Biological and Clinical Sciences Research Journal
ISSN: 2708-2261
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2022i1.152
*Biol. Clin. Sci. Res. J., Volume, **2022**: 152*
Original Research Article

ESTABLISHMENT OF STRATEGY FOR MANGO HOPPER *IDIOSCOPUS CLYPEALIS*(LETHIERRY) MANAGEMENT AND IMPACT OF WEATHER FACTORS ON ITS POPULATION IN SOUTH PUNJAB PAKISTAN

GHAFFAR A[1], KHAN AH[1], HAMEED A[1*], IQBAL J[2*], AHMAD M[1], RAZA S[1], IMRAN M[1], MUHAMMAD N[3], SHAH SAH[4], RAZA MA[5]

[1]*Mango Research Institute, Multan-60000, Pakistan*
[2]*Mango Research Station, 6-km Basti Malook Road, Shujabad 59220, Pakistan*
[3]*Central Cotton Research Institute, Multan-60000 Punjab Pakistan*
[4]*Soil and Water Testing Laboratory, Mianwali, Pakistan*
[5]*Rice Research Institute, Kala Shah Kaku, Pakistan*
**Correspondence author email address:* asifa_hameed_sheikh@yahoo.com, javedsaqi@gmail.com

(Received, 4th June 2022, Revised 2nd December 2022, Published 4th December 2022)

Abstract: *Mango is an important, exportable fruit crop of Pakistan. Pakistan is occupying 6th position on the basis of mango production in almost 90 mango producing countries of the world. The mango hopper Idioscopus clypealis is a most destructive insect pest of mangoes in Pakistan. This pest may cause the economic loss to the mangoes due to due to its abundance and high population in dense traditionally managed mango orchards. Keeping in view the importance of the pest, a study was designed with an objective to determine comparative efficacy of four different insecticidal spray modules for effective control of mango hopper on cultivar Sufaid Chaunsa in the research orchards of Mango Research Institute, Multan during 2019-2021. Another objective was to determine the population dynamics of mango hopper and the effect of weather factors on the population of mango hopper. The infestation of the pest was examined by observing nymphs and adults in a single panicle/inflorescence (10-inch long) from each cardinal directions of the selected trees visually counted during the flowering season on weekly basis. In module 1, Thiamethoxam (Actara 25 WG) was sprayed after the fruit harvest. In module 2, the insecticide Thiamethoxam (Actara 25WG) was sprayed after the fruit harvest, followed by second spray of Clothianidin (Trunk 20SC) only on tree trunks in the month of December. In module 3, first spray of thiamethoxam was done after fruit harvest, second spray of Clothianidin (Trunk 20SC) only on tree trunks in the month of December and a subsequent third spray of Spinetoram (Delegate 25 WG) was done on mango trees before flowering season in the month of January. The population of mango hopper was significantly lowest in module 3 and higher population of hopper was recorded in control. Population dynamics studies revealed that mango hopper population reached at its peak in 2nd week of April during 2020 and 3rd week of March in 2021. The population of mango hopper was maximum during mango flowering period, while in the later months the population of mango hopper declined. The effect of weather factors on population abundance of mango hopper revealed that significantly positive correlation and regression was observed with relative humidity and wind while negative correlation was observed with increased temperature and rainfall.*

Keywords: Population dynamics, correlation, regression, weather factors, percent mortality, spray modules

Introduction

Mango (*Mangifera indica*; Anacardiace) is an important, highly nutritious and delicious fruit popular in the most parts of the world (Singh, 1960; Lizada, 1993; Kole, 2021; Rajan*et al.*, 2021; Lebaka*et al.,* 2021). Delicious, highly nutritious, aromatic mangoes are also known as "The King of fruits" (Tharanathan*et al.*, 2006; Sagar*et al.*, 1999; Lebaka*et al.*, 2021). Mangoes probably originated in South Asia mainly because they are under cultivation for the last four hundred years (Yadav and Singh, 2017).

The climate of Pakistan is favorable for the cultivation of mangoes (Rizwanulhassan and Shafiqurrehman, 2015; Usman*et al*., 2003).Pakistan is 6th largest world mango producer (Anonymous, 2014). In 2021,Punjab province produced 135.02 thousand tons of mangoes from 244673 acres (Anonymous, 2022), however, per acre qualitative mango fruits production and export is very low. Pakistan exports this valuable commodity to United Kingdom, Germany, Norway, U.A.E, Oman, Iran, Afghanistan, Azerbaijan, Saudi Arabia (Rizwanulhassan and Shafiqurrehman, 2015).

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

Although Pakistani mangoes are delicious and extremely liked, export of Pakistani mangoes is low due to multiple factors including the non-uniform size, decreased production of qualitative large sized exportable mangoes and reduced quality due to insect pest attack.

Mango hopper is the most serious, highly abundant, insect pest at flowering and fruiting stages and could cause yield loss up to 100% (Rahman, 2007; Rahman *et al*., 2018; Rahman *et al*., 2007; Adnan *et al*., 2014; Talpur and Khuhro 2003). In Pakistan 4 species of hoppers are observed on mango crop viz., *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lethierry), *I. niveosparsus* (Lethierry) and *I. nitidulus* (Walker). Out of these different hopper species of mango, *I. clypealis* is the most destructive one and aggravating day by day (Tandon*et al.,* 1983; Adnan*et al.,* 2014; Srivastava and Tandon, 1986). Immature and mature hoppers puncture the plant parts and suck the sap from tender parts including shoots, inflorescences, and leaves resulting in poor setting of flowers, delayed or reduced pollination, reduced production of qualitative large sized mango fruits and dropping of immature fruits, thereby reducing the yield and export of mangoes (Pezhman and Radjabi, 2002). Hopper feces'honey dew'promotes development of fungi e,g. *Meliola mangiferae* (Earle) under moist conditions, resulting in growth of sooty mould on both sides of leaves, branches, and fruits. Sooty mould growth may interfere in plant photosynthetic activity and ultimately resulting in non-setting of flowers and dropping of immature fruits. Heavy infestation of mango trees may result in 50% or more yield reduction (Godase*et al*., 2004). Globally, various new concepts for pest management are getting popularized day by day to protect the environment from various hazards (Munj*et al*., 2020; Rahman*et al*., 2019; Patel and Kumar 2020) but farmers mostly rely on chemical control for hopper management when its population approaches or exceeds the economic threshold (Adnan*et al*., 2014). However, farmers still need a strategy of chemical rotation to avoid the insecticide resistance, inadequate control and residues on fruits. In this research, we developed a strategy of pest management involving judicious use of chemicals at various timings in a modulated form which will be helpful for mango growers for management of this pest.

