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ICT-based surveillance of hoppers and thrips in mango orchards of Maharashtra, India

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ABSTRACT: The present global mango production faces various kinds of environmental and ecological fluctuations including biotic and abiotic stresses. Therefore in order to develop suitable management techniques, it is essential to have thorough understanding of the population dynamics and damage potential of the mango pests. Hence the present experiment was carried out to study the influence of particular seasonal months on the incidence of mango hoppers and thrips under field conditions. The highest degree of infestation by hoppers was detected in March (22.210 hoppers per shoot/panicle), followed by February (21.336) and January (18.863). The peak prevalence of the thrips were observed in the month of February (26 - 50% of fruit area damaged) followed by January and March (1 - 25% of fruit area damaged). The occurrence and seasonal prevalence data generated from the present study can be used to manage the population of hoppers and thrips on mango and this study have far-reaching implications in pest management strategy and the data so generated would help in the forecast of hoppers and thrips.

Keywords: Mango, ICT, seasonal prevalence, hoppers, thrips, forecast, pest management

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important tropical fruits in the world. Mango output in the world is anticipated to be more than 26 million tonnes per year, with India leading the way with 40% of total mango production (APEDA, 2020). During the vegetative and reproductive stages, more than 300 insect pest species plague mango crops globally (Pena *et al.,* 1998), with 188 of these documented from India (Tandon and Verghese, 1985). Mango hoppers are a significant, serious and ubiquitous insect problem in the Indian Mango ecosystem throughout the year. Hoppers species, especially *Idioscopus clypealis* (Lethierry), *Idioscopus nitidulus* (Walker) and *Amritodus atkinsoni* (Lethierry), remain active and cause damage at all stages of mango starting from fresh flush emergence to flowering, fruiting and harvesting results in losses of up to 100 per cent (Gundappa *et al.,* 2015; Babu *et al.,* 2002).). Both nymphs and adults of hoppers have been recorded sucking cell sap from young leaves, fragile shoots, inflorescences or panicles and the rachis of young fruits, resulting in the dropping of immature fruits. Hoppers also produce a lot of honeydew, which causes sooty mould to grow and as a result, hinders plant photosynthesis (Kumar *et al*., 2014).

Thrips are a growing hazard to mango production, causing significant economic loss in mango orchards. *Scirtothrips dorsalis* and *Thrips hawaiiensis* have been identified as serious pests of several vegetables, fruits and ornamental crops in Eastern Asia (Reynaud *et al.,* 2008). *Thrips palmi* was found on mango inflorescences in India (Verghese *et al.,* 1988) and three thrips species, *Megalurothrips distalis* (Karny), *Thrips hawaiiensis* and *Haplothrips tenuipennis* have been found on mango in Andhra Pradesh (Kannan and Rao, 2006). Kumar and Bhatt (1999) found two species of thrips, *Scirtothrips mangiferae* and *S. dorsalis* on mango in Gujarat. *Scirtothrips mangiferae*, *S. dorsalis* and *Rhipiphorothrips cruentatus* were found on mango by Kumar *et al* (2002) in Cuttack. *R. cruentatus* was discovered in Haryana by Dahiya and Lakra (2001). Patel *et al.* (1997) discovered three thrips species on mango rootstock: *Pantachaetothrips* sp., *Selenothrips rubrocinctus* and *Caliothrips impurus* in addition to *Scirtothrips dorsalis*. *S. rubrocinctus* was found on mango by Ananthakrishnan and Muraleedharan (Ananthakrishnan and Muraleedharan, 1974). Recently *Frankliniella schultzei* and *Thrips subnudula* were found on mango inflorescence from Tamil Nadu (Krishnamoorthy *et al.,* 2012).

