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INCIDENCE OF MANGO MEALY BUG, *DROSCHIA MANGIFERAE* (COCCIDAE: HEMIPTERA) IN THE AGRO-CLIMATIC CONDITIONS OF THE UPPER GANGETIC PLAIN OF WEST BENGAL, INDIA

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ABSTRACT
Incidence of mango mealy bug, *Droschia mangiferae* population in mango orchard (*mangifera indica*) was assessed by both twig tagging and visual counting during four consecutive summer months of 2011-2014 at Kaligram, Malda, West Bengal, India. Grossly *D. mangiferae* population was initiated at about 07 standard meteorological weeks (SMW), improved at first slowly up to 11 SMW then steadily up to 13 SMW attaining the maximum at about 15 SMW which was maintained up to about 17 SMW. Then the population declined abruptly and by 20 SMW conspicuously disappeared. Abiotic conditions such as minimum temperature, temperature gradient, maximum relative humidity and average relative humidity had significant positive influence on *D. mangiferae* population. In case of minimum relative humidity and sunshine hours a negative influence was observed. In addition, other factors such as relative humidity gradient, average relative humidity and rainfall imparted insignificant positive effect on population development. Based on the nature of incidence and abundance of *Droschia mangiferae* , a package can be generated and accordingly time fitted mango orchard prophylactic measure as the precautionary measure may be taken.

KEY WORDS: *D. mangiferae*, climatic factors, mango orchard, seasonality.

INTRODUCTION
Mango (*Mangifera indica* L.) is a member of the family Anacardiaceae. It is regarded and appreciated for its strong aroma, delicious taste, and high nutritive value (Singh, 1968; Litz, 1997). This tropical fruit mango is being grown in more than 100 countries (Sauco, 1997). Apart from that, it is also valuable ornamental and shade tree with medicinal virtues (D Almeida, 1995). Annually, about 12.5 million tonnes of mangoes from an area of 2021 thousand hectares of mango orchard is harvested in India (Sekhar *et al.,* 2013). West Bengal is the one of the largest state in consideration of the production of mango in India(http://nhb.gov.in/report_files/mango/MANGO.htm.). West Bengal has grossly 65,400 hectares of mango orchard which shares about 44% of the total area employed for food crop cultivation of the state (http://www.nhb.gov.in/report_files/mango/MANGO.htm. The Gangetic plain of West Bengal offers a congenial environment for mango production (Singh *et al.*, 2012). Out of the all administrative district of West Bengal, Malda tops the list with an annual net production of about 196 metric tons (Evaluation wing. Directorate of Agriculture GoWB, Bureau of Applied Economics and Statistics, Livestock population handbook, 2009-2010). Insect pests have been regarded as an important constrain to garden fruits throughout the centuries (Hill, 2008). A number of insect pest are known to attack the mango trees, which have economic importance (Giani, 1968; Herren, 1981, Tandon *et al*., 1985). Occurrence of pest outbreaks has increased with the change of pest complexities in the last few decades. Some insects have gained momentum, whereas others have declined in importance (Crawley, 1983). There are convincing documents that 'minor pest species' have been favoured by selective crop intensification (Berge *et al.,* 2012). Insect pests are the major threat to underscore the mango production accounting for huge seasonal loss (Ishaq *et al.*, 2004**).** Grossly 400 insects and non insect pests have been recorded from Indian subcontinents that have pest property. However, out of that thirty are obnoxious and serious pests to mango orchard (Kapadia, 2003). Application of newer brands of insecticides though in practice in large scale but very often is less prudent to check the pest hazards (Ishaq *et al.,* 2004). Several insects attack mango from nursery stage to fruit maturity.

