CHAPTER THREE

CITRUS (*CITRUS SINENSIS*) DISEASE SURVEY: KNOWLEDGE, ATTITUDE AND MANAGEMENT PRACTICES IN ETHIOPIA

Sissay B. Mekbib[a,b], Thierry J.C. Regnier[a], Lise Korsten[a]
[a]Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria, 0002, South Africa
[b]Department of Plant Science, Alemaya University, P.O. Box 138, DireDawa, Ethiopia

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Abstract

Pre- and postharvest practices ultimately determine fruit quality. A survey of actual management practices and growers' perception of effective postharvest citrus disease management strategies in Ethiopia was conducted from August 2003–February 2004. A total of 24 questionnaires were used to interview farm experts and horticultural researchers. Citrus pests and pathogens were equally identified for high preharvest fruit disease incidence. Methidathion (Propoxur, BPMC, China) and Diazinon (BASF, Germany) insecticides are currently used as predominant control methods before harvest. Most respondents spray crops only once disease and/ or pest symptoms have been observed. A high incidence (46.7%) of postharvest fruit infection was recorded from a fruit storage house in Addis Ababa. *Penicillium digitatum* Sacc. was identified as a major citrus postharvest pathogen. Although the fresh fruit market in Ethiopia has a high turn over, improvements in field production practices and general hygiene in storage facilities and packing houses are crucial to improve quality for the local and export markets.

***Key words*:** Postharvest; Fruit quality; *Penicillium* decay

3.1 INTRODUCTION

Citrus (*Citrus sinensis* L.) is a high value crop grown in the tropical and subtropical regions of the world. In world trade, citrus generates about 105 billions USD/ year (Ismail and Zhang, 2004). Currently, citrus is cultivated in more than 130 countries (Ismail and Zhang, 2004) with Brazil, China and the USA being the biggest producers and Spain, USA and South Africa the most important exporters (Citrus Commodity Notes, 2005).

Ethiopia is a relative small newcomer in citrus trade (Seifu, 2003), and the area under production has increased over the past 20 years from 3 115 ha to 4 500 ha in 2004 (Table 2). Ethiopia had been known to export citrus from the 1960's to the Middle East and Western Europe (New, 1984). However, over the past 30 years export volumes have dropped due to poor quality delivered onto the market, which is mainly due to lack of improved production practices and technology transfer has hampered industry growth (Harris, 1985).

Harvested fruits are highly perishable due to release of heat from respiration, consequently losing moisture. This characteristic may detract the appearance, weight and marketability of fruit and could make them susceptible to attack by postharvest pathogens while in storage.

In developing countries, where disease control and proper handling of fresh fruit is inadequate, losses during transit and storage have been reported to be as high as 50% of the harvested crop (Wisniewski and Wilson, 1992). In Ethiopia, no comprehensive study has been done dealing with the incidence and identity of the pathogens.

In this study, we report on a questionnaire to determine the level of knowledge, attitude and disease control management practices on citrus farms in Ethiopia and the incidence of postharvest diseases and its main causal organism.

3.2 MATERIAL and METHODS

3.2.1 Field survey: area description

A field survey was conducted between August 2003 and February 2004 in the major citrus production areas of Afar, Somali, Oromia and Amhara Regional States of Ethiopia representing about 70% of the industry. Farms were selected based on location and/ or production importance. Specific locations of places are indicated on a map (Fig. 3.1).

