



Survey of insect-pests of citrus crop in Eritrea

A Haile^a, T Mesghena^b, S Nuredin^{b*} and M Yemane^b

Summary

Citrus is the main fruit crop in Eritrea with the main citrus species being orange, lemon and mandarin that are produced in 2064, 328 and 17 ha, respectively. The production and productivity of these fruit crops are affected by several pests. Citrus pest survey was conducted in major citrus growing regions of the country with the objectives to assess the type of citrus insect-pests in the different areas, study the natural enemies of the citrus pests and assess the nature of pest damage on the fruit crop. Pest assessments and counts by species were done using hand lenses under field condition and microscope in laboratory. The result of the study showed that citrus is affected by 21 different species of arthropods out of which 19 are insect species and the remaining 2 species are Acarina (mites). The insect pests cause citrus tree damage at different stage and on different parts of the tree such as leaves, stem, fruit and root. Of the 21 species, six are major pest and the remaining 15 species are minor pests. The six important pests are leaf miner, red scale, black scale, fruit fly, whitefly and red spider mites. Leaf miner, fruit fly and red spider mites were observed in all citrus production areas while the remaining three species were recorded in limited areas. Black and red scales incidence and severity were high in Hamelmalo, Elabered, Alla, and Durfo. Fruit fly is the main pest of citrus throughout the fruit producing areas of the country, threatening its production and cause 20-40 percent fruit dropping and rotting.

JAE 2022, Vol 14

Received: 22 Aug. 2022

Accepted: 05 Sept. 2022

Published: 20 Oct. 2022

<https://doi.org/10.53911/JAE.2022.14207>

JAE.2022.14207

Associate Editor: Dr.

Shravan M Haldhar

Copyright © 2022 The Author(s). Published by Society for Agriculture and Arid Ecology Research (SAAER). This is an Open Access article under the Creative Commons Attribution License 4.0 (CC BY-NC-SA).



Keywords: citrus; survey; insect-pest; natural enemies

INTRODUCTION

In Citrus is one of the most important fruit crops known by humans since antiquity. It is a flowering tree or shrub, small to moderate-sized tree, reaching 5–15 m tall, with spiny shoots and alternately arranged evergreen leaves, and it belongs to the family Rutaceae. Its center of origin is in Southeast Asia in parts of Northeast India, Burma (Myanmar) and the Yunnan province of China. The crop was first distributed to different parts of the world through trade; today the crop is cultivated in wide areas mainly in tropical and sub-tropical regions of the world between 40° north and south latitude in over 137 countries in six continents. Brazil, China, the United States of America, Mexico, India, and Spain are the world largest citrus producing countries in the world; the most common and widely cultivated citrus types in the world are orange, mandarin, lemon, lime, and grape fruit.^{2,3}

In Eritrea, citrus is a major fruit crop cultivated in the lower and mid altitudes of the country under irrigation; the history of citrus production in Eritrea goes back to the colonial times especially during the occupation of Eritrea by Italy. In the early 1960's, Eritrea used to export citrus fruits to the neighboring countries and Italy; later this was discontinued due to the long war with Ethiopia for independence. Citrus production in Eritrea covers over 2409 ha of land and the major citrus producing areas in the country are Alla, Ghindae, Anseba, river Barka, Shambuko, Tesseneye (river bank of Gash) and Omhajer along the bank of river Setit/Atbara. The main citrus types that are produced in the country are orange, mandarin, grab fruit, lemon and lime, and among these orange is the dominant type that covers the largest area 2064 ha; lemon and mandarin are produced in 397 and 45 ha in the country, respectively.^{8, 11, 14} Citrus fruits in Eritrea are consumed as table fruit and for making juice and as source of foreign currency through export. The production of this fruit crop is affected by different pests such as black scale, spider mites, aphids, whitefly and others; these pests cause great damage to the fruit crops and when unchecked by proper control methods, the loss

^aHamelmalo Agricultural College, Eritrea

^bMinistry of Agriculture, Eritrea

*Corresponding author: S Nuredin, E-mail: saidnur265@gmail.com

due to the pests is very high. In addition to the insect problems, inappropriate management practices such as spacing, poor irrigation system or poor soil fertility and unwise use of pesticides cause poor or low production. To understand the main causes for the decline of the citrus production in the country, study on citrus pests' and their nature of damage was investigated with the following objectives.^{1,12}

Materials and Methods

Surveys on citrus pests were carried out in main citrus producing regions of Eritrea; the study was conducted in five regions of the country that include Maekel, Debub, Northern Red sea, Anseba and Gash Barka. In each region the main citrus producing sub-regions and administrative villages were identified and selected for the study (Fig. 1). In each administrative village 4-5 citrus farms/orchards were selected at random and in each farmer's field 5-7 citrus trees were selected again at random for sampling

of citrus insect pests. From each tree, 7-10 leaves; 1-3 fruits and 4-5 stem (branches) samples were taken each from the lower, middle and upper part of the tree's canopy. The sample leaves, fruits and stem were collected each in separate paper bag for pest assessment. Pest assessments and counts by species were done using hand lenses and results were recorded. New pests that were difficult to identify under field condition were collected for identification in the laboratory by comparing with the already collected samples in the laboratory and by comparing with different figures or photos of books and references. Those pests that were difficult to identify in the lab were preserved and were sent abroad for identification by specialists. Some of the good samples were preserved and kept in the laboratory for future reference. During the survey samples of the citrus pests and pest infested citrus parts from each surveyed areas were collected and reared in the laboratory to study their natural enemies.