Among all of the mango insect pests, mealy bug, *Droschia mangiferae* (G.) is one of the notorious and destructive pests rendering huge scale of fruit loss (Karar *et al.*, 2006). In consideration to tree/fruit injury, it ranked 2nd after leaf hopper. Extent of loss may extend up to 50% in some occasional cases (Atwal, 1976). Severe infestation affects the growing fruits resulting in fruit drop. Both the quality and the quantity of the food are greatly affected due to this infestation (Herren, 1981). Mango mealy bug became a serious pest of mango and citrus in West Africa which reduced mango fruit 50-90% and pest caused serious nuisance (Moore, 2004). *D. mangiferae*, *is* considered to be prime destructive mealy bugs species of mangoes in subcontinent of South East Asia. *D. mangiferae* is the serious, dilapidating, polyphagus, dimorphic and notorious pest of mango orchards in Indian sub-continent**.** Rao *et al*. (2006) had pointed out that mealy bugs posed a serious threat for cultivation of many fruit crops including Mango. A total of nine mealy bug species have been reported on citrus including *D. mangiferae* from Nagpur region of Maharashtra, India. Butani, (1974) and Sen *et al.,* (1956) had mentioned that *D. mangiferae* was widely distributed in indogangetic plains from Punjab to Assam and found to attack about 62 host plants including jackfruit *Artocarpus heterophyllus* Lam., banyan *Ficus bengalensis*, guava *Psidium guajava* L., Papaya *Carica papaya* L., Citrus *Citrus* spp. and *Jamun Syzigium* spp. Sathe (1998) from Kolhapur region of India had noted that *D. mangiferae* perpetuates on mulberry *Morus alba*, *D. guajava*, *C. papaya*, *Syzigium* sp., *Citrus* sp. and *Tamarandus indica* Lim., cotton, okra, *Hibiscus* and brinjal. Bhagat (2004) had mentioned that though this insect is mainly a pest of mango tree, however, in the areas of heavy populations, it has the tendency to attack a variety of other fruit trees like peach (*Prunus persica*), plum (*P. domestica*), papaya (*Carica papaya*) and all citrus species. Karar (2010) had opined that mealy bug preferred mango varieties differentially. Survey carried out in Punjab proviencves, India revealed that *Chaunsa* cultivar was the most susceptible to mango mealy bug followed by '*Fajri*', '*Langra*' and '*Black Chaunsa*, whereas '*Dusehri*' was resistant. Damage to plants is principally manifested due to the unremitting sucking of 'cell sap' from tender leaves, stem, inflorescence and even from the growing fruits.The nymphs and females of this bug suck sap from inflorescence, tender leaves, shoots and fruit peduncles. Affected panicles shrive and become died. Infested plants are affected by the sooty mould (Tandon *et al.*, 1978). Severe infestation often leads to fruit drops or makes the fruit unfit for marketing (Karar *et al.*, 2013). In general, *D. mangiferae* is found to infest almost all mango cultivars resulting severe fruit necrosis. Due to the growth of sooty mould on the leaves, photosynthetic activity is affected (Pruthi *et al*., 1960). Further the sooty mould of *D. mangiferae* provides an effective medium for rapid growth of black and sooty fungi which decolorizes the fruit and makes it unacceptable to consume (CAB International, 2005). Intensification engrosses the changes in cultural practices such as (i) augmentation of agricultural chemicals (fertilizer and pesticides), (ii) improvement of watering facilities, and (iii) enhancement of higher tree densities (Sen, 1955). Severity of mango pests is influenced both by fruit/tree growth and prevailing environmental conditions. In the context of climate change, we expect both the crop in terms of plant penology and physiology which inturn dictate insect pests occurrence. Study of impact of climate change on mango crop-pest interactions requires carefully collected data on long term basis. The response of insects to the climatic conditions is very imperative to predict possible geographic range of a species and to develop phenological models to forecast pest population dynamics and its periodicity. For pest surveillance programmes the study of insect pest periodicity becomes essential. Detection of the field dynamics of *D. mangiferae* population in relation to crop phenology and climatic conditions is considered as a prime requisite for the execution of the subsequent crop protection package in view of modern IPM practices. The district Malda offers a congenial environment for mango production. But the farmers do follow improper surveillance schedule disregarding the incidence of insect pests' incidence. Therefore understanding the recent trends of seasonal abundance of *D. mangiferae* is the precondition to develop an integrated management system for this pest. Grossly, there are three specific objectives of this study. (i) to define the basic population system of *D. mangifer a*t Kaligram, Malda, West Bengal (ii) to consider the role of weather parameters on the incidence of *D. mangiferae* population and (iii) to apply the generated information relating to *D. mangiferae* population dynamics in integrated pest management decision-making.