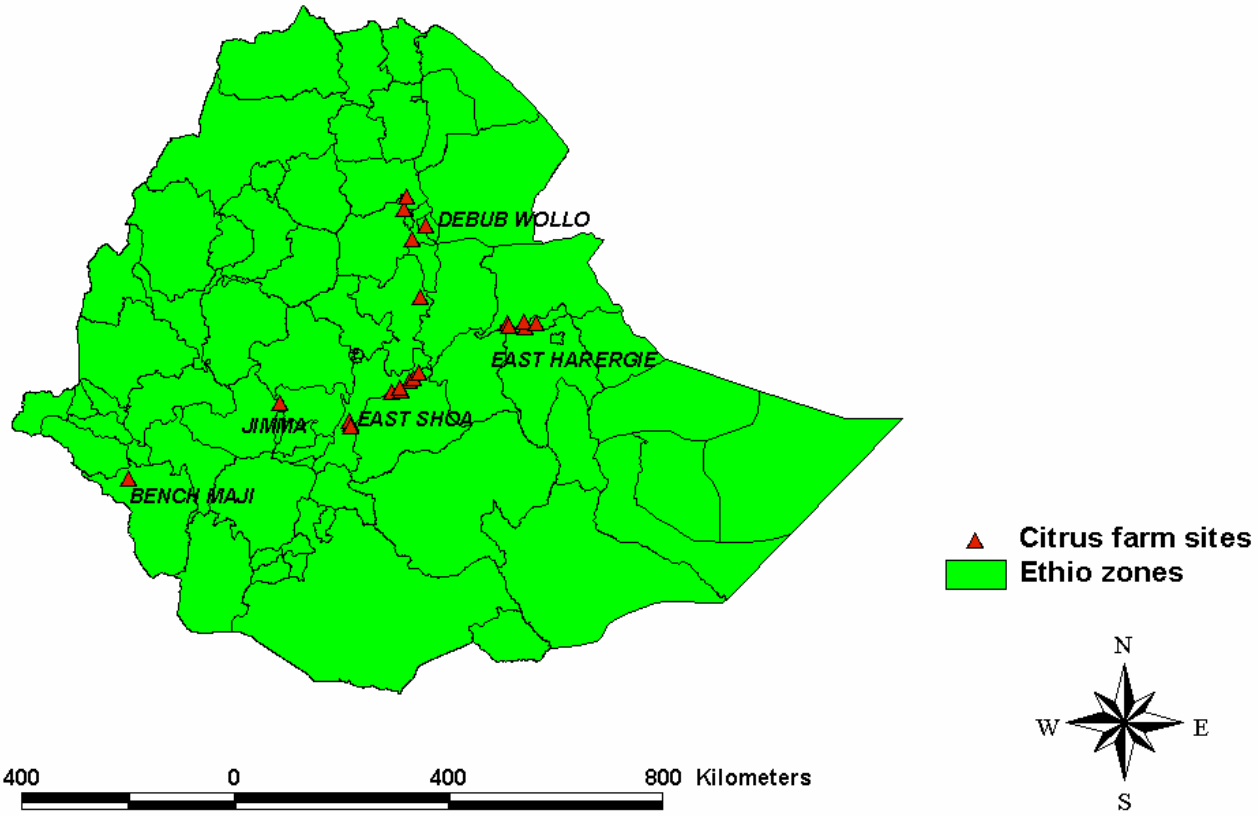

Fig. 3.1. Major citrus production regions in Ethiopia.

In total, 24 crop protection and unit farm managers were selected for a personal interview. The questionnaire has been compiled in two parts. The first part deals with preharvest citrus disease management practices containing four sections. Section 1 deals with geographical aspects of the production regions i.e. mean annual, maximum and minimum temperatures during summer and winter, water source (rainfall and or irrigation), average rainfall per year, altitude and average relative humidity (RH). Section 2 covered the history of the citrus farm and orchards, farm size, cultivars planted, stalk and scion source, orchard age, ownership of the farm, flora composition around the citrus farm, soil type and application of fertilizer. Section 3 included preharvest epidemiology and disease management practices referring to disease type manifestation, occurrence, severity and control practices. The fourth section referred to farm input, cost and production statistics including labour, pesticide and fertilizer expenses. The average annual citrus production income and loss due to postharvest pathogens

was also assessed in this section. The second part of the questionnaire dealt specifically with postharvest citrus (sweet orange) fruit handling and disease management practices covering three sections. Section 1 referred to environmental conditions at harvest (average daily maximum and minimum temperature, RH), harvesting practices, persons involved in picking of fruits, material used for picking and transporting fruits and storage temperature. Section 2 covered fruit transportation and duration, handling, cold storage conditions, types of postharvest diseases, incidence and control strategies. The third section dealt with marketing, estimated production gain or loss per year both in local and export markets.

3.2.2 Postharvest pathogen survey and disease incidence determination

Freshly harvested citrus fruits, 70 in a box were collected from eight citrus farms, Error Gota, Zeway and Shewarobit Prison farms, Methahara, NuraEra, Ghibe, Jarri Children Village, and Tisabalima citrus farms and nine local markets: Harrar, DireDawa, Nazareth, Addis Ababa (Etfruit) houses and private greengrocers. The experiment was done in triplicate and repeated twice. Samples were kept at room temperature (25 ºC) under regulated moisture (> 85% RH) for 30 days. Fruit evaluation for disease development was done after five days and thereafter every two days. Infection rate was recorded and percentage disease incidence was determined according to Vero *et al*. (2002). Percentage disease incidence (% Inc) was defined as:

$$\% \text{ Inc} = \frac{\text{Number of fruits decayed}}{\text{Number of total fruits}} \times 100$$

Potential pathogens were isolated, preliminarily identified and identity confirmed for pathogenicity by Dr. Amare Ayalew, Plant Pathology division, Department of Plant Science, Alemaya University, Ethiopia. Samples were freeze dried for three days and stored at room temperature until further use.

3.2.3 Statistical analyses

For statistical analyses and data interpretation, questionnaires collected from areas were combined for each question and descriptive statistical analyses for the main parameters were done to give an over view of citrus cultivation and disease management practices in Ethiopia. Data obtained from the postharvest disease incidence experiment were subjected to ANOVA analyses using Fisher's protected test at $P < 0.05$ using SAS software (version 8.2), 2001.

3.3 RESULTS and DISCUSSION

Categories of information and the representative answer given are indicated in (Appendix 1 table 5). The number of questionnaires completed per citrus farm and/or enterprises represent seven for Upper Awash Agro Industry, six for Horticulture Development Enterprise, two for Prison citrus farms. The rest all completed one questionnaire each.

3.3.1 Citrus farms in Ethiopia: location, climate and area coverage

Citrus producing areas surveyed in Ethiopia are indicated in Table 3.1. Sweet orange cultivation covers 82% (1 732.51 ha) of the total citrus area surveyed in the country (Table 3.2). Of these, Government ownership represented 97% of citrus farms cultivated. Upper Awash Agro Industry Enterprise owned the largest area under production (Table 3.2) and was the major marketing company in the country (78 805 tonnes/ year) (Upper Awash Agro-Industry Enterprise, 2000). Individual and association farm holdings accounted for only 2.6 and 0.4% share of the total holdings, respectively. In total, production and area harvest of citrus has increased in Ethiopia by 35.1% (Table 2.1).