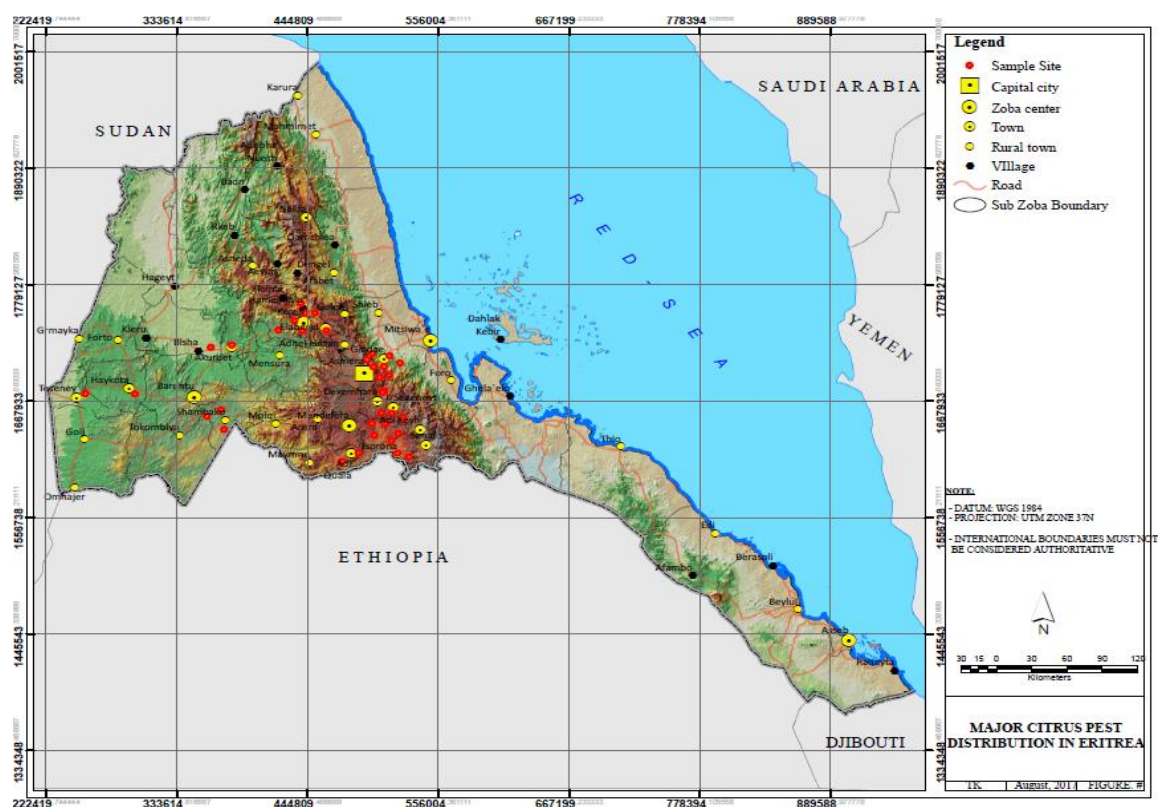


Fig. 1: Mapping of citrus insect-pest during survey areas

Results and Discussion

Citrus pests survey

Fibers The survey results showed that citrus trees are infested by several insect pests that vary from place to place. During the survey the citrus insect pests were found to affect the different stages of the crop and plant

parts such as leaf, stem, fruit and root. The majority of the citrus pests belong to Homoptera (aphid, whitefly, scale insects, mealy bug) followed by Coleoptera (citrus root chafer grub, wood borer), Lepidoptera (leaf miner, false codling moth), Diptera (fruit fly), Thysanoptera (thrips), Termites and Acarina (mites of different species). The result also divulged about 21 pest species affect the fruit

crops among these arthropod pests, fruit fly, black scale, woolly whitefly, leaf miner and red spider mites were recorded/observed throughout the survey areas causing severe damage on the different species of citrus fruit by

affecting the quality and quantity of the orange fruits (Tables 1-3). The study also showed that orange, lemon/lime and mandarin are affected by 19, 14 and 10 insect pests respectively (Fig. 2).

