Prior to that NPK fertilizer is applied at the rate of 20kg/ha as 'basal application'. After emergence of twig most of the farmers from three administrative blocks had applied urea at a rate of 12 kg/ha with an interval of average three consecutive weeks. During last week of May to early weeks of June jute plant attains the maximum growth. The leaf was equidistantly divided in 8 (Z1 to Z8) 'zones'. 15 leaves from each of the places were collected. Chlorophyll content of jute leaf was assessed in consideration of the 8 zones. Average value of the 15 leaves was considered. The laminar distribution of chlorophyll of jute leaves were recorded at Raiganj, Hemtabad and Kaliyaganj were shown in table 1 as; Z1: 42±0.244949, Z2: 41.8±0.08165, Z3: 41.5±0.163299, Z4: 38.4±0.326599, Z5:37.9±0.326599, Z6: 35±0.08165, Z7: 32±0.571548 and Z8: 31±0.408248 at Raiganj; Z1: 38±0.244949, Z2: 37.6±0.08165, Z3: 36.6±0.163299, Z4: 37.2±0.244949, Z5: 36.3±0.326599, Z6: 37.4±0.408248, Z7: 36.8±0.612826 and Z8:35.6±0.489898 at Hentabad; Z1: 42.7±0.489898, Z2:35.5±0.244949, Z3: 42.7±0.489898, Z4:38.2±0.326599, Z5:35.5±0.408248, Z6:32.4±0.979796, Z7: 32.7±0.531246 and Z8: 31.5±0.979796 in SPAD unit respectively.

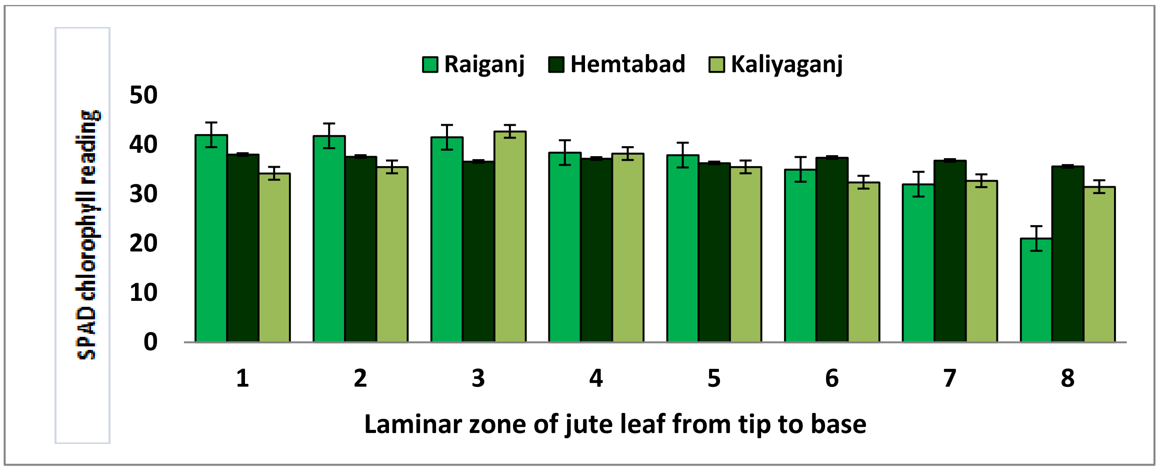

Figure 3: Chlorophyll Distributions in Relation to Laminar Zone of Jute Leaf

Observation on the Extent of Leaf Laminar Damage by Jute Semilooper in Relation Field Management Practices (Table 1 and Figure 4):

Jute seeds were shown at about 15th SMW followed by 'basal application' of NPK fertilizer at the rate of 20kg/ha at field level. Farmers apply N fertilizer at 12 kg/ha with an interval of average three weeks after 'twig emergence'. The crop matures with bright green leaves in the late weeks of May or early weeks of June. At this stage incidence of *A. sabauifera* gradually started (Sadat and Chakraborty, 2015). Voracious feeding of *A. sabuliferais* only restricted to the top eight leaves in a growing plant (Sadat and Chakraborty, 2017) which results into stunted growth of plant and low fibre yield (Rahman and Khan, 2012a).