Citrus farms surveyed in this study can be classified in to three agro climatic belts according to Mersha (2000) classification:

1= Single growing seasons (SS) referring to warm arid low lands (600-900 m.a.s.l.) with long growing season (LGS),

2= Two growing seasons (TS) (901-1500 m.a.s.l.) with tepid to cool areas and bimodal but distinct rainfall patterns,

3= Merging growing seasons (MS) (1501-1800 m.a.s.l.) with moist mid highlands having long and continuous rainy seasons (Table 3.1).

All citrus farms, which reported to have a lower temperature range between mid May and October (Federal Democratic Republic of Ethiopia Metrology Institute, 2004), exhibited high incidence of disease. According to the survey made, all citrus producing regions have long growing seasons with minimal precipitation and ground water supplies (Table 3.1). The period of rainy season and precipitation volumes varies from area to area. According to the climatic information obtained from Federal Democratic Republic of Ethiopia Meteorology Institute (2004), the annual rainfall of the major citrus producing areas ranges between 25-350 ml and the minimum temperature ranges from 10 ^{o}C at Degaga to 19 ^{o}C at DireDawa with the maximum temperature from 23 ^{o}C at Tulubollo to 34 ^{o}C at Methahara. The monthly mean rainfall is relatively higher at TuluBolo from June to mid-September and lower in December at Methahara and Ghibe. The climatic norm of an area is very important for disease

management and product improvement. According to Davies and Albrigo (1994), the optimum growth temperature necessary to induce flowering in citrus is between 13-24 ºC with a tolerance range of ± 3 ºC. Long wet rainy seasons (7-9 months/year) favour the development of high disease pressures and increase the volume of citrus loss at a preharvest level. Tepi and Bebeka are high altitude areas (Table 3.1) with high moistures for longer extended periods between March and December, and unlike other citrus farms, they have currently shifted to the production of coffee (Seifu, 2003).

3.3.2 Cultivation and preharvest disease management practices

3.3.2.1 Citrus cultivars

Different varieties of sweet oranges [Valencia (35.8%), Washington navel (23.9%), Hamlin (19.4%), Pineapple (7.5%), Shamuti (4.5%), Jaffa (1.5%), Robbins blood (1.5%), and other unknown cultivars (5.9%)] were described. According to the survey, Valencia was identified as the dominant variety followed by Washington navel and Hamlin. More than 70% of the total citrus area surveyed constituted old orchards (>20 years of age) and the rest represented areas with younger plantings (<20 years of age) of Valencia cultivars. However, the original source of old orchards scion and rootstock combinations is unknown and more than 84% of the respondents didn't have available information. The lack of information in this regard complicated management and breeding programs aimed at improving citrus production.

3.3.2.2 Citrus farm cultural practices and preharvest disease prevalence

Citrus farming in Ethiopia is a mixed agriculture (Seifu, 2003). Many crops, vegetables and other non-citrus trees are grown in and around citrus farms. Vegetables (mainly tomato and onions), fruits (mainly banana, papaya and avocado), and maize were reported as crops integrated in almost all citrus farms. During production, 40% of respondents differentiated between citrus pests, diseases and disorders and if assessed only do so by physical inspection. Insect pests were reported equally important to diseases (Fig. 3.2). Virus problems (13.6%), prevalence of nematodes (12.1%) and mole rats (1.5%) were also reported to cause dieback at Error Gota, Toni, Hursso and Tisablalima farms. The use and application of expert knowledge and scientific technology for the identification of diseases and disorders was found to be very limited. The development and use of diagnostic techniques for accurate identification is therefore crucial for more effective disease management strategies and to improve production practices.

Table 3.1 Major citrus farms in Ethiopia in terms of location and climatic information

	Farm name	Specific location	Distance from Addis Ababa in (km)	Altitude (m.a.s.l.) in (m)	Relative Humidity (RH)	Soil type and nutrient status	Chemical pesticides use	Fertilizer use
1	**Upper Awash Agro Industry (UAAI)***							
	i) Tibila							
	a) Degaga unit farm	N:8.428 E:39.415	135EN	1201-1500	nd	Loam and sandy soil	Methidathion, Diazinon and Metalaxyl	DAP and UREA
	b) Menberhiwot unit farm	N:8.470 E:39.589	149EN	1201-1500	nd	nd	Methidathion, Diazinon and Metalaxyl	DAP and UREA
	c) Tifsihtegenet unit farm	N:8.470 E:39.589	157EN	1201-500	nd	nd	Methidathion, Diazinon and Metalaxyl	DAP and UREA
	ii) Merti Jeju citrus farm							
	a) Merti unit farm	N:8.623 E:39.722	183EN	901-1200	nd	nd	Methidathion, Diazinon and Metalaxyl	DAP and UREA
	b) Jeju unit farm	N:8.514 E:39.569	172EN	1201-1500	nd	nd	Methidathion, Diazinon and Metalaxyl	DAP and UREA
	iii) Nura Era	N:8.670 E:39.779	178EN	901-1200	44.3	Clay, loam and sandy	Methidathion, Diazinon and Metalaxyl	DAP, UREA and manure
	iv) Awara Melka	N:8.763 E:39.877	198EN	601-900	nd	nd	Methidathion, Diazinon and Metalaxyl	DAP and UREA
2	**Horticulture Development Enterprise (HDE)***							
	i) Zeway citrus farm	N:7.899 E:38.731	165S	1501-1800	52	Sandy and loam soil	Methidathion	DAP and UREA
	ii) Gibe citrus farm	N:8.248 E:37.540	185S	901-1200	nd	Vertisol	Methidathion and Diazinon	DAP and UREA

