INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-5, Issue-1, Jan-Mar-2015 Coden: IJPAJX-USA, Copyrights@2015 ISSN-2231-4490

Received: 20th Nov-2014 Revised: 30th Nov-2014 Accepted: 1st Dec-2014

Research article

INCIDENCE OF *HELOPELTIS* INFESTATION IN POPULAR TEA CLONES OF NORTH-EAST INDIA IN RELATION TO AGRO-CLIMATIC CONDITION

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ABSTRACT: Tea (*Camellia sinensis*) the most popular cash crop of North East India is attacked from past to recent times by a major insect pest, *Helopeltis theivora* (tea mosquito bug).The incidence of pest attack on the four commonly used tea clones of North East India viz, TV1, TV23, S3A3 and Tinali was correlated with climatic conditions (temperature, rainfall, humidity) and soil conditions (pH, organic carbon, sulphur, potash) during the period 2011-2013. A study was carried out on 4 popular clones (TV1, TV23, S3A3, Tinali) planted at 7 tea gardens located at Dibrugarh district, Assam, India during the period 2011-2013 to investigate the relationship of pest incidence with climatic conditions and soil conditions. Monthly attack of pest were recorded from 7 tea estates throughout the year (divided into 4 rain flush) of seasons. The meteorological data was collected for the study from Meteorological station, TRA, Dikom, India for the period of 3 years. The insect infestation was severe during 2nd and 3rd flush while lower during 1st and 4th flush. Climatic parameters viz, temperature, rainfall, humidity was found to be positively correlated to *helopeltis* infestation (with correlation coefficient r= 0.621, r=0.796, r=1 respectively).The soil collected from infected and non infected tea plants was analysed for their organic carbon %, available sulphur, available potash and pH level. Results of organic carbon, sulphur, potash showed that the infected soil samples are either having higher or lower level than the required amount which indicated that imbalanced nutrients might be the reason for *helopeltis* infestation. While pH level was found to be in same acidic range for both infected and non-infected soil. As pest population vary with changes in climatic parameter, this study might be informative in using the right doses of pesticides as well as maintaining soil nutrients to minimize the pest attack in tea.

Keywords*:* *Camellia sinensis*, *Helopeltis theivora*, infestation, climatic condition, soil condition.

INTRODUCTION

Tea (*Camellia sinensis*) is the most popular cash crop of North East India and its beverage is prepared from two and a bud of the plant. The state of Assam located in the North- Eastern part India is the largest tea growing area in the world.In North East India, the tea gardens are dependent on 4 popular clones TV1, TV23 (Tocklai variety clones) and S3A3, Tinali (garden series clones) for their quality and yield [1]. But from past to recent times, the tea plants are getting a major threat by a most dreaded insect pest which is the tea mosquito bug (*Helopeltis theivora*) causing considerable degree of crop loss(10-50%) thus affecting approximately 80% of tea plantation [2,3].Tea being a perennial crop surviving upto 100 years probably provided a stable climate for this pest thus making it the most dreaded pest of North East India and West Bengal [4].The nymph and adults of *Helopeltis theivora* suck the sap of young leaves by inserting their labial stylet which result in brown spot while extensive feeding lead to leaf curling, blackening and ultimately drying [5].This finally affects the yield of the plant. Soil nutrients plays an important role in tea productivity. But due to extensive monoculture of tea, changes such as increased acidity, nutrient depletion, loss of organic matter has resulted in tea soils [6].Thus soil nutrient changes might have some effect on higher pest infestation which is the prime need of the hour to be investigated. Also unremitting rainfall and low temperature in the month of June, 2010 in North East India has created a major demolition to the tea plants by tea mosquito bug [7].
As soil nutrients and climatic parameters are essential for growth of tea plants as well as the pest population by regulating its incubation period, reproduction capacity and development of pest [8].So an attempt has been made to correlate the *helopeltis* incidence with climatic condition and soil parameters as this information might be fruitful in minimizing the *helopeltis* attack on tea plants.