To design an early warning weather-based system for any pest in a given agro-ecosystem, a basic understanding of pest population dynamics and seasonal occurrence in relation to the most prevalent weather parameters is required. This will make it simpler to decide when to act and how to apply the best pest management techniques. It is well known that weather variations have a significant impact on pest dynamics, making site-

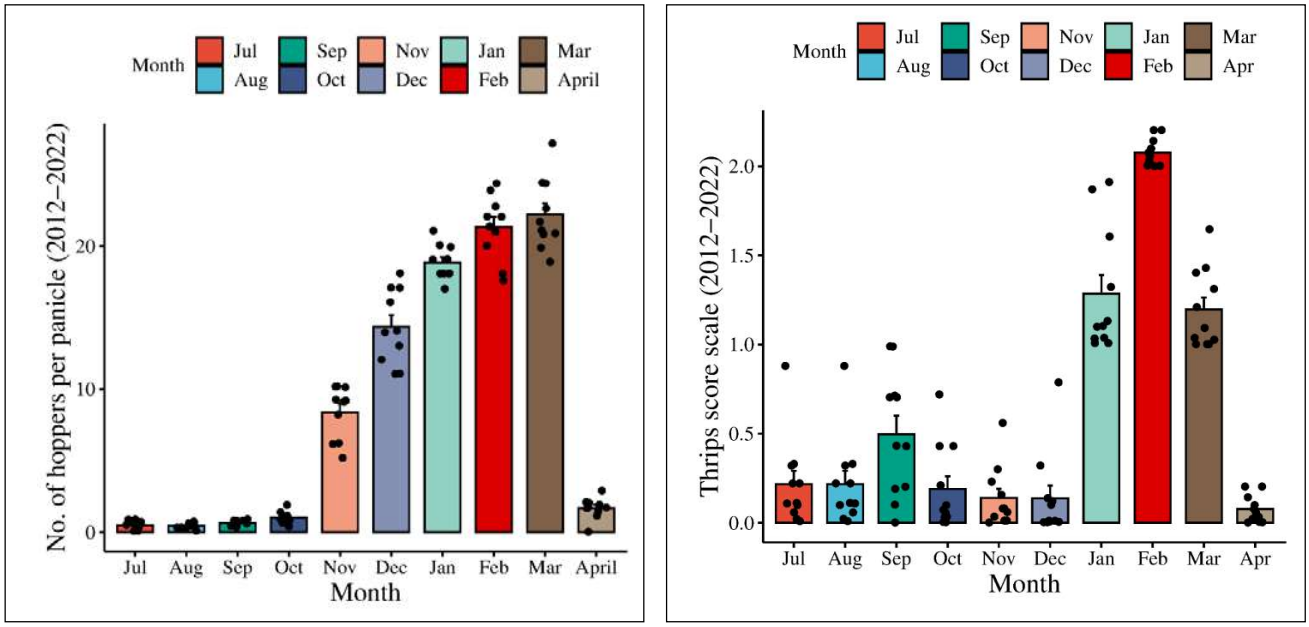

Fig. 1. Seasonal activity and damage of hoppers (top) and thrips (bottom) in ango (2012-2022)

specific research even more important. That is the reason why this current study was carried out to investigate the seasonal occurrence of mango hoppers and thrips. Based on work carried out between 2012 and 2022, we have compiled an inventory of hoppers and thrips prevalence on mango trees in Maharashtra. This is a step in studying the seasonal occurrence of mango hoppers and thrips in order to develop appropriate defense strategies against the pests, thereby contributing to increased Mango production.

MATERIALS AND METHODS

The investigation was carried out during the crop-growing seasons from 2012 to 2022. The pest surveillance programme was implemented in the four districts of Maharashtra, namely Aurangabad, Beed, Osmanabad, Raigad, Ratnagiri, Shindhudurga and Thane and it was made possible through the use of information technology, which aided in the development of an e- pest surveillance programme by recording pest occurrence data with the assistance of scouts and pest monitors employed by the Department of Horticulture, Govt. of Maharashtra.

A system based on three-tier architecture was developed, consisting of three functional components, namely a mobile app for data collection, a central database and a web-based pest reporting and consulting application. This system was designed with the challenges of pest monitoring and internet connectivity in remote areas of the state in mind. The pest observers were trained to capture pest observations in farmers' fields via a mobile app. The app has the built-in feature to automatically sync the collected data to the central database of the National Research Center for Integrated Pest Management in New Delhi once the device enters an internet-connected area.