Table … continued

	iii) Errer citrus farm							
	a) Fetuli unit farm	N:9.616 E:41.395	567E	901-1200	nd	Sandy and loam	Methidathion and Medapozoil	DAP and UREA
	b) Errer unit farm	N:9.575 E:41.384	563E	901-1200	nd	Sandy and loam	Methidathion and Medapozoil	DAP and UREA
	c) Gota unit farm	N:9.550 E:41.389	571E	901-1200	nd	Sandy and loam	Methidathion and Medapozoil	DAP and UREA
	iv) Ellen	N:9.527 E:41.662	556E	901-1200	nd	nd	Methidathion and Medapozoil	DAP and UREA
3	**Prison citrus farms***							
	i) Zeway	N:7.945 E:38.712	158S	1501-1800	52	Sandy and loam***	Mancozeb and Bayleton	DAP,UREA and manure
	ii) Shewarobit	N:10.002 E:39.899	225N	1201-1500	44.5	nd	Mancozeb and Bayleton	UREA
4	Abadir citrus farm (Methahara sugar estate)*	N:8.763 E:39.877	116E	901-1200	43.9	Vertisol, alluvial and sandy soil****	Methidathion and Lambdacyhalothrin	DAP and ASN
5	Ethioflora citrus farm**	N:7.868 E:38.726	165S	1501-1800	nd	Sandy soil	Diazinon and Tiodan	DAP,UREA and manure
6	Hursso citrus farm* Tony citrus farm*	N:9.614 E:41.643	560E	901-1200	nd	Sandy and loam	Mancozeb, Diazinon and Sumathion	DAP,UREA and manure
7		N:9.592 E:41.862	531E	901-1200	42.2	Sandy and loam	Methidathion and Sumathion	DAP and UREA
8	Jarri children village citrus farm*	N:10.973 E:39.771	440N	1501-1800	nd	Clay and loam*****	No application	DAP,UREA and manure

Table … continued

9	Amhara Regional State Development Enterprise (ARSDE) (Tisabalima citrus farm)**	N:11.459 E:39.628	450N	1501-1800	nd	Clay and sand soil	No application of pesticide. Instead, cattle urine with plant decoction were used	DAP, UREA and manure
10	Merssa citrus farm**	N:11.668 E:39.663	490N	1501-1800	nd	Clay and sand soil	Mancozeb and Malathion	Manure and seeding a legume (Lab-lab)
11	Kersa citrus farm, Bati*	N:11.190 E:40.000	417NE	1501-1800	47.3	Clay and sand soil	Malathion	Manure and mulching

Legend: * = Government ownership, ** = Private ownership, N = North, S = South, E = East; W = West, NE = Northeast, SE = Southeast, SW = Southwest, SE = Southeast, (% RH) = Percentage Relative Humidity, nd = Data not available.

*** = Soil deficient in Nitrogen and Phosphorus but high with Potassium, **** = Deficient in Iron and Zinc, ***** = deficient in nitrogen, DAP = Diammonium Phosphate.

Table 3.2 Summary of major citrus farms in Ethiopia and area coverage under sweet orange cultivation

	Citrus farms/Enterprises	Total citrus area coverage (ha)	Total citrus area coverage (%)	Sweet orange area coverage (ha)	Sweet orange area (%) as compared to the total
1	Upper Awash Agro Industry Enterprise (UAAIE)	1 496.83	71.2	1 181.25	68.2
2	Horticulture Development Enterprise (HDE)	259.66	12.3	222. 61	12.84
3	Prison citrus farms	57	2.7	39.75	2.29
4	Methahara Sugar state (Abadir) citrus farm	140	6.7	133	7.67
5	Ethioflora	2	0.095	1.5	0.12
6	Hursso, military training camp citrus farm	41.22	1.96	20	1.15
7	Toni, Alemaya University farm	10.5	0.49	9.5	0.54
8	Jarri children village citrus farm, Hike, Wollo	20	0.95	15	1.15
9	Amhara Regional State Development Enterprise farm, Tisabalima, citrus farm, Wollo (Association)	8.5	0.4	8	0.46
10	Merssa private citrus farms (individuals)	52	2.47	41	2.36
11	Ghion Hotel citrus farm, Kersa, Bati	3.5	0.17	3.2	0.18
12	Coffee Plantation Development Enterprise (CPDE)*	11.4	0.54	10.4	0.65
Total		**2 102. 61**		**1 732. 51**	

Legend: ha = Hectare, % = Percentage, * = The citrus farms currently shifted to coffee production.

