

Impact of integrated pest management strategies on thrips infestation and yield of Kinnow Mandarin (*Citrus reticulata* Blanco)

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Summary

Kinnow mandarin is one of the most important fruit crops in the citrus group, owing to its expanding cultivation area, rising production, and increasing market demand. However, thrips infestation from flowering to fruiting stages has emerged as a serious challenge for growers. In the absence of effective alternatives, farmers often rely on unlabeled or non-recommended insecticide mixtures, which adversely affect beneficial microorganisms and natural enemies, while also contributing to soil degradation and water pollution. Integrated Pest Management (IPM) offers the most sustainable solution to address these issues. To evaluate its effectiveness, field trials were conducted during 2021–2023 at Hisar, Haryana. Results showed that the lowest thrips populations (1.00 ± 0.77 , 2.36 ± 0.76 , and 2.55 ± 1.33 adults per branch/tapping in 2021, 2022, and 2023, respectively) were recorded under the IPM module. This success was attributed to the combined use of blue sticky traps (20/ha), neem seed kernel extract (NSKE) 5% on young leaves, and cyantraniliprole 10.26% OD @ 600 ml in 500 litres of water. In contrast, higher thrips populations were observed under farmer practice (2.05 ± 1.25 , 3.40 ± 1.07 , and 3.04 ± 1.46) and untreated control (3.05 ± 1.65 , 4.39 ± 1.28 , and 3.78 ± 1.68). These findings validate IPM as an economically viable and environmentally sound strategy for the successful management of thrips in Kinnow mandarin.

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Keywords: Kinnow mandarin, thrips, population dynamics and IPM strategy

Introduction

Citrus is one of the most important fruit crop that is cultivated more than 109.6 million hectares of land with a total production of 14.25 million tonnes (FAO 2023). It is mostly grown in Haryana, Uttaranchal, Bihar, Karnataka, Gujarat, Orissa and the North East region of India. Among the citrus fruits, Kinnow mandarin is an important fruit which is primarily grown in Haryana, Punjab and Rajasthan and occupies 90% area in Haryana in both area and production (HDH 2024). Kinnow mandarin, belonging to the Rutaceae family and has high economic importance due to high juice content and vitamin C (Lotha & Khurdiya 1994). The quality and production of Kinnow mandarin are affected by several factors, including pests. Citrus is attack by more than 250 insect pests out of which 22 insect species are reported in Punjab (Singh et al. 2016), 20 species in West Bengal, 50 species in Karnataka and 42 species in the north eastern region (Pathak and Rao, 1999). Among the insects, thrips (*Scirtothrips citri* (Moulton) belong to the order Thysanoptera and family Thripidae is one of the potent insects that damage the Kinnow plants from nursery to young plantation and fruits till harvesting. Thrips is a minute insect, but can be seen with the naked eye. Both nymph and adult cause damage to flowers, leaves and young as well as

grown-up fruits by lacerating, rasping and sucking the cell sap (George et al. 2022). The attacked flowers dry up and shrivel. On leaves, two whitish lines parallel to the midrib can be seen. Leaves become cup-shaped, leathery, distorted and wrinkled. Thrips damage in the nursery causes stunted growth of the plant. Silvery-white irregular patches and a circular ring appear around the neck of the fruit is a peculiar symptom of thrips damage on fruits. Fruits become discoloured, thereby reducing the consumer preference for such fruits (Perrotta and Conti, 2008; Teksam and Tunc, 2009). The peak activity of thrips in Kinnow mandarin is mostly seen in the first week of March to the third week of April and continues till harvesting of fruits. Thrips and mite causes the fruit yield loss in the range of 4.8 – 38.82% (Pathania et al. 2021). Presently, thrips is managed by the injudicious use of insecticides, which are present in the food and cause chemical residue in soil, water, disturb the population of beneficial microorganisms, natural enemies, and also cause human and animal health hazards (Kranthi et al. 2002; Haldhar et al. 2025). Besides, farmers follow the management practices based on the advice of local shop dealers and spray insecticides on Kinnow mandarin based on a yearly calendar. Therefore, to overcome the insecticide load in fruits, it is necessary to validate and implement an effective IPM strategy, which can reduce the population of thrips below the economic threshold level (ETL). Hence, the present study was carried out for three years against thrips to

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assess and devise the management strategies that can be adopted widely as a component of Integrated Pest Management (IPM) by the Kinnow farmers.