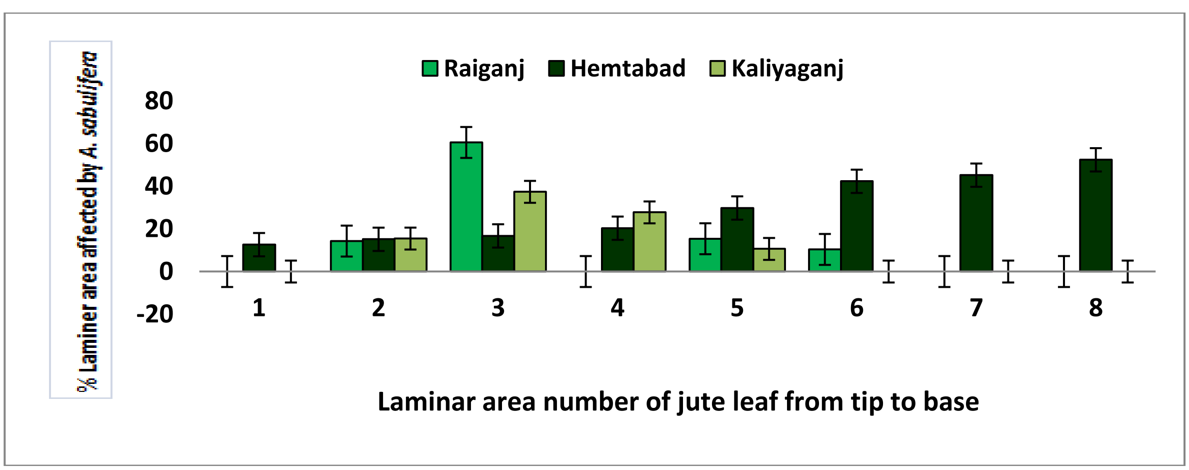

Figure 4: Feeding Preference of *A. Sabulifera* in Relation to Laminar Area of Jute Leaf

Laminar distribution of chlorophyll of jute leaves and in relation to the feeding preference of jute semilooper were recorded at all of the three study sites. Feeding preference of semilooper along with spatial chlorophyll content were recorded as: Z1:00, Z2:14.28, Z3:60.54, Z4: 00, Z5:15.37, Z6: 10.37, Z7: 00.00 and Z8: 00.00% at Raiganj; Z1:12.60, Z2:15.12, Z3:16.70, Z4: 20.32, Z5: 29.79, Z6: 42.32, Z7: 45.20, Z8:52.40% at Hemtabad andZ1: 00.00, Z2: 15.46, Z3: 37.37, Z4:27.74, Z5:10.60, Z6:00.00, Z7:00.00 and Z8:00.00% respectively. Present investigation showed an increase in pest attack with an increase in chlorophyll content which recorded from all study sites of the district Uttar Dinajpur.

Table 1: Relation between Chlorophyll Reading of Jute Leaf in SPAD (502) Chlorophyll Meter at Different Laminar Position and % Laminar Area of Leaf Affected by *Anomis Sabulifera* at Raiganj, Hemtabad and Kaliyaganj of Uttar Dinajpur District (2017)

Laminar Area Number in Leaf from Tip to Base	Raiganj		Hemtabad		Kaliyaganj	
	Chlorophyll Content (SPAD 502)	Affected Laminar Area (%)	Chlorophyll Content (SPAD 502)	Affected Laminar Area (%)	Chlorophyll Content (SPAD 502)	Affected Laminar Area (%)
1	42±0.244	00.00	38±0.244	12.60	34.2±0.163	00.00
2	41.8±0.081	14.28	37.6±0.081	15.12	35.5±0.244	15.46
3	41.5±0.163	60.54	36.6±0.163	16.70	42.7±0.489	37.37
4	38.4±0.326	00	37.2±0.244	20.32	38.2±0.326	27.74
5	37.9±0.326	15.37	36.3±0.326	29.79	35.5±0.408	10.60
6	35±0.081	10.37	37.4±0.408	42.32	32.4±0.979	00.00
7	32±0.571	00.00	36.83333±0.612	45.20	32.7±0.531	00.00
8	31±0.408	00.00	35.6±0.489	52.40	31.5±0.979	00.00

Note: Data of chlorophyll reading represented as Mean ± SD After four replications.