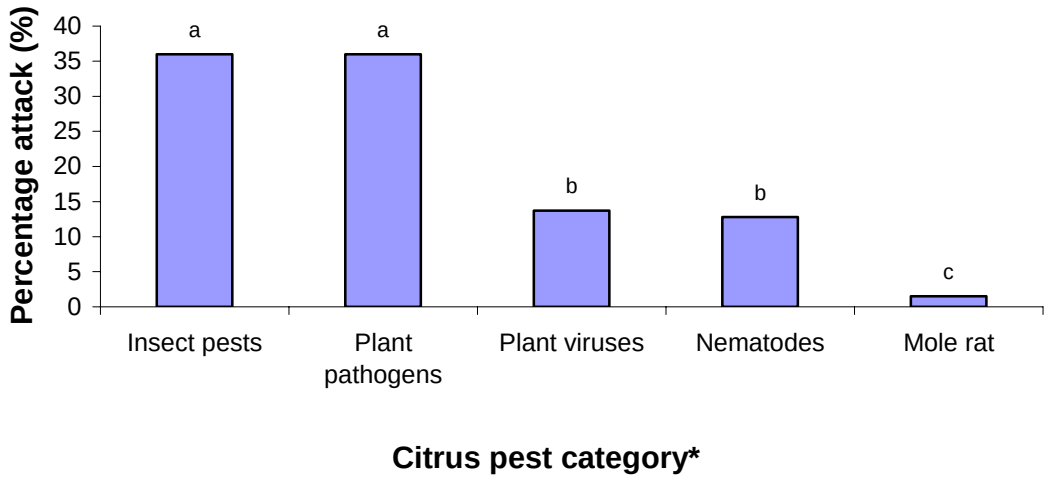

Fig. 3.2. Preharvest citrus pest category and percentage attack as identified by Ethiopian citrus producers.

Insect pests and microbial pathogens are equally important to cause high rates of disease incidence. Mediterranean fruit fly (*Ceratitis capitatia* Wiedemann), false codling moth (*Cryptophlebia leucotreta* Meyr) and thrips (*Scirtothrips aurantii* Faure) are the most important insect pests reported. Plant Pathogens such as *Phytophthora*, *Penicillium* and *Colletotrichum* spp. mostly from all citrus farms and *Phaeoramularia angolensis* in particular from Ghibe and Tisabalima, were reported. A high rate (>70%) of citrus tree dieback combined with soil borne pathogens (mainly *Phytophthora* spp.) was reported from all citrus farms in Ethiopia.

Similar reports by Seifu (2003) indicated a high severity of soil borne diseases caused by *Phytophthora* spp. The general yield loss impact of *Phytophthora* spp. in all citrus growing regions of the world has also been reported by Graham and Menge (1999). Intrinsic factors such as inadequately selected seeds and seedlings and/or inappropriate use of cultural practices such as irrigation systems (Fig. 3.3) as well as adverse edaphic conditions may increase the rate of infection and spread of the disease in an orchard (Salerno and Cutuli, 1981). According to Ippolito *et al*. (1996) poor root stock combinations attributed to high levels of gummosis and phytophthora root rotting.

Fig. 3.3. Improper use of double ring basin irrigation system.

The traditional method of irrigation in Ethiopia is the double ring basin system. The improper use of the system (Fig. 3.3) creates a direct contact between tree bark and surface water. This practice resulted in an increased phytophthora infection and eventually tree dieback (Caruso and Wilcox, 1990; Oudemans, 1999). According to Salerno and Cutuli (1981), improvement in the proper use of irrigation methods and selection of disease resistant rootstock can reduce the risk of infestation by soil borne pathogens and should be implemented.

High infestation of citrus leaf and fruit spot diseases caused by mainly *Phaeoramularia angolensis* Cavalho and Mendes was found in this survey as reported from Ghibe and Tisabalima citrus farms. This result is in agreement with previous similar reports, which showed the high incidence of the disease at Ghibe citrus farm (Mohammed, 1995) and Northwest of Ethiopia (Dessalegn and Girma, 2002). Although the detailed information about the inoculum source and disease cycle of the pathogen is not known, wind-borne conidia infect fruits and/or planting materials such as seedlings. Windbreak trees planted around the periphery of the farms are thought to be the potential sources of the pathogen (Whiteside *et al*., 1988). Although the application of this practice seems important from an agro-ecological point of view and pest trap, field disease control by sanitation and clearing of inoculum source is important (Sierra *et al*., 1993). The disease remains a major problem in the citrus production regions of Ethiopia and fruits were often observed with black stony centres, which are unmarketable.

3.3.2.3 Citrus insect pests

Red scale (*Aonidiella aurantii* Maskell), leaf minor (*Phyllocnistis citrella* Stainton), Mediterranean fruit fly (*C. capitatia*), false codling moth (*C. leucotreta*), thrips (*S. aurantii*), aphids (*Toxoptera citricidus* Kirkaldy), and bud mite (*Eriophyes sheldoni* Ewing) were identified as major pests on all citrus farms of Ethiopia. In this survey, scale insects, leaf minor and fruit fly were found to be the most important problems and cause more than 50% preharvest fruit damage. Attacks by thrips (mostly at UAAIE farms (16.6%)), bud mite (14.2%), aphids (7.1%), cotton cushion insects, (*Icerya purchasi* Maskell) (9.5%) and orange dogs (2.4%) have also been found from Toni, Tisabalima and Shoarobit farms.

