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RESEARCH ARTICLES

Assessment of Major Diseases and Insect Pests of Horticultural Crops in Eastern Amhara, Ethiopia

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Abstract

Diseases and insect pests are serious problems affecting horticultural crops grown in mid and lowland areas. A systematic survey was conducted to assess the distribution, incidence, and severity/damage levels of diseases and insect pests of horticultural crops in the mid- and lowland areas of the North and South Wollo zones (Kalu, Tehuledere, Habru, and Kobo districts) during the 2017/2018 main and irrigation seasons. During the survey, a total of 279 fields on 14 different horticultural crop types were addressed. As revealed by the assessment, horticultural crops are subjected to numerous pests. Citrus woolly whitefly (*Aleurothrixus floccosus*) and leaf miner (*Phyllocnistis citrella*) on citrus; fruit flies (*Thepritidea species*) on coffee; diamondback moth (*Plutella xylostella*) on cabbage; and thrips on onion were the most destructive insect pests in the area. Especially, woolly whitefly in Kobo and leaf miner in Kalu districts were the major pests of citrus, with severities of 38.97% and 31.84%, respectively. Regardless of location, leaf miner was the most severe pest (42.31%) at the seedling stage of citrus. whereas, anthracnose (*Colletotrichum* species) and powdery mildew (*Oidium caricae*) on mango, anthracnose on avocado, purple blotch (*Alternaria porri*) on onion, and black sigatoka (*Pseudocercospora fijiensis*) on banana were found to be the major diseases in their order of damage level and occurrence. This clearly indicates the need for regular and targeted pest monitoring on the one hand and the development of management options for the most important horticultural crop pests of the area on the other.

Keywords: citrus, diseases, insect pests, mango, severity, survey

Introduction

Horticultural crops play a significant role in developing countries like Ethiopia, both in social spheres for improving income and nutrition status. In addition, it helps in maintaining ecological balance since horticultural crop species are so diverse (Jibat, 2003). Several species of fruit crops, such as citrus, grape, pineapple, banana, papaya, avocado, mango, and temperate fruits like peach and apple, are grown in Ethiopia (Abraham, 2009). Similarly, different types of leafy, root, bulb, and fruit vegetables are grown in different agro-climatic regions of the country under rain-fed and irrigated conditions. The most important ones include tomato, onion, hot pepper, and cabbage. The production of vegetable crops in Ethiopia is expanding as irrigation schemes expand (Gashawbeza et al., 2009).

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The Amhara region is endowed with diverse agro-ecologies, fertile soil, and abundant water resources. It has a huge potential for the production of a variety of agricultural products, including horticultural crops (Melkamu et al., 2015). According to the Central Statistics Agency (2016), 4,839.14 ha of land were under fruit crop production in the Amhara region, and 23,803.3 tons of yield were obtained in the 2015/2016 season. Within five years, the area covered rose to 5,823.79 ha, with 34,357.9 tons of production (Central Statistics Agency, 2021). According to the 2015/2016 area coverage, 2,257.1 ha of fruit land was in the North Wollo, South Wollo, and Oromia zones of Eastern Amhara (Central Statistics Agency, 2016). Production trends over the last five years indicate that total area planted and production quantities have expanded by 25% and 45%, respectively. However, national average yields fluctuated, and this variation considerably varies across fruit crops. For example, from 2015 to 2020, orange yields declined by 17.6%, while mango yields increased by 3.02% (Central Statistics Agency, 2016; Central Statistics Agency, 2021). The occurrence of diseases and insect pests is among the serious problems affecting most horticultural crops grown in mid- and low-altitude areas of the Amhara Region (Melkamu et al., 2015). It is known that the occurrence and severity of crop pests vary with crop type, environment, farming system, and crop variety. The problem is particularly more serious on citrus fruits, which could reach up to 50% (Gezahegne et al., 2016). Seid et al. (2013) pointed out that insect pests and diseases were severe during the winter season. The major cause of post-harvest loss in horticultural crops is pre-harvest infection. Despite numerous efforts to promote and distribute improved production packages in major tropical fruit-growing areas, disease and insect-pest management packages were found to be limited, especially for perennial fruit crops (Minyahil, 2015).

The Eastern Amhara region is characterized by a bimodal rainfall pattern with short rainy seasons from March to May due to easterly winds and the main rainy season from mid-June to September (Wale et al., 2013). The bimodal nature of the study environment favors the development of most diseases and insect pests. Previous studies on fruit crop protection focused on assessing and documenting pests that attack horticultural crops and prioritizing their importance in certain regions. These include the Central Rift Valley, North Shoa, Eastern Ethiopia, Southern Ethiopia, and Gambella regions (Minyahil, 2015). There are also limited and fragmented reports on diseases and insect pests attacking vegetable crops. However, documentation and research interventions on major diseases and insect pests of horticultural crops in the Eastern Amhara region are either old or lacking. Thus, this study was conducted to gather baseline information on the diseases and insect pests of horticultural crops to inform future research and development interventions.