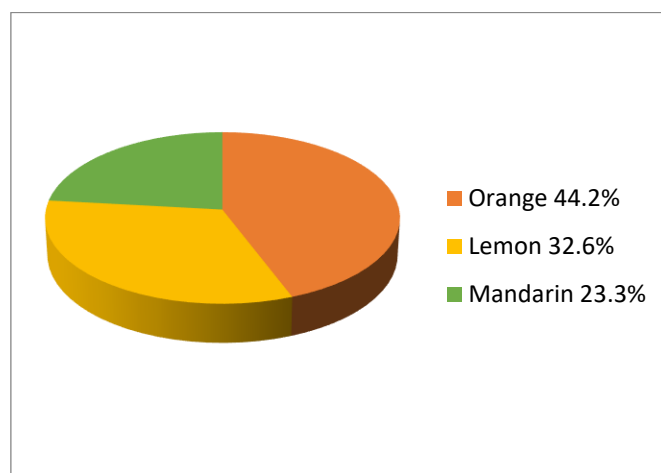


Fig. 2: Pest incidence on orange, lemon and mandarin

Pests of orange

Field survey on orange (*Citrus sinensis* L.) pests presented that this fruit crop is affected by 19 arthropod species out of which 17 species are insect pests while the remaining 2 species are Acarina (Table 1). The impact of these pests varies where some of them affect orange leave, other stem and some cause damage to orange fruits. Again out of the 19 species that affect orange trees, six are major pests that cause crop damage and reduce fruit production while the remaining are minor or sporadic pests that are found in low population and their distribution are limited to some areas (Table 1). The six major pests that have an effect on orange trees are leaf miner, red spider mite, fruit fly, citrus whitefly, black scale, and red scale. The incidence and infestation level of the six species vary from site to sites where leaf miner, red spider mite, and fruit fly were recorded in all the survey areas while the others are limited to some areas (Fig. 2). Yellow or orange scale, aphid species, false codling moth, citrus chafer grub, soft brown scale and citrus bud mites were recorded in one or few sites at a very low population, this could be due to climatic factor or they have efficient natural enemies that control the pests as soon as their population increases. Citrus chafer grub is a pest of lemon and orange when the orchard of these species is over 25 years old (Table 1).

The distribution and population of the major orange pests varies within locations. For example citrus whitefly was mostly distributed in the higher and mid altitudes, while its population in the lower altitudes of Tesseney,

Shambuko, Aquardate and Ghindae was low or absent. Leaf miner was recorded in all the surveyed areas, at low population and its impact on the crop is seasonal mostly after the rainy season or present in those farms which are irrigated frequently throughout the year (Fig. 3). Similarly the population and damage of the red spider mites is variable, its population and impact is severe in Tserona, Mai Aini and river Sebene basin as compared to other sites. Black and red scales do not have any pattern, these pests are found both in lower, middle or higher altitudes and their impact on the crop is very high by causing die back of the trees and affecting the quality of the fruit to have low market demand and value. Fruit fly was recorded and reported in all farmers and surveyed areas to cause high fruit damage and fruit droppings in all locations. During the survey two species of fruit fly were observed and their samples are collected for identification and for reference. In some areas like Binbina (sub zoba Shambuko), Alla (*Chehot*), Sebene basin, Mai Aini and Tserona the fruit dropping due to this pest is very high and sometimes rich over 40 % fruit damage and droppings (Fig. 3). In sub zoba Hagze orange was observed severely damaged by long tail blue bird, causing fruit damage at maturity. According to the farmer, the effect of the bird on fruit production is very high 1 to 3%.^{4,5}

Table 1: Insect pests of orange in major citrus growing areas of Eritrea, 2017

Insect pests	Scientific name	Orange insect pests and mites in the survey areas																
		1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Black citrus aphid Bca	<i>Toxopteraaurantii</i> B.de.F		Bca	Bca	Bca			Bca	Bca		Bca							
Aphid	<i>Aphis spiraecola</i> P			aphid														
Citrus whitefly wf	<i>Aleurothrix floccosus</i> Ash	wf	wf	wf	wf		wf	wf	wf	wf	wf							wf
Citrus thrips Cth	<i>Scirtothrips citri</i> Moul.		cth	cth	cth	cth			cth	cth	cth				cth			
Leaf miner Lm	<i>Phyllocnistis citrella</i> Stnt	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm
Black scale Bs	<i>Parlatoria zizyphus</i> L	Bs	BS						Bs	Bs	Bs		Bs	Bs			Bs	Bs
Red scale Rs	<i>Aonidiella aurantii</i> Mask	Rs	RS	Rs	Rs	Rs	Rs	Rs	Rs		Rs							
Orange scale Os				Os														
Soft brown scale Sbs	<i>Coccushesperidum</i> L	SbS	Sbs	Sbs				Sbs	Sbs		Sbs							Sbs
Cottony cushion scale Ccs	<i>Icerya purchasi</i> Mask	Ccs	Ccs	Ccs	Ccs			Ccs	Ccs	Ccs	Ccs				Ccs		Ccs	Ccs
Mealy bug Mb	<i>Pseudococcus citriculus</i> G		Mb						Mb		Mb							
Fruitfly FF1	<i>Ceratitis capitata</i>	FF	FF	FF	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1
Fruitfly FF2	<i>Bactrocera invadens</i>			FF2	FF2	FF2												
Orange dog Od	<i>Papilio demodocus</i> Esp		Od	Od	Od	Od	Od	Od	Od	Od	Od	Od					Od	
False codling moth Fcm	<i>Cryptophlebia leucotreta</i> M		Fcm	Fcm					Fcm									
Chafer grub Chg									Chg									
Red spider mite Rsm	<i>Tetranychus cinnabarinus</i> B	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm
Citrus bud mite Cbm	<i>Phyllocoptruta oleivora</i> A				Cbm				Cbm								Cbm	
Termite Ter	<i>Termite</i> spp															Ter		

