



Incidence and severity of insect-pests and diseases of Kinnow mandarin

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ABSTRACT

With significant increase in area and production, the incidence of insect pests and diseases increased dramatically. Therefore, the study was conducted to find out major insect-pest threats to kinnow mandarin crop in south-western Punjab. The results revealed 18 species of insects, mites and 7 diseases as major threats to kinnow mandarin in South-western Punjab. Citrus psylla (*Diaphorina citri*) was observed as a major and severe (15.75 – 48.25%) insect pest of kinnow mandarin, followed by thrips and mite pests (4.8 – 38.82%). Citrus leafminer (*Phyllocnistis citrella*) infestation was 8.4 – 25.23%, whereas it was 4.65 – 21.25% by lemon butterfly (*Papilio demoleus*). The orchards also observed aphids, mealy bugs, whitefly, blackfly, fruit fly, fruit-sucking moth, root borers, white grubs, etc. In addition, natural enemies, viz. *coccinellids*, spiders, chrysopids, mantids and syrphid flies were also observed in the orchards. Among diseases, foot rot/gummosis (*Phytophthora parasitica*), pathological fruit drop and die back (*Colletotrichum gloeosporioides* & *Diplodia natalensis*), sooty mould (*Capnodium citri*), citrus canker (*Xanthomonas axonopodis* pv. *citri*) and citrus greening (*Candidatus liberibacter asiaticus*) were interfering with the kinnow cultivation in the region.

Keywords: Kinnow, Insect pests, Diseases, Incidence, Severity, Punjab

INTRODUCTION

India ranked fourth in citrus production in the world. Citrus is the third major fruit after mango and banana in India (Anonymous, 3). In Punjab, citrus is commercially grown in over 57,288 hectares (66.09% of total fruits) with production of 1281.632 thousand MT during the year of 2018-19 (Anonymous, 2021). Kinnow (*Citrus nobilis* x *Citrus deliciosa*) ranks first with respect to area (62.41% area of total fruits) and production (68.0% of total fruit production), followed by sweet orange and limes and lemons in Punjab (Anonymous, 2). District Fazilka (South-western Punjab) alone occupy more than 57.51 per cent of the total area under Kinnow in the State (Anonymous, 2). Besides having favorable conditions for citrus cultivation, there exists large number of constraints hindering the production of quality fruits in Punjab, and insect-pests and diseases are major amongst all. Almost all parts of kinnow plants are vulnerable to insect infestation and disease attack. Citrus is attacked by more than 250 species of insects (Wadhi and Batra, 19) and number of diseases and disorders in India resulted remarkable yield loss in India. Kinnow in Punjab is damaged by number of pests like citrus psyllid (*Diaphorina citri*), leaf miner (*Phyllocnistis citrella*), citrus whitefly (*Dialeurodes citri*), citrus black fly (*Aleurocanthus woglumi*), citrus thrips (*Scirtothrips citri*) and different species

of aphids, mites, mealy bugs and many other important pests (Sharma, 14 and Singh *et al.*, 16). Among different diseases, citrus foot rot/gummosis (*Phytophthora* spp.), fruit drop (*Colletotrichum* spp.), citrus canker (*Xanthomonas axonopodis*), scab (*Elsinoe fewctii*), sooty mould (*Capnodium citri*), citrus greening (*Liberobacter asiaticum*), ring spot (CRSV), citrus tristeza (CTV) etc. are of economic importance in India and Punjab (Kumar and Dhaliwal, 10 and Savita *et al.*, 13). Though, kinnow mandarin is widely grown in South-western Punjab, there have been limited studies on the surveillance, incidence and abundance of insect-pests and diseases particularly in this zone of Punjab. This survey has become more pertinent in perspective of changing climatic conditions. Therefore, our study has aimed at understanding the incidence and severity of various insect-pest and diseases associated with kinnow mandarin in South-western Punjab under the prevailing agroclimatic conditions.