MATERIALS AND METHODS

Sample for study

Tea (*Camellia sinensis*) plants of 7 tea gardens consisting 4 clones viz; TV1, TV23, S3A3 and Tinali located in Dibrugarh district, Assam, India was selected for the study. The list of the 7 tea gardens which were selected are as follows: Ethelwood, Borborooah, Lepetkotta, Moran, Deohal, Tippuk and Anandabag tea estates. Samples which were considered for our study purpose was the healthy and naturally infected two and a bud of the tea plants. Soil samples from the healthy and infected tea bushes were also collected from these gardens at a depth of 0-30 cm from each plot for experimental study.

Survey of *helopeltis* incidence

Helopeltis incidence was determined on 4 tea clones viz; TV1,TV23, S3A3 and Tinali of 7 tea gardens located in Dibrugarh district, Assam, India. Incidence of pest attack were recorded every month all throughout the 4 rain flushes of the year (March-april→1st flush, May-June→2nd flush, July-Aug→3rd flush, Sept-Oct→4th flush) and their averages were considered for a period of 3 years from 2011-2013. *Helopeltis* incidence was computed as the percentage of shoot infested on each of 36 tea bushes.

Meteorological data

Meteorological data of maximum and minimum temperature, rainfall and relative humidity was collected for a period of 3 years from 2011-2013 from the meteorological station, TRA, Dikom, India.

Determination of organic carbon % from soil samples

For soil analysis, soil samples from healthy and infected plants were collected for all the 4 tea clones. Organic carbon % was determined by wet oxidation method [9]. 0.5gm of top soil was mixed with $K_2Cr_2O_7$ (0.2 M) diluted in H_2SO_4 (1:1). The solution was allowed to stand for 30 minutes after which sodium fluoride added.The above mixture finally titrated with ferrous ammonium sulphate. Diphenyl amine was used as indicator for the titration.
The organic carbon % was determined using the following equation:

$$\text{Organic C \%} = \frac{10(B-T)}{B} \times 0.003 \times \frac{100}{wt\ of\ soil} \times 1.94$$

Where,

B= volume of ferrous ammonium sulphate required for Blank.

T= volume of ferrous ammonium sulphate required for soil.

Determination of available sulphur in soil

The available sulphur in soil was determined by Turbidimetric method [10]. For the analysis, soil sample (5 gm) was mixed with KH_2PO_4 and charcoal and then filtered. To the filtrate finally HCl (6N) and $BaCl_2$ fine crystals (0.4 gm) added. The resulting turbidity (in terms of % transmittance) was measured at 420 nm on a photoelectric colorimeter (ERMA INC, Model AE 11M). All the soil samples were analysed in triplicate and the average of the three were taken. The % transmittance reading was plotted against concentration on a linear graph paper and the concentration of sulphur was determined from the standard curve.

Determination of available potassium in soil

The available potassium in soil was determined by flame photometrical method [11].For the analysis, 5 gm soil mixed with neutral ammonium acetate and then shaked for 5-10 minutes. The solution was then filtered. The filtrate containing concentration of potassium “K” was determined by a Flame photometer (Systronic, Model 121). A standard curve was then plotted by putting mean of “K” on X-axis and reading on Y- axis to get the final concentration of potassium.

Determination of pH of soil by glass electrode method

For determination of pH of soil samples, 20 gm soil was mixed in 50 mL distilled water. The solution was then shaked for half an hour. The pH of the clear supernatant was finally measured by a digital pH meter (Systronic, Model 335) at 20°C.
All the chemicals used in the study were procured from Merck India Pvt. Ltd. All the tests were performed in triplicate.

Statistical analysis

The values reported are the mean of at least three independent determinant. Pearson’s correlation coefficient, Student’s ‘t’ test was employed in different experiments using SPSS-13 for windows to determine the significance of the study.

RESULTS

The present study was conducted on 4 clones (TV1, TV23, S3A3, Tinali) of tea plants (infected and non infected) collected from 7 tea estates located in Dibrugarh district, Assam, India.

Helopeltis incidence in relation to climatic condition

Helopeltis theivora infestation on 4 different tea clones was determined for four flush of the year for 3 consecutive years (2011, 2012, 2013). The incidence was computed as the mean of 3 years and the year was further divided into 4 flushes beginning in March (Table 1). Results revealed that incidence was highest in the second (May-June) and third flush (July-Aug) while considerable lower incidence was found during 1st (March-April) and 4th flush (Sept-Oct). Among the 4 tea clones, TV1 and TV23 was found to be the most susceptible as the attack was significantly higher for the two clones during the 4 flushes of the year. Again the other two clones namely, S3A3 and Tinali was found to be moderately susceptible as the incidence was lower in these 2 clones for all the flushes of the year.