For pest monitoring, data formats were developed in consultation with plant experts to record pest observations in the fields. Field location details and pest information were key components of these data formats that were integrated into the mobile app. Each field was assigned a unique ID and its geographic coordinates were also recorded by the mobile app while pest information was collected from the field. Pest experts from state agencies reviewed the pest reports generated by the web-based reporting and advisory application for the collected data and submitted the appropriate pest management decisions to the system. SQL 2012, ASP.net, Android Studio and XML technologies were used to create the system (Ahuja and Chattopadhyay, 2015).

The orchards were selected one each on hill slope and on plane for fixed and random survey. From each selected orchard, randomly 4 trees were selected, and on each selected trees, 5 shoots/panicles were observed randomly for recording observation of hoppers. Two fixed orchards and two random orchards were selected by one scout who covers two villages per day. Observations on hoppers were recorded in structured sheet which was prepared for the pest scouts. Five shoots/panicles were selected per tree, one from each direction and centre of selected tree. Weekly observation on number of both nymphs and adults were recorded on selected shoots or panicles. Mean hoppers per shoot/panicle were calculated as Total

No. of values/20. Total number of fruits from pea nut stage onwards are recorded per shoot/ panicle selected.

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The statistical analysis was based on the seasonal incidence data of hoppers and thrips collected during the study period from 2012 to 2022. The data generated were subjected to an analysis of variance (ANOVA) and the statistical procedures were performed using the R program. Since it turned out that the seasonal mean incidence values of one or more months in the study years 2012 to 2022 were not similar, we performed the Shapiro-Wilk normality test. The change in pest infestation scenario was visualized with bar charts and a circular heat map using the R program. Total infestation percentage and average seasonal frequency figures were plotted using Google Colab by examining the Matplotlib library of Python program.

RESULTS AND DISCUSSION

Trends in Seasonal incidence of mango hoppers: The results showed a significant difference between the hoppers that infested mango orchards in the seasonal months from 2012 to 2022. The data revealed that the highest infestation of mango hoppers was recorded in the month of March with an average of 22.210 hoppers per shoot/panicle followed by February (21.336 hoppers per shoot/panicle). A significant infestation was observed in the month of January (18.863) and December (14.364) (Fig. 1A, Fig. 2A and Table. 1). In terms of per cent incidence, mango hoppers showed their peak incidence in March (24.5%) followed by February (23.5%). The total percentage of hoppers infestation in the months of July, August, September, October, November, December, January, April ranged from 0.9 to 20.8% for the years under study (Fig. 3A). Several previous studies also reported that the incidence of mango hopper reached its peak (12.41 hoppers/panicle) during 4th week of March (Gundappa *et al.,* 2016) and among the three species of mango hoppers, *Idioscopus clypealis* and *I. nitidulus* were the dominating species during full bloom period (January to March) where *Amrasca splendens* was also active during marble and stone sized fruit stage of the