MATERIALS AND METHODS

Surveillance of insect-pests and diseases of kinnow mandarin was carried out in Fazilka region of southwestern Punjab during the 2016 and 2017. The study area receives 75-300 mm of annual rainfall occurring mostly during July to September. Climate of study area is semi-arid, characterized by hot and dry weather. The average annual temperature is 24.96°C and 24.26°C, whereas the maximum air temperature varied from 18.8 – 41.74°C and 17.94 – 40.42°C

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and the minimum temperature varied from 7.27-27.97°C and 6.91 – 27.35°C during 2016 and 2017, respectively. The daily weather data was recorded (Fig. 1) on Automatic Weather Station (Model No. DCPAW502, BioScientific Limited, UK).

Roving surveys were carried out to identify the key insect-pests and diseases of kinnow mandarin in semi-arid irrigated zone of South-western Punjab. The area was divided into 3 blocks. Ten villages were selected per block and within each village 10 random kinnow orchards were surveyed at fortnight interval during March - April; August – September and November-December months for the presence and severity of insect-pests and diseases. Five terminal shoots in all the directions of plant (10 cm length) per tree were selected for taking observations on different insect-pests viz. citrus psylla, aphids, leafminer, lemon butterfly, leaf folder etc. Population counts and damage levels were recorded for different pests. The natural enemies of the insect pests were also monitored. Incidence of trunk borer, bark eating caterpillar and white grubs were observed in the tree

trunk/roots and recorded at fortnight intervals for the whole year. The grading of population/ damage levels was done following the methodology of Sreedevi (17) with slight modification as given in Table 1a and 1b.

For recording disease incidence in each orchard, 20 trees were selected and disease incidence on fruits/foliage was assessed. These trees were sampled by making two diagonal transects across the field in the form of an “X” (10 plants along each diagonal). Disease incidence was determined as the proportion of plants showing disease symptoms, expressed as a percentage of the total number of plants assessed (Teng and James, 18). Diagnosis of the different diseases was based on morphological symptoms and except for citrus greening which was confirmed after molecular characterization of fruits from ICAR-Central Citrus Research Institute, Nagpur.

RESULTS AND DISCUSSION

The data on the survey conducted during 2016 and 2017 revealed that 18 insect pest and mites, 6 different species of natural enemies and 7 diseases

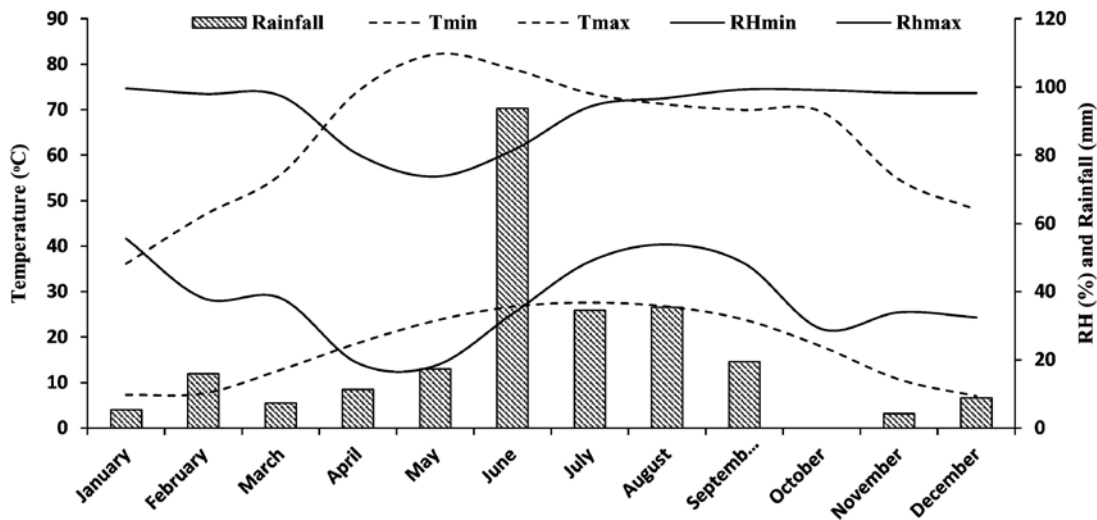


Fig. 1: Meteorological observations of Fazilka region of South-western Punjab during 2016 and 2017 (pooled)

Table 1a: Scoring of population/ damage levels of major insect pests of kinnow mandarin