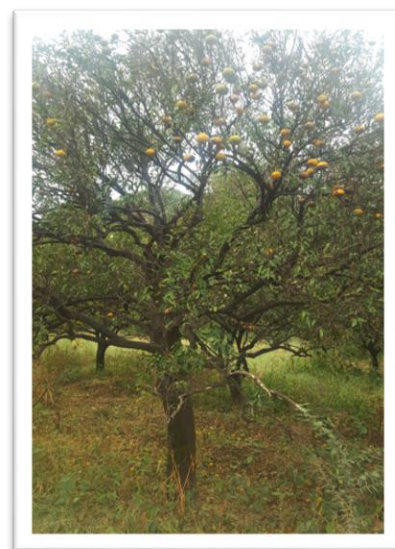
*1=Durfo, 2=Alla, 3=R.Sebene, 4=M.Aini, 5=Tserona, 6=K.Kemte, 7=Gundet, 8=Elaberred, 9=Keren, 10=Hamelmalo, 11=Hagaz, 12=Aquardet, 13=Degee, 14=Shambku, 15=Tesseney, 16=Ghindae, 17=M.Habare



Fruit fly Mai Aini



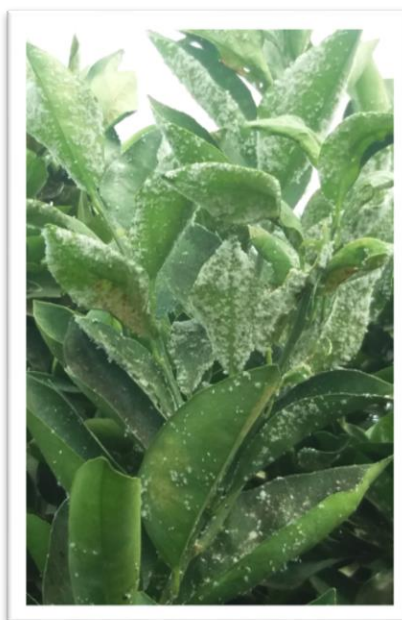
Fruit fly Binbina



Fruit fly Sebene



Cottony cushion scale-Sebene



Whitefly-Alla



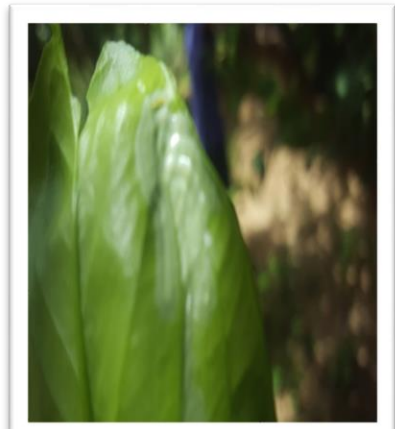
Red Spider mite-Mai Aini



Red scale Gundet



Black Scale-Hamelmallo



Leaf miner-Tekreret

Fig. 3: Pests of orange in different sites

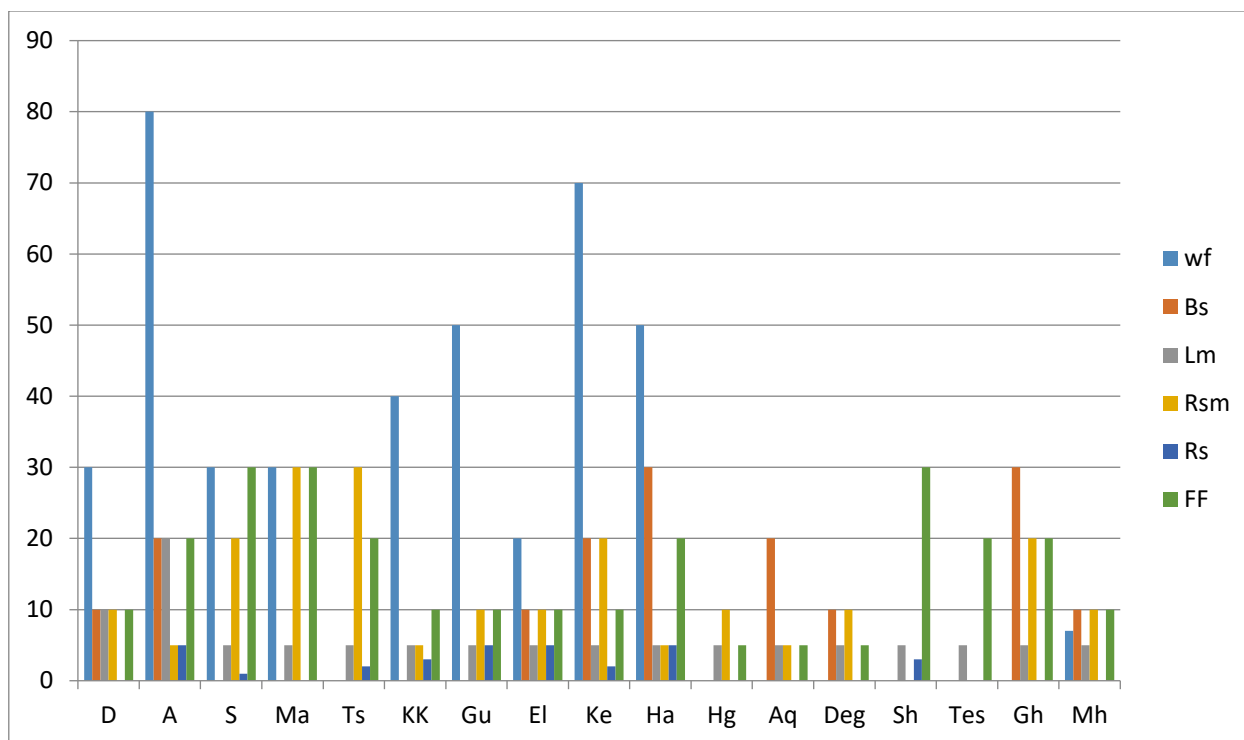


Fig. 4: Incidence of major orange pests

Pests of lemon and lime

Lemon and lime in Eritrea are infested by different insect pests and mites (Acarina). During the survey it was observed that these crops were attacked by 12 insect pests and 2 Acarina species (Table 2). The distribution and importance of these pests varies from area to area. Some of them are major pests of lemon and lime while others are minor pests and their impact on the fruit production is quite low. Like that of orange, leaf miner, red spider mites, black scale, red scale, whitefly and white scale are the major pests of lemon and lime in the country (Fig. 5).

Incidence and severity of lemon and lime pests

White scale was observed in Hamelmalo, Keren, Elabered, Mai Aini and Ghindae as major pest of lemon, affecting its fruits quality and reduce its market demand (Fig. 6). The severity and incidence of this pest was very high in Alla and Hamelmalo with 10% infestation each followed by Keren, Elabered and Durfo (Fig. 6). There was no whitefly infestation on lemon in Hagaz, Deggee and Shambuko. Black scale highest incidences was recorded in Hamelmalo and Keren with 30 and 20 % infestation respectively, whereas in Alla, Mai Aini, and Elabered the infestation of this pest was 10% in each of these sites.

The incidence of red scale was low in all the sites when compared to black scale but its damage on the lemon trees was very severe, causing die back and plant death in some cases. The infestation of whitefly in the survey sites was very high as compared to other pests of lemon. The highest whitefly infestation was recorded in Hamelmalo (40%) followed by Keren (30%) and Alla (30%). Its incidence in Durfo, Mai Habaer and Mai Aini was 10 percent for each site. There was no whitefly infestation in the lower altitudes of Hagaz, Deggee, Shambuko and Ghindae. Leaf miner was observed in all the lemon and lime producing sites, however, its population was very low to cause tree or leaf damage. Red spider mite was recorded in 14 sites of lemon growing areas.¹⁷ Its incidence and damage was high in Ghindae and Mai Aini where it causes leaf damage and fruit discoloration. The fruit discoloration and scarification cause lower market demand and value (Fig. 5). A new lemon pest was recorded in sub zoba Hamelmale at Gonfol that attack stem of lemon. It belongs to Order Coleoptera, Family Bostrychidae very similar to the greater borer of cereals. The damage is caused by the black adult beetle, which make a tunnel upward of the stem and make sawdust-like fragments drop to the ground. Specimen of the pest is collected and it will be sent overseas for identification.^{6, 7, 13, 15, 16}

Table 2: Insect pests and mites pests of lemon and lime, 2017

Insect pests	Scientific name	Lemon and lime insect pest and mites													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Black citrus aphid Bca	<i>Toxoptera aurantii</i> B.de.F			Bca		Bca			Bca	Bca					
Whitefly wf	<i>Aleurothrix floccosus</i> Ash	wf	Wf	wf	wf	wf	wf	wf	wf	wf					wf
Citrus thripscth	<i>Scirtothripscitri</i> Moul.		Cth				cth	cth	cth	cth			cth		
Leaf miner Lm	<i>Phyllocnistis citrella</i> Stnt	Lm	Lm	Lm	Lm	Lm	Lm	Lm	Lm	lm	Lm	Lm	Lm	Lm	Lm
Black scale Bs	<i>Parlatoria zizyphi</i> L	Bs	Bs		Bs			Bs	Bs	Bs				Bsc	Bsc
Lemon White scalelws			lws					lws	lws	lws					
Red scale Rs	<i>Aonidiella aurantii</i> Mask	Rs	Rs	Rs		Rs	Rs	Rs	Rs	Rs					
Soft brown scale Sbs	<i>Coccus hesperidum</i> L						Sbs			Sbs					
Cottony cushion scale Ccs	<i>Icerya purchasi</i> Mask	Ccs	ccs	Ccs	Ccs				ccs	CCs					
Orange dog Od	<i>Papilio demodocus</i> Esp		Od	Od	Od					Od					
Chafer grub Chg	<i>Rhobdotiss obrina</i> G							Ch							
Red spider mite Rsm	<i>Tetranychus cinnabarinus</i> B	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rsm	Rem	Rsm	Rsm	Rsm
Citrus bud miteCrm	<i>Aceria sheldoni</i>													Crm	
Wood borer wb	<i>Apatemonachus</i> G									wb					