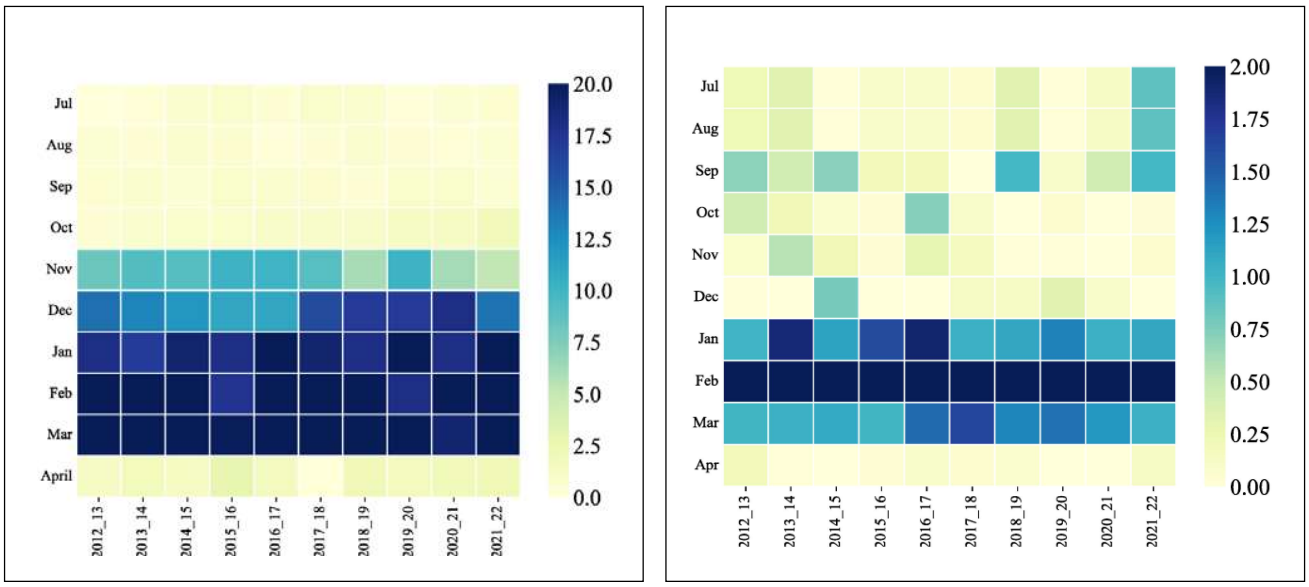

Fig. 2. Heat map depicting the seasonal abundance of hoppers and thrips in Mango (2012-2022)

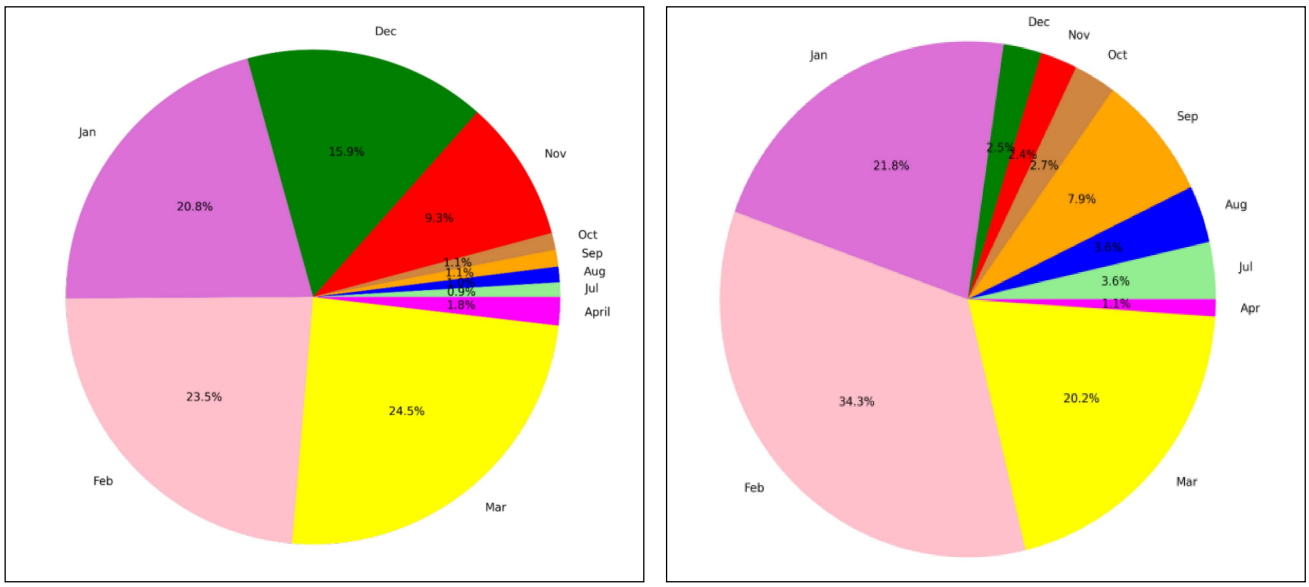

Fig. 3. Trend in percentage incidence of mango hoppers and thrips in Mango (2012-2022)

crop (March–April) (Bana *et al.,* 2018). Mango hoppers appeared during last week of October with 1.70 hoppers per twig/panicle. The hoppers population continued to build up and attained peak incidence (12.38/twig/panicle) during third week of February at flowering stage. Declining trend of hoppers population was recorded from last week of February, when tree enters in fruiting stage. The lowest hopper population (0.13/twig/panicle) was recorded during first week of April at fruit maturity stage (Anant *et al.,* 2019).

