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ROLE OF WEATHER PARAMETERS ON SEASONAL ABUNDANCE OF INSECTS IN A MANGO-BASED AGROFORESTRY IN BANGLADESH, WITH PARTICULAR REFERENCE TO MANGO HOPPER

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Abstract

Weekly sweeping was done by sweep net in order to collect insects to study the effect of weather parameters on the seasonal abundance of total insect species as well as mango hopper population in a mango-based agroforestry in Bangladesh during January to June 2013. The total insect species abundance was the highest during April to May, following the flushing of inflorescence and fruit set. At that time temperature and relative humidity were comparatively higher and there was rainfall. Mango hopper population was the highest in May and synchronized to fruit set. The abundance of total insect species and mango hopper population showed significant positive correlation with temperature, and relative humidity, while significant negative correlation with light intensity and non-significant positive correlation with rainfall. Multiple linear regression equation based on weather parameters revealed 59.2% and 61.7% role on population build up of total insect species and mango hopper, respectively. Temperature was found to be the most important effect which individually contributed 31.3% on population abundance of total insect species and 29.9% on mango hopper.

Keywords: Abiotic factors, agroforestry, insects, *Mangifera indica.*

Introduction

Mango (*Mangifera indica* L.) is one of the most popular fruits of Bangladesh and also popular in the tropical and subtropical countries of the world like Pakistan, India, South China and Malaysia (Joshi and Kumar, 2012). This fruit is very popular due to its delicious taste, captivating flavor with multifarious color and excellent source of nutritive values. Mango is not only a delicious fruit but also a rich source of carbohydrate, fiber, carotene, thiamine, riboflavin, niacin, ascorbic acid, tryptophan, lysine and minerals (Ojokoh, 2007). Many insect species damage mango crops by feeding on leaves, stems, flowers, and fruits. Also, many insect species play a vital role on pollination as well as fruit set, and predator-prey interactions keep balance between pest incidence and fruit production.

Agricultural land in Bangladesh is being converted to non-agricultural purposes like housing, transportation, establishment of educational institutions, offices, hospitals etc. to fulfill the demands for increasing population. Due to the

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conversion of agricultural lands to commercial establishments, it is necessary to diversify and maximize yield per unit area. On the contrary, intensive agricultural system is creating disturbance on natural habitats, and affects species richness, abundance and community structure of insects (Debinski and Holt, 2000). Therefore, strategies are taken by the farmers to grow lower storied crops under upper storied trees which are known as agroforestry system.

Agroforestry technology is a diversified agricultural system which serves as a tool in nature conservation with maximum utilization of natural resources viz., land, sunlight, air and water (Donald, 2004; Putz *et al*., 2001). This practice can increase the overall diversity of plants and physical structure in a landscape that provides habitat for native pollinators, which are linked to crop productivity. About two decades ago, mango plants were grown in homesteads, nurseries and traditional orchards in Bangladesh. But in the recent years, mango-based agroforestry system has been developed and due to its increased production, it has become a popular concept. It includes cultivation practices of mango along with guava, pineapple, garlic, turmeric, bitter gourd, carrot, kangkong, okra, etc.

In Bangladesh, vegetative growth of mango plants starts from July and continues up to December. Here, the plants produce flower buds in January, full bloom period ranges from February to March, fruit formation occurs from March to April, and the fruits become mature in June. Insect pests play a significant role on yield and quality of mangoes in Bangladesh. A total of 30 insect species damage mango crops in Bangladesh and mango hopper is the most destructive insect (Hossain, 1989). Many insects in the order Diptera and Hymenoptera help in pollination of this crop (Singh, 1997; Dag and Gazit, 2000). Seasonal variations of the weather factors play a vital role in multiplication, growth, development and distribution of insects, and influence on their population dynamics (Qayyum and Zalucki, 1987; Dhaliwal and Arora, 2001). Joshi and Kumar (2012) reported that comparatively higher temperature and lower relative humidity increased hopper population.

The mango-based agroforestry constitutes with mango trees, crops, weeds, insect pests, predators and pollinators. Weeds and the cultivated ground cover crops provide shelter and food for pests, predators, pollinators and parasites (Bugg and Waddington, 1994; Desaeger *et al*., 2004). So, yield and quality of mangoes grown in an agroforestry are partially related to insect abundance and diversity. However, no study on this matter in Bangladesh has been made so far. Therefore, with a view to providing information to mango growers on insect abundance, especially mango hopper in respect to weather parameters, the study was conducted in a mango-based agroforestry.

