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Cassava Scale: A New Threat for a Food Security Crop in Ethiopia

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ABSTRACT

In Ethiopia, cassava is mainly cultivated and consumed in Segen Peoples, Gedeo, Gamo Goffa, Sidama and Wolyita zones of the southern region. Farmers in these areas grow cassava as a food security crop in small irregular scattered plots either alone or intercropped with different crops. However, production and productivity of the crop is seriously affected by cassava scale, *Aonidomytilus albus*. It was first observed in 2001 at Amaro, Southern Ethiopia. It has become important to integrate various information on cassava scale in order to grow cassava sustainably. Therefore, this study was conducted to determine the distribution of *A. albus*, to identify alternate hosts and natural enemies and to test hot water temperatures against it. Scale insects were collected from cassava stems and buds and stems of different crops and sent to IITA, Benin for identification. Different hot water treatments for different time durations were tested to disinfest cassava cuttings from cassava scale. Cassava scale was recorded in Segen peoples, Gedeo, Sidama and Wolyita zones. It was recorded on *Solanum incanum*, *Abitilion tiophreslium*, Buzuwa and *Nuxia congesta*. Scale samples taken from the stems of *Grabilia robusta*, *Melia azadirachta* and *Erytrina abyssinica* were identified as *Coccus* sp., *Parlatoria camelliae* and an undetermined species, respectively. *Cybocephalus* sp., which is a predator of scale insects including whiteflies, was recorded at Amaro at two locations. Boiling water treatment at all durations totally killed cassava cuttings. Relatively better germination of cassava cuttings were obtained at 55°C. However, complete removal of cassava scale was not possible.

Keywords: alternate hosts, *Aonidomytilus albus*, disinfestations, germination, mortality

INTRODUCTION

Root and tuber crops are very important in Ethiopia as they support a large sect of the population. The most important root and tuber crops include enset (*Ensete ventricosum*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), taro (*Colocassia esculenta*), yam (*Dioscorea* spp.), Ethiopian dinich (*Coleus* spp.), anchote (*Coccinia abyssinica*) and cassava (*Manihot esculenta*).

The Southern region is well known for its production of root and tuber crops such as enset, sweet potato, cassava and yam. However, a number of insect pests are emerging and challenging the production of these crops in the region. Among these, enset root mealybug, *Cataenococcus ensete*, which was first reported from Wonago in 1988, is seriously challenging all enset-growing areas of the region. In addition to cultivated enset, this insect has started to attack both banana and wild enset. There has also been an increase in the damage and occurrence of enset leaf hopper, *Poecilocarda nigrinervis*, first reported from Wolyita in 1981. This insect causes direct damage and is suspected of transmitting enset bacterial wilt. Since then the insect has caused damage to enset, especially when it occurs in the dry season. Another emerging insect pest, cassava scale (*Aonidomytilus albus*), which was first recorded in Amaro, Southern Ethiopia, in 2001, has become a devastating pest (pers.obs.).

In Ethiopia, cassava is mainly cultivated and consumed in the southern part of the country, especially in low land agro-ecological zones. The average total area coverage and production per year in the southern region is 4942 ha and 54036 tones, respectively (BoA 2000). The crop is well adapted and grows in Amaro, Konso districts and Gedeo, Gamo Goffa, Sidama, and Wolyita zones of southern region (**Fig. 1**). Farmers in these areas usually grow cassava in small irregular scattered plots either alone or intercropped with different crops (Eyasu 1997).