Materials and Methods

Description of the Survey Area

The survey was conducted in the south Wollo and north Wollo zones at two districts from each zone, viz., Kalu, Tehuledere, Habru, and Kobo. The survey sites are found in latitude 10.13136–11.13122, longitudes 39.72491–39.97927, with an altitude range of 1405–1595 masl. At Kalu citrus, mango, onion, and tomato are dominant horticultural crops, and it is located with a latitude of 11.28903–11.37495, a longitude of 39.6443–39.71928, and an altitude range of 1666–2153 masl. At Tehuledere, citrus and hot pepper are dominant crops, and the district is located with a latitude of 11.56392–11.68402, a longitude of 39.60838–39.72466, and an altitude range of 1411–1891 masl. At Habru, mango, citrus, and coffee are dominant horticultural crops, and it is located with a latitude of 11.70086–12.08251, a longitude of 39.62047–39.68848, and an altitude range of 1242–1582 masl. Similarly, at Kobo, citrus, onion, and mango are dominant horticultural crops.

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Sampling and Assessment of Disease and Insect Pest

The survey was conducted during the 2017/2018 main and irrigation production seasons in the major horticultural crop production areas of Eastern Amhara (Figure 1). The sampling method was multi-stage. Representative horticultural crop-producing districts were selected purposively in consultation with the respective zone experts, based on existing horticultural crop production. Then, for a particular horticultural crop, fields were selected in each district using systematic random sampling within a 3-5 km radius, following the main and side roads. Whereas for a field having more than one horticultural crop, either mixed or side by side with more than 10 perennial fruit trees and/or 0.125 ha annual horticultural crop field, was considered as an independent sampling field.

The assessment was conducted on an individual-tree basis for perennial fruit crops (3-5 fruit trees per field) and using a 1 m × 1 m quadrat for annual horticultural crops (5 quadrats per field). Data on incidence (%), severity (1-9 scale), and number of insects per plant at different growth stages, damaged plant parts, and altitude were collected. For most of the insect pests direct coverage of infestation percentage was recorded while for some insect pests like wooly whitefly infestation score for the whole plant was done using a 1-5 scale as described by Kerns and Tony (1998): 1, no whiteflies; 2, <10% leaf area covered; 3, 11%-20% covered; 4, 21%-50% covered; and 5, >50% covered. Moreover, diseases and insect pests were categorized as major, intermediate, and minor, based on their level of occurrence and damage. Pest identification was conducted under field conditions using field guidebooks and in the laboratory following standard procedures for insects and diseases.

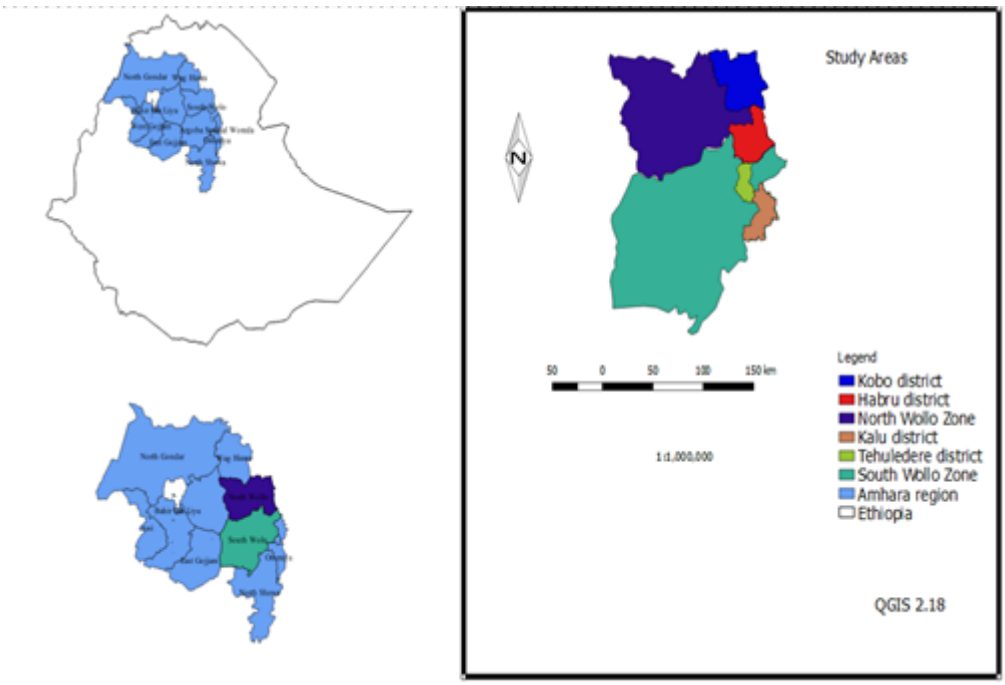
The severity grades were converted into a percentage severity index (PSI) for analysis (Wheeler, 1969).

$$\text{PSI} = \frac{\text{Snr}}{\text{Npr x Msc}} x100$$

Where Snr is the summation of numerical ratings, Npr is the total number of plants rated,

Figure 1

Map of Ethiopia Showing the Amhara Region and Specific Study Districts



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and Msc is the maximum score of the scale. Means of the severity from each plot were used in data analysis. The recorded pests were categorized as minor, intermediate, and major pests based on the pest assessment manual developed by Crew (Crew, 1984) as cited on (Shibabaw et al., 2013).