MATERIALS & METHODS

Geographic location and agro-climatic conditions (Fig.1): The district Malda [26.50^0 N-89.52^0 E] is situated in the upper gangetic plains. The climate of this zone is sub-tropical humid in nature. The average annual rain fall varies from 1500-1700 mm (approx), the maximum rainfall occurs during the rainy months of June to September amounting to more than 80% of the total rain fall. Whereas February to April when the study was done, it is relatively drier with average annual rainfall ranging from 10-40 mm only. The annual average day night temperature ranges between 19.7and 29.9^{o}C with the mercury soaring even as high as 33^{o}C in April and cascading to a low of 3°C in January. The relative humidity at 8:30 hours is 58% and 81% in March and May respectively. Incidence of *D. mangiferae* was carried out at Kaligram [25.38^0N-88.04^0E] that is located in the Chanchal-I block under the administrative jurisdiction of Malda District, West Bengal.

FIGURE1: Place of study (a) Map of India, (b)Map of West Bengal, (c) Map of Malda (Showing the location of Chanchal-I block)

The pest (Fig.2): Scientific name: *Drosicha mangiferae*, Family: Coccidae, Order: Hemiptera. *D. mangiferae* is prominent the agro-ecological condition of Malda, West Bengal. The insect aggregate on the bark, stem, twig and also on leaf. Assembly of the insect is less on growing fruit. The excretion of *D. mangiferae* is creamy white in colour and indulges the growth of black and sooty fungi which decolorizes the fruit and makes it non-marketable.

FIGURE 2. Incidence of mealy bug in its natural abode (2a) heavily infested mango stem (2b) Moderately infested mango twig (2c) and (2d) infestation free mango orchard (2e) infestation on bark.

The cultivars: Five indegenous mango cultivars namely (i) *fazli* (ii) *langra* (iii) *lakhanbhog* (iv) *guti* and (v) *himsagar* were selected to observe for the incidence of *D. mangiferae*.

The replication: Each cultivar has three replications during each observation. The attack of *D. mangiferae*.was recorded by recording the number of damaged fruits out of 100 shoots randomly from each direction

***Experimental layout*:**

Period of observation: The infestation of *D. mangiferae* was noticed at the pea to marble stage of the fruit when kernels were yet to harden *i.e.* during last week of February to last week of May. The plants under observation were kept free from any insecticide application.

Place of observation: The mango trees of about 10-12 years old are inspected starting from the fruting season. The desired trees of different cultivars are labelled and the incidence of the pest in noted early in the morning. All the parts of the tree (i) bark (ii) leaf (iv) twig (iv) stem and (iv) fruits are periodically inspected. Averages of all the observation are considered. Special attention was given to record mealy bugs on the inflorescence or flower panicle where these pests infest most.

Record on pest incidence:

Twig tagging: Ten trees were selected randomly from each orchard and tagged and assessed for *D. mangiferae* incidence to the twig of the tree. 10 to 20 samples were also taken by 'tapping' flower panicles into plastic bags and collecting all species that were on the flower panicle.

$$\text{Mean number of } D.\,mangiferae \text{ population} = \frac{\text{N1 + N2 + N3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\text{Nn}}{\text{Total number of observation/No of panicle observed}} + \cdots$$

Where, N= number of *D. mangiferae* individuals/observation

***Statistical analysis*:** Weekly noted *D. mangiferae* population were correlated with the prevailing climatic factors such as maximum temperature (Tmax), minimum temperature (Tmin), temperature gradient (Tgr), maximum humidity (RHmax), minimum humidity (RHmin), humidity gradient (RHgr), sunshine hour (Shr) and rainfall (Rfall).Further inter relationship of the climatic factors was also worked out and then tabulated in matrix pattern.

Record on climatological factors: Maximum (Tmax) and minimum temperature (Tmin) was recorded by digital thermometer (RH-temperature, Lutron MHB-382SD/ Kusum-Meco hygro-thermometer KM 918 A) While relative humidity (RHmax and RHmin) was also registered (Lutron HT 3007 SD) Duration of sunshine hour (Shr) and rainfall (Rfall) was estimated by Sunshine Recorders and Rain gauges respectively.