Pest	% infestation in different categories				
	Negligible	Low	Moderate	High	Severe
Citrus psylla	<1	1-5	6-10	11-15	>16
Citrus aphids	<1	1-10	11-30	31-40	>50
Leaf miner	<1	1-5	6-15	16-30	>30
Thrips & Mites	<1	1-10	11-30	31-40	>50
Butterfly	<1	1-5	6-15	16-30	>30
Mealy bug	<1	1-10	11-30	31-40	>50

Table 1b: Scale used for recording mite and thrips infestation in kinnow fruits

Scale	Infestation level
1	Healthy
2	< 5% fruit scaring
3	5 - 20% fruit scaring
4	21 - 50% fruit scaring
5	> 50% fruit scaring

occurred in Kinnow mandarin ecosystem of South-western Punjab (Table 2). Citrus psylla, *D. citri* (30.99% incidence); Thrips, *Scirtothrips citri* and mites (26.68 % incidence); leafminer, *P. citrella* (15.44% incidence); lemon butterfly, *Papilio demoleus* (13.67% incidence); citrus aphids, *Toxoptera aurantii*, *Aphis gossypii* and *Myzus persicae* (8.05% incidence) and mealy bug (3.44% incidence) were the major insects infesting kinnow mandarin in the region (Fig. 3). Other insect-pests viz. citrus whitefly, *Dialeurodes citri*;

citrus black fly, *Aleurocanthus woglumi*; leaf folder, *Psorosticha zizyphi* bark eating caterpillar, *Indarbela quadrinotata*; root borer, fruit fly, *Bactrocera* spp.; and fruit sucking moths, *Otheris fullonica*; were found to infest kinnow plants in almost all the orchards in moderate to negligible intensity, respectively (Table 1a, 1b). It was imperative from the results that the incidence of insect-pest and diseases was more pronounced in kinnow orchards in Khuyian sarwar block of South-western Punjab as compared to other blocks (Fig. 3). Citrus psylla ranked first among different insect-pests in terms of its incidence and severity in surved kinnow orchards. The pest is highly severe in all the three blocks with its incidence ranged from 15.75 to 48.25 per cent. Though, infestation of thrips and mites on kinnow plants were moderate in the region but the scarring on the rind interferes with marketability. The incidence of thrips and mites on fruits ranged from 4.80 to 38.2 percent. Larvae of whitegrub, *Adoretus* sp. feeding on the roots of kinnow plants in some poorly managed orchards

Table 2: Insect-pest incidence in kinnow mandarin in different blocks of district Fazilka during 2016 and 2017

Sr. No.	Common Name	Scientific Name	Level of infestation in different blocks of district Fazilka			Period of activity
			Fazilka	Abohar	Khuyian Sarwar	
1	Citrus psylla	<i>Diaphorina citri</i>	Severe	Severe	Severe	Throughout the year
2	Aphids	<i>Toxoptera aurantii</i> , <i>Aphis gossypii</i> and <i>Myzus persicae</i>	Low	Low	Low	Feb. - April & August-September
3	Thrips	<i>Scirtothrips citri</i>	High	High	High	Feb-April & August-September
4	Leaf miner	<i>Phyllocnistis citrella</i>	Moderate	High	High	Feb. - April & August-September
5	Mites	Different species	Moderate	Moderate	Moderate	May-June & August-September
6	Mealy bug	<i>Planococcus citri</i> <i>Planococcus lilacinus</i>	Low	Low	Low	July-August
7	Whitefly	<i>Dialeurodes citri</i>	Low	Low	Low	March-November
8	Blackfly	<i>Aleurocanthus woglumi</i>	Low	Low	Low	March-November
9	Leaf folder	<i>Psorosticha zizyphi</i>	Low	Low	Low	May - October
10	Bark eating caterpillar	<i>Indarbela quadrinotata</i>	Negligible	Negligible	Negligible	September-October & January-February
11	Root Borer	Unknown species	Negligible	Negligible	Negligible	September-October & January-February
12	Whitegrub	<i>Adoretus</i> sp.	Negligible	Negligible	Negligible	August-November
13	Fruit fly	<i>Bactrocera</i> spp.	Low	Low	Low	July-August
14	Lemon butterfly	<i>Papilio demoleus</i>	Moderate	Moderate	Moderate	March-November
15	Fruit sucking moth	<i>Otheris fullonica</i>	Negligible	Negligible	Negligible	September - November