Materials and Methods

***Experimental layout*:** This study was conducted in experimental area of Mango Research Institute, Multan, Pakistan. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four modules (including control) each replicated thrice during two consecutive years i.e. 2019-20 and 2020-21 to evaluate the efficacy of these modules applied at different times against mango hopper. About 25-30 years old trees of Cv. Sufaid Chaunsa were included in this experiment.

Population dynamics studies of mango hopper during flowering season of 2019-2021

Hopper population (nymph and adult) was visually counted from single panicle / inflorescence from each direction of selected trees during flowering and fruit setting season at standing height of the plant on weekly basis. Field observations were taken during 07.00-09.00 a.m. Visual observations were made from 3 plants per replicate and 9 plants per treatment. The inflorescence length of each observatory branch was 10 inches. The branches selected were not touching the ground and were approximately 5-6 feet above the ground. The experiment consisted of 4 treatments and total 36 plants. The observation started at initiation of flowering in the month of March and continued until the first week of May each year. The population data was not transformed.

***Insecticidal modules*:** The experiment consisted of three modules viz., Module I (M1), module II (M2) and module III (M3) (Table 1). The calculated amount of insecticide for each replicated plot (determined on the basis of active ingredient) was diluted with water and sprayed with the help of tractor mounted Jacto Canon sprayer (model 400 CH8, USA). The thorough coverage of the trees was ensured @12L (spray-able liquid) per tree was applied by taking necessary care to avoid drift. However, knapsack sprayer (INGCO HSPP4161, China) was used to spray only the tree trunks in the month of December in module II and III. In module I, II and III the insecticide Thiamethoxam was sprayed in the month of August just after fruit harvest. In module II and III the insecticide clothianidin (Trunk 20 SC) was sprayed during mid-December only on tree trunks using Knap sack sprayer. In module III the spray of insecticide Thiamethoxam and Spinetoram was done after crop harvest and in mid-February through Jacto Canon sprayer (model 400 CH8, USA) while insecticide clothianidin (Trunk 20 SC) was sprayed on tree trunks in the month of December. Hopper population (nymph and adult) was visually counted from 10-inch long single panicle / inflorescence from each cardinal direction of selected trees during flowering and fruit setting season at standing height of the plant on weekly basis. Field observations were taken during 07.00-09.00 a.m.

Table 1: Different insecticidal modules for the management of mango hopper

Modules	Name of insecticide	Time of application
Module-I	Thiomethaxam (Actara 25WG) @10g / 100L water	Spray after harvest
Module-II	Thiomethaxam (Actara 25WG) @10g / 100L water	Spray after harvest
	Clothianidin (Trunk 20SC) @75ml/ 100L water	Spray only on trunks in December
Module-III	Thiomethaxam (Actara 25WG) @10g / 100L water	Spray after harvest
	Clothianidin (Trunk 20SC) @75ml/ 100L water	Spray only on trunks in December
	Spinetoram (Delegate 25WG) @10g/100L water	Spray before flowering
Module-IV	Control	No spray

It is worth mentioning here that the selection of the insecticides for each module was made on the basis of personal communication with the mango growers and field observations recorded as preliminary studies.

Effect of weather factors on the population abundance of the mango hopper

Weather data was taken from weather station at Central Cotton Research Institute, Multan Pakistan during 2019-2021 field seasons. Mean maximum temperature, mean minimum temperature, average, wind speed, relative humidity rainfall (mm) was calculated for the specific week. Correlation and regression analysis was done with the average population of mango hopper in each week in control plants with the average maximum temperature, average minimum temperature, average wind speed, average rainfall. The coefficient of correlation and regression was determined.

Data analysis

The data was analyzed through ANOVA analysis in R. Data were analyzed using R version 3.5.3 (Team, 2019). Data were checked for normality through residual plotting. For estimation of average leaf blotch miner number per week during both years 2019-2021. Bar graphs were developed using ggplot 2 package in R. The correlation and linear regression analysis were conducted using package 'cor' and 'lm' in R and the graphs were plotted using the scatter plot package in GGplot 2. Multiple comparisons were evaluated using the package "agricolae" in R 3.5.3. Tukey honest significant difference was used to compare the individual means. Letters were used to rank the groups. The results were considered significant if the P values were less than 0.05. The Tukey Test at 5% level of significance was used to establish statistical ranks. Graphs were plotted using ggplot2 software (Wickham, 2016).

Results

***Population of mango hopper during 2019-2020*:**

The mango hopper population was recorded from inflorescence of each cardinal direction during 2019-2020. In the first week of observation, the average population of mango hopper was 6.03 which touched its peak in 3rd week of March and second peak was observed in 2nd week of April. The population declined in the month of April and further declined in the month of May, 2020 (Fig 1). In the year 2021, the population of mango hopper showed the same trend. Higher population was observed in third week of March and declined later on. Minimum population was observed in the first of May, 2021 (Fig 2).

Effectiveness of different insecticidal modules on mango hopper population during 2019-2020

In module 1, where only the Thiamethoxam (Actara 25 WG) was sprayed after the fruits harvest, the average per week population was 5.40 (Fig 3A) and the average percent mortality compared to the control during all observation period was 30.42 percent ($P<0.01$; $F=193.71$; $DF=3$) (Fig 3A). Average per week population in module 1 was lower than control. Tukey honestly significant difference was significant ($p < 0.01$) (Fig 3A). The population of mango hopper was observed from 04.03.2020 to 06.05.2020 (Fig 1). In the first week of march the population was lower and it reached at its peak in 4th week of March, 2020. The population again declined in the late April and reached to minimum in the month of to May (Fig 1). The mango hopper population was higher during mango flowering and fruit setting period where its population buildup may cause severe yield loss.

In module-2, the hopper population was lower than module 1 (Fig 3A). Overall the population was highest in the 4th week of April and then decreased until the first week of May (Fig 1). The average percent population reduction or mortality in module II was 49.46 percent (Fig 4A) ($P<0.01$; $F=193.71$; $DF=3$).