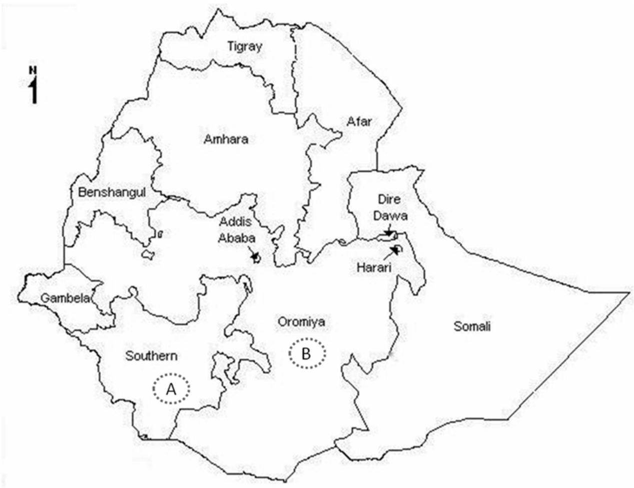

Fig. 1 Administrative map of Federal Republic of Ethiopia. (A) Cassava-growing area and (**B**) cassava potential area.

Production and productivity of the crop is constrained by biotic and abiotic factors. In the world more than 200 species of cassava pests representing a wide range of arthropods that include mites, thrips, stem borers, horn worms, whiteflies, and scale insects have been recorded (Bellotti and Van Schoonhoven 1978).

Cassava scale is the major pest of cassava in Ethiopia and can cause total crop failure, especially in Segen people’s zone where cassava is a major crop. In general, cassava is a recent introduction to the country and there are no many alternatives for cassava germplasms to grow. It

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Research Note

Table 1 Identification report of samples of cassava scale collected from cassava and other alternate hosts and identified in IITA, Benin (2007).

Host	Location	Altitude (masl)	Identification result
Abutilon tiophreslium	Amaro	1420	*Aonidomytilus albus* (Hem.: Diaspididae)
Buzuwa stem	Bensa	2000	*Aonidomytilus albus* (Hem.: Diaspididae)
Cassava stem	Amaro	1530	*Cybocephalus* sp. (Col.: Cybocephalidae)
Cassava stem	Amaro	1510	*Aonidomytilus albus* (Hem.: Diaspididae)
Cassava stem	Amaro	1500	*Crematogaster* sp. (Hym.: Formicidae)
Cassava stem	Amaro	1320	Undetermined sp. (Drosophilidae)
Cassava stem	Amaro	1420	Camponotus sp. (Hym.: Formicidae)
Cassava stem	Hawassa	1700	*Aonidomytilus albus* (Hem.: Diaspididae)
Cassava stem bud	Amaro	1500	*Aonidomytilus albus* (Hem.: Diaspididae)
Erytrina abyssinica stem	Sodo Zuria	1970	Undetermined sp. (Hem.: Diaspididae)
Grabilia robusta stem	Amaro	1330	*Coccus* sp. (Hem.: Coccidae)
Nuxia congesta stem	Damot Woide	1970	*Aonidomytilus albus* (Hem.: Diaspididae)
Melia azadirachta	Amaro	1330	*Parlatoria camelliae* (Hem.: Diaspididae)
Solanum incanum	Amaro	1530	*Aonidomytilus albus* (Hem.: Diaspididae)

attacks all available cassava varieties namely 'Kelle' (= Nigeria White) and 'Qulle' (= Nigeria Red), both of which were found to be good after selection from local collections and introductions abroad and released in 2005 by the Hawassa Agricultural Research Center. Infested cassava cuttings by cassava scale do not root, and use of infested cuttings at planting can result in rooting failure of up to 80% (Lal and Pillai 1981). Heavy infestation causes desiccation of the stems, and the plant becomes thin, weak and breaks in the wind and death of the plant may result. According to Degu *et al.* (2006), more than 85% of cassava-growing farmers in southern Ethiopia obtain planting materials from their own farms and store it by burying in the soil and mulching under shade for 2 weeks to 3 months. The purpose of burying in the soil and mulching under the shade keeps the germination potential of the planting material active. However, insect attack has been increasing recently and there is a risk of distribution to new areas through infested cuttings and a lack of planting material.