Materials and Methods

An investigation into the effect of IPM strategies on population dynamics of thrips was carried out at Hisar district of Haryana state in collaboration with Krishi Vigyan Kendra (KVK), Sadalpur, Choudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) during 2021-2023 in a farmer participatory mode. The IPM techniques were validated against thrips following a Randomized Complete Block Design (RCBD) having plant spacing 6 x 6 m in a 1-acre area. A total of 8-10 years old 120 plants of local variety per acre were maintained in the orchard. Randomly, 25 plants in five replications from each orchard were used for recording the thrips observations in IPM and Farmers' practice fields. Besides, control plants were also maintained in the orchard for comparison with T₁-IPM and T₂-farmer practices. Different Integrated Pest Management (IPM) strategies mentioned in Table 1 like deep summer ploughing; pruning the excess branches and bottom leaves of the tree for proper ventilation; destruction of rotten and dropped infected fruits; regular monitoring of orchard to assess the damage of thrips; Installation of blue sticky traps @ 20/ha placed 1–1.5 m above tree canopy height and distributed uniformly across the orchard; growing intercrop with onion/garlic/chickpea between rows of trees which helps in moisture and natural enemies' conservation and reduce irrigation frequency, and suppression of weeds; conservation of

natural enemies (spider, chrysoperla and coccinellidae) to enhance their population through ecological engineering (marigold, sunflower etc.); need-based spray of neem seed kernel extract (NSKE) 5% on young leaves of Kinnow mandarin; if populations of insect is above ETL then use need-based spray of label claim cyantraniliprole 10.26 % OD @ 600ml in 500 liter of water to manage thrips were validated in T₁-IPM treatment. In T₂-farmer practice treatment, farmers do not practice IPM techniques and use 8-12 sprays of insecticides such as diafenthiuron 50% WP @ 2ml/l, ethion 50 EC @ 1ml/l, diafenthiuron 48 % + dinotefuran 8% WG @1.25ml/l and mostly rely on local shop dealers for advice and use higher than recommended doses of insecticides. In the T₃-Only control treatment. The recommended dose of fertilizers (urea, muriate of potash), minerals (copper, manganese, boron, zinc, etc.) and farm yard manures were applied as and when required during crop growth and fruiting stage. All IPM inputs, like blue sticky traps, NSKE 5%, and label-claimed insecticides, etc., were supplied by the institute and used in IPM orchards. Farmers' field school (FFS), kisan ghosti, demonstration of IPM inputs, identification, and awareness about thrips and their natural enemies were also created among the farmers. Observations recorded on thrips were transformed into square root values to normalize data before statistical analysis (Haldhar et al. 2014 & 2021). The data is expressed as the mean $\pm$ standard error of the mean. Randomized complete block design (RCBD) was used to decrease experimental error.

Table 1. Details of practices used in IPM, farmer practice and control

Management practice	Details
T₁- Integrated pest management (IPM)	Common practices: Deep summer ploughing; pruning the excess branches and bottom leaves of tree for proper ventilation; destruction of rotten and dropped infected fruits; regular monitoring of orchard to assess the damage of thrips; IPM practices: 1. Installation of blue sticky traps @ 20/ha placed 1–1.5 m above tree canopy height and distributed uniformly across the orchard. 2. Growing intercrop with onion/garlic/chickpea between rows of trees which helps in moisture and natural enemies' conservation and reduce irrigation frequency, and suppression of weeds. 3. Conservation of natural enemies (Spider, Chrysoperla and Coccinellidae) to enhance their population through ecological engineering (marigold, sunflower etc.). 4. Need-based spray of neem seed kernel extract (NSKE) 5% on young leaves of kinnow mandarin. 5. If populations of insect is above ETL then use need-based spray of label claim Cyantraniliprole 10.26 % OD @ 600ml in 500 liter of water to manage thrips.
T₂- Farmer practice (FP)	1. Generally, farmers not practice IPM techniques and injudiciously used 8-12 sprays of pesticides such as Diafenthiuron 50% WP @ 2ml/l; Ethion 50 EC @ 1ml/l; Diafenthiuron 48 % + Dinotefuran 8% WG @1.25ml/l. 2. Farmers mostly depend on local shop dealer for advice and used higher than recommended dose of pesticides.
T₃- Control	Control