In module III, where the thiamethoxam (Actara 25 WG) was sprayed after the fruit harvest, Clothianidin (Trunk 20 SC) was sprayed during the month of December and the Spinetoram (Delegata 25 WG) was sprayed at flowering the population of mango hopper was lowest about 1.42/week (Fig 3A). The population of mango hopper was lowest in the module 3 (Fig 3 A) and highest in control ($p < 0.01$; Table 1). The percent population reduction was 81.52 (Fig 4A) ($P<0.01$; $F=193.71$; $DF=3$).

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

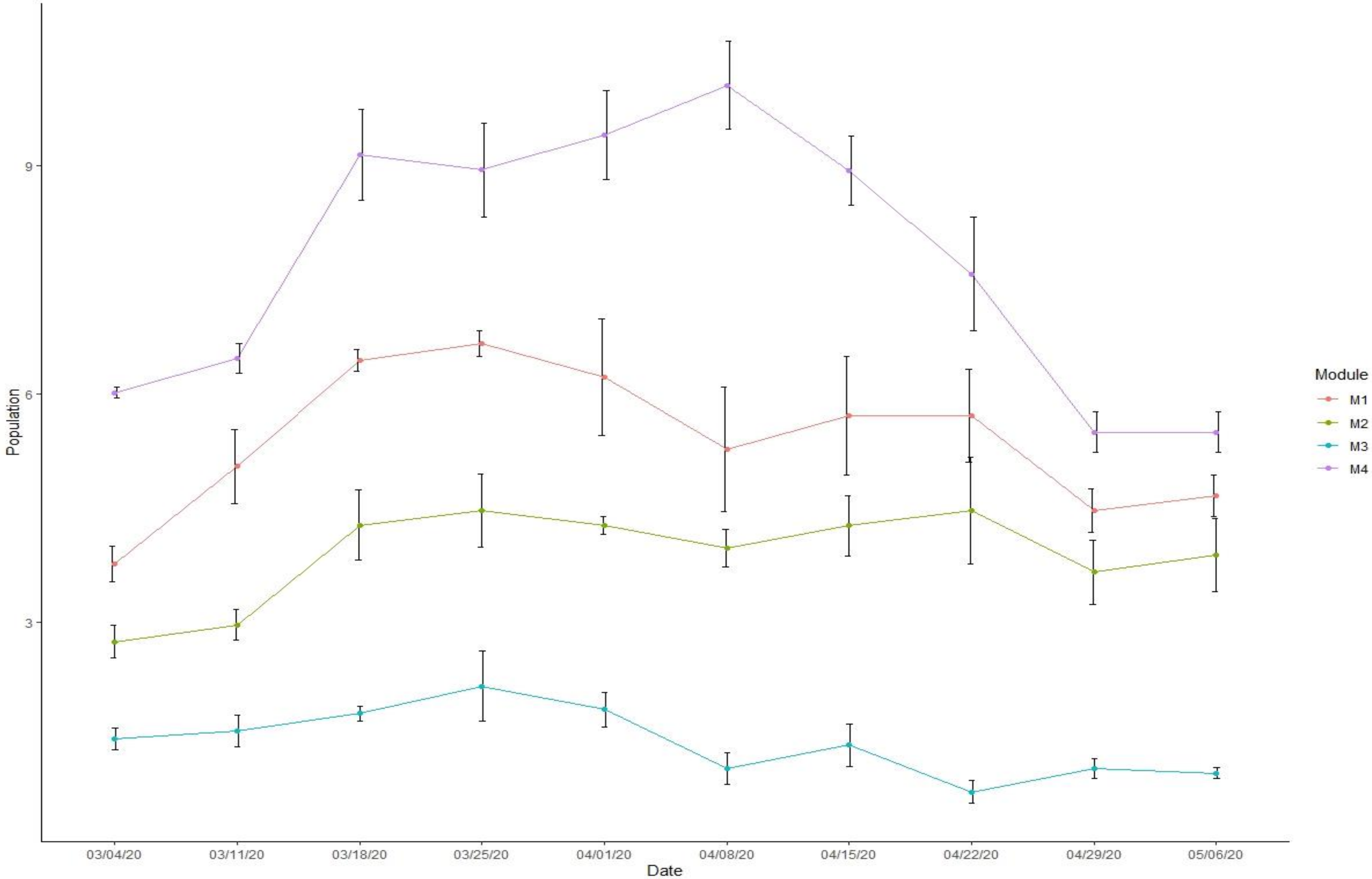

Figure 1. Population dynamics of mango hopper during 2019 to 2020. Here error bars represent standard error around mean.

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.*, **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