Data Analysis

The data on disease and insect pest incidence and severity were summarized in Microsoft Excel and reported in tabular form as mean, maximum, minimum, and standard deviation. To assess whether there were statistically significant differences between treatments or sampling sites, the data were further analyzed using the Kruskal–Wallis test in R. While the direct field presence or absence was described for some migratory insect pests, such as the blister beetle on pepper and tomato, and entire plant-damaging diseases, such as wilt on pepper and dieback on citrus.

Results and Discussion

According to Ministry of Agriculture (1988), the assessment areas, covering an altitude range of 1242 to 2153 masl, could be classified into two agro-ecologies. The midland, which includes areas with an altitude greater than 1800 masl, and the lowland, with an altitude less than 1800 masl. The agro-ecologies differ with the different horticultural crops grown. Of the 279 fields, 14 different horticultural crops were assessed. The most common fruit crops were mango, sweet orange, banana, and coffee. whereas onion, hot pepper, tomato, and head cabbage were among the vegetable crops (Table 1). Papaya (91.7%), lemon (85.7%), hot pepper (58.3%), coffee (52.2%), tomato (43.7%), avocado (42.9%), banana (37.5%), and sweet orange (32.6%) were assessed at the fruiting growth stage. whereas mango (65.4%) was assessed in the shoot dormancy period (Table 2). Clearly, most of the assessed horticultural crops were in the reproductive growth stage, except for mango, which was in shoot dormancy.

Table 1

Horticultural Crops Assessed at each District, North Wollo and South Wollo Zones, 2018

Horticultural crops	Districts				Total
	Habru	Kalu	Kobo	Tehuledere	
Avocado	3	3	6	2	14
Banana	12	2	5	5	24
Carrot	0	0	0	2	2
Coffee	11	3	5	4	23
Head cabbage	0	2	4	5	11
Hot pepper	3	7	6	8	24
Lemon	1	3	2	1	7
Mango	22	13	12	5	52
Mandarin	1	3	0	5	9
Onion	8	10	8	1	27
Sweet orange	15	13	6	12	46
Papaya	4	3	5	0	12
Potato	3	0	0	2	5
Tomato	3	10	7	3	23
Total	86	72	66	55	279

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Table 2

Number of Horticultural Crop Fields Assessed by Growth Stage in 2018 Season

Host plant	Growth stages						Total
	Dormancy	Flowering	Fruiting	Ripening	Seedling	Vegetative	
Avocado	1 (7.1)	2 (14.3)	6 (42.9)	0	2 (14.3)	3 (21.4)	14
Banana	0	0	9 (37.5)	2 (8.3)	1 (4.2)	12 (50.0)	24
Carrot	0	0	1 (50.0)	0	0	1 (50.0)	2
Coffee	0	0	12 (52.2)	10 (43.5)	0	1 (4.3)	23
Cabbage	0	0	3 (27.3)	2 (18.2)	1 (9.1)	5 (45.4)	11
Pepper	0	1 (4.2)	14 (58.3)	1 (4.2)	4 (16.7)	4 (16.7)	24
Lemon	0	0	6 (85.7)	1 (14.3)	0	0	7
Mango	34 (65.4)	4 (7.7)	0	0	7 (13.5)	7 (13.5)	52
Mandarin	0	0	2 (22.2)	7 (77.8)	0	0	9
Onion	0	0	0	7 (26.0)	4 (14.8)	16 (59.2)	27
S.Orange	4 (8.7)	0	15 (32.6)	16 (34.8)	4 (8.7)	7 (15.2)	46
Papaya	0	1 (8.3)	11 (91.7)	0	0	0	12
Potato	0	2 (40.0)	0	1 (20.0)	0	2 (40.0)	5
Tomato	0	4 (17.4)	10 (43.7)	3 (13.0)	1 (4.3)	5 (21.7)	23
Total	39	14	89	50	24	63	279

Notes. Numbers in parenthesis is the percentage, fruiting in the table stands for tubering for tuber crops, head forming for vegetables like cabbage, and ripening is maturity for fruit crops.

Table 3

Insect Pests Recorded, Affected Plant Species, Plant Part, and Status in Eastern Amhara During 2017/2018 Season

Common name	Scientific name	Plant species	Plant part	Status
African bollworm	*Helicoverpa armigera*	Tomato	Fruit	Intermediate
Fruit fly	*Tephritidae s*pp	Coffee, Sweet orange	Fruit	Major on coffee
Diamondback moth	*Plutella xylostella*	Head cabbage	Whole aerial part	Major
Aphid	Different spp.	Head cabbage, Tomato, mango	Succulent part	Minor
Leaf miner	*Phyllocnistis citrella* Stainton	Citrus	Leaf	Major
Citrus psyllid	*Trioza erytreae* Del Guerico	Citrus	leaf	Intermediate
Citrus woolly whitefly	*Aleurothrixus floccocus* (Maskell)	Citrus	Whole aerial part	Major
Spider mite	*Tetranychus* spp.	Tomato and limon	Leaf	Minor
Onion thrips	*Thrips tabaci* L.	Onion	Succulent part	Major
Striped blister beetle	*Epicauta albovittata (*Gestro*)*	Hot pepper and tomato	Leaf	Intermediate