*1=Durfo, 2=Alla, 3=R.Sebene, 4=M.Aini, 5=K.Kemte, 6=Gundet, 7=Elabered. 8=Keren, 9=Hamelmalo, 10=Hagaz, 11=Degee, 12=Shambku, , 13=Ghindae, 14=M.Habare

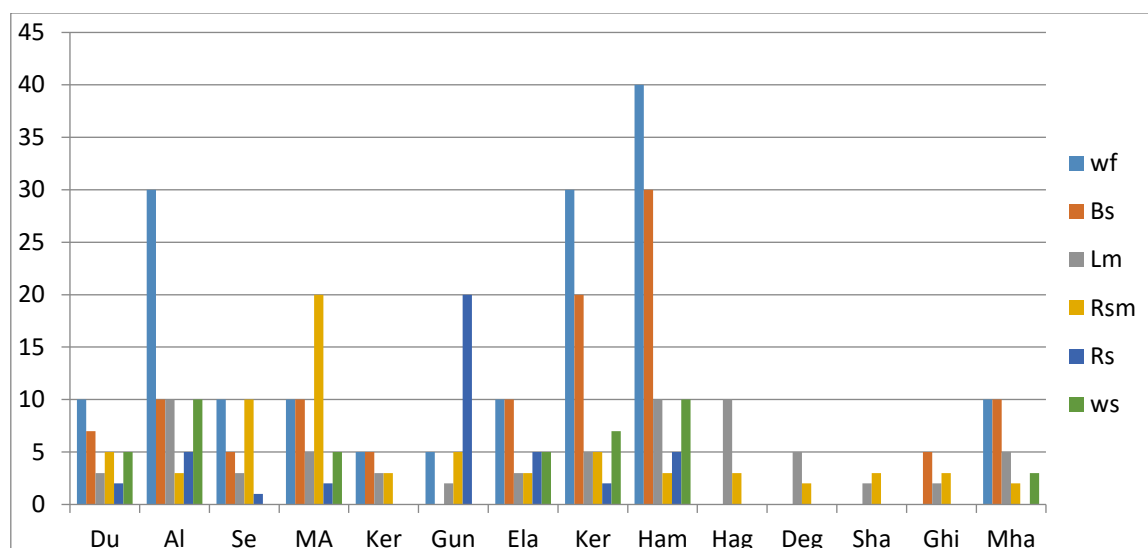


Fig. 5: Incidence and severity of lemon pests, Eritrea 2017



Fig. 6: White Scale on lemon in Alla

Pests of mandarin

It During the survey mandarin was recorded in nine location mostly produced by big farms like Elabered, Eritrean Defence Force (EDF), Chatolic church and few private farms that are distributed in different parts of the country. The pests of Mandarin and orange are almost the same except they varies in incidence and severity. Survey of mandarin pests showed that the fruit crop is affected by 10 pest species of which 9 are insect pests and one is Acarina (Table 3).

Incidence and severity of mandarin pests

The most important pests of mandarin are whitefly, black scale, leaf miner, red spider mite and fruit fly (Fig. 7) and (Table 3). Whitefly infestation is very high in Hamelmalo, Alla and Keren with 50, 40, and 30% respectively followed by Mai Aini 20% and Durfo 10%. Heavy infestation of this

pests results in sooty mold covering of leaf and fruit discoloration. Whitefly infestation was not recorded in Hagaz, Ghindae and Shambuko. Fruit fly (*Ceratitis capitata*) is one of the major pest of mandarin fruit that cause fruit damage and rotting. The pest was recorded in all the mandarin growing areas. The incidence of fruit fly in Shambuko, Mai Aini, Alla and Ghindae was 40, 30, 25, and 20% respectively. Lowest infestation (15%) was recorded in Durfo, Keren and Hagaz. Leaf miner infestation was recorded in all mandarin growing areas, like orange and lemon its population was low during the dry period. There was black scale infestation in most mandarin growing areas except Hagaz, Shambuko and Ghindae. Highest infestation was recorded in Hamelmalo (30%) followed by Keren, Elabered, Alla, and Mai Aini. Red spider mite was observed in all mandarin growing areas its highest infestation and damage was recorded in Ghindae and Mai Aini (Fig. 7).

Table 3: Insect pests and mites pests of mandarin, 2017

Insect pests	Scientific name	Mandarin growing areas								
		Durfo	Alla	M.Aini	Elaberid	Keren	Hamelmalo	Hagaz	Ghindae	Shambko
Citrus whitefly wf	<i>Aleurothrix floccosus</i> Ash	Wf	wf	wf	wf	wf	wf			
Citrus thrips Cth	<i>Scirtothrips citri</i> Moul.		Cth		cth		cth			
Leaf miner Lm	<i>Phyllocnist citrella</i> Stnt	Lm	Lm	Lm	lm	lm	lm	lm	lm	lm
Black scale Bs	<i>Parlatoria zizyphus</i> L	Bs	Bs	Bs	Bs	Bs	Bs	Bs	Bs	
Red scale Rs	<i>Aonidiella aurantii</i> Mask		Rs			Rs				
Cottony cushion scale Ccs	<i>Icerya</i> 52urchase Mask		Ccs	Ccs	Ccs	Ccs	Ccs		Ccs	
Fruit fly FF1	<i>Ceratitiscapitata</i>		FF1	FF1	FF1	FF1	FF1	FF1	FF1	FF1
Red spider mite Rsm	<i>Tetranychus cinnabarinus</i> B	RSm	Rsm	Rsm	Rsm	RSm	RSm	Rsm	Rsm	Esm
Soft brown scale Sbs	<i>Coccushesperidum</i> L	Sbs			Sbs	Sbs				
Orange dog	<i>Papiliodemodocus</i> Esp									