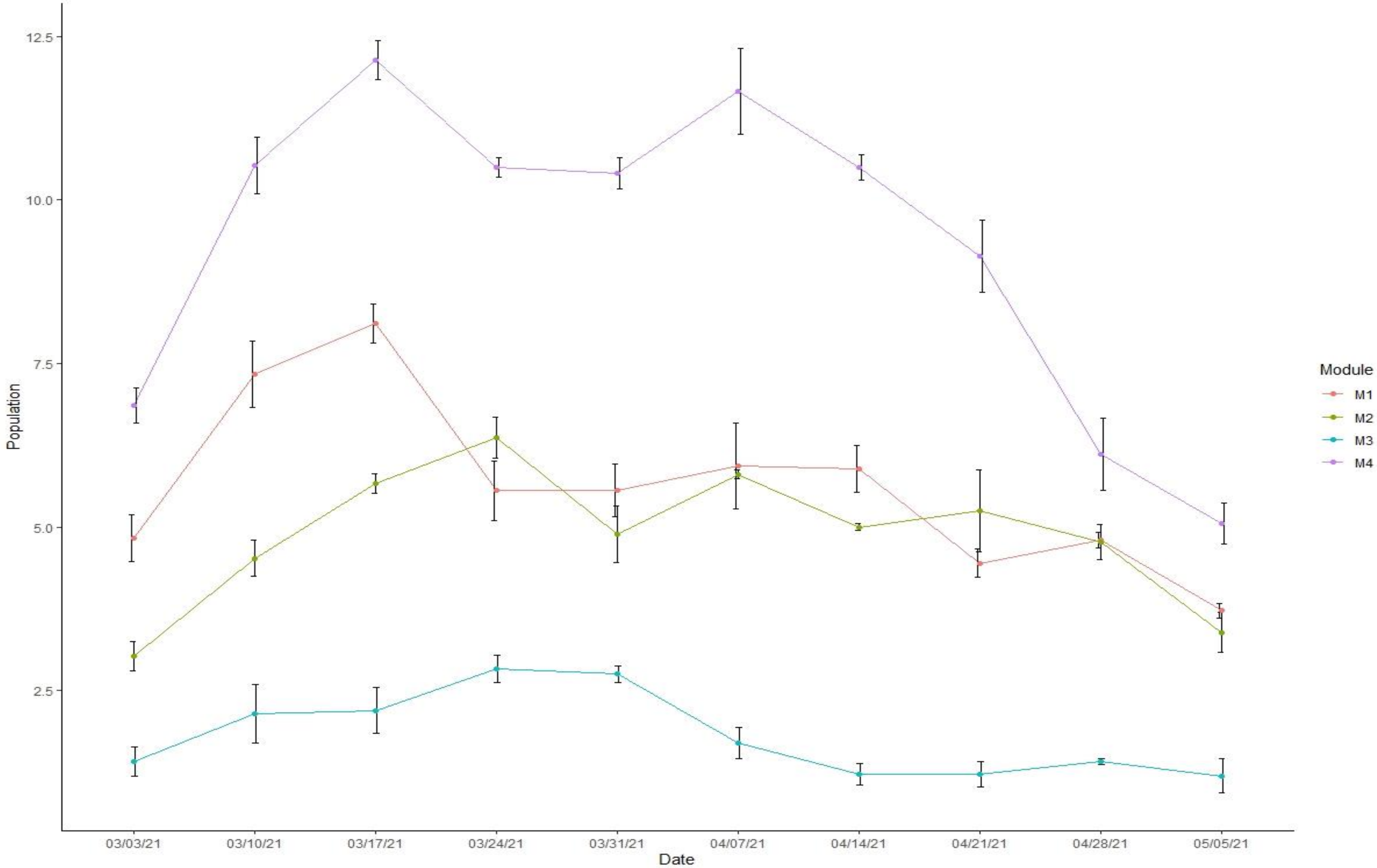

Figure 2. Population dynamics of mango hopper during 2020 to 2021. Here error bars represent standard error around mean.

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.*, **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

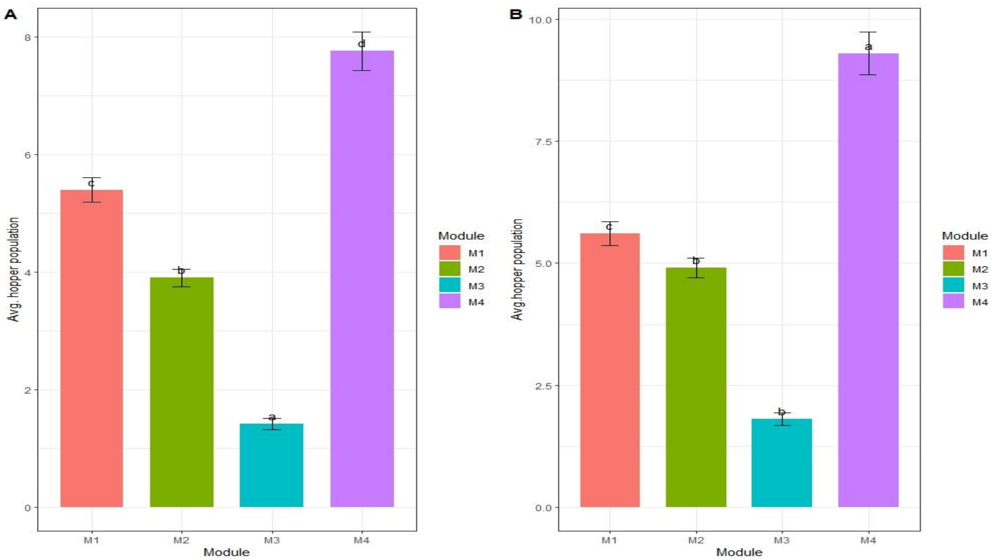

Figure 3. Percent mortality of mango hopper in different modules during 2019-2021, A) Average per week population of mango hopper in different insecticide modules during 2019-2020 ($p<0.01$, DF=3, F=121.5 B). Average per week population of mango hopper in different insecticide modules during 2020-2021.

Effectiveness of different insecticidal modules on mango hopper population during 2020-2021

During 2020-2021, the population of mango hopper showed same trend being highest in 4th week of April and then reduced. In module 1, the population of mango hopper was 5.62, lower than the control ($p < 0.01$; Fig 3B). Percent reduction in hopper population was 39.55 in module 1, and was significantly lower than the percent mortality in module II (47.08%) (Fig 4 B). Significantly higher population reduction or percent mortality was observed in module III (80.70%) ($p < 0.01$;F=103.48; DF=3) (Fig 4B). Population was minimum in module III where one spray of thiamethoxam, one spray of clothianidin (Trunk 20SC) and one spray of spietoram (Delegate 25 WG) was done (Fig 3B).