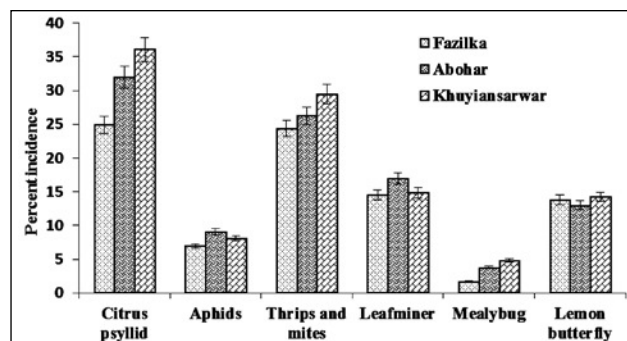


Fig. 3: Percent incidence of major insect pests of kinnow mandarin in semi-arid irrigated zone of South-western India

was reported for the first time from Punjab. Also the natural enemies prevalent in Kinnow agro-ecosystem were recorded during surveys. Overall 6 species of natural enemies viz. *Coccinella septempunctata*, *Coccinella transversalis*, *Brumus suturalis*, *Scymnus* sp. (Coleoptera: Coccinellidae), *Chrysoperla carnea* (Neuroptera: Chrysopidae), *Syrphid* sp. (Diptera: Syrphidae) and different species of spiders were prevalent in the kinnow agro-ecosystem.

During the survey, seven diseases infesting different parts of kinnow mandarin plants were observed in South-western Punjab (Table 3). Foot rot or gummosis (*P. parasitica*) was more prevalent in kinnow orchards with 23.33% incidence and high severity in the region followed by sooty mold (*C. citri*), fruit drop (*C. gleosporioides* & *C. natalensis*), physiological fruit drop (Hormonal imbalance), citrus canker (*X. axonopodis* pv. *citri*), citrus die back (*C. gleosporioides* & *D. natalensis* with 18.28, 13.33, 10.62, 4.39, 4.35% incidence, respectively, in the studied area during the study period (Table 3). Citrus greening (*L. asiaticus*) was observed in

some orchards of the region but the intensity was low (1.33% incidence). The disease was confirmed through molecular diagnosis of collected fruit samples at ICAR-CCRI, Nagpur, India.

Due to the changing agro-climatic conditions, considerable increase in monoculture, introduction of planting material from foreign countries and introduction of new crops affects the distributions of insect-pests, diseases and their vectors thus increased the threat of new plant pests are on higher side in the present era. We cannot deny the ill effects of globalization in agriculture sector but we can somehow manage them with proper monitoring and surveillance of the target crops to find out the introduction, incidence, dynamics and severity of the insect-pest and diseases.

In Punjab, area and production in Kinnow mandarin increased 2.61 and 4.02 folds from 2004-05 to 2016-17, respectively (Anonymous, 2). Resultantly the insect-pest and disease incidence was also increased. We have recorded 18 species of insects and mites and 7 diseases infesting kinnow plants in the region. We have only recorded insect-pests and diseases of major economic importance which are able to cause economic damage. Our findings are in accordance with the reports of Sreedevi (17) and Deka *et al.* (16) who reported 12 major species of insect pests damaging citrus during their studies conducted at Andhra Pradesh and Assam, respectively. However, Singh *et al.* (16) observed forty-five insect and mite pests on different parts of Kinnow tree in Punjab. The more number of species recorded by the authors are due to their efforts to collect more comprehensive and detailed information on citrus insect-pests irrespective of their economic importance. Kinnow is a perennial plant, thus prone to insect-pest and disease attack round the year. The insect activity on kinnow tree starts with the rise in

Table 3: Incidence of major diseases of kinnow mandarin in South-western Punjab during 2016 & 2017