RESULTS & DISCUSSION

Incidence of mango mealy bug , *D. mangiferae* population in mango field (*mangifera indica*) was assessed by both twig tagging and visual counting during four consecutive summer months (from February to May) of 2011-2014 at Kaligram, Malda, West Bengal.The results are delineated below:

Major arthropods of mango orchard: The dominant groups of insects and spiders collected from mango flower panicles: flower thrips (Thysanoptera) 93%, ants (Hymenoptera: Formicidae) 2%, spiders (Araneida) 2%, beetles (Coleoptera) 1%, dimpling bugs (Hemiptera: Miridae) 1% and others 1%; (after fruit set): flower thrips 66%, ants 10%, beetles 9%, caterpillars (Lepidoptera) 4%, dimpling bugs 4%, spiders 3%, wasps (Hymenoptera) 2%, flower bugs (Hemiptera: Anthocoridae) 1% and the remains are 1%.

Population dynamics of *D. mangiferae* (Table1, Fig.3.) Incidence of the pest starts from December, gains gradual momentum and attains the peak incidence during the middle of April when it is numerically more abundant. Dynamics of mealy bug population in relation to SMW was noted by visual counting and twig tagging. During winter season, initially, at 07 SMW the population was very low. It then increased gradually from about 11 SMW. At that time the mango crop was nearly remained free from *D. mangiferae* infestation. High number of adult population was noted till 14 SMW which was maintained nearly up to 16 SMW. Till to 20 SMW extent of infestation was negligible. The appearance of first peak of adult *D. mangiferae* population was noted at about 15 SMW. Considerable number of shooty mold due to *D. mangiferae* infestation was noted only after 10 SMW. The extent of infestation was moderate at about 12 SMW (10.6±0.81%).

Correlation study (Table 2 and 3): In all the years except in 2013, *D. mangiferae* population showed an insignificant positive relation with the Tmax. While Tmin had imparted a significant positive effect on the incidence of *D. mangiferae* in all the years except in 2013. Except in 2013, the incidence of *D. mangiferae* population showed significantly positive relation with Tgr. An insignificantly positive relation was also found with the Tavg in 2012, 2013 and 2014, but in 2011 relations were significantly positive. Persistent RHmax (71-81%) exerted a significantly positive impact on the abundance of *D. mangiferae* population in all the years. Significant positive relations existed between the RHgr and the field *D. mangiferae* population in all the years except in 2011 where the relation was insignificantly positive. Incidence was positively influenced by RHavg almost in all the years. But the values of relation differed among the years, particularly in 2012 and 2014. Bright sunshine hour for an average of 8.23 hrs/day had a significant negative effect on the *D. mangiferae* population with the exception of 2011 where the relation though negative, was non-significant. Drizzling Rainfall had an insignificant positive effect on the pest structure. But heavy shour within a short time had significant negative effect on pest appearance in all the years (Table 2).

Matrix analysis of important climatic factors leads to determine the relative dynamic of the mealy bug population. As most of the climatic factors are interdependent, any change of single climatic factor will lead to multiple effects on pest structure. However impact of temperature was more profound (Table 3, Fig.2, 3, 4 and 5).

TABLE1: Average climatic parameters and the incidence of *D. mangiferae* population during the period of study