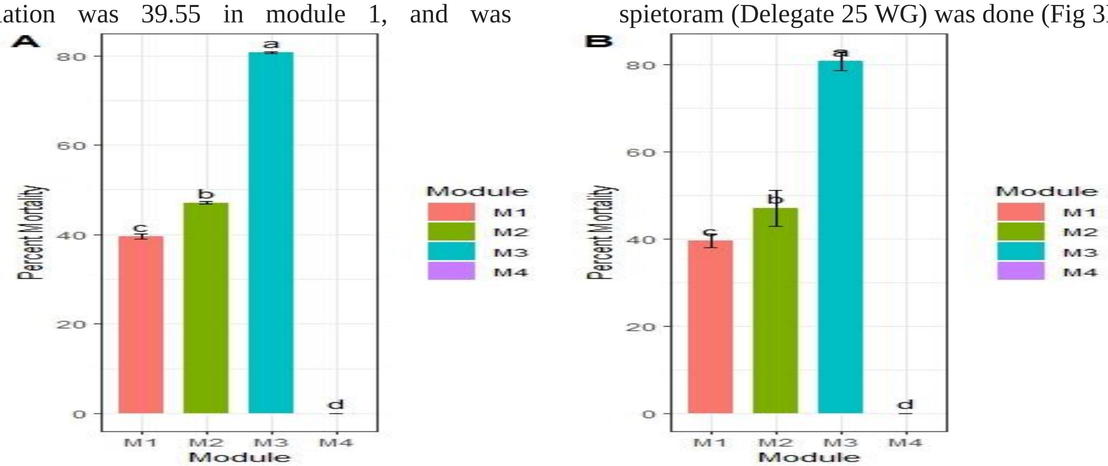

Figure 4. Percent mortality of mango hopper in different modules during 2019-2021, Tukey Honestly significant difference test at 5% indicated a significant difference in percent mortality during both years. A) Comparative efficacy of different modules during year 2021 ($P<0.01$; F=193.71; DF=3). B) Comparative efficacy of different modules during year 2020($p < 0.01$; F=103.48; DF=3).

***Impact of weather factors on the population dynamics of mango hopper*: **Effect of weather factors on the population dynamics of mango hopper was calculated during both years 2019-2021 (Fig 5). Overall, it was found that there was a negative correlation between maximum temperature and hopper abundance (Fig 5A). The value of correlation coefficient was -0.376 (Fig 2A). The value of correlation coefficient was -0.26 with minimum temperature (Fig 5B). The correlation of relative humidity with hopper abundance was positive with a value of correlation co-efficient 0.138(Fig 5C). The correlation of wind speed with the hopper population was positive (Fig 5D). The value of correlation coefficient was 0.10399 (Fig 5D). The correlation of rainfall with the weather factors was poor and negative (Fig 5E). The value of correlation coefficient was -0.065 (Fig 5E).

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

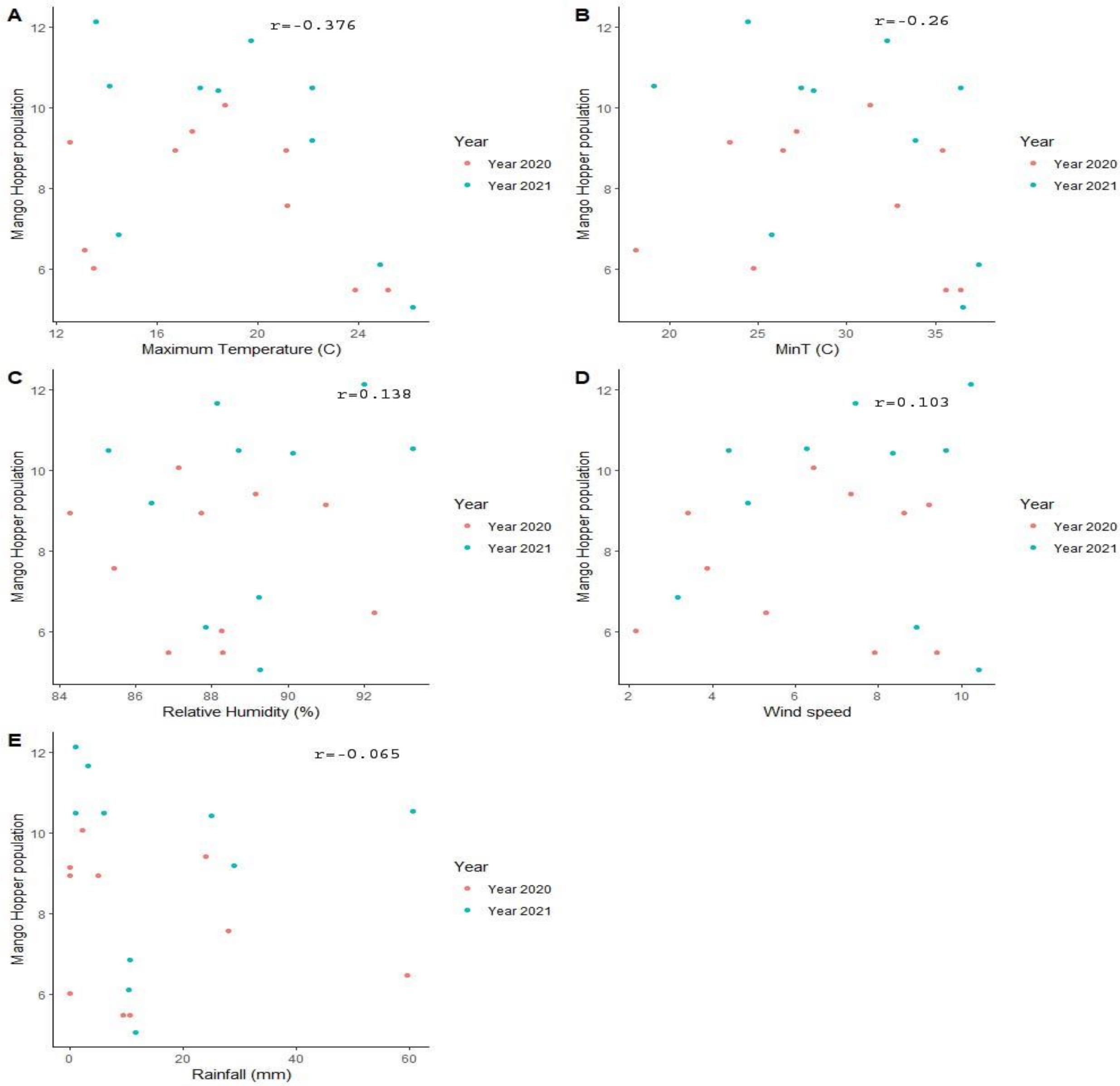

Figure 5. Effect of weather factors on the population dynamics of mango hopper, A) Negative correlation was observed between maximum temperature and hopper abundance, correlation coefficient value (r) was -0.376. B) Correlation between minimum temperature and hopper population. The value of correlation coefficient 'r' was -0.26 with minimum temperature. C) The correlation of relative humidity with hopper abundance was positive with a value of correlation co-efficient 0.138. D) The correlation of wind speed with the hopper population was positive. The value of correlation coefficient was 0.10399. E) The correlation of rainfall with the weather factors was poor and negative. The value of 'r' was -0.065.