Observation on the Interrelationship between SPAD Chlorophyll Index and the Extent of Jute Leaf Area Damage by semilooper (Table 2 and Figure 5):

In present study linear regression analysis and correlation analysis (r value) showed a well fitted and non-significant positive relation among laminar distribution of jute leaf chlorophyll and pest feeding prediction in Raiganj (Figure 5a) and this relation showed significantly positive relation in Hemtabad and Kaliyaganj (Figure 5b and 5c).

SPAD chlorophyll content were significantly and positively correlated ($P<=0.05$) with the feeding damage due to semilooper attack in all of the three provinces. Linear models explain the correlation value (r value) 0.0865^{NS}, 0.3711*and 0.1387*** for Raiganj, Hemtabad and Kaliaganj respectively (Table 2).

Table 2: Linear Regression Analysis and Correlation Analysis (r Value) between Chlorophyll Reading of Jute Leaves in SPAD (502) Chlorophyll Meter and % Laminar Area of Leaf Affected by *Anomis Sabulifera* at Raiganj, Hemtabad and Kaliyaganj of Uttar Dinajpur District (2017)

Linear Regression Analysis			Correlation Analysis (r Value)		
Raiganj	Hemtabad	Kaliyaganj	Raiganj	Hemtabad	Kaliyaganj
$y = 0.37867x + 1.89$	$y = 0.73352x + 1.54$	$y = 0.42412x + 1.25$	0.0865^{NS}	0.3711*	0.1387***

Note: Significant at: * $P<=0.05$, *** $P<=0.0001$, NS<=not significant

Findings of present study are unswerving with the observation of Sawicka and Michalek (2005); and Taiz and Zeiger (2010). They had independently observed that SPAD 502 meters give variable ‘prediction responses’ for different plant species. The ‘calibration line’ prepared in this study is species specific.

Thus, any attempt to illustrate calibration lines it is important task to developed regression analysis model for each specific plant species and cultivar (Santos *et al.*, 2011).

In present study linear Regression analysis and correlation analysis (r value) showed a well fitted and positive relation laminar distribution of jute leaf chlorophyll and pest feeding predilection (Figure 5).