Different approaches have been developed to clean infested banana and yam planting materials from pests and pathogens (Speijer 1999). Exposure of banana and plantain suckers to heat for a relatively long period has been used to obtain clean planting materials (Colbran 1967). The simplest thermal banana and plantain sucker sanitation method consists of immersing suckers for 30 s in boiling water (100°C) (Tenkouano *et al*. 2006). Lemawork (2008) also recommended that immersion of enset seedlings in boiling water for 10 to 30 s prior to planting completely eliminates enset root mealybug (*Cataenococcus ensete*) and could easily be adopted by farmers because of its ease of application. A combination of hot water treatment with insecticides is used for quarantine security work to eliminate pests like mealy bugs, aphids, thrips, soft scales and ants (Hara *et al*. 1995; Hu *et al*. 1996). Based on this information there was a need to test hot water temperatures in an attempt to eliminate cassava scale.

Recently, it has become important to integrate various control options in order to grow cassava and sustainably control *A. albus*. Knowledge about the pest and its ecology is very important. Therefore, the objectives of this study were to study the geographical distribution of the pest, its alternate hosts and natural enemies and to evaluate the effectiveness of hot water treatment at different temperatures and durations of exposure for the control of cassava scale.

MATERIALS AND METHODS

Identification

Cassava scale samples were collected from different locations of southern Ethiopia ranging from 1320 to 2000 meters above sea level (masl) (**Table 1**). For cassava scale and other scale insects, samples were taken together with a piece of cuttings of stem and buds and kept in 70% ethanol in 1.8 ml size vials. Predators and ants were collected and kept directly in 70% alcohol in 1.8 ml size vial. All the samples were sent to the International Institute of Tropical Agriculture (IITA), Biological Control Center for Africa/ Biodiversity Center in the Republic of Benin where they were identified. For each of the samples sent for identification a given number of specimens were retained in IITA, Benin.

Alternate hosts of scale

Weeds, shrubs and trees with scale insects were targeted and samples were collected from those infested plants. Samples were taken from cassava stem, cassava bud, stems of *Solanum incanum*, *Melia azadirachta*, *Grabilia robusta*, *Abitilion tiophreslium*, Buzuwa (not yet identified), *Nuxia congesta* and *Erytrina abyssinica* using a similar procedure above. Samples were kept separately in 70% ethanol in 1.8 ml size vials and sent to the International Institute of Tropical Agriculture (IITA), Biological Control Center for Africa/ Biodiversity Center in the Republic of Benin where they were identified.

Hot water treatment

Different hot water temperatures and durations were used to treat cassava cuttings of varieties called 'Kelle' and 'Qulle'. Cassava cuttings were cut into 20 cm length and treated at the respective temperature and durations using a water bath. Infested cassava cuttings were obtained from Amaro where cassava scale infestation is serious and first observed in 2001 where as clean cassava cuttings were collected from Hawassa Agricultural research center research station. The hot water temperatures used were 55, 75, and 95°C (boiling water) and room temperature (23°C). Duration of 10, 30, 60 and 300 s were used for each of the hot water temperatures in a factorial arrangement. Clean and infested cuttings were treated and planted in plastic posts. For each of the treatments five cassava cuttings were used for both clean and infested cuttings of 'Kelle' and 'Qulle'.

The trail was established at the Southern Agricultural Research Institute (SARI), Hawassa Agricultural Research Center (7° 03' N, 38° 30' E, 1,700 m above sea level) in a screen house; Hawassa, Ethiopia, and evaluation was continued for a month. For each of the treatments five cassava cuttings were planted in plastic pots with a size of 22 cm diameter and 22 cm height. Weeding, watering and other agronomic practices were carried out when it is necessary. Data was analyzed using Xlstat for windows.

RESULTS AND DISCUSSION

Identification

All scale insect samples collected from cassava stems and buds were identified as *Aonidomytilus albus*. Based on the result, *A. albus* is distributed from 1320 to 2000 masl. This indicates that *A. albus* has a wide range of distribution as long as cassava plant grows. However, in order to determine its geographical distribution a well structured base line survey of the pest is undergoing. In addition to cassava, *A. albus* was recorded from stem samples of *Solanum incanum*, *Abitilion tiophreslium*, Buzuwa and *Nuxia congesta* (**Table**

Table 2 Germination percentage of infested and clean cassava planting materials of variety 'Kelle' one month after treatment application at different hot water temperatures and durations.