SMW	Temperature				Relative humidity				Average sunshine hour (hr/day)	Rainfall (mm)	Individuals /twig	Extent of infestation to twig (%)
	Tmax	Tmin	Tgr	Tavg	RHmax	RHmin	RHgr	RHavg				
07	33.00	19.00	14.00	26.00	78.12	58.56	19.56	68.34	5.41	0.00	4.5±0.91	0.30±0.11
08	35.00	21.00	14.00	28.00	77.00	54.25	22.75	65.62	5.78	0.00	4.7±0. 87	0.50±0.14
09	32.00	17.00	15.00	24.50	74.47	55.38	19.09	64.92	5.84	0.00	5.3±0.87	0.66±0.17
10	34.00	21.00	13.00	27.50	77.83	52.14	25.69	64.98	5.97	0.00	5.7±1.03	1.79±0.15
11	37.00	21.00	16.00	29.00	71.53	56.12	15.41	63.82	8.47	0.00	7.9±1.12	1.78±0.84
12	39.00	24.00	15.00	31.50	73.22	50.01	23.21	61.61	8.29	0.00	10.6±2.51	2.98±0.41
13	39.00	24.00	15.00	31.50	79.53	56.27	23.03	67.90	6.04	2.53	10.8±2.56	4.18±0.13
14	36.00	24.00	12..00	30.00	78.11	51.53	26.58	64.82	6.48	2.12	14.8±1.84	6.33±0.81
15	40.00	26.00	14.00	27.00	77.84	55.12	22.72	66.48	7.47	0.00	18.4±2.21	4.81±0.67
16	36.00	24.00	12.00	30.00	78.25	58.12	20.13	68.18	6.94	3.12	12.8±0.71	5.41±1.47
17	39.00	24.00	15.00	31.50	79.76	52.79	26.97	66.27	8.69	2.14	9.2±0.43	5.87±1.08
18	40.00	28.00	12.00	34.00	80.28	56.41	23.87	68.34	8.35	1.19	4.3±0.21	6.45±1.61
19	42.00	29.00	13.00	35.50	81.01	59.59	21.42	70.30	8.51	1.15	2.1±0.27	7.78±1.75
20	41.00	30.00	11.00	35.50	84.12	59.25	24.87	71.68	5.61	2.89	0.2±0.61	7.04±2.97

TABLE 2: Correlation coefficient of incidence of *D. mangiferae* population with the climatic factors indicating the level of significance

Climatic parameters	Years of observation			
	2011	2012	2013	2014
Maximum temperature (Tmax)	0.202	0.345	0.501*	0.311
Minimum temperature (Tmin)	0.567*	0.511*	0.425	0.651*
Temperature gradient (Tgr)	0.508*	0.578*	0.420	0.721*
Average temperature (Tavg)	0.518*	0.358	0.575*	0.265
Maximum humidity(RHmax)	0.575*	0.525*	0.501*	0.534*
Minimum humidity (RHmin)	-0.795*	-0.891*	-0.748*	-0.605*
Humidity gradient (RHgr)	0.379	0.528*	0.623*	0.828*
Average humidity (RHavg)	0.501*	0.506*	0.587*	0.819*
Sunshine hours / day(Shr)	-0.435	-0.752*	-0.778*	-0.831*
Rainfall (Rfall)	0.329	0.345	0.267	0.415

Significant at 5% level

Meteorological data *viz.*, mean monthly maximum temperature, minimum temperature, morning and evening relative humidity affects population of coccids (Sundaraj *et al*., 2011).Similarly, gross effect of agro-climatic factors on the incidence and numerical abundance of *D. mangiferae* was studied by Karar *et al*. (2013) and Sathe *et al*. (2013). Incidence of *D. mangiferae* in the present findings partly corroborates to their observation. They have noted that a profound effect of the agro-climatic parameter on *D. mangiferae* incidence. Nandi *et al*.(2015)

had also shown that temperature fluctuation has severe effect on abundance and mortality of mango mealy bug. Present observation is partly supported by Atwal (1963) who had reported that the activity of *D. mangiferae* was restricted to December to May only. He had also noted that mealy bug deposited eggs in soil mostly in April that hatched in the last week of December to the first week of January. First instar nymphs were noted during December to February, second instars during February to mid March and third instars from March to April and then became adults. Present study is in consonance with Tanga (2013) who from Kenya and Tanzania, had observed on the effects of climatic factors on the occurrence and seasonal variations in population of a mango mealy bug *Rastricoccus inceryoides* (Pseudococcidae). The study evicted that the populations of *R. inceryoides* followed as annual cycle which was synchronized with the mango fruiting season, with a peak incidence occurred during the Northeast monsoon (December- February) at a temperature range of 23-33^{0}C and relative humidity of 54-86% and total rainfall from 0-63mm. The population trend of *R. inceryoides* was climate dependent and declined sharply following the onset of the heavy rains from March- May and continued through the coldest and driest period of year from June- October (Southern monsoon). In the present study population of mealy bugs was increased by increase in temperature and suddenly declined due to harvest of crop fruits.