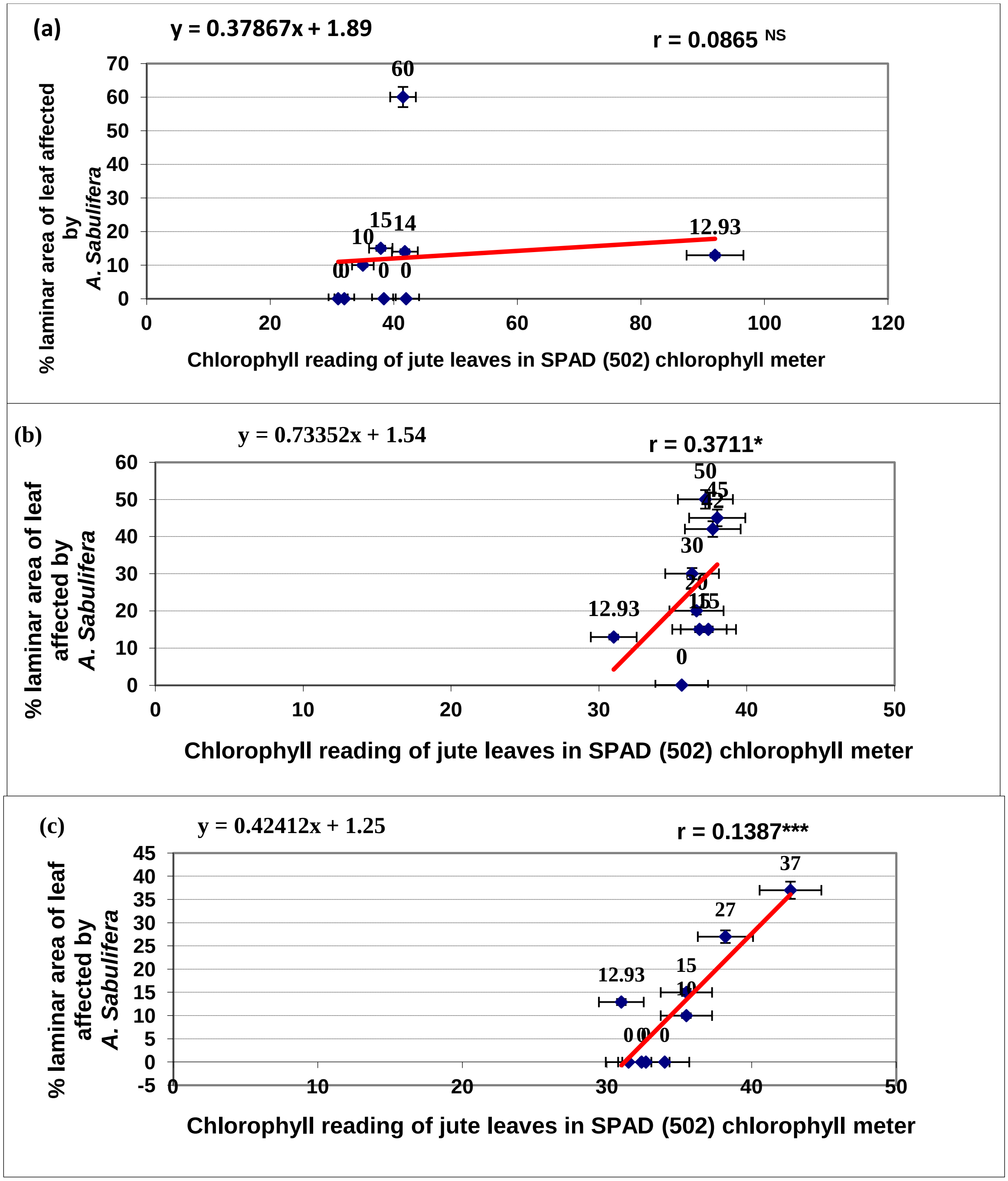

Figure 5(a-c): Relation between % Laminar Area of Leaf Affected by *A. Sabulifera* and Chlorophyll Reading of Jute Leaves in SPAD (502) Chlorophyll Meter at Raiganj, Hemtabad and Kaliyaganj of Uttar Dinajpur District (2017)

This little variation within three study sites may be due to other meteorological factors or phyto-chemical factors that that influence pest incidence (Sadat and Chakraborty, 2017). Rahman and Khan (2012b) also reported that agro-climatic conditions have an effect on Incidence and abundance of *Anomis sabulifera.*
Chlorophyll content of leaves is a useful indicator of both potential photosynthetic productivity and general plant vigour (Alonso *et al*., 2002; Zarco-Tejada *et al.*, 2002). Chlorophyll accounts for about 98% gross primary production (Gitelson and Merzlyak, 1997). The chlorophyll content of leaf corroborates to predict field crop productivity.
Non-destructive methods of chlorophyll measurement provide reliable and effective means of plant analysis in a wide range of biological context (Silva *et al.*, 2012). Changes in leaf chlorophyll content often have been regarded as a relatively 'late mechanism' of photosynthetic adaptation (Wiesler *et al.*, 2002) and changes in the amount of chlorophyll may be a part of adaptive responses (Morales *et al.*, 2002) specifically to the phyto-phagous pests (Rodriguez, 1960; Onuf, 1978).

Conclusion

It was concluded that present study evicted apparent relation between feeding preference of *A. Sabulifera* and laminar distribution of jute leaf chlorophyll. Profusion of pest population changes with changing amount of leaf chlorophyll throughout the jute growing season. Further studies based on this information may be utilized for planning the appropriate time fitted insect pest management strategies for sustainable agriculture. Stipulated data in the present study may provide foundation to other researchers for developing their research model and understanding the pest-chlorophyll relation.

ACKNWLEDGEMENT

We are grateful to Department of Zoology, University of Gour banga, Malda, West Bengal, for their constructive cooperation.

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