The regression of mango hopper population with weather factors was variable (Fig 6). The regression of mango hopper population with the minimum temperature was negative (Fig 6A). The regression coefficient value R^2 was -0.01984 and highly significant ($P < 0.01$) (Fig 6A). The regression equation was Y= 11.46 - 0.0986 (minimum temperature) ($P < 0.01$). The role of minimum temperature was 1.984 (Fig 6A). The regression of mango hopper population with the maximum temperature was negative (Fig 6B). The regression equation was Y=12.1045 -0.189 (Maximum temperature (C^o)). The regression coefficient R^2 was 0.09378. The role of maximum temperature 100 R^2 was 9.378 percent and highly significant ($P < 0.01$) (Fig 36B). The regression of mango hopper population with relative humidity was positive and non-significant (Fig 6C). The regression equation was Y= -2.8634 + 0.1287 (Relative humidity (%)). The value of regression co-efficient was -0.035 ($P > 0.05$) (Fig 6C). The role of relative humidity (100 R^2) was 3.5% in population growth. The regression

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

of the mean mango hopper population with the wind speed was positive and highly significant (P < 0.01) (Fig 6D). The regression equation Y = 7.91 + 0.0899 (Wind). The value of regression coefficient was -0.044 (Fig 6D). 100 R^2 was 4.4. About 4% dispersal in mango hopper population take place through wind. The regression of mean hopper population with the rainfall was significantly negative (Fig 6E). The value of regression equation was Y = 8.64 – 0.007936 (Rainfall). The value of the regression coefficient was –0.05109 (p <0.001) (Fig 3E). The role of rainfall was 5.109 %. (Fig 6E).

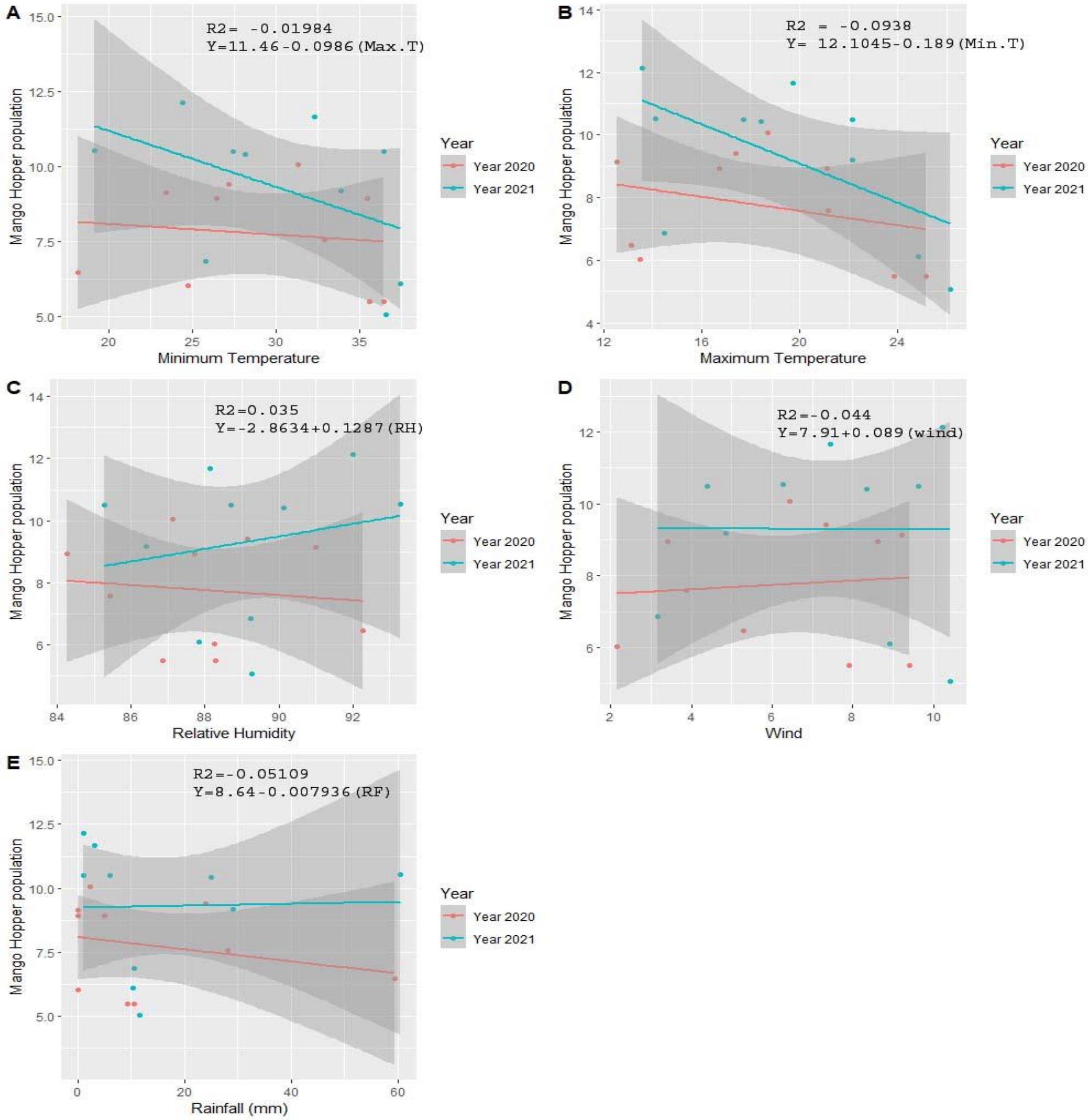

Figure 6. The regression of mango hopper population with weather factors was variable. A) The regression of mango hopper population with the minimum temperature was negative. The regression coefficient value was -0.0986 and highly significant (P < 0.01). B) The regression of mango hopper population with the maximum temperature was negative. The regression coefficient value was -0.189 and highly significant (P < 0.01).C) The regression of mango hopper population with relative humidity was positive and non-significant. The value of regression co-efficient was 0.1287 (P > 0.05). D) The regression of the mean mango hopper population with the wind speed was positive and highly significant (P < 0.01). The value of regression coefficient was 0.0891. E) The

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

regression of mean hopper population with the rainfall was significantly negative. The value of the regression coefficient was -0.007936 (p <0.001).