Materials and Method

Study site and conditions: The study was conducted from January to June 2013 in a mango-based agroforestry field laboratory of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur (25°25′ North latitude and 89°5′ East longitude), Bangladesh. The site is surrounded by sal, *Shorea robusta* Gaertn forest. The climate of this area is seasonally characterized by a well-defined dry season (February to May), rainy season (June to September) and short winter (December and January). Annual mean maximum and minimum temperature, relative humidity and rainfall are 36.0 ºC and 12.7 ºC, 65.8% and 237.6 cm, respectively. The mango-based agroforestry system is interrupted by different management intensity, grasslands, paddy and vegetable fields. The area of the study agroforestry is 2205 m^2, and constituted with 45 mango trees (variety Amrapali) each 11 years old, 3-4 m height and 7 m apart. During the study, bitter gourd, *Momordica charantia* (Family: Cucurbitaceae) and kangkong, *Ipomea reptans* (Family: Convolvulaceae) were cultivated as middle and lower storied crops, and 20 weed species emerged.

Collection of weather data: Light intensity in the mango-based agroforestry system throughout the study was measured with a digital light meter (Model 401025, Extech Instruments Corporation, USA). Data were collected weekly and in between 10.00 and11.00 am at the canopy area of the trees. Mean daily temperature, relative humidity and rainfall data were collected from the weather station of BSMRAU.

Insect collection and identification: To assess the seasonal changes of insect abundance in the mango-based agroforestry system, sampling protocol was targeted on free-living insects foraged during the daytime. Insects were collected using a 30 cm diameter sweep net having1.5 mm mesh, and attached with a 2 m long rod. Every week, sweeping was done in between 09.00 and 11.00 am, and each sample consisted of 30 sweeps encompassing an area from ground level to the top of the trees. The collected insects were brought from the experiment field to the Entomology Laboratory of BSMRAU for counting total abundance as well as mango hopper population/30 sweeps.

Statistical analysis: One way analysis of variance (ANOVA) followed by Duncun’s Multiple Range Test (DMRT) was employed for analyzing monthly abundance. Correlation coefficients were calculated for total species abundance and hopper population with meteorological parameters. All the analyses were performed using IBM SPSS 19.0.

Results

Table 1 shows that monthly mean temperature, light intensity, relative humidity and rainfall during the study varied from 19.0 ± 0.5 to 32.2 ± 0.4 ºC, 1625 ± 480 to 11580 ± 1790 lux, 69.0 ± 4.7 to 83.0 ± 1.7 % and 0.0 ± 0.0 to 4.9 ± 4.9 mm, respectively. There was significant difference ($F_{5, 16} = 9.8$, $p < 0.0001$) among the monthly abundances of insect population, which varied from 36.5 ± 5.5 to 125.0 ± 10.9 /30 sweeps. Hopper abundance during the study varied from 1.0 ± 1.0 to 100.8 ± 10.6 /30sweep. Total insect abundance was the lowest in January and peaked in May when the mean temperature, light intensity, relative humidity and rainfall were 28.2 ± 0.5 ºC, 4500 ± 957 lux, 83.0 ± 1.7% and 1.5 ± 0.9 mm. respectively. Abundance of hopper was the lowest in January and reached to the peak in May.