The relationship between the *helopeltis* infestation and the climatic conditions: temperature, rainfall, humidity; was determined by Pearson's correlation coefficient (Table 2-4). For incidence of *helopeltis*; mean of all four varieties were considered and for the climatic parameters, mean of the maximum and minimum was considered. Pearson's correlation analysis (Table 5) revealed that the *helopeltis* infestation was positively correlated with temperature, rainfall and humidity for the three years (r=0.621, r=0.796, r=1 respectively).

Table 1: Average incidence of *Helopeltis* infestation in 4 tea clones (TV1, TV23, S3A3, Tinali) over 3 years (2011-2013) (Year divided into: first flush=March-April; second flush=May-June); third flush=July-August; fourth flush=September-October)

Helopeltis incidence in 4 clones over 3 years(2011-2013)				
Average percentage(%)of infested shoot ±SD				
Tea clones	First Flush (Mar-Apr)	Second Flush (May-Jun)	Third Flush (Jul-Aug)	Fourth Flush (Sept-Oct)
TV1	19.09±0.992	36.21±0.409	45.94±0.404	20.79±1.10
TV23	16.83±0.508	31.58±0.430	37.14±0.399	20.49±0.531
S3A3	11.62±0.670	26.94±0.566	27.85±0.736	11.23±0.454
Tinali	11.91±0.251	21.14±0.455	22.60±0.526	10.51±0.218

*Correlation is significant at 0.05 level (2-tailed)

Table 2: Correlation coefficients of *Helopeltis* infestation during four flush of the year with temperature over 3 years.

Correlation coefficient(r) over 3 years					
Climatic condition	Clones	Infestation during first Flush	Infestation during second Flush	Infestation during third Flush	Infestation during fourth Flush
Mean Temperature	TV1	0.596	0.663*	0.741*	0.996*
	TV23	0.999*	0.549	0.871*	0.592
	S3A3	0.985*	0.848*	0.991*	0.982*
	Tinali	0.824*	0.954*	0.917*	0.647

Table 3: Correlation coefficients of *Helopeltis* infestation during four flush of the year with rainfall over 3 years.

Correlation coefficient(r) over 3 years					
Climatic condition	Clones	Infestation during first Flush	Infestation during second Flush	Infestation during third Flush	Infestation during fourth Flush
Mean Rainfall	TV1	0.658	0.672*	0.957*	0.676
	TV23	0.870*	0.812*	0.998*	0.989*
	S3A3	0.795*	0.578	0.836*	0.752*
	Tinali	0.993*	0.999**	0.999**	0.698

*Correlation is significant at 0.05 level (2-tailed) ** Correlation is significant at 0.01 level (2-tailed)

Soil analysis

Results of soil analysis (Table 6-8) for organic carbon, sulphur and potash has revealed that the infected soil samples are either having higher or lower level than the required amount (optimum levels of organic C, S, K for the soils are > 0.80%, = or > 40 ppm, between 60-100 ppm respectively). While the pH level (Table 9) was found to be more or less same (i.e in the acidic range) for the infected as well as the non- infected soil samples (optimum pH level for tea soils is between 4.5-5.5).
The difference between the infected and non-infected soil samples was significant by Student's 't' test at P= 0.01.

Table 4: Correlation coefficients of *Helopeltis* infestation during four flush of the year with humidity over 3 years.

Correlation coefficient(r) over 3 years					
Climatic condition	Clones	Infestation during first Flush	Infestation during second Flush	Infestation during third Flush	Infestation during fourth Flush
Mean Humidity	TV1	0.923*	0.568	0.805*	0.943**
	TV23	0.677*	0.862*	0.737*	0.555
	S3A3	0.504	0.811*	0.776*	0.902*
	Tinali	0.550	0.932**	0.668	0.785*

Table 5: Correlation coefficients of *Helopeltis* infestation and climatic conditions over 3 years.