Damaged fruits by thrips

Results and Discussion

The IPM practices pose a significant effect on the population dynamics of thrips in IPM plots compared to Farmer practice and Control plots, which is clearly evident from the experimental findings shown in Table 2. The data on seasonal dynamics and effect of IPM strategies against thrips in IPM, FP and Untreated Control plots was recorded from 25th -52nd standard metrological weeks (SMW) and are presented in Table 2. It was apparent that the lowest population of thrips (1.00 ± 0.77 , 2.36 ± 0.76 and 2.55 ± 1.33 adults per branch/tapping) occurred in T₁-IPM compared to T₂-farmer practice (2.05 ± 1.25 , 3.40 ± 1.07 and 3.04 ± 1.46 adults per branch/tapping) and T₃-control (3.05 ± 1.65 , 4.39 ± 1.28 and 3.78 ± 1.68 adults per branch/tapping) during 2021, 2022 and 2023, respectively (Table 2). The lowest mean population of thrips was recorded in T₁-IPM (1.96 ± 0.95), while the highest population was noticed in T₂-farmer practice (2.82 ± 1.26) and T₃-control (3.74 ± 1.54). The highest reduction in thrips population over the control was also observed in T₁-IPM (47.59%) compared to T₂-farmer practice (24.59%). From the investigation, it was revealed that the seasonal dynamics of thrips were lowest in T₁-IPM compared to T₂-farmer practice and T₃-control during the years of 2021-2023. In our study, installation of blue sticky traps @ 20/ha plays a potent role for the monitoring, early detection and mass trapping of the thrips in Kinnow mandarin. Bara & Laing (2020) reported that the citrus thrips, *Scirtothrips aurantii*, is one of the economic insect of South African avocado, which damages corky tissue and makes the fruit unsuitable for export. They used the blue and yellow sticky traps against thrips, which drastically reduced the population from flower to till fruit establishment, and recommended the best monitoring tool, which also corroborated our study. In our investigation, we also found that growing intercrop with onion/garlic/chickpea between rows of trees not only helps in conservation of moisture and natural enemies but also reduces the irrigation frequency, and

suppresses the unwanted weeds. Application of green pesticides, clean cultivation, cultural control, monitoring of pests, and intercropping of onion, garlic, chickpea were found very effective in reducing the pest populations and give favorable conditions for multiplication and augmentation of natural enemies (Sreedevi 2010; Gogi et al. 2014; Deka et al. 2016; Hussain et al. 2017), which are supported to our investigation. During the study, we found that growing marigold and sunflower between rows of Kinnow mandarin increased the population of spider, chrysoperla and coccinellidae, which were also had a significant role in managing the population of thrips. We observed that the population of thrips started from April onwards and persisted till harvesting and reducing the quality and marketing value of fruits. Spray of neem seed kernel extract (NSKE) 5% on the young leaves of Kinnow mandarin reduced the population of both nymphs and adults thrips. The azadirachtin compound present in neem extract reduces the feeding activity and disrupts the reproduction of many sucking insects. Spray of neem oil (1%) in rotation with other insecticides against thrips and aphids of sweet orange during the button stage of fruits was suggested by AICRP on fruits. In our findings, spray of NSKE @ 5% effectively controlled psylla and whitefly in Kinnow mandarin, which are similar to reports of previous researchers (Chakravarthi et al. 1998b; Hussain et al. 2017). Similarly, Aliakbarpour et al. (2011) found positive results on the efficacy of neem oil against thrips on mango panicles and its compatibility with mango pollinators, which also supports our results. When populations of thrips were above ETL, then we used a need-based spray of label claim cyantraniliprole 10.26 % OD @ 600ml in 500 litres of water against thrips. Gore and Jadhav (2019) tested the bio-efficacy of cyantraniliprole 10.26% OD insecticide against citrus thrips in sweet orange and found excellent in suppression of thrips populations compared to the untreated control. Similarly, Samruddhi et al. (2024) reported that application of cyantraniliprole 10.26% OD

in citrus nursery was found very effective against thrips, which is also corroborated by our findings. The activity of thrips started from April and continuous till harvesting. The thrips appeared during 25th SMW in IPM, farmer practice and in control and reached peak in 36th and 48th SMW, thereafter its population declined (Figure 1). Sharma (2007) also reported the activity of thrips in the month of March to April. Similarly, Kaur et