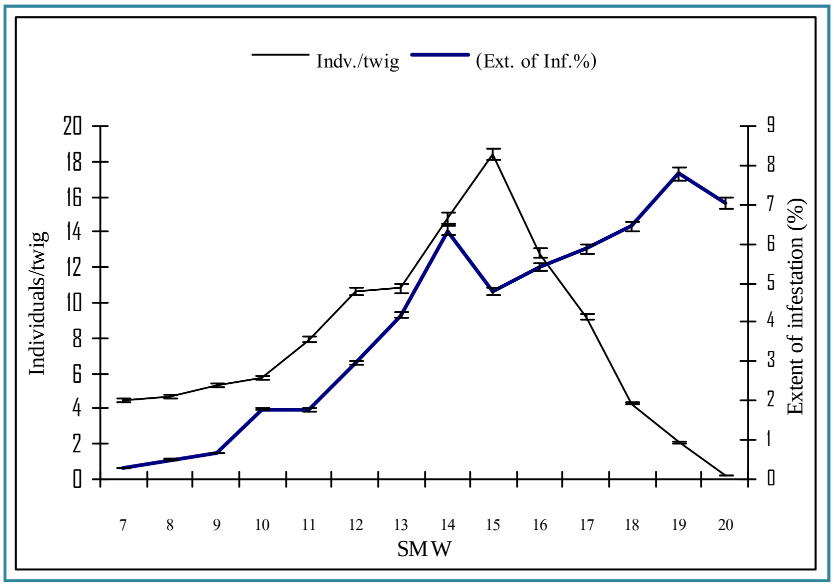

FIGURE 3: Incidence of *D. mangiferae* and the extent of damage in relation to mango growth and development

TABLE 3: Matrix combination showing linear correlation coefficient (r) of important climatic factors in relation to *D. mangiferae* incidence

	Tmax	Tmin	Tgr	Tavg	RHmax	RHmin	RHgr	RHavg	Shr	Rfall	Rdays
Tmax	1.0000										
Tmin	0.8031*	1.0000									
Tgr	0.5457*	-0.0270	1.0000								
Tavg	1.0000	0.8070*	0.5733*	1.0000							
RHmax	-0.5759*	-0.5384*	-0.2168	-0.5756*	1.0000						
RHmin	-0.1769	0.1938	-0.5547*	-0.1740	0.1765	1.0000					
RHgr	-0.0548*	-0.4012	0.4578	-0.0556	0.2164	-0.9258*	1.0000				
RHavg	-0.3520	-0.0176	-0.5623*	-0.3530	0.5001*	0.9327*	-0.7334*	1.0000			
Shr	0.4858	0.1635	0.4964	0.4373	-0.2288	-0.0784	-0.0127	-0.1444	1.0000		
Rfall	0.5269*	0.7558*	-0.1566	0.5235*	-0.2857	0.3036	-0.4154	0.1620	-0.1817	1.0000	
Rdays	0.8046*	0.8579*	-0.1768	0.8063*	-0.5265*	0.1160	-0.3161	-0.0818*	0.0343	0.8652*	1.0000

Each correlation coefficient (r) is calculated independently without considering other variables

Present study is with the agreement with the findings of Bajwa *et al.* (2000) who reported similar results on *Paulownia* spp. attacked by mango mealy bug. Present study is in concurrence with that of Kumar *et al.* 2009**.** They had reported that the occurrence of mealy bug on mango plants started from 1st week of December till May. Yadav *et al.* (2004) recorded the maximum incidence of *D. mangiferae* at first week of April and the lowest population at the end of March. Incidence of the bug population on the tree trunk was noted starting from the middle of May. The results are in agreement with those of Karar (2010) who had recorded that the number of nymphs of insect present on the tree trunk, terminal twigs or on inflorescences at an interval of a week. From the visual observation of their study, it is evicted that first instar nymph of mealy bug was noted during the second week of February. Karar (2010) had counted that the numerical abundance of mango mealy bug was 26.63 per 30-cm branch. This finding is partly with the agreement of the present observation. However contrary to the present findings Boavida, *et al*. (1992) had mentioned that the significant differences were observed among different quadrates, but not between old and young leaves, nor between top and bottom of the trees.