The start of insect attack and extent of damage in citrus orchards were found to vary depending on orchard/tree age and maturity. In the current study, 40% respondents indicated initial infestation of scale insects and fruit fly attacks during fruiting and fruit repining stages. Citrus cultivation and regular monitoring of farm practices from land preparation to fruit maturity and harvesting will provide sufficient information to control infections of citrus (Taylor, 1996).

3.3.2.4 Chemical pesticides and use in citrus preharvest disease control

About 80% of the citrus farms surveyed applied commercial chemicals (pesticides) as a major means of pest control. Different pesticides [Methidathion (Propoxur, BPMC, China), Diazinon (BASF, Germany), Metalaxyl (Syngenta Phils. Inc., Switzerland), Mancozeb (Leads Agri Product Corp., China), Lambdacyhalothrin (Syngenta Phils. Inc., Switzerland), Thiophanate Methyl (Bayer Phils. Inc., Germany), Malathion (Zagro Corp, Singapore)] were applied during the initial observation of pests and/or diseases in the orchard. Of these, Methidathion was the most widely applied chemical followed by Diazinon for pest control. The application of chemical pesticides only during the first observation of the pest may lead to ineffective control and can result in build up of inoculum over time and disease outbreaks in the area (Fry, 1977). To reduce the risks associated with the ineffective application of chemicals and its environmental and health considerations require the investigation into alternative natural plant products (Tripathi and Dubey, 2004), microbial antagonists (Droby *et al*., 1991) and the application of improved pre- and postharvest sanitary practices (Sierra *et al*., 1993; Wilson *et al*., 1995).

3.3.2.5 Citrus farm irrigation and production practices

Moisture is a limiting factor for good quality citrus production. The annual rainfall recorded on citrus farms in Ethiopia is range between 25-350 mm (FDREMI, 2004). In almost all citrus farms, the surrounding rivers were used for irrigation purposes. Except Tisabalima and Bati (Kerssa) where irrigation schedules were reported to be twice per week, the rate of surface water application to the rest of the farms averaged twice per month (1.5l/sec). Application of surface water at longer intervals creates moisture stress during early spring while the tree is at the flowering stage (Directorate Communication National Department of Agriculture, 2000). This could result in excessive drop of flowers and fruit-lets, and result in a smaller crop with fruit having a more acidic taste (DCNDA, 2000). Drought followed by good rains could produce out-of season flowering and fruit setting. As observed from the survey, in saturated and poorly drained soils on citrus farms like Degaga (Appendix 1 table 5), such conditions have reportedly contributed to root rotting and tree die back, which ultimately resulted in total yield loss.

3.3.3 Fruit harvesting and postharvest handling practices

Traditionally, in all citrus farms, fruit is harvested manually by hand picking, tree shaking, long-stick pulling and dropping to the ground (Fig. 3.4).

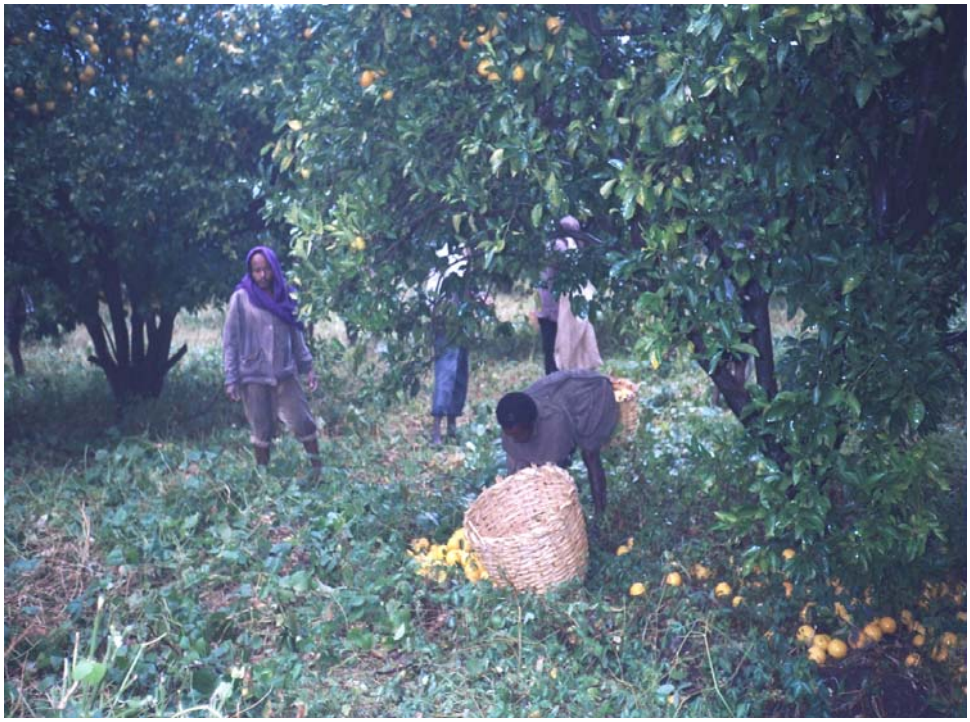

Fig. 3.4. Traditional fruit collection

Although citrus is harvested year round in Ethiopia, the peak harvesting seasons are form June to December at UAAIE and from April to August in other farms (Table 3.3). Human labour

and open private trucks are the major method of fruit transportation in almost all farms. Etfruit trucks with cooling unit facilities maintained at 4-7 °C were used at UAAIE and HDE farms to transport fruit to Addis Ababa markets. Once harvested, fruits are stored temporarily at room temperature (18-25 ºC) for about two weeks in untidy storage houses in Addis Ababa without air conditioner or other cooling facilities. Fruits were handled during distribution to buyers by jolting down crates on rough surfaces. Such handling practices of freshly picked fruits disrupt fruit physiology and may induce ethylene production, which ultimately increases fruit senescence.