Correlation coefficient(r)	
Climatic condition	Infestation over years(2011-2013)
Mean temperature	0.621*
Mean Rainfall	0.796*
Mean Humidity	1**

*Correlation is significant at 0.05 level (2-tailed) **Correlation is significant at 0.01 level (2-tailed)

Table 6: Organic carbon % in soils of healthy and infected tea plants (tea clone;TV1, TV23, S3A3, Tinali) of 7 tea gardens located in Dibrugarh district , Assam, India(data are averages ± SD)(NI=non infected, I=infected, [a]=differences are significant at P=0.01 between healthy and infected leaves).

SOIL TESTING														
Tea clone	Ethelwood Tea Estate		Borborooah Tea Estate		Moran Tea Estate		Deohal Tea Estate		Tippuk Tea Estate		Anandabag Tea Estate		Lepetkotta Tea Estate	
	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]
	Organic carbon (%)(Mean ±SD)													
TV1	0.98± 0.007	0.79± 0.004	0.99± 0.007	0.67± 0.004	0.82± 0.006	0.35± 0.004	1.19± 0.003	0.70± 0.004	1.31 ± 0.007	1.63± 0.008	1.08±0 .004	0.64±0 .005	0.93± 0.006	0.64 ± 0.005
TV23	1.39± 0.005	0.85± 0.004	0.93± 0.005	0.84± 0.006	0.80± 0.005	0.47± 0.006	1.63± 0.006	0.78± 0.004	0.90 ± 0.007	0.73± 0.006	×	×	×	×
S3A3	0.90± 0.006	0.78± 0.004	1.25± 0.007	1.05± 0.006	0.36± 0.004	0.55± 0.005	0.81± 0.004	0.67± 0.006	0.80 ± 0.004	0.70± 0.007	0.90±0 .006	0.78±0 .004	0.84± 0.007	0.90 ± 0.004
Tinali	0.95± 0.005	0.80± 0.007	0.84± 0.008	0.79± 0.005	0.81± 0.003	0.49± 0.004	0.90± 0.005	0.78± 0.009	1.19 ± 0.003	0.67± 0.006	1.17±0 .004	1.66±0 .003	0.90± 0.006	0.70 ± 0.008

Table 7: Available sulphur in soils of healthy and infected tea plants (tea clones=TV1, TV23, S3A3, Tinali) of 7 tea gardens located in Dibrugarh district, Assam, India (data are averages ± SD)(NI=non infected,I=infected, [a]=differences are significant at P=0.01 between healthy and infected leaves).

SOIL TESTING														
	Ethelwood Tea Estate		Borborooah Tea Estate		Moran Tea Estate		Deohal Tea Estate		Tippuk Tea Estate		Anandabag Tea Estate		Lepetkotta Tea Estate	
Tea clone	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]
	Available Sulphur(ppm)(Mean ± SD)													
TV1	40± 0.004	18± 0.005	35± 0.006	25± 0.004	47± 0.007	8± 0.004	40± 0.003	29± 0.002	55± 0.006	18±0. 004	54± 0.002	26±0 .005	55±0 .003	26±0 .004
TV23	44± 0.006	25± 0.007	44± 0.003	22± 0.005	39± 0.005	8± 0.003	45± 0.004	25± 0.005	46± 0.008	28± 0.005	×	×	×	×
S3A3	55± 0.007	19± 0.006	42± 0.004	32± 0.003	56± 0.004	14± 0.006	46± 0.003	20± 0.004	56± 0.009	24± 0.007	48±0.0 03	20±0 .005	46±0 .006	32±0 .004
Tinali	43± 0.005	14± 0.003	39± 0.005	19± 0.006	45± 0.002	12± 0.004	48± 0.007	21± 0.006	45± 0.004	22± 0.006	52±0.0 04	28±0 .006	42±0 .005	24±0 .006

Table 8: Available potash in soils of healthy and infected tea plants (tea clones= TV1, TV23, S3A3, Tinali) of 7 tea gardens located in Dibrugarh district, Assam, India (data are averages ± SD) (NI=non infected,I=infected, [a]=differences are significant at P=0.01 between healthy and infected leaves).