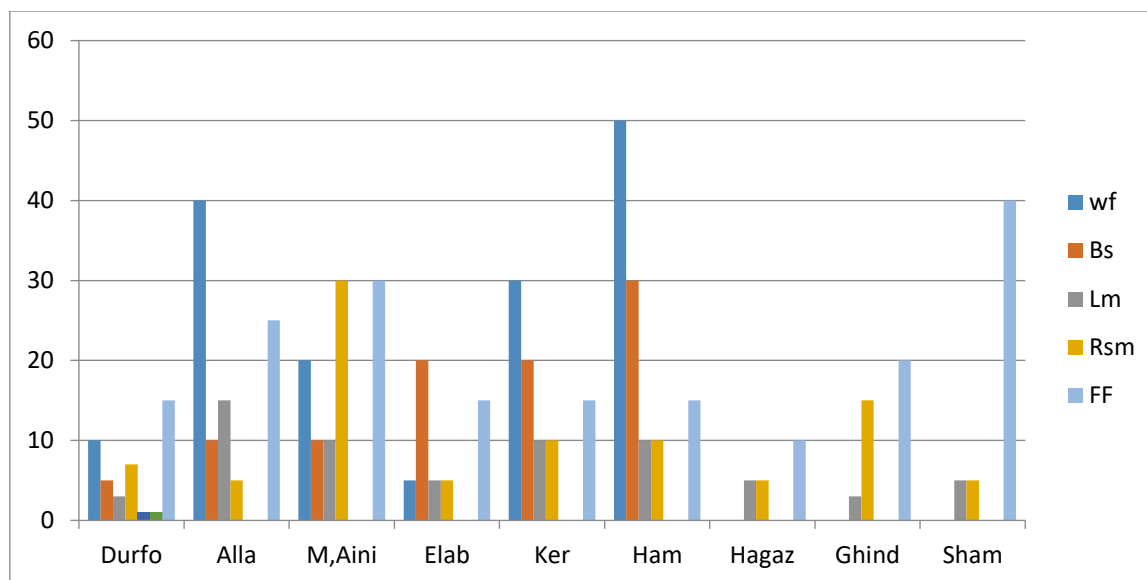


Fig. 7: Incidence and severity of mandarin pests, Eritrea 2017

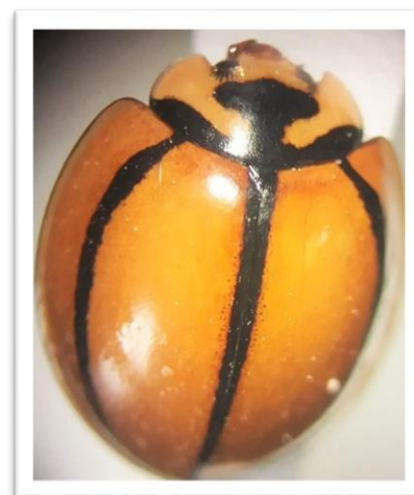
Natural enemies

Natural enemies of citrus pests that include predators and parasitoids were collected and reared in the laboratory (Table 4). Natural enemies are very important in biological and eco-friendly pest management. Some of the natural enemies are very common and present in large number. Whitefly is affected by two Coccinellid predators and two parasitoids, similarly both black and red scales observed affected by predators and parasitoids. High parasitism of leaf miner was observed

in Hagaz. In most citrus producing parts of the world leaf miner is miner pest mainly due to this pest is controlled by natural enemies. During the survey it was noted that soft brown scale and aphids were highly parasitized by natural enemies, it could be due to the natural enemies that the population of these pests is very low. The collected natural enemies will be sent overseas for identification and to have expertise view on their efficiency to be used in biological control of their respective hosts.^{9, 10, 18}

Table 4: Natural enemies of some citrus pests

Pest	Predators		Parasitoids	
	Family	No species	Family	No species
Whitefly	Coccinellidae	2	Braconidae	2
Red scale	Coccinellidae	2	Braconidae	3
Black scale	Coccinellidae	1	Braconidae	2
Leaf miner			Braconidae	1



Coccinellid predator of citrus pests



Fig. 8: Natural enemies of citrus pests

Conclusion

The present study exhibited that citrus is affected by 21 arthropod species out of which 19 are insect species and two are Acarina (mites). Again out of the 19 insect species 5 are major pests that threatened the production of citrus while the remaining 15 species are minor pests that are sporadic and found in low population with less effect on the fruit crop. The six major citrus pests are whitefly, leaf miner, black and red scale, fruit fly and red spider mites. Leaf miner, red spider mites and fruit flies were recorded in all the survey areas. During the survey different natural enemies that consisted of five predators and seven parasitoids were recorded to affect the citrus pests. These natural enemies are collected and preserved for identification by experts. The citrus management practices disclosed that farmers in the citrus producing areas exercise pest control using insecticides such as Malathion and dimethoate and cultural practices like pruning and washing of the infested parts. The frequency of pest control and its efficiency were low to control and minimize the pest population in all areas. During the study it was observed that knapsack is the main type of sprayer used and farmers do not wear protective cloth during pesticide application. In addition, the survey revealed that integrated pest management is not practiced by most farmers even by the large farms owned by the state.