3.3.4. Citrus postharvest disease incidence survey and pathogen identity

Penicillium. digitatum was identified as the major citrus postharvest pathogen followed by *Colletotrichum gloeosporioides* and *Geotrichum candidum* (data not shown) in both market and farm fruit collections (Fig. 3.5 and 3.6). All fruits collected from farms exhibit some degree of postharvest disease development, which ranged between 5.7- 28.5%. Low rate of disease incidence (5.7%) was observed on fruits from NuraEra whereas a higher disease incidence (26.5%) was found on fruits from Jarri children's village, South Wollo (Fig. 3.5).

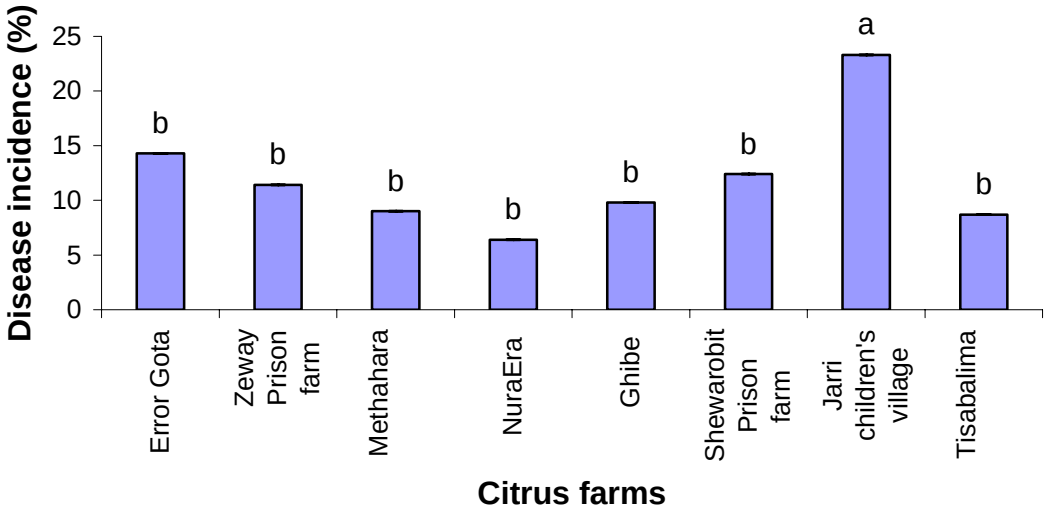

Fig. 3.5. Postharvest disease incidence of fruits collected directly from citrus farms in Ethiopia. Bars with the same letter are not significantly different (P <0.05) according to Fisher's protected LSD test and t- grouping.

Table 3.3 Peak harvesting seasons of citrus in Ethiopia based on a 2003-2004 survey

Farm units	Enterprise	Season											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Nura-Era	UAAIE[a]	x	x	-	-	-	x	x	x	x	x	x	x
Tibilla	UAAIE[a]	-	-	-	-	-	-	x	x	x	-	-	-
Merti-Jeju	UAAIE[a]	-	-	-	-	-	-	x	x	x	x	x	-
Awara-Melka	UAAIE[a]	-	-	-	-	-	-	x	x	x	x	x	x
Zeway	HDE[b]	-	-	-	x	x	x	x	x	-	-	-	-
Zeway	Prison farm[c]	-	-	-	x	x	x	x	x	-	-	-	-
Errer Gota	HDE[b]	-	-	-	-	-	-	-	-	-	x	x	x
Fetuli	HDE[b]	x	x	-	-	-	-	-	-	x	x	x	x
Methahara	MSE[d]	-	-	-	-	-	-	-	-	x	x	-	-
Ethioflora	Private	-	-	-	-	-	x	x	x	-	-	-	-
Toni	Alemaya University	-	-	-	-	-	-	-	-	x	x	x	x
Hursso	Defence force	-	-	-	-	-	-	-	-	x	x	x	x
Shewarobit	Prison farm[c]	-	-	-	-	-	-	x	x	x	-	-	-
Kerssa, Bati	Ghion Hotel	-	-	-	-	-	x	x	x	x	-	-	-
Jarri Children's Village	S W A O[e]	-	-	-	-	-	-	-	x	x	x	-	-
Tisabalima	ARSAF[f]	-	-	-	-	-	-	-	x	x	x	-	-
Merssa	Private[g]	x	x	x	x	-	-	-	-	-	-	-	-
Ghibe	HDE[b]	-	-	-	-	x	x	x	x	-	-	-	-

Legend: X = Peak harvesting time

- = Not peak harvesting time

[a] = Upper Awash Agro Industry Enterprise

[b] = Horticultural Development Enterprise

[c] = Government prison farms

[d] = Methahara Sugar Estate

[e] = South Wollo Agricultural Office

[f] = Amhara Regional State Association Farm

g = Private individual holdings

Fruits collected from markets had similar postharvest disease development that ranged between 5-46.7%. Significantly (P <0.05) higher rates of disease incidence (46.7%) was exhibited on Tibila pineapple fruits obtained from Addis Ababa Etfruit market whereas the lowest rate (5%) was observed on fruits collected from Addis Ababa greengrocer (Fig. 3.6).