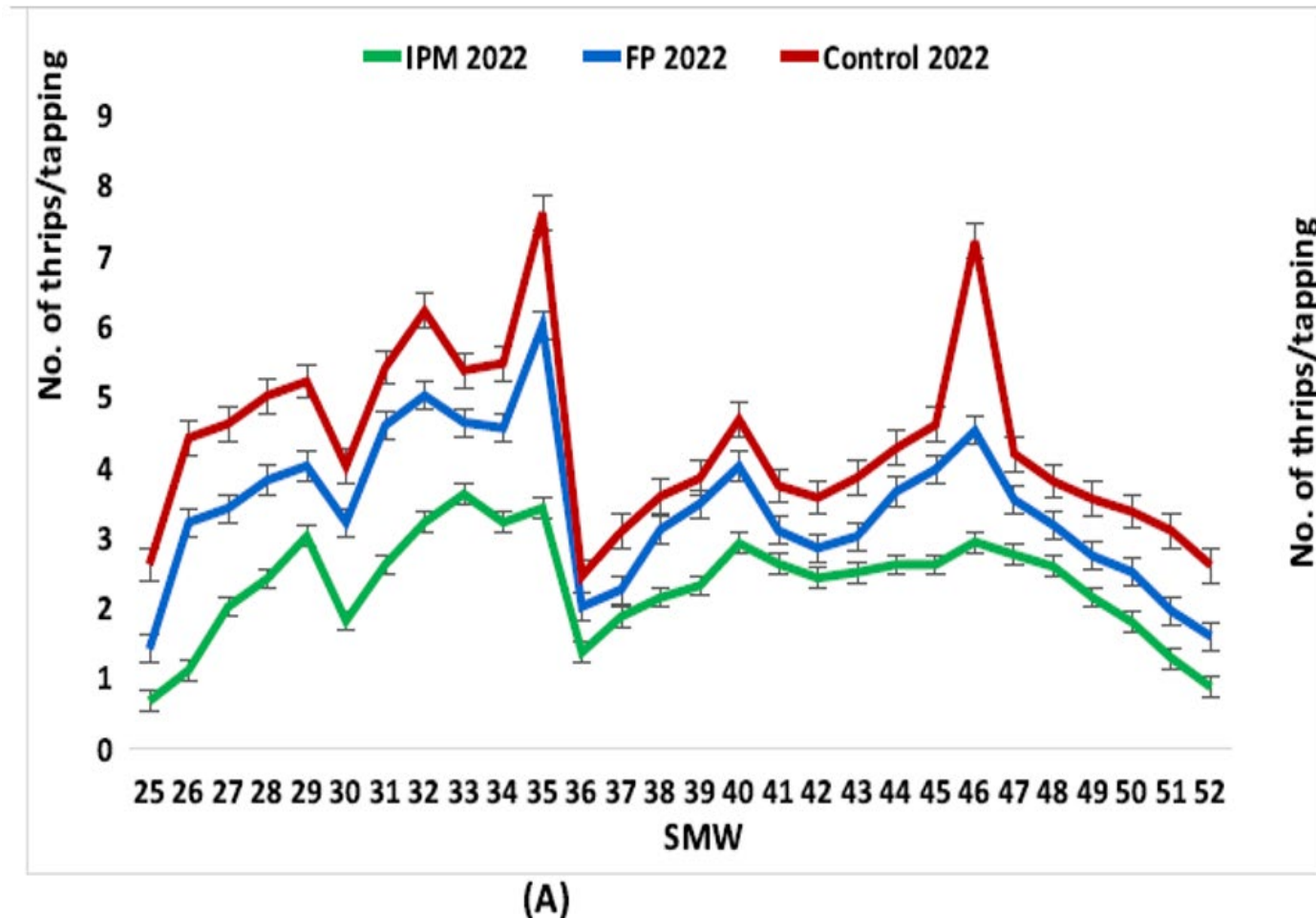
al. (2020) also observed the activity of thrips from the first week of March with the initiation of flowering and noticed their attack continued up to the last week of May in both years, while Li et al. (2003) reported the occurrence of citrus thrips during May-June and July-August in China, that results also close agreement with our study.