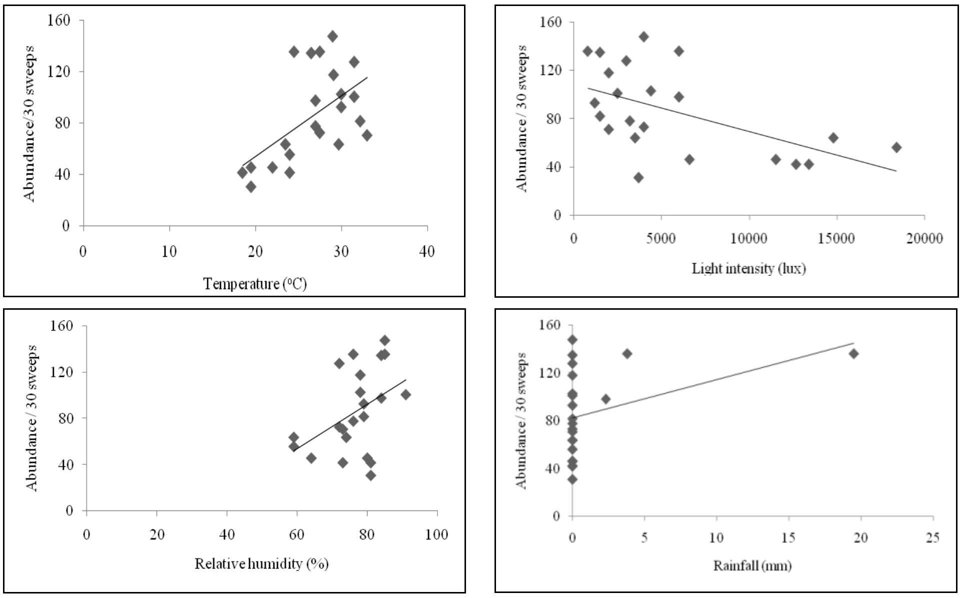

Fig. 1. Relationship between weather parameters and total insect abundance in a mango-based agroforestry in Bangladesh during January to June 2013.

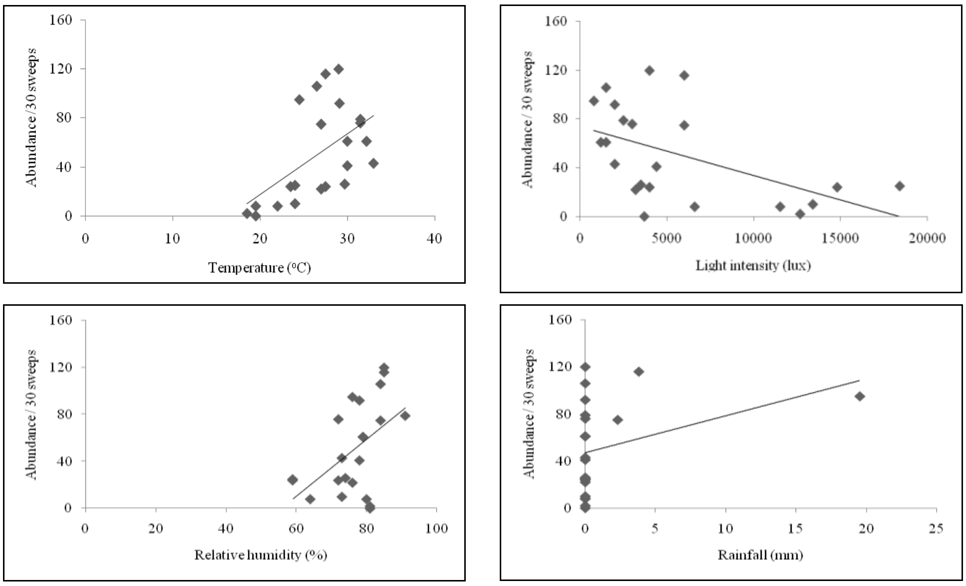

Fig. 2. Relationship between weather parameters and mango hopper population in a mango-based agroforestry in Bangladesh during January to July 2013.

Relationship between total insect abundance and weather parameters presented in figure 1 revealed that insect abundance had significant positive correlation with temperature ($y = -40.02 + 4.72x$, $r = 0.56$, $F_{1,20} = 9.1$, $p < 0.01$), significant negative correlation with light intensity ($y = 108.5 - 0.003x$, $r = 0.55$, $F_{1,20} = 8.7$, $p < 0.01$), significant positive correlation with relative humidity ($y = - 60.80 + 1.918x$, $r = 0.43$, $F_{1,20} = 4.6$, $p < 0.05$), and non-significant positive correlation ($y = 82.20 + 3.22x$, $r = 0.38$, $F_{1,20} = 4.2$, $p = 0.08$) with rainfall.

Figure 2 showed that the hopper abundance during the study revealed significant positive correlation with temperature ($y = -82.77 + 5.00x$, $r = 0.547$, $F_{1,20} = 8.5$, $p < 0.01$), significant negative correlation with light intensity ($y = 73.688 - 0.004x$, $r = 0.55$, $F_{1,20} = 7.3$, $p < 0.05$), significant positive correlation with relative humidity ($y = - 134.52 + 2.420x$, $r = 0.503$, $F_{1,20} = 6.8$, $p < 0.05$), and non-significant positive correlation with rainfall ($y = 46.960 + 3.159x$, $r = 0.34$, $F_{1,20} = 2.62$, $p = 0.12$).