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Table 4

Diseases Recorded, Host Plants Infected, Plant Parts and Status in Eastern Amhara During 2017/2018 Season

Common name	Scientific name	Plant species	Plant part	Status
Anthracnose	*Colletotrichum gloeosporioides*	Mango, avocado	Leaf and some topical shoots	Major
Black sigatoka	*Mycosphaerella fijiensis*	Banana	Leaf	Major
Citrus tritiza virus		Citrus	Leaf	Minor
Early blight	*Alternaria solani*	Tomato	Leaf	Minor
Fusarium wilt	*Fusarium oxysporum*	Hot pepper	Whole plant	Intermediate
Late blight	*Phytophthora infestans*	Tomato	Leaf	Minor
Powdery mildew	*Oidium caricae*	Mango, s.orange, Papaya	Leaf and fruit	Major
Purple blotch	*Alternaria porri*	Onion	Whole above ground part	Major
Fruit cracking	Unidentified	Avocado	Fruit	Minor
Dieback	Phytoplasma	Citrus	Whole plant	Minor
Leaf curl virus		Papaya	Leaf	Intermediate

The type and status of horticultural crop insect pests and diseases during the 2017/2018 survey seasons at the selected four districts of the South and North Wollo zones are presented in Tables 3 and 4. The survey results indicated that horticultural crops are subject to various diseases and insect pests. Eleven diseases and ten insect pests were recorded on the assessed horticultural crops.

Five insect pests and four diseases have been found to be major threats to different horticultural crops in the area during the assessment. Citrus woolly whitefly and leaf miner on citrus; fruit flies on coffee; diamondback moth on head cabbage and thrips on onion were the major insect pests in north and south Wollo. Anthracnose for mango and avocado, black sigatoka, powdery mildew, and purple blotch were major diseases on banana, mango, and onion, respectively. Whereas African bollworm on tomato, citrus psyllid, striped blister beetle on hot pepper and tomato, from insect pests, and fusarium wilt disease on hot pepper, and leaf curl virus on papaya had intermediate significance.

Distribution and Severity of Major Diseases and Insect Pests

Horticultural crops were found to be afflicted by a range of insect pests at varying levels of infestation during the assessment. Citrus are heavily infested with a variety of insect pests under varying conditions; diseases and insect pest distribution and severity/damage levels differed from location to location; and depend on a number of variables, including the growth stage of the host plant, altitude, growing season, and field slope. Diseases and insect pests that caused potential damage in that particular location during the survey but had a restricted distribution have been categorized as having an intermediate status based on the survey's total sample size. Such as Citrus psyllid on citrus around Tehuledere, specifically at Gobeya (Kebele 012). Striped blister beetle chews leaf and active growing tips of hot pepper and tomato around Kobo and Habru (Girana). Fusarium wilt at Girana and leaf curl virus on papaya causes leaf deforming and overall plant yellowing mainly in Kobo district at Aradum kebele.

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Details of the recorded data of the most important and highly distributed five insect pests and four diseases damage level/severity at each surveyed location, growth stage, altitude range, and host plant are shown as follows.

Insect Pests

Citrus Woolly whitefly (*Aleurothrixus floccosus*). Citrus woolly whitefly was the most common insect pest found infesting citrus fields in eastern Amhara in 2017/2018, causing damage to sweet orange and lemon crops at rates of 32.3% and 31.8%, respectively. Its prevalence was higher (33.01%) in citrus fields located in mid-altitude areas, while its damage was severe in farms located in low-lying areas (<1800 masl). The distribution's extent was nearly constant across crop development stages and districts; damage levels were also nearly equivalent across lemon, mandarin, and sweet orange. In agreement with Belay et al. (2011), who found that it was uniformly dispersed in most citrus-growing districts of Ethiopia, infesting all citrus crops. However, the Kobo area has sustained considerable damage; Table 5 shows that the incidence and damage levels are 55.87% and 38.97%, respectively. This is most likely due to Kobo receiving sufficient water on a regular basis, which keeps the crop succulent and invites pests for longer periods. We observed that certain producers were able

Table 5

Average Severity and Incidence of Woolly Whitefly on Citrus for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				1.129	0.568			0.071	0.965
N/Wollo	25	38.82	42.37			32.57	19.57		
S/Wollo	36	22.85	29.40			30.78	21.47		
Districts				4.165	0.384			1.881	0.757
Kalu	19	16.42	26.44			29.03	23.09		
Tehuledere	18	28.87	31.09			33.36	19.61		
Habru	17	30.80	38.92			29.55	20.39		
Kobo	8	55.87	46.93			38.97	17.15		
Growth stage				4.907	0.297			2.937	0.568
Dormancy	4	50.31	57.38			34.45	24.00		
Fruiting	23	36.76	34.51			37.48	16.53		
Ripening	24	24.65	34.22			28.64	21.23		
Seedling	4	6.16	7.19			24.52	28.32		
Veg. growing	7	19.87	36.57			25.82	24.35		
Altitude				0.021	0.885			0.438	0.507
Mid	20	33.01	39.47			28.70	22.16		
Lowland	42	27.19	34.02			33.14	19.71		
Host plant				1.182	0.553			0.776	0.678
Lemon	7	23.79	36.66			31.80	22.69		
Manderin	9	16.71	23.48			28.62	22.06		
S.orange	46	32.29	37.41			32.30	20.25		

Note. SD= standard deviation.