S. No.	Common Name	Scientific Name	Severity of infestation	% incidence	Period of Activity
1	Foot rot /Gummosis	<i>Phytophthora parasitica</i>	High	23.33	Feb - March July - Aug
2	Physiological fruit Drop	Hormonal imbalance	High	10.62	May - June
3	Pathological fruit drop	<i>Colletotrichum gleosporioides</i> ; <i>Diplodia natalensis</i>	High	13.33	Sep - Oct
4	Die back	<i>Colletotrichum gleosporioides</i> & <i>Diplodia natalensis</i>	Low	4.35	Dec - Jan
5	Citrus greening	<i>Liberibacter asiaticus</i>	Low	1.33	Sep - Oct
6	Sooty mould	<i>Capnodium citri</i>	Moderate	18.28	Sep - Oct.
7	Citrus canker	<i>Xanthomonas axonopodis</i> pv. <i>citri</i>)	Low	4.39	July - August

temperature in second fortnight of February on the newly formed soft and succulent leaves and twigs. The nymphs and adults of citrus psylla along with different aphid species attacked new flush of kinnow plants. However, citrus psylla is more dangerous and notorious pest which is difficult to control as compared to aphids. Both adult and nymphs of citrus psylla sucks sap from the young leaves and twigs. High incidence cause mortality of new flush and the tree shows dieback symptoms. Also honey dew secreted by nymphs and adults of citrus psylla results in sooty mould development on leaves which interferes with photosynthetic activity of the plant. This is the major pest of kinnow in Punjab. Citrus psylla and aphid species are active in kinnow orchards of south-western Punjab in February to April and again in August – September, however, the adults of citrus psylla can be found on kinnow plants during the cool winters in December- January also. Our studies are in concurrence with the observations of Sharma (14) who worked on bio-ecology of citrus psylla.

Thrips infest flowers, leaves and developing fruits and the incidence was higher in March. Kaur (9) also suggest that *Scirtothrips citri* incidence is higher in South-western Punjab and its incidence was more during March-May months which also substantiate our findings. Leaf miner mainly a pest in kinnow nursery plants but its incidence was higher in on new flush of young kinnow plantations during February to April and again in August-September months which got support from the findings of Jadhav (8). Different species of mites are active on kinnow plants in Punjab were reported by Kaur (9). Mites infest kinnow leaves and fruits and the incidence was higher during hot and dry weather of May-June months and again during August onwards in south-western Punjab. Both mites and thrips make their economic importance by damaging rind in kinnow fruits and the average incidence recorded was 26.68 per cent on fruits during September month. The affected fruits don't show any biochemical changes, but gives a dusty/ scary look due to which these are not accepted by the consumers globally, which results in heavy monetary loss. The activity of citrus butterfly in kinnow orchards was noticed in between March to November months. The larvae defoliate the new and tender leaves, and the incidence was more severe in nurseries. Such type of studies will help in quantification of seasonal incidence and infestation dynamics of major pest species so that suitable management practices can be recommended and timely control measures can be adopted. Citrus psylla, citrus butterfly, leaf miner, leaf roller and thrips attack the new flush and tender leaves so a prophylactic spray during flushing stage will save the

crop from these pests. Fertilizer splits (mainly N) and irrigation scheduling also helps in regulating plant growth vis-a-vis insect-pest incidence.

Mealy bug, whitefly and black fly had shown low level of incidence in isolated and mismanaged orchards. Fruit flies though active in July - August months but their incidence in kinnow observed were very low. Similarly leaf folder incidence also on lower side but the activity of this pest was noticed up to October month. Among different soil borne pests bark eating caterpillar, root borer and whitegrub forming a major group of significant importance. These pests are generally occurred in old, infested, weedy and poorly managed orchards. But in severe form they cause heavy damage to plant system. During our survey we have recorded negligible incidence of these pests in few neglected or poorly managed orchards.

In perennial crops natural enemies plays a foremost role in regulating insect-pest populations to more or less extent. Pollen and nectar from flowering plants definitely enhance longevity, reproductive capacity and biological control impact of predators and parasitoids. Thus confirmation for the presence or absence of these beneficial insects in orchards and their *in situ* conservation is of prime importance for maintaining ecological stability. The survey showed the occurrence of about four coccinellid predator beetles, two general predators (*C. carnea* & *Syrphid* sp.) and different species of spiders found in the kinnow ecosystem. The intensity of bioagents was low in the kinnow orchards of the region due to intensive insecticide and fungicide applications. However, a good numbers of these agents were observed in organically managed orchards. The biological control forms the more viable component of integrated pest management systems. Hence, measures *viz.* to promote non-chemical approaches, use of selective molecules of green chemistry and to avoid broad spectrum non-selective insecticides should be considered while planning pest management strategies. The present work is substantiated with the findings of Sreedevi (17) and Deka *et al.* (6).