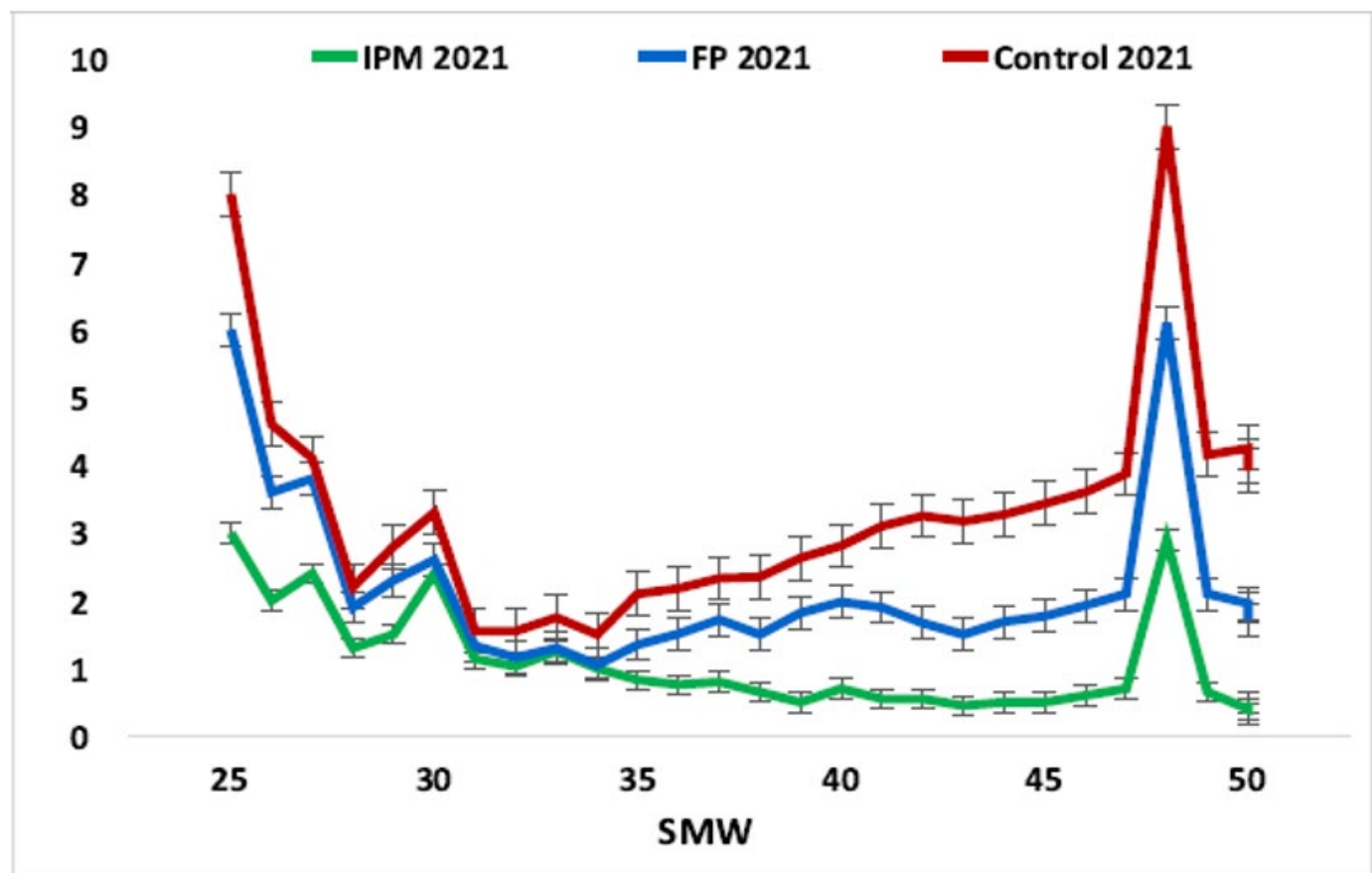
Table 2. Seasonal dynamics and effect of IPM strategies against thrips in IPM, FP and Untreated Control plots

SMW	Treatment	2021 Thrips (No/branch/ tapping)	2022 Thrips (No/branch/ tapping)	2023 Thrips (No/branch/ tapping)	Pooled Mean	Reduction of thrips over Untreated control (%)
25-52	IPM	1.00±0.77	2.36±0.76	2.55±1.33	1.96±0.95	47.59
25-52	FP	2.05±1.25	3.40±1.07	3.04±1.46	2.82±1.26	24.59
25-52	UC	3.05±1.65	4.39±1.28	3.78±1.68	3.74±1.54	-
	SEm (±)	0.99	0.04		1.01	
	CD at p<0.5	3.15	0.13		1.63	
UC-Untreated control; Mean of seven replications						