Table 1. Monthly distribution of meteorological parameters and insect population buildup in a mango-based agroforestry in Bangladesh during January to June 2013

Month	N	Temperature (°C)	Light intensity (lux)	Relative humidity (%)	Rainfall (mm)	Total abundance/30 sweeps	Hopper abundance/30 sweeps
January	2	19.0 ± 0.5	8185 ± 4485	81.0 ± 0.0	0.0 ± 0.0	36.5 ± 5.5 d	1.0 ± 1.0 d
February	4	22.3 ± 1.0	11580 ± 1790	69.0 ± 4.7	0.0 ± 0.0	49.5 ± 4.9 cd	12.5 ± 3.9 cd
March	5	27.6 ± 1.1	6700 ± 2932	71.8 ± 3.4	0.0 ± 0.0	74.8 ± 8.0 bc	27.6 ± 3.4 c
April	4	28.1 ± 1.6	1625 ± 480	77.8 ± 2.5	4.9 ± 4.9	123.0 ± 10.2 a	84.5 ± 9.9 ab
May	4	28.2 ± 0.5	4500 ± 957	83.0 ± 1.7	1.5 ± 0.9	125.0 ± 10.9 a	100.8 ± 10.6 a
June	2	32.2 ± 0.4	2000 ± 289	81.0 ± 5.3	0.0 ± 0.0	84.7 ± 8.8 b	61.0 ± 10.4 b

N = Number of collection in a month. Data expressed as mean ± SE. Means within a column followed by same letter (s) are not significantly different (DMRT, $p \leq 0.05$).

Table 2. Multiple linear regression models along with coefficients of determination (R^2) regarding the impact of weather parameters on the seasonal abundance of total insects in a mango-based agroforestry in Bangladesh during January to June 2013

Regression equation	R^2	100 R^2	%Role of individual factor	F statistic
$Y = 40.02 + 4.77 X_1$	0.313	31.3	31.3	$F_{1, 20} = 9.1$ $p < 0.01$
$Y = 18.337 + 3.054 X_1 - 0.002X_2$	0.388	38.8	7.5	$F_{2, 21} = 6.0$ $p < 0.05$
$Y = -89.49 + 3.559X_1 - 0.001X_2 +1.130X_3$	0.426	42.6	3.8	$F_{3, 21} = 4.5$ $p < 0.05$
$Y = -178.24 +5.053X_1 + 0.001X_2 +1.572X_3 + 3.794X_4$	0.592	59.2	16.6	$F_{4, 21} = 6.2$ $p < 0.05$

Y, insect population /30 sweeps; X_1, temperature (°C); X_2, light intensity (lux); X_3, relative humidity (%); X_4, rainfall (mm).

The multiple linear regression analysis presented in table 2 showed that temperature individually contributed 31.3% abundance and its effect was significant. The combination effect of temperature and light intensity was significant and exerted 38.8% abundance. The individual contribution of light intensity was 7.5%. The relative humidity along with temperature and light intensity contributed 42.6% abundance of insect which was statistically significant. The individual effects of humidity and rainfall on insect abundance were 3.8% and 16.6%, respectively. The multiple linear regression analysis showed that all the weather parameters together contributed 59.2% population abundance of insects in the mango-based agroforestry and the equations were significant.

Table 3. Multiple linear regression models along with coefficients of determination (R^2) regarding the impact of weather parameters on the seasonal abundance of mango hopper in a mango-based agroforestry in Bangladesh during January to June 2013

Regression equation	R^2	100 R^2	%Role of individual factor	F statistic	
$Y = -82.77 + 5.00\ X_1$	0.299	29.9	29.9	$F_{1, 20} = 8.2$	$p < 0.05$
$Y = -25.52 + 3.393\ X_1 - 0.002X_2$	0.358	35.8	5.9	$F_{2, 21} = 5.3$	$p < 0.05$
$Y = -216.241 + 4.281X_1 + 0.00009X_2 + 1.989X_3$	0.457	45.7	9.9	$F_{3, 21} = 5.1$	$p < 0.05$
$Y = -310.75 + 5.871X_1 + 0.002X_2 + 2.459X_3 + 4.041X_4$	0.617	61.7	16.0	$F_{4, 21} = 6.9$	$p < 0.05$

Y, insect population /30 sweeps; X_1, temperature (ºC); X_2, light intensity (lux); X_3, relative humidity (%); X_4, rainfall (mm).