Declaration of interests

The authors have no conflict of interest to declare.

Data sharing

All relevant data are within the manuscript.

Acknowledgments

The authors acknowledge all farmers for their unreserved cooperation in providing the necessary information, and for allowing us to assess pest intensity and to collect samples from their orchards. The authors also gratefully acknowledge FAO-Eritrea for financial support and The Ministry of Agriculture for transport support and for allowing laboratory use for insect rearing and identification.

References

- 1 Adugna H. 2014. An Annotated list of Field Insect Pests, Storage Pests and Acarina in Eritrea, Hamelmalo Agricultural College.
- 2 Andemeskel WH. 1987. Handbook of insect pests of major crops in Eritrea Administrative Region of Ethiopia and their control, Asmara University.
- 3 Crow, T & Shitay GM. 1977. Crop pest Handbook. Institute of Agricultural Research, Ethiopia.
- 4 Crow T, Tadesse GM & Tsedeke A. 1975. An Annotated list of Field Insect Pests, in Ethiopia, Institute of Agricultural Research, Ethiopia.
- 5 Goosens PA, Adhanom N & Tsedeke A. 1981. Armoured scale on citrus in Ethiopia. Their identification and control. Institute of Agricultural Research Ethiopia, 1981.
- 6 Hill D & Waller JM. 1985. Pests and diseases of Tropical Crops. Vol. 1: principles and methods of control. Intermediate Tropical Agriculture. Longmans, ISBN 0582 606144 London, 1985.
- 7 Hill D. 1974. Agricultural insect pests in the tropics and their control. Cambridge University press ISBN 0521 24628 5, London, 1974.

- 8 ISPM 6. 2016. Guidelines for Pest Surveillance. International Plant Protection Convention, FAO, Rome, 1997
- 9 James K. & Munyaradzimukoni. 2017. Fruit fly control in Kenya. Spore: No. 185, June-August 2017.
- 10 Pinhey ECG. 1968. Introduction to insect study in Africa. Oxford University Press, London 1968.
- 11 Tsedeke A. 1985. A Review of crop Protection Research in Ethiopia. Proceedings of the First Ethiopian crop protection Symposium. Institute of Agricultural Research, Ethiopia.
- 12 Tsedeke A. 1984. Observations on populations of red Scale *Aonidirla aureantii* and its Natural Enemies on citrus at Koka. *Ethiopian Journal of Agricultural Sciences*, 2: 102-114.
- 13 Singh KI, Dilip RK, Sanatomba A & Haldhar SM. 2021a. A case study of insect pests responsible for mass citrus decline in Manipur and their control remedies. *J. Appl. Zool. Res.*, 32 (2): 187-195.
- 14 Gora JS, Chet Ram, Poonia PK, Choudhary M & Haldhar SM. 2022. Polyploid rootstocks in citrus for mitigation of biotic and abiotic stresses: A review. *Journal of Agriculture and Ecology*, 13: 1-19.
- 15 Singh S, Sandhu RK and Haldhar SM. 2021b. Biodiversity and integrated management of insect and mite pests of citrus in India In: Souvenir-cum-abstracts book: National Seminar on Conservation and Commercialization of Citrus Biodiversity in NEH Region (Eds. Singh SB, Dilip Singh RK, Haldhar SM, Piloo Ng, Sarangthem I and Hazarika BN). *Pub: Directorate of Research, CAU, Imphal*, pp. 151-165; ISBN: 978-81-947184-2-0.
- 16 Singh S, Sandhu RK, Haldhar SM, Reddy PVR, Deka S, Reddy DS, Irulandi S, Shete MH, George A, Singh V, Siraj M & Patil P. 2021c. Integrated pests management in citrus crops. In: Pest Management in Dryland Horticultural Crops (Eds. Haldhar SM and Maheshwari SK). *Biotech Books*, pp: 243-268; ISBN: 978-81-7622-491-8.
- 17 Gora JS, Kumar R, Chet Ram, Berwal MK & Haldhar SM. 2021. Citrus decline and its management in arid region. In: Pest Management in Dryland Horticultural Crops (Eds. Haldhar SM and Maheshwari SK). *Biotech Books*, pp: 269-280; ISBN: 978-81-7622-491-8.
- 18 Haldhar SM & Deshwal HL. 2017. Fundamentals of Agriculture Entomology. *New vishal publication, New Delhi* pp: 1-452, ISBN: 819333970-3.