SOIL TESTING														
	Ethelwood Tea Estate		Borborooah Tea Estate		Moran Tea Estate		Deohal Tea Estate		Tippuk Tea Estate		Anandabag Tea Estate		Lepetkotta Tea Estate	
Tea clone	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]
	Available Potash(ppm)(Mean ± SD)													
TV1	65± 0.005	144± 0.006	98± 0.003	90± 0.004	62± 0.004	36± 0.005	110± 0.008	168± 0.005	140± 0.008	252± 0.007	111± 0.006	120± 0.003	99± 0.003	102± 0.009
TV23	72± 0.006	252± 0.007	61± 0.004	264± 0.005	66± 0.006	54± 0.003	106± 0.004	288± 0.006	104± 0.006	120± 0.004	×	×	×	×
S3A3	64± 0.004	132± 0.008	96± 0.005	102± 0.004	100± 0.006	42± 0.005	104± 0.005	132± 0.004	106± 0.003	138± 0.005	116± 0.003	184±0 .007	60± 0.005	78±0 .004
Tinali	98± 0.005	150± 0.005	105± 0.006	138± 0.007	61± 0.004	30± 0.006	72± 0.006	180± 0.005	101± 0.004	108± 0.007	60± 0.005	126±0 .007	90± 0.006	96±0 .005

Table 9: pH level in soils of healthy and infected tea plants (tea clones=TV1, TV23, S3A3, Tinali) of 7 tea gardens located in Dibrugarh district, Assam, India (data are averages ± SD) NI=non infected,I=infected, [a]=differences are significant at P=0.01 between healthy and infected leaves).

SOIL TESTING														
	Ethelwood Tea Estate		Borborooah Tea Estate		Moran Tea Estate		Deohal Tea Estate		Tippuk Tea Estate		Anandabag Tea Estate		Lepetkotta Tea Estate	
Tea clone	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]	NI[a]	I[a]
	pH (Mean±SD)													
TV1	4.64 ± 0.012	4.18± 0.005	4.39± 0.011	4.30± 0.005	4.35± 0.010	4.21± 0.006	4.45± 0.006	4.30 ± 0.009	4.26± 0.005	4.09± 0.007	4.68± 0.006	4.05 ± 0.009	4.12 ± 0.011	4.06± 0.005
TV23	4.56 ± 0.001	4.28± 0.006	4.45± 0.009	4.49± 0.006	4.66± 0.013	4.39± 0.005	4.93± 0.004	4.20 ± 0.010	4.32± 0.007	4.01± 0.006	×	×	×	×
S3A3	4.71 ± 0.009	4.04± 0.008	4.41± 0.008	4.24± 0.008	4.74± 0.008	4.59± 0.006	4.17± 0.008	4.02 ± 0.012	4.28± 0.006	4.13± 0.009	4.43± 0.011	4.20 ± 0.008	4.34 ± 0.007	4.09± 0.006
Tinali	4.61 ± 0.006	3.98± 0.005	4.52± 0.011	4.24± 0.009	4.54± 0.006	4.50± 0.003	4.65± 0.003	4.50 ± 0.008	4.35± 0.005	4.19± 0.004	4.30± 0.010	4.05 ± 0.006	4.45 ± 0.004	4.20± 0.007

DISCUSSION

Tea industry is greatly influenced by abiotic factors such as climatic conditions (rainfall, temperature, humidity) and also by biotic factors (pests and diseases) [12]. Both these factors in some way or the other influence tea cultivation. In the present study, *Helopeltis theivora* infestation on 4 different tea clones was determined for four flush of the year namely: 1st (March-April), second (May-June) , third flush (July-Aug) and 4th flush (Sept-Oct).The winter season was not considered for the present study as during this period the leaves are not abundant due to pruning of the tea bushes. A positive correlation has been established between *helopeltis* infestation and temperature, rainfall and humidity. Similar study on brinjal plant has shown that temperature, rainfall and relative humidity are responsible for the incidence of pest like leaf hopper and white fly [13].Study conducted on neem plant for *Helopeltis antonii* pest incidence showed positive relation with relative humidity and rainfall [14].In yet another study in Indonesia, *Helopeltis antonii* attack was found to be more during the humid rainy months of the year [15]. Several studies on aphids and moth indicated that temperature facilitate pest infestation in plants [16, 17].