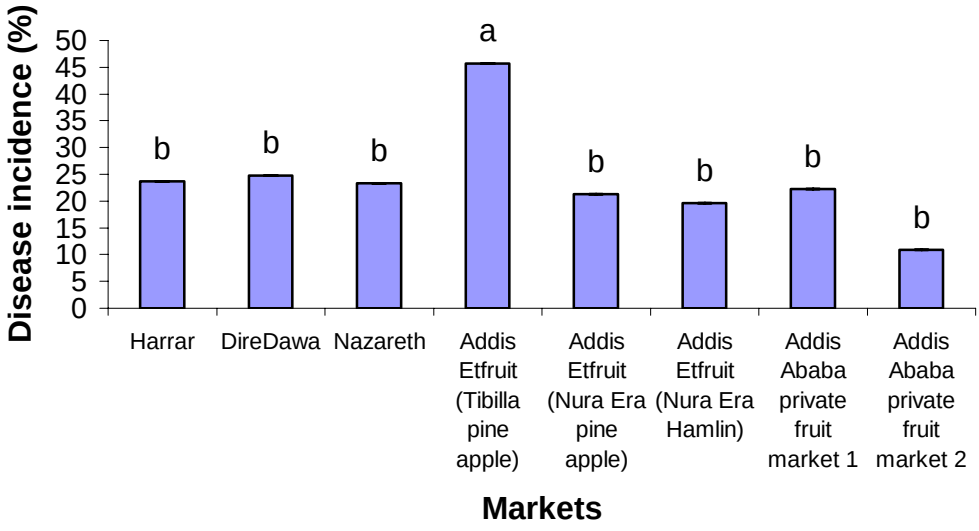

Fig. 3.6. Postharvest disease incidence of citrus fruits collected from fresh produce markets in Ethiopia. Bars with the same letter are not significantly different (P <0.05) according to Fisher's protected LSD test and t-grouping.

High postharvest disease incidence of fruit decay reported indicate that pre-and postharvest handling practices were inadequate in this sector. In the process of harvesting, fruit dropping to the ground by tree shaking was found to be common harvesting practices, which includes plugging create fruit punctures which could be contaminated by mould and sour rot pathogens (Kanopacka and Plocharski, 2004). Careful harvesting by hand picking with gloves, placing fruit in bags, protecting fruits from direct sun after harvest and avoiding jolting of bins over rough roads could decrease fruit contamination and postharvest decay.

3.3.5 Fresh produce and marketing

More than 98% of the fruit produced in Ethiopia are supplied to the nearest local markets. Most of the produce on the local market is supplied by UAAIE and HDE farms, which is marketed to Addis Ababa, Nazareth, Methahara, Diredawa and Harar. The fruit produce from Toni, Hursso and Errer Gota is supplied to the eastern capital

cities (Dire Dawa, Harar) and to a lesser extent to Addis Ababa. Fruits from the North Central Ethiopia citrus farms (Merssa, Tisabalima and Jarri) are marketed to Dessie, Woldya and Mekele towns. A very small proportion of fruit produce (2%) from the central east parts of Ethiopia (UAAIE, Tonni, Hursso and Error Gota) is exported to the neighbouring countries i.e. Djibouti and Somalia. Movement of produce across the border is mainly by private dealers using railway transport and trucks where there are no cooling facilities except spraying water manually over the surface of the fruit during the long hours (10-12 hr) of travel, which could also be at night.

CONCLUSION and RECOMMENDATION

The wide range of altitudes, climates and soil types in Ethiopia allowed for effective production of a variety of crops. Citrus is one of the high value crops cultivated in the country next to coffee in terms of local production. However, the production and export of citrus fruit to international markets is minimal and/or non-existent. Pre- and postharvest practices attribute to quality deterioration of citrus fruit. Improvements in the following practices are therefore crucial:

1. Selection of known disease resistance root stock varieties,
2. Improvement in field sanitation and controlling of weeds, infected trees and/or other crops growing around or in citrus farms. Cultivation of legumes (*Lablab purpureus* L.) (*Fabaceae*) under the orchard after land clearing during the onset of the second harvesting season (e.g. at Tisabalima, South Wollo), control weed growth and ameliorate soil nitrogen,
3. Development of appropriate alternative irrigation practices to replace the currently used double ring basin system,
4. Maintaining the water balance between onset of flowering, fruiting and ripening of fruit to avoid saltiness and fruit burst,
5. Improvement in harvesting practices and in fruit handling, and the subsequent training of these workers in best practices,
6. Although fruit volumes on the Ethiopian local fruit market is fast moving, the use of cold storage and clean packinghouse facility is important to retain quality,
7. Establishment or upgrading of centres for disease and pest identification and control studies, and

8. Careful integration of production and marketing for local and export products to improve the Ethiopian citrus industry.

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