DISCUSSION

In this experiment, we found that for management of mango hopper three sprays one after fruit harvest, second in the month of December when the insects are less active and hibernates in cracks and crevices and third spray in the month of April can provide enough pest control (Fig 3 A & B). The mango hopper population was highest in the month of March-April during peak inflorescence and fruit setting period (Fig 1). The correlation of mean hopper population with the minimum temperature, maximum temperature, and rainfall was negative while the correlation of mango hopper was positive with relative humidity and wind (Fig 5). The regression of mango hopper population with weather factors was variable phenomenon (Fig 6). The regression of mango hopper population with the minimum temperature, maximum temperature, and rainfall was negative, while the regression of mango hopper population with relative humidity and wind speed was positive (Fig 6). On the basis of this information we conclude that mango hopper is dispersed along with high winds to the nearby trees.

Godase *et al*. (2004) determined that 42 % increase in yield is expected by two sprays of insecticide monocrotophos one at panicle emergence and 2nd spray subsequently after 15 days were effective in controlling the hopper population. Adnan*et al*. (2014) found that spray of insecticide imidacloprid, endosulfan and cypermethrin provided effective pest control about 90 percent reduction in pest population while neem based bio-pesticides provided 60 percent population reduction. Verghese and Rao (1987) determined that three stages are critical for the management of the hopper which include post bloom, marble stage and pre-harvest are required for the management of mango hopper. We also suggest that three sprays one after harvest, second spray when the pest is hibernating in cracks and crevices during the month of December and third spray at the bloom stage are required for the hopper population suppression. Tandon*et al.* (1983) described the effect of weather factors in regulating the population abundance of mango hopper. It was found that mango hopper population was higher in March to April in India (Ramachandra, 1930) we also found the maximum population during the March-April months. Moreover, we conclude that the relative humidity and wind speed had positive effect on mango hopper population increase.

Munj *et al*. (2018) determined the efficacy of various insecticides in managing mango hopper, it was found that mango hopper population can be effectively controlled (upto 99% mortality) with the spray of thiamethoxam and spreader insecticides. We also document that three sprays of thiamthoxam, clothianidin and spinetoram subsequently at the early harvest, in trees dormancy stage and at the bloom stage are required for the effective suppression of mango hopper population. However, our results are in contradiction with Patel*et al.* (2003) described that two sprays of thiamthoxam can prevent the population build-up of mango hopper. We instead suggest three sprays of insecticides are required for the suppression of mango hopper. Kumar*et al.*, (2005), Samanta*et al.* (2009); Kumari*et al.*(2014); Ray*et al.*(2014) and various others reported that thiamethoxam can control mango hopper population. However, our results of increase in hopper population during the month of April is in contradiction with Namni*et al.* (2017) who reported that mango hopper population reached at peak in the month of May in Bangladesh while the minimum population was observed in the month of December. In present studies we report significant negative correlation with increase in temperature, and rainfall, while the positive correlation was observed with relative humidity and wind speed. However, our results were in agreement with Namni*et al.* (2017) who reported positive correlation with relative humidity, significant negative correlation with rainfall.

Chaudhari *et al.* (2017) reported that imidacloprid, provided 93% mortality in mango hopper population in laboratory and field conditions in mango orchards of Tamil Nadu, India. Similarly, the entamophagous fungi have also been reported to control mango hopper population 66-79%. However, insecticides are still the best way to reduce the pest numbers. Keeping in view the importance of mango hopper three sprays is suggested for hopper management.

Conclusions

For mango hopper management, we recommend three sprays of insecticides 1. After fruit harvest. 2) During the month of December when the population is hibernating in trunks cracks and crevices. 3) During flowering or bloom period. The timing of pesticide application is very important to get rid of pest population and avoid unnecessary expenditure. It is concluded from the present studies that Module-III in which three sprays (1st spray of Thiamethoxam (Actara25WG)@10gm/100L of water after fruit harvest, 2nd spray of Clothianidin (Trunk 20SC)@75ml/100L of water only on trunks during the month of December and 3rd spray of Spinetoram (Delegate 25WG)@10gm/100L of water before flowering) has been proved to be most effective in managing the population of mango hopper population in south Punjab Pakistan.

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

***Conflict of interest*:** The authors declare that there is no conflict of interest among them.
***Authors' Contribution Statements*:** AG supervised the project; AHK, HK, MI, NM, and AI executed the field research experiment; AH & JI analyzed the data, wrote the manuscript, HK technically checked the manuscript for the corrections.
***Acknowledgement*:**
The authors are highly thankful to Dr. Hameed Ullah Ex-Director, Mango Research Institute, Multan Pakistan, and Muhammad Tariq Malik Senior Scientist, Mango Research Institute, Multan Pakistan for the positive inputs, arrangement of provision of funds for the research work. Special thanks to Ghulam Mustafa Senior Scientist, Mango Research Institute, Multan and Maqbool Ahmad Scientific officer, Mango Research Institute, Multan for the provision of the vehicles and chemicals. The research studies received grant from the regular research funds for the research and development section of the ministry of agriculture, Government of Punjab, Pakistan.

References

Adnan, S., Uddin, M., Alam, M., Islam, M., Kashem, M., Rafii, M., & Latif, M. (2014). Management of mango hopper, Idioscopus clypealis, using chemical insecticides and neem oil. *The scientific world journal* **4,** 400-414.

Anonymous. 2014. Agricultural statistics of Pakistan. Government of Pakistan Islamabad, Pakistan. Available online at https://www.pbs.gov.pk/content/agriculture-statistics.

Anonymous. 2022. Mango District wise historical data. Directorate of Agriculture, Crop Reporting Service, Government of Punjab, Pakistan. pp. 1-3.

Chaudhari, A., Sridharan, S., & Sundar Singh, S. (2017). Management of mango hopper with newer molecules and biopesticides under ultra high density planting system. *Journal of Entomology and Zoology studies* **5**, 454-458.

Godase, S., Bhole, S., Shivpuje, P., & Patil, B. (2004). Assessment of yield loss in mango (Mangifera indica) due to mango hopper (Idioscopus niveosparsus)(Homoptera: Cicadelidae). *Indian Journal of Agricultural Sciences* **74**, 370-372.

Kole, C. 2021. The Mango Genome. Springer., New York. Available at: *https://link.springer.com/book/10.1007/978-3-030-47829-2*

Kumari, D. A., Anitha, V., Girwani, A., & Reddy, C. N. (2014). Efficacy of various insecticidal modules against hoppers in mango. *International Journal of Plant Protection* **7**, 99-103.