Soil fertilization plays a vital role in plant body in making it resistant or more susceptible to the pests [18].Plant disease or their severity solely lies on the type of soil [19].Agricultural practices which causes soil nutrient imbalance can lower plant's resistance to the pest [20]. While on the other hand, an increase in the soil nutrient makes plants more vulnerable to the pests as the plant serves as food source for the pest [21]. Soil organic carbon has direct relationship with soil organic matter which can be judged by the following equation:

Soil organic carbon %= organic matter % ÷ 1.73

Therefore, decrease in soil organic carbon will indicate decrease in soil organic matter %.

Organic matter in soil act as a store for all the available nutrients of the plant [22]. In the present study for soil organic carbon % in infected tea clones (TV1, TV23, S3A3,Tinali), it has been found that % was below 0.80 for all the 7 tea estates with exception of very high organic C% for only the following clones: 1.63%(TV1 in Tippuk),1.05%(S3A3 in Borborooah), 1.66% (Tinali in Anandabag). In tea plants, low organic carbon in soil affects yield and use of other nutrients by the plant system [23]. Thus, due to lower organic C% imbalance of nutrients develop in the plant system which might make them suitable for the *helopeltis* infestation. For plants, carbon and sulphur are important nutrients for their life cycle and are cycled in the soil between organic matter and plant available nutrients. Soils containing high organic matter donot suffer from sulphur deficiency as sulphur mineralizes from the organic matter. Thus, soil with low organic carbon suffers from sulphur(S) deficiency. Also from previous reports, it is quite evident that sulphur deficiency is indicative of nitrogen (N) deficiency as S and N enter together into the plant system to form protein complexes [24]. In the present study, available sulphur analysed for the 4 clones collected from 7 gardens has been found to have sulphur level below 40 ppm (parts per million).Hence, sulphur deficiency indicating deficiency of other nutrients creates an imbalance in the plant body which might facilitate the pest, *Helopeltis theivora* to infest tea plants. Potassium is a macronutrient which is required by the plant sysem in large amount. It helps in activating many enzymes and thus is very vital for synthesis of protein and carbohydrate. It also helps in hydrating the plant. Potassium must be adequate for maintaining optimum levels of minerals in the plant system. On the other hand, very high potash suppresses the uptake of calcium, magnesium, silicon, sugars and amino acids [25]. In the present investigation of available potassium in tea soils, it has been found that all the 4 clones in the 7 tea estates are having a high potassium level (> 100 ppm) with exception of Borborooah (TV1 clone) and Moran tea estate which showed low potassium level (< 60 ppm) for TV23,S3A3,Tinali. Soil pH indicates balance between cation elements (calcium, magnesium,sodium etc) and soil acidity. Acidic pH range of soil is essential for proper working of fertilizers while very low pH can reduce the availability of nutrient. Therefore, adjusting soil pH is a must for proper growth of the crop plant [26].

In the present study, soil pH for all the 7 tea estates has been analysed. It has been found that the infected soils are more or less within the acidic range (i.e, between 4.5-5.5) which is required pH for tea soils. Thus, it can said that imbalanced nutrients along with climatic factors might be the possible reason for *Helopeltis theivora* infestation on tea plants.

CONCLUSION

Thus the present study showed that *Helopeltis theivora* incidence is higher for clones; TV1 and TV23 while lower incidence for clones; S3A3 and Tinali all throughout the year. The results also indicated that climatic factors along with imbalanced nutrients in soil influenced the *helopeltis* infestation in tea plants. As pests has the tendency to modulate with the climatic factors so this study might be helpful in using the right doses of pesticides and balanced soil nutrients for minimizing the pest attack without compensating its yield. Moreover, the findings also seems to be fruitful for determining clones for selection programmes and also prevent such attack in future through well-planned integrated pest management programme.

Conflict of interest: The authors declare that they have no conflict of interest.

ACKNOWLEDGEMENT

The authors acknowledge Director, Centre for Studies in Biotechnology, Dibrugarh University for providing all the facilities to carry out the study and DBT-NE project, Govt. of India for funding.

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