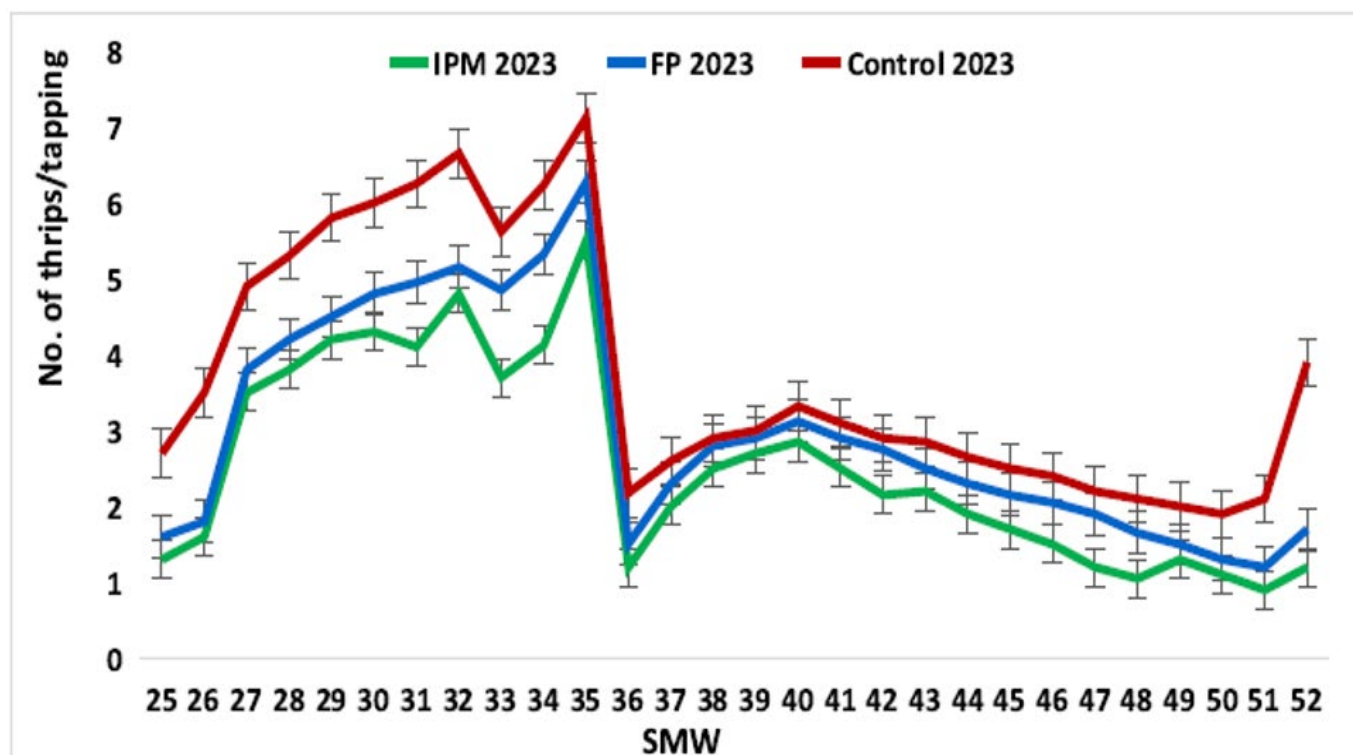
In addition, farmers were trained and empowered with enhanced knowledge and skills to adopt appropriate Integrated Pest Management (IPM) practices in Kinnow mandarin cultivation. Regular demonstrations of NSKE 5% pruning techniques, farmers' gatherings, Farmers' Field Schools (FFS), and Kinnow Mandarin Day events were also conducted to create awareness. These initiatives focused on pest identification, recognizing

natural enemies, understanding pest damage, and the practical application of IPM strategies. IPM plays a crucial role in minimising pest damage while maintaining ecological balance. It also helps reduce pesticide residues, supports ecosystem services, boosts farmers' income, and strengthens their decision-making capacity through improved knowledge.





(B)



(C)

Figure 1. (A, B & C), illustrated seasonal dynamics of thrips in Kinnow during 2021-23 at Hisar, Haryana

Conclusion

To conclude, the present study demonstrates that the IPM strategy comprising cultural, mechanical, and chemical approaches is an economically viable option for the management of thrips. The validated IPM practices were found effective and proved efficient

against thrips, in comparison to the farmer practice. The validated IPM strategy viz; installation of blue sticky traps @ 20/ha followed by spray of neem seed kernel extract (NSKE) @ 5% and cyantraniliprole 10.26 % OD @ 600ml in 500 liters of water against thrips, are

thus recommended as key management technique in Kinnow mandarin.

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Author contribution statement

PNM: Conceptualization, investigation, final draft preparation. DR: Investigation, formal analysis. NK: Resources. SMH: Estimations, Investigation. RT: proofreading.

Conflict: No conflict declared by authors

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