Lebaka, V. R., Wee, Y.-J., Ye, W., & Korivi, M. (2021). Nutritional composition and bioactive compounds in three different parts of mango fruit. *International Journal of Environmental Research and Public Health* **18**, 741.

Lizada, C. 1993. Biochemistry of fruit ripening. In: Mango: Springer, USA. pp. 255-271.

Munj, A., Reddy, P., Gundappa, J., & Irulandi, S. (2020). Management of mango hopper using entomopathogens.

Munj, A., Sawant, B., Raut, R., Dheware, R., & Salvi, B. (2018). Evaluation of insecticides for management of mango hopper, Idiscopus niveosparsus Leth. *Journal of Entomology and Zoology studies* **6**, 950-952.

Namni, S., Amin, M., Miah, M., Rahman, M., & Suh, S. (2017). Role of weather parameters on seasonal abundance of insects in a mangobased agroforestry in Bangladesh, with particular reference to mango hopper. *Bangladesh Journal of Agricultural Research* **42**, 197-205.

Naseer, M. A. u. R., Ashfaq, M., Hassan, S., Adil, S. A., & Ariyawardana, A. (2019). Outlook on the global trade competitiveness of Pakistan's mandarin industry: An application of revealed symmetric comparative advantage framework. *Outlook on Agriculture* **48**, 66-74.

Patel, K., & Kumar, S. (2020). Screening of mango cultivars against important insect-pests of mango.

Pezhman, H., & Radjabi, G. (2002). Study on biology of mango hopper" Idioscopus clypealis Letheirry"(Hom: Cicadellidae) in Hormozgan Province. *Applied Entomology and Phytopathology* **70**.

Rahman, M., Jahan, M., Islam, K., & Ahmmed, S. (2018). Biorational Management Of Mango Hopper Idioscopus Clypealis (Leth.) Using A Microbial Pesticide (*Beauveria Bassiana*) and Some Botanicals. *Int. J. Sustain. Agril. Tech* **14**, 01-06.

Rahman, M. S., Rahman, M. A., Mia, M. M., & Jahan, M. (2019). Comparative study on microbial and botanical pesticides as biorational control of mango hopper. *Asian Journal of Medical and Biological Research* **5**, 330-335.

Rahman, S., Gajendra, S., & Singh, V. (2007). Effect of plant density on the population of mango hopper. *Progressive Research* **2**.

Rahman, S. M. A. (2007). Mango hopper: Bioecology and management–A review. *Agricultural Reviews* **28**, 49-55.

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152*. doi: https://doi.org/10.54112/bcsrj.v2022i1.152]

Rajan, S., Srivastav, M., & Rymbai, H. (2021). Genetic Resources in Mango. In *The Mango Genome* (pp. 45-73). Springer.

Ramachandra, R. (1930). The Mango Hopper Problem in South India. *Agric. J. India* **25.**

Ray, S., Saha, T., & Nithya, C. (2014). Field efficacy of pest management modules against mango hopper, Amritodus atkinsoni (Leth.) on Langra mango in Zone III of Bihar. *Annals of Plant Protection Sciences* **22**, 10-13.

Sagar, V., Khurdiya, D., & Balakrishnan, K. (1999). Quality of dehydrated ripe mango slices as affected by packaging material and mode of packaging. *Journal of food science and technology (Mysore)* **36**, 67-70.

Samanta, A., Gosh, A., Hembram, T., Patra, S., & Somchowdhury, A. (2009). Efficacy of insecticides against mango hoppers and fruit yield. *Annals of Plant Protection Sciences* **17**, 243-244.

Singh, L. (1960). The Mango. Botany, cultivation, and utilization. *The Mango. Botany, cultivation, and utilization.*

Srivastava, R., & Tandon, P. (1986). Natural occurrence of two entomogenous fungi pathogenic to mango hopper, Idioscopus clypealis Leth. *Indian Journal of plant pathology* **4**, 121-123.

Srivastava, R. P. (1997). *Mango insect pest management*. International book distributing Co.

Sushil, K., Raghvani, B., & Bhatt, R. (2005). Bioefficacy of newer insecticides against hopper complex on'Alphonso'mango in humid tropics of South Gujarat. *Journal of Applied Zoological Researches* **16**, 64-66.

Talpur, M. A., & Khuhro, R. D. (2003). Relative population of mango hopper species on different mango varieties. *Journal of Asia-Pacific Entomology* **6**, 183-186.

Tandon, P., Lal, B., & Rao, G. (1983). Prediction of the mango hopper, Idioscopus clypealis Leth. population in relation to physical environmental factors. *Entomon* **8**, 257-261.

Team, R., 2019. RStudio: Integrated Development Environment for R. Boston, MA: RStudio, Inc; 2016. Available at https://www.rstudio.com/products/rstudio/download/

Tharanathan, R., Yashoda, H., & Prabha, T. (2006). Mango (Mangifera indica L.),"The king of fruits"—An overview. *Food Reviews International* **22**, 95-123.

Usman, M., Fatima, B., Khan, M. M., & Chaudhry, M. I. (2003). Mango in Pakistan: A chronological review. *Pakistan Journal of Agricultural Sciences* **40**, 151-154.

Verghese, A., & Rao, G. (1987). Determination of Relevant Critical Stages for the Management of the Mango Hopper, Jdioscopus Clypealis Lethierry. *Indian journal of Horticulture* **44**, 280-283.

Wickham, H. (2016). Data analysis. In *ggplot2* (pp. 189-201). Springer.

Yadav, D., & Singh, S. (2017). Mango: History origin and distribution. *Journal of Pharmacognosy and Phytochemistry* **6**, 1257-1262.

[Citation: Ghaffar, A., Khan, A.H., Hameed, A., Iqbal, J., Maqbool, A., Raza, S., Imran, M., Muhammad, N., Shah, S.A.H., Raza, M.A. (2022). Establishment of strategy for mango hopper *Idioscopus clypealis* (Lethierry) management and impact of weather factors on its population in South Punjab Pakistan. *Biol. Clin. Sci. Res. J.,* **2022***: 152.* doi: https://doi.org/10.54112/bcsrj.v2022i1.152]