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to efficiently control the problem by using high-pressure water to hose down the tree's lower leaf surface, a recommendation we particularly made for homestead producers. Pesticidal control has been demonstrated to be ineffective and infeasible in many countries worldwide once the pest has established itself (Gashawbeza & Abye, 2012). However, Hadush et al. (2019) reported superior efficacy of Agro-Thoate, Karate, and Decis in reducing white flies in northern Ethiopia

Citrus Leaf Miner (*Phyllocnistis citrella* Stainton). Citrus leaf miner is the second most common insect pest of citrus crops in eastern Amhara, after citrus woolly white fly. Citrus leaf miner was prevalent in all districts surveyed that produced citrus crops (Table 6). Tehuledere had the highest incidence (17.3%), and Kalu had the highest damage (31.84%). The overall higher incidence and damage levels were observed in South Wollo zone (14.81%, 23.70%), primarily at the seedling stage (60.9%, 42.31%). Low performance, particularly in newly established citrus orchards starting at the nursery level, is caused by the co-infestation of citrus leaf miner and citrus psyllid, especially in mid-altitude producing areas like Tehuledere around Gobeya (Kebele 012). Compared to sweet orange (11.87%, 24.38%) and lemon (18.88%, 29.60%), mandarin (2.10%, 13.14%) had comparatively less damage and infestation.

Citrus leaf miner is present across the evaluated citrus-growing areas, as demonstrated

Table 6

Mean Incidence and Severity of Citrus Leaf Miner on Citrus for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				0.332	0.847			0.92	0.632
N/Wollo	25	6.31	8.39			22.21	19.30		
S/Wollo	36	14.81	29.57			23.70	21.89		
Districts				2.589	0.581			9.678	0.046
Kalu	19	11.99	23.00			31.84	20.16		
Tehuledere	18	17.30	35.06			15.92	20.76		
Habru	17	5.51	6.44			25.20	17.64		
Kobo	8	8.01	11.90			15.84	22.31		
Growth stage				16.275	0.002			14.312	0.006
Dormancy	4	6.40	7.79			29.91	21.67		
Fruiting	23	14.59	24.87			26.63	20.28		
Ripening	24	2.79	5.88			12.29	18.06		
Seedling	4	60.90	46.12			42.31	7.36		
Veg. growing	7	3.58	3.68			35.77	18.20		
Altitude				0.5577	0.455			0.113	0.736
Mid	20	14.47	29.92			22.44	19.62		
Lowland	42	9.70	19.79			23.76	21.33		
Host plant				3.756	0.152			2.862	0.239
Lemon	7	18.88	28.92			29.60	20.76		
Manderin	9	2.10	3.79			13.14	19.82		
S.orange	46	11.87	24.53			24.38	20.54		

Note. SD= standard deviation.

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by our results, which also show that the degree of infestation varies with host fruit, growth stage, and altitude. This is similar to a previous research by Ferdu et al. (2009). Citrus leaf miner is found in all areas of Ethiopia where citrus.

Fruit flies (*Tephritidae*). Fruit flies were found to be heavily infesting ripe coffee berries during the survey, with incidence and damage levels of 25.45% and 19.85%, respectively (Table 7). The damage level was higher in the Habru district (22.79%) and the mid-altitude areas (21.83%). The coexistence of coffee plantations and other fruit fly hosts, such as guava, in the Habru district may complicate the effect of this critical insect pest of coffee berries. According to Aderajew et al. (2020), this insect pest is known to cause significant damage during the peak ripening period of sweet orange and guava. Fruit production in the Habru district has been declining annually due to this insect pest, in addition to other constraints. However, for nearly a decade, the Habru district has shared nearly one-tenth of the region's and three-quarters of the zone's fruit production area and quantity (Berihun, 2007).

Diamondback Moth (*Plutella xylostella*). The most damaging insect pest on cabbage was the diamondback moth (DBM), which was most prevalent in mid-altitude areas with incidence and damage levels of 67.68% and 34.78%, respectively. Tehuledere district had the highest infestation and damage levels (67.68% and 34.78%, respectively), the infestation was significantly severe in the main rainy season (40.67%) (p = 0.04) (Table 8). Particularly in the area around Logo Haik, which is the main area that produces cabbage we observed the producers spraying karate to overcome this major problem on the field having reached head forming, which requires critical consideration of the safety period of the insecticide for harvesting in addition Gashawbeza and Ogol, (2006) reported the failure of karate to reduce the DBM infestation in the Central Rift Valley, where pesticides are used continuously.

Table 7

Mean Incidence and Severity of Fruit Flies on Coffee for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				0.048	0.824			0.048	0.824
N/Wollo	16	21.60	32.66			15.67	21.05		
S/Wollo	7	19.32	26.48			17.21	18.54		
Districts				5.21	0.266			4.857	0.302
Kalu	3	35.25	36.43			18.45	22.31		
Tehuledere	4	7.37	8.58			16.27	18.79		
Habru	11	31.42	35.51			22.79	22.05		
Kobo	5	0	0			0	0		
Growth stage				1.361	0.506			1.063	0.587
Fruiting	12	18.87	32.50			14.39	21.42		
Ripening	10	25.45	29.67			19.85	18.98		
Veg. growing	1	0	0			0	0		
Altitude				1.692	0.193			2.068	0.15
Mid	13	27.62	33.83			21.83	21.36		
Lowland	10	12.18	23.94			8.74	15.91		

Note. SD= standard deviation.