Duration	Clean cassava cuttings ('Kelle')				Infested cassava cuttings ('Kelle')				Infested cassava cuttings ('Qulle')			
(sec.)	Boiling	75°C	55°C	21°C	Boiling	75°C	55°C	21°C	Boiling	75°C	55°C	21°C
10	0* (0)**a	1 (20) aA	4 (80) bB	5 (100) b	0 (0) a	0 (0) a	0 (0) aA	2 (40) aB	0 (0) a	1 (20) aA	4 (80) bB	4 (80) bA
30	0 (0)a	0 (0) aA	4 (80) bB	5 (100) b	0 (0) a	0 (0) a	3 (60) bBC	4 (80) bC	0 (0) a	0 (0) aA	1 (20) aA	3 (60) bA
60	0 (0)a	0 (0) aA	5 (100) bB	5 (100) b	0 (0) a	0 (0) a	1 (20) aAB	0 (0) aA	0 (0) a	0 (0) aA	5 (100) bB	4 (80) bA
300	0 (0)a	0 (0) aA	2 (20) aA	5 (100) b	0 (0) a	0 (0) a	2 (40) aB	2 (20) aAB	0 (0) a	0 (0) aA	1 (20) aA	4 (80) bA

*number of plants germinated; **germination in percentage. Means within a row followed by the same lowercase letters are not significantly different ($P \leq 0.05$); means followed within a column followed by the same uppercase letters are not significantly different according to Tukey's HSD test, $P \leq 0.05$.

Fig. 2 Damage symptoms and progress of cassava scale infestation (A-D).

1).

Scale samples taken from stems of *Grabilia robusta*, *Melia azadirachta* and *Erytrina abyssinica* were identified as *Coccus* sp., *Parlatoria camelliae* and undetermined sp., respectively. *Cybocephalus* sp. which is a predator of scale insects including whiteflies was recorded at Amaro at two locations. In addition to *A. albus*, *Crematogaster* sp., *Camponotus* sp. and undetermined sp. were recorded from cassava stem samples (**Table 1**)

The scale cover of the adult female *A. albus* in life is elongate, mussel-shaped, 1.75-2.5 mm long, straight or curved whitish to dark-brown, with slightly darker terminal exuviae (Watson 2002). The scale cover of the second-instar male is similar to that of the adult female, but smaller (1.0-1.25 mm long) and narrower, with terminal exuviae (Ferris 1941; Dekle 1976). The non-feeding immature stages of the male develop beneath this scale cover. After molting to the adult stage, the male rests beneath the scale cover before emerging to seek for females.

Damage symptoms

On cassava, *A. albus* coats the stems, side shoots and even sometimes the leaf petioles and leaf undersides. Infestation in the field occurs in patches around a cutting that was infested at planting. Heavy infestation causes desiccation of the stems, making them become thin and weak so that they often break in the wind; death of the plant may result. The breakage of stems leads to profuse branching so infested plants often appear bushy. Root development in infested plants is poor, and the roots become unpalatable (Lal and Pillai 1981).

Infestation of cassava cuttings starts in the new shoots from planted cuttings. Crawlers of cassava scale moves from infested planted cuttings to newly developed shoots and progresses upwards (**Fig. 2**). Based on the observation in the field at a given interval the infestation increases during the dry season. Lal and Pillai (1981) also reported that the severity of cassava scale attack becomes worse in drought conditions, aggravating drought stress.