Results of our current investigation are in line with Kadavkar *et al.,* (2021) in which they revealed that incidence of the mango hopper was noticed from month of September corresponding to 36 M.W, (1.19 hoppers/panicle) and the peak incidence of mango hopper was found to be in the 49th M.W i.e. (12.31 hoppers/panicle) whereas the first minimum appearance of hoppers population were 13.75 and 13.40 on the branches/tree trunk of mango trees recorded in September. Peak hoppers population were 146.65 and 137.00 on the inflorescence of mango tree in second fortnight of March (Kaushik and Nirmalkar, 2021) and in the similar study, incidence of hopper population was noted from 4th week of January which reaches its peak (80 hoppers/20 panicles) during fourth week of February corresponding with 8th standard week. The hopper population declined from second week of March which disappeared during second week of May (Chaudhari *et al.,* 2017).

Trends in Seasonal incidence of thrips: The variation in the incidence of thrips on the mango crop over seasonal months from 2012 to 2022 showed significant differences and the data revealed that the highest infestation of thrips were recorded in the month of February (26 - 50% of fruit area damaged) followed by January (1 - 25% of fruit area damaged). A significant infestation of thrips were observed with 1 - 25% of fruit area damaged in the month of March whereas no significant differences were recorded during the other months viz., August, September, October, November, December and April (Fig. 1B, Fig. 2B and Table. 1). Furthermore the incidence in terms of overall percentage by thrips observed to be highest in the month of February (34.3%) and January (21.8%) followed by March (20.2%) (Fig. 3C). The overall percentage infestation of moths in the month of July, August, September, October, November, December and April ranged from 1.1-7.9% for the years under study. Similar studies on the seasonal incidence of mango thrips revealed that appearance of thrips started from the third week of January. Thereafter, the thrips population increased continuously till the last week of March and reached to peak at 13th standard week. The maximum population was recorded during 11th to 14th standard week, after which the population declined (Patel and Shukla, 2021). One another similar investigation with eight years study from 2012-19 on mango cv. Kesar, Alphonso and Amrapali revealed two peaks of incidence of thrips, first during flowering-cum-fruit setting stages and the second during new flush stage (Bana *et al.,* 2021). The maximum population of thrips observed on flower (43.33/panicle) and foliage (29.46/twig) on 15th and 42nd SW coinciding with stone sized fruit and emergence of new flush stages respectively (Patel *et al.,* 2018).

In conclusion, the information on the seasonal incidence of any insect pest in a specific ecological niche

Table 1. Trends in seasonal incidence of mango hoppers and thrips in a particular month of mango growing seasons of the years from 2012 to 2022 in the state of Maharashtra, India

Month	Mango hoppers	Thrips
July	0.477 [e]	0.215 [cd]
August	0.413 [e]	0.215 [cd]
September	0.627 [e]	0.475 [c]
October	1.000 [e]	0.165 [cd]
November	8.390 [d]	0.144 [cd]
December	14.364 [c]	0.149 [cd]
January	18.863 [b]	1.312 [b]
February	21.336 [a]	2.064 [a]
March	22.210 [a]	1.216 [b]
April	1.673 [e]	0.064 [d]

Note: Means in the same row followed by the same letters are not significantly different (P>0.05) using the Shapiro-Wilk normality test.

should be taken into consideration for the development of an eco-friendly pest management programme. Although similar studies on population dynamics have been conducted elsewhere but this is the first of its kind in the state of Maharashtra, exploring continuous pest monitoring over the seasons from 2012 to 2022. The current study compared the occurrence and severity of hoppers and thrips on Mango. The data so generated would help in the forecast of the pests and prove helpful in devising an effective strategy for their management.

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AUTHOR CONTRIBUTIONS

Niranjan Singh and Devaramane Raghavendra contributed to experimentation, data collection and original draft writing; Ramesh K. B analyzed the data, wrote the original draft and edited the manuscript; Subhash Chander edited the manuscript. All authors have read and agreed to the published version of the manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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