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Onion Thrips (*Thrips tabaci*). Onion thrips were the most damaging insect pest, causing a noticeable reduction in the yield and quality of onion production in the North and South Wollo zones. As shown in Table 9, onion thrips was the most widely distributed insect pest in North and South Wollo, wherever onion is grown, with 80.51%-100% incidence and 36.85%-46.67% damage level, regardless of location, growth stage, season, and altitude range. However, there was relatively higher damage level in the active growing stage (41.59%) of onion during irrigation production condition (41.47%) either of the predicting factors do not reached to statistical significant level ($p > 0.05$.) which is in line with earlier report in North Shewa zone (Yeshitla, 2014) and Tigray region (Gebretsadkan, 2017). Its effect is reported in all onion-growing areas in Ethiopia as a persistent problem. If onion thrips are not controlled, damage can routinely reduce bulb yields (Tadele & Amin, 2014).

In general, the most significant insect pests of the common annual horticultural crops in the area were the African bollworm and spider mite on tomatoes, the diamondback moth and aphid on cabbage, the onion thrips on onions, and the blister beetle on tomatoes and hot peppers. However, some of these pests appeared minor, likely due to producer management practices and their restricted distribution. Due to our attempt to address multiple pests on various crops at once and the management strategies implemented by the producers, particularly in the Kobo-Girana valley portion of the survey area, the significance of some insect pests may have been undervalued or even ignored during the assessment. Chemical control measures are available for most of the insect pests, but they are

Table 8

Mean Incidence and Severity of Diamondback Moth on Cabbage for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				1.515	0.218			0.035	0.849
N/Wollo	4	42.12	25.83			26.87	11.55		
S/Wollo	7	60.81	34.44			28.84	15.32		
Districts				2.037	0.361			2.175	0.336
Kalu	2	43.63	61.71			14	19.80		
Tehuledere	5	67.68	24.92			34.78	9.99		
Habru	0	0	0			0	0		
Kobo	4	42.12	25.83			28.87	11.55		
Growth stage				4.596	0.331			3.957	0.411
Maturing	5	51.2	25.59			25.65	11.08		
Head forming	1	26.75	0			26	0		
Veg. growing	5	25.33	36.77			29.55	16.11		
Altitude				1.883	0.169			1.414	0.234
Mid	5	67.68	24.92			34.78	9.99		
Lowland	6	42.62	34.10			22.58	14.23		
Season				1.768	0.183			4.185	0.040
Main	3	78.91	18.34			40.67	8.08		
Belg	8	44.68	31.13			23.42	12.18		

Note. SD= standard deviation.

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Table 9

Mean Incidence and Damage Level of Onion Thrips on Onion for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				3.021	0.082			1.183	0.276
N/Wollo	16	100	0			40.59	4.33		
S/Wollo	11	82.28	39.44			39.38	13.18		
Districts				3.53	0.473			4.781	0.310
Kalu	10	80.51	41.11			38.82	13.76		
Tehuledere	1	100	0			44.94	0		
Habru	8	100	0			41.91	4.92		
Kobo	8	100	0			39.28	3.47		
Growth stage				0.943	0.814			1.385	0.709
Maturing	7	85.71	37.80			36.91	16.81		
Seedling	4	100	0			39.60	3.62		
Veg. growing	16	93.67	24.51			41.59	3.64		
Altitude				0.079	0.777			2.382	0.122
Mid	1	100	0			46.67	0		
Lowland	26	92.50	26.49			39.85	8.91		
Season				0.491	0.483			0.691	0.405
Main	8	87.5	35.36			36.85	15.51		
Irrigation	19	95	21.78			41.47	3.53		

Note. SD= standard deviation.

not simply applicable to the smallholder farmers' conditions under which most of the horticultural crops, especially fruits are grown in homestead and most of the horticultural crops are freshly consumable; which is highly sensitive for the health and environmental risks associated with the use (and misuse) of such chemicals.

Diseases

Anthracnose and Powdery Mildew. Mango (*Mangifera indica*) is an important fruit crop in Eastern Amhara; however, most of the fields were in shoot dormancy when the assessment was conducted, therefore, pests of the reproductive part could not be well explained with a representative sample size. With this limitation, the most significant diseases affecting mangos during the assessment were powdery mildew and anthracnose (*Colletotrichum* spp.). With an incidence and severity of 26.20% and 18.35%, respectively, anthracnose was severe in the South Wollo zone compared to 3.46% and 4.28% in the North Wollo zone ($p < 0.001$). Mango fields in the Kalu district were primarily badly affected by anthracnose; in contrast, the majority of mango fields in the Habru district were evaluated to be in the mid-altitude range, and there was no incidence of anthracnose. The overall incidence and severity of anthracnose on mango were high in the lowland areas (Table 10).