Seven different diseases with varying degree of incidence were observed to occur in kinnow plants in the studied region. Among all foot rot or Gummosis is highly active in south-western Punjab. The fungus i.e. *P. infestans* though active in soil throughout the year but its symptoms were more pronounced during February-March and July-August months on plants. Wilting, bark splitting and gummy substance oozes from stem and branches are one of the major symptoms of the disease. Initially plant shows yellowing and wilting of plant from one side

and lead to complete drying of fruits and foliage later in the season. *P. parasitica*, *P. citrophthora* and *P. palmivora* have been mostly involved in causing damping off, collar rot, foot rot, root rot and gummosis in citrus (Gade, 7 and Shekari *et al.*, 15). The possible region of higher incidence of foot rot in the studied region was infested planting material used by the farmers, flood irrigation and unawareness among farmers towards this disease was noticed during this study. About 20-50 per cent plants of Nagpur mandarin in Vidarbha, Maharashtra, 10-80 Per cent plants of *C. sinensis* and 10-100 Per cent plants of kinnow mandarin in Punjab (Naqvi 2002_a and Naqvi 2002_b) and almost all the citrus orchards in Tripura and Mizoram are seriously infested by *P. parasitica*, *P. citrophthora* and *P. palmivora*. They also suggested excessive flood irrigation is primary factor responsible for spread of disease which is in confirmation with our findings. The other diseases of major significance in South-western Punjab recorded were sooty mould and fruit drop. Sooty mould *i.e* black coloured superficial fungus develops on leaves which interferes with photosynthetic activity of the plant. The incidence was higher during September-October months. The severity of fruit drop in kinnow is high during September-October months in the region. There are several factors which affect its occurrence *viz.* physiological, environmental, and pathological factors (Ashraf *et al.*, 4). Citrus greening is emerging in orchards of south-western Punjab to a limited extent. Morphological symptoms showed variability in incidence and severity of the disease. The symptoms are mottling and chlorosis of appeared on leaves. Mottling in affected leaves resembles zinc deficiency symptoms and is important characteristic for this disease. However, fruits are under-developed, lopsided, poorly coloured (half green and half yellow/orange) with aborted seeds. The disease is widely distributed in almost all citrus growing countries in Asia and Africa (Batool *et al.*, 5). Akhtar and Ahmad (1) reported 22, 25 - 40, 15, 10 and 2 per cent incidence of citrus greening in Kinnow, sweet orange, grapefruit, sweet lime, and lemon orchards in Pakistan, respectively. They also observed variability in incidence and severity of disease at different locations which is in concurrence with our findings.

The schematic monitoring and surveillance of a particular cropping system in particular geographical area will help understanding the dynamics of insect-pests and diseases in relation to changing agroclimatic conditions. From the present study it can be concluded that 18 species of insects and mites and 7 diseases infesting kinnow plants in South-western Punjab. Obviously citrus psylla, *D. citri* is the

major pest-insect of kinnow mandarin in the region from the last decade but it gained more importance in the present time as vector of citrus greening disease. Incidence of mite and thrips has been increased in kinnow from last 2-3 years. Problem of pathological fruit drop showed significant rise in the region. Infestation of whitegrub in kinnow plants has been noticed for the first time. Keeping in view of this surveillance study we need to emphasize and start focused research on these new and emerging pest problems of kinnow mandarin.

AUTHORS' CONTRIBUTION

Conceptualization of research (MP & JKA); Designing of the experiments (MP & JKA); Contribution of experimental materials (MP & JKA); Execution of field/lab experiments and data collection (MP & JKA); Analysis of data and interpretation (MP, JKA & PKA), Preparation of the manuscript (MP, JKA & PKA).

DECLARATION

The authors declare no conflict of interest.

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