Ishaq *et al.* (2004) worked on the integrated management of mango mealy bug and reported that this pest can be checked with insecticide in view of the seasonal dynamics.

Gul *et al*. (1997) similarly had mentioned that by following the life cycle and seasonal dynamics, *D. stebbingi* can be checked by integration of banding of tree trunks, destruction of eggs by soil working and application of insecticides.

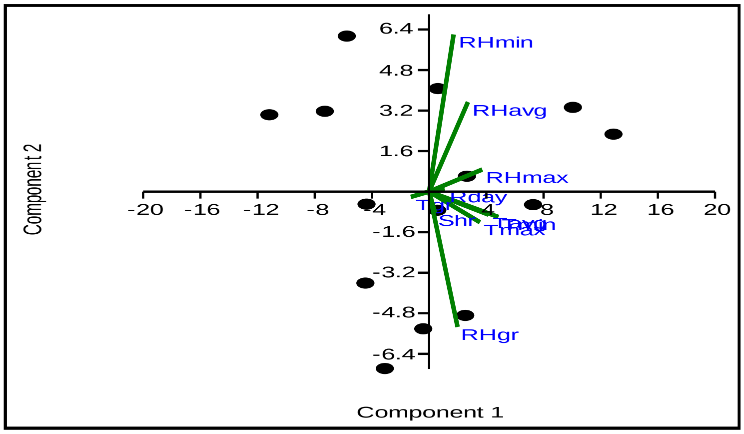

FIGURE 4: Principal component analysis of the important climatic factors in relation to *D. mangiferae* incidence

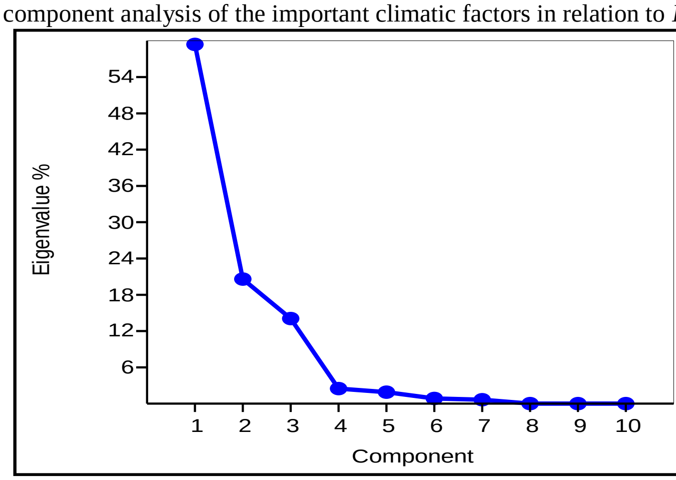

FIGURE 5: Eigen value of the important climatic factors in relation to *D. mangiferae* incidence.

CONCLUSION

Plant protection deserves chief weightage in fruit production because of the fact that potential yield of fruit are limited by pest groups of various categories and primarily due to the insects. Since pests are biotic natural resources of the Earth, their inter-reliant interactions between system variables are equally dictated by the factors of climate change at regional level. Climate effects on pests could be direct as well as fruit plant phenology mediated. Most often the available historical data as taken from the farmers by questioning lack continuity and their holistic retrieval is cumbersome. Availability of data base tools and sequential programme based data collection on insect pest incidence has made it possible to create centralized database of desired resources and associated activities with ease, in turn making scientific analyses for generating insect pest calendar with inferences and also makes it more meaningful.

Our present study is revealing that this pest starts to attain its peak number during March-April and then subsides during May with the variation of agro-climatic conditions. It would be beneficial to predict pest outbreak time and accordingly Integrated Pest Management practices, like pesticide application schedule, ploughging of orchard, water spray, banding of trunks etc. can be planned.

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