Anthracnose were not only the problem on mango, but also recorded on Avocado with different levels of incidence on assessed districts Kalu (4%), Tehuledere (53.65%), Habru (41.01%) and Kobo (31.75%) and its incidence was high on the avocado fields found in the mid altitude

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55.8%, 36.67%) and flat fields (35.83%, 34.72%) incidence and severity respectively (Table 12) and the current result is in line with (Zemenu et al., 2018). Anthracnose was an important disease on both mango and avocado in Waglasta producing areas. Whereas powdery mildew was the other threat for mango in the study area, its distribution was high in mid altitude (35.82%), and sloppy fields (65.68%), and its severity was high on the steep slope fields (38.50%) and in mid altitude areas (25.95%) (Table11).

Purple Blotch. Purple blotch was the major disease recorded during the assessment in almost all addressed onion fields, though its incidence and severity vary with crop growth stage, altitude, growing season, field slope, and between districts and Administrative zones. Its incidence and severity was high in South Wollo zone (15.37%, 17.68%); Kalu district (16.91%, 19.45%); at maturity stage of the crop (19.28%, 27.75%); in fields found at mid altitude (26.09%, 44%); during main (first round irrigation season) (17.46%, 27.27%); on flat fields (19.95%, 31.16%) respectively. Its damage showed a significant increasing trend with crop growth stage and was severe in onion seed production fields (p = 0.039) (Table 13). Growers in some newly established irrigation schemes confused the blotch disease symptom with onion thrips damage and tried to protect their crops by spraying various insecticides. According to Mengesha et al. (2022), among onion varieties, the application of Bombay red integrated with active ingredient Mefenoxan reduced severity.

Table 10

Mean Incidence and Severity of Anthracnose on Mango for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				15.433	<0.0001			13.109	0.0002
N/Wollo	34	3.46	16.11			4.28	14.22		
S/Wollo	18	26.20	37.59			18.35	17.01		
Districts				22.789	0.0001			23.356	0.0001
Kalu	13	28.18	36.54			21.72	17.55		
Tehuledere	5	21.06	44.19			9.56	13.13		
Habru	22	0	0			0	0		
Kobo	12	9.80	26.66			12.13	22.42		
Growth stage				3.665	0.299			3.278	0.35
Dormancy	34	7.81	22.93			8.05	16.27		
Flowering	4	9.87	15.72			21.21	24.99		
Seedling	7	38.14	48.83			13.30	17.50		
Veg. growing	7	2.44	6.46			3.43	9.07		
Altitude				4.723	0.029			5.81	0.015
Mid	17	5.88	24.25			1.42	5.83		
Lowland	35	13.98	28.96			12.91	18.68		
Slope				2.832	0.242			2.345	0.309
Flat	33	17.37	33.21			11.86	18.67		
Gentle	15	0.71	2.14			4.04	10.91		
Steep	4	1.32	2.64			5.97	11.94		

Note. SD= standard deviation.

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Purple blotch resistance is controlled by a single dominant gene (Dar et al., 2020).

Black Sigatoka*.* During this assessment, the prevalent banana disease, black sigatoka, was found to have a high incidence rate (0%–100%) and a wide range of severity (0%–49.25%). Its prevalence and severity vary across evaluated administrative zones and districts, with North Wollo having the highest incidence and severity, at 86.35% and 26%, respectively. Its occurrence was also more common in mid-altitude areas (Table 14). Sirinka Agricultural Research Centre and other stakeholders have to prioritize the development of this disease management option, in addition to promoting banana production, by distributing planting materials for the establishment of new fruit plantations (Banana village) derived from tissue culture in the North Wollo and South Wollo zones. Since bananas are one of the most important and promising fruit crops, they are farmed extensively to provide both food security and income (Mohammed et al., 2009).

Table 11

Mean Incidence and Severity of Powdery Mildew on Mango for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				0.232	0.63			0.105	0.745
N/Wollo	34	31.92	39.38			23.64	18.07		
S/Wollo	18	27.51	38.11			21.35	20.73		
Districts				6.119	0.19			4.293	0.367
Kalu	13	14.15	15.13			18.91	19.29		
Tehuledere	5	62.24	58.28			27.68	25.30		
Habru	22	34.33	39.44			26.91	17.41		
Kobo	12	27.50	40.61			17.63	18.44		
Growth stage				3.883	0.274			6.185	0.102
Dormancy	34	33.29	38.01			26.82	18.44		
Flowering	4	10.33	15.61			11.94	13.79		
Seedling	7	15.08	37.47			9.92	13.78		
Veg. growing	7	43.09	49.30			22.70	22.49		
Altitude				0.369	0.543			0.752	0.385
Mid	17	35.82	42.02			25.95	19.44		
Lowland	35	27.76	37.22			21.34	18.67		
Slope				3.436	0.179			3.139	0.208
Flat	33	29.20	38.14			21.40	18.59		
Gentle	15	23.62	32.76			21.85	19.59		
Steep	4	65.68	54.17			38.50	14.65		

Note. SD= standard deviation.