Table 3 showed that temperature individually exerted 29.9% population abundance of mango hopper and its effect was significant. The temperature with combination of light intensity revealed 35.8% abundance, which was statistically significant. The individual effect of light intensity demonstrated 5.9% abundance. The combination effect of temperature, light intensity and relative humidity depicted 45.7% abundance and the result was statistically significant. The individual contribution of rainfall on mango hopper abundance was 16.0%. The multiple linear regression analysis showed that all the weather parameters together contributed 61.7% abundance of mango hopper and the equations were significant.

Discussion

For development of an agroforestry technology it is important to understand the diversity, abundance, damage threshold and biology of the insect species in the locality (Epila, 1988). Information on different insect species abundance due to variations in meteorological parameters are to be noted for effective management of the pests and proper use of pollinators. This is the first report on the effect of weather parameters on insect abundance in a mango-based agroforestry in

Bangladesh. During 3rd week of January to 3rd week of June 2013 a total of 1751 insects were collected in 21 working days. A total of 1114 hopper population was found among the collected insects. The lowest abundance of total insect species as well as hopper population was observed in January and the results were significantly different from other months. The total insect species abundance was the highest from April to May, and hopper population reached to the peak in May. The increased abundance of the insect population during April to May was associated with increased temperature, relative humidity, rainfall and flushing of inflorescence. The insect population was the lowest in January and February due to higher light intensity. High light intensity occurred in these months because of clear sunshine and deciduous plant characteristics of the mango based agroforestry. Paul and Lalnunsalgi (2011) studied insect population abundance at some agroforestry systems in Mizoram, India during 2000 to 2002 and found significantly higher and lower abundances in summer and winter seasons, respectively.

Kannan and Rao (2006) conducted a field experiments in Andhra Pradesh, India and reported that the host plants and weather parameters played role on the abundance and population dynamics of mango hopper, *Amritodus atkinsoni*. They observed the peak incidence of the hopper during third week of January (85.0 hopper/12 inflorescence). They also observed negative correlations between the incidence of hopper and minimum temperature, relative humidity, evening rainfall, and positive relationship with maximum temperature, and morning relative humidity. High temperatures (18-28˚C) and relative humidity (> 90%) favored the incidence of mango hopper (Gan *et al.*, 2000). Shekh *et al*. (1993) carried out field studies in Gujarat, India and reported that temperature < 20˚C kept population of *A. atkinsoni* under control and pest outbreak occurred when the temperature ranged between 20 and 25˚C. They also found that fruit fly, *Ceratitis cosyra* population was positively and negatively correlated with temperature and humidity, respectively while the population of *Bactrocera invadens* showed vice versa.

Higher abundance of hopper was observed covering 63.6% of the total abundance. It may be due to the perennial nature of the crop, large scale monoculture, high plant density and excessive use of fertilizer, irrigation, and pesticides favoring the multiplication of this pest. It has been reported that plant species diversity in an agro-forestry influences the survival and abundance of insects by modifying the microclimate in the agro-ecosystem and could reduce pest attack, however the natural enemies decrease (Ram *et al.,* 1989). On the contrary, crop species sometimes may create favorable conditions for pest incidence and damage (Ram *et al.,* 1989). So, plant species combinations for cropping pattern of a mango-based agroforestry technology must be on the basis of least favorable conditions for the survival and multiplication of major pest species.

In the study field, two vegetable species *M. charantia* and *I. reptans* were cultivated as middle and lower storied crops, while 20 herb species were found as weeds. These crops and weeds species may have provided habitat for insects or interrupted their abundance. Mango hopper was abundant throughout the study and reached to the peak at flowering and fruiting stage (March-May).

This study showed that overall population abundance was lower during cold and dry months and started to increase with the onset of the rainy season, coinciding with the blooming. The highest records were noticed during the monsoon, possibly with the addition of the new individuals emerged from the overwintering population of the dormant eggs and pupae. The present study also showed that total insect abundance as well as hopper population was positively correlated with temperature, relative humidity and rainfall. Pushpalatha *et al.* (2008) observed positive correlation between hopper population and maximum temperature and negative correlation with relative humidity.

Occurrence of different insect species in significant numbers in an agroforestry could influence the productivity and sustainability of the system. Mango hopper was the most abundant because they prevailed dominantly on mango flower panicles during cooler and dry season. Higher fecundity and rapid generation ability of this pest contributed to higher abundance. The present findings showed harmony with Kaushik *et al.* (2012) who observed significant abundance of hopper on mango plants.

This study clearly focused the seasonal abundance of insects particularly mango hopper in a mango-based agroforestry in Bangladesh, which could be helpful to mango growers for development of IPM program emphasizing on the restoration of predator and pollinator species.

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