Alternate hosts of cassava scale

The major hosts of cassava scale, *A. albus* are species of *Manihot*, but this insect has been recorded feeding on a variety of other hosts. Cassava scale affects leaves, stems and whole plant. The major hosts of cassava scale are, *Manihot esculenta* and minor hosts are *Atriplex*, *Carica papaya*, *Chrysanthemum*, *Croton bonplandianus*, *Flourensia*, *Harrisia*, *Jatropha gossypifolia*, *Malvastrum americanum*, *Mangifera indica*, *Mimosa*, *Salvia*, *Sechium*, *Sida*, *Solanum*, *Suaeda* and *Turnera ulmifolia* (CABI 2005). In Ethiopia *Solanum incanum*, *Abitilion tiophreslium,* Buzuwa and *Nuxia congesta* were recorded as alternate hosts of *A. albus* (**Table 1**). *Solanum incanum* was highly infested with *A. albus* and the infestation was serious especially in the dry season. However in the rainy season the infestation level on *Solanum incanum* was minimal.

Hot water treatment

A significant difference in mean germination was observed between clean and infested cassava cuttings of 'Kelle' treated at room temperature ($P < 0.0001$). Clean cassava cuttings of 'Kelle' showed 100% germination whereas infested cutting germinated only to 35% (**Table 2**). Infested cuttings of 'Qulle' treated at room temperature showed a germination percentage of 75% relatively better when compared with 'Kelle'. In general 'Qulle' was better in germination when compared with 'Kelle'; however, infestation level of these two varieties may not be exactly the same.

Based on data taken one month after treatment application all clean and infested cassava cuttings treated in boiling water and 75°C at all durations (except 10s duration) were failed to germinate (**Table 2**). Similarly, only 20% of the cuttings were germinated at 75°C for 10 s. At 55°C relatively better germination percentage was observed for both clean and infested cassava cuttings. For clean cassava cuttings 80-100% germination was found except at 300 seconds in which only 40% mean germination found (**Table 2**). Significant difference was observed among hot water temperatures ($P < 0.0001$). However, there was no significant difference among durations of hot water treatment ($P < 0.4696$).

For infested cassava cuttings even a complete failure of germination was observed in the control treatments. The maximum germination was 80% where as in clean planting materials a 100% germination was observed for all time durations (**Table 2**).

Observation was made to investigate survival of cassava scale insects. It was not possible to see survival of insects on boiling water and 75°C at all the time durations since the plant itself died. However, cassava scale insects were able to survive hot water temperature treatments at 55°C in all time durations. It was not possible to find a complete removal of cassava scale using hot water temperatures without affecting germination of cassava cuttings.

Parathion, endrin, dimethoate, monocrotophos and endosulfan were tested in sprays against Aonidomytilus albus infesting stored stems of cassava and reducted the infestation level by 93.3, 48.6, 36.6, 29.7 and 20.5%, respectively and none of the treatments had any adverse effects on sprouting (Rao and Pillai 1972). Immersion of cassava cuttings in manipueira [a liquid extract from cassava roots] and immersion in hot water were tested against the scale insects *Mytilaspis dispar* and *Phenacoccus manihoti and* one single immersion in manipueira for 60 min showed the best result (Razafindrakoto 1999). Dipping of heavily infested cassava cuttings in DDT oil emulsion for 5 min showed a good control of *Aonidomytilus albus* however with extremely poor germination (1.2% germination) that indicates the most successful method of control of cassava scale is through use of clean planting material (Swaine 1950).

CONCLUSION

Aonidomytilus albus has a wide range of geographical distribution in Ethiopia ranging from 1320 to 2000 masl. It was recorded on *Solanum incanum*, *Abitilion tiophreslium,* Buzuwa and *Nuxia congesta*. However, detailed survey should be made in order to determine its geographical distribution, alternate hosts and its natural enemies. Hot water treatment is not a good option to clean infested cassava cuttings from cassava scale. A complete removal of the insect was not possible at 55°C even at 300 seconds which reduced germination percentage to a level of 40%. Therefore, it is necessary to use clean planting material or look for insecticides which could have a better effect to clean infested cassava cuttings.

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