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Table 12

Mean Incidence and Severity of Anthracnose on Avocado for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				1.14	0.285			2.594	0.107
N/Wollo	9	34.86	29.66			40.57	23.17		
S/Wollo	5	23.86	42.77			20.21	11.46		
Districts				5.423	0.246			3.348	0.501
Kalu	3	4.00	5.63			16.16	14.00		
Tehuledere	2	53.65	65.55			26.29	3.23		
Habru	3	41.07	48.64			40.89	35.44		
Kobo	6	31.75	20.64			40.41	18.89		
Growth stage				6.464	0.167			7.462	0.113
Dormancy	1	28.41	0			60	0		
Flowering	2	5.22	7.38			12.12	17.14		
Fruiting	6	32.50	33.03			45.63	18.69		
Seedling	2	83.5	23.33			20.96	4.31		
Veg. growing	3	10.73	17.23			22.08	21.08		
Altitude				0.846	0.357				
Mid	4	55.8	49.45			36.67	30.14		
Lowland	10	20.98	20.93			31.95	19.34		
Slope				1.19	0.275			0.393	0.53
Flat	11	35.83	36.19			34.72	20.56		
Gentle	3	12.95	14.37			28.08	30.18		

Note. SD= standard deviation.

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Table 13

Mean Incidence and Severity of Purple Blotch on Onion for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				1.673	0.195			1.675	0.195
N/Wollo	16	5.69	14.39			8.20	15.38		
S/Wollo	11	15.37	23.29			17.68	21.03		
Districts				4.002	0.405			3.646	0.456
Kalu	10	16.91	23.96			19.45	21.29		
Tehuledere	1	0	0			0	0		
Habru	8	3.26	9.22			5.5	15.56		
Kobo	8	8.11	18.58			10.90	15.75		
Growth stage				6.782	0.079			8.315	0.039
Tuber initiation	1	4.69	0			23.88	0		
Maturity	7	19.28	20.72			27.75	20.14		
Seedling	4	1.87	3.75			5.97	11.94		
Veg. growing	15	7.53	19.90			5.58	14.77		
Altitude				1.896	0.168			3.098	0.078
Mid	1	26.09	0			44	0		
Lowland	26	9.0	18.83			10.84	17.32		
Season				6.730	0.009			8.296	0.003
Main	8	17.46	19.86			27.27	18.70		
Irrigation	19	6.34	17.77			5.66	13.91		
Slope				8.999	0.002			10.877	0.0009
Flat	7	19.95	20.06			31.16	16.32		
Gentle	20	6.02	17.36			5.38	13.60		

Note. SD= standard deviation.

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Table14

Mean Incidence and Severity of Black Sigatoka on Banana for Different Independent Variables in 2018, Eastern Amhara

Independent variables	No of fields	Incidence %				Severity %			
		Mean	SD	Chi-square	*P*-value	Mean	SD	Chi-square	*P*-value
Zone				0.985	0.32			0.404	0.524
N/Wollo	17	86.35	20.57			26	13.82		
S/Wollo	7	57.14	53.45			22.15	20.94		
Districts				7.409	0.115			5.731	0.22
Kalu	2	0	0			0	0		
Tehuledere	5	80	44.72			31.01	17.74		
Habru	12	83.42	22.45			27.50	14.56		
Kobo	5	93.4	14.76			22.40	12.55		
Growth stage				2.257	0.52			1.057	0.787
Fruiting	9	81.56	33.76			28.11	15.93		
Ripening	2	67	0			18.03	8.53		
Seedling	1	100	0			16	0		
Veg. growing	12	75	40.54			24.33	17.55		
Altitude				0.715	0.397				
Mid	7	90.57	16.10			24..74	13.58		
Lowland	17	72.59	39.51			24.93	17.05		
Slope				1.787	0.409			4.066	0.13
Flat	13	84.69	29.18			30.72	16.15		
Gentle	10	66.7	41.60			17.38	13.43		
Steep	1	100	0			23.88	0		

Note. SD= standard deviation.

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Conclusions

This survey study provides important insights into the current status of major horticultural crop pests in eastern Amhara. While all the recorded diseases and insect pests have been reported in various parts of Ethiopia over the past two decades through research on fruit and vegetable crops, the present findings highlight their occurrence in this specific region. According to the results, citrus crops were highly infested by various insect pests at different growth stages. Among these, the woolly whitefly severely affected nearly all aerial parts of the plants; the leaf miner mostly targeted seedlings, especially in nurseries; and the psyllid was particularly prevalent in mid-altitude production areas such as Tehuledere. Additionally, fruit flies on coffee, diamondback moth on cabbage, and thrips on onion were identified as some of the most destructive insect pests. Major diseases observed in the survey area included anthracnose on mango and avocado, powdery mildew on mango, purple blotch on onion, and black Sigatoka on banana. Citrus is the dominant crop across the study areas and is highly threatened by various pests. Since the survey attempted to assess multiple pests across different crops simultaneously, and given the time differences between the survey period and pest occurrences, the significance of some pests and diseases may have been underestimated or overlooked. For instance, fruit flies were detected only on coffee during this survey; however, a subsequent study in the same location found them causing up to 28% damage to mango nearly a year later. Therefore, in addition to developing management strategies for key diseases and insect pests, regular monitoring is essential to detect pest occurrences and shifts in their status. Furthermore, both producers and experts require training on the most common pests, their modes of spread, and possible management options.

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