Short Communication

Cotton Mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae): a Newly Introduced Pest Threatening Cotton Production in Ethiopia

Miesso Hemba[1], Bayeh Mulatu[2] and Hiwot Lemma[3]
[1]EIAR, Werer Research Center; [2]FAOET, Addis Ababa, Ethiopia
3MoA, Crop Protection Directorate

Abstract

Following the interception of a mealybug by crop protection staff of the Werer Agricultural Research Center and the Amibara Agricultural Enterprise on cotton, survey was made to determine the identity, distribution, incidence and severity of damage on cotton by this new pest in cotton growing areas of Ethiopia. Through the surveys, the pest was intercepted in the cotton fields of Awash River basin, Southern Ethiopia, Gambella, and Humera areas but with varying degrees of incidence and severity and the most affected was cotton in the Awash River basin. The mealybug was identified as *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), which is commonly known as cotton mealybug and represented a newly recorded pest of cotton in Ethiopia. This pest causes quantitative yield loss through direct feeding. It also releases a large quantity of honeydew onto the plant surface resulting in reduced photosynthetic activity and significant lint quality degradation. In addition to cotton, the pest infested many field crops and a number of weed plants growing within or around cotton fields. Although the how and when of the introduction of the pest has not been fully determined, its means of movement to other areas within the country were determined through discussions made during the survey work. There are four possible causes of cotton mealybug introduction to new places and include movement of farm machineries, laborers and jut bugs. Although the pest is new to the country, significant number of predatory coccinelides (larvae and adults) and larvae of green lacewing were found actively preying on the cotton mealybug in most of the infested cotton fields mainly after cotton is picked.

Key words: Cotton mealybug, cotton, introduced pest threatening

Introduction

Cotton, *Gossyium* sp., is an important industrial crop grown on an area of more than 32 million hectares in about 80 countries of the world located in the tropics and temperate climate zones (Lundback, 2002; Serunjogi *et al.*, 2001). China, USA and India are the main producers contributing 29.0, 19.9 and 14.2% of world production, respectively (YnFx, 2011). Cotton is one of the most important internationally traded agricultural commodities in terms of volume and value traded (Serunjogi *et al.*, 2001). Its main uses are in manufacturing of textile fiber, food

oil, animal feed and industrial materials such as soap (Zhang *et al.*, 2007). In Ethiopia, the total agro-ecologically potential area for cotton production is estimated to be 2, 575, 810 hectares (Hiwot, 2007) and actual production was estimated 42,371 hectares (MoA, 2012). The major growing areas are Metam, Humera, Asossa, Gambella, Omo valley, Arbaminch areas, and different localities of Awash River basin. Currently; cotton production has become an attractive business for foreign and local investors which in turn contribute to economic growth of the country. However, its production and productivity is constrained by a number of challenges among which insect pest menace has become the main one. More than 51 arthropod pests have been known to attack cotton of which African bollworm (*Helicoverpa armigera*), Sudan bollworm (*Diparopis watersi*), Flea beetle (*Podagrica* sp.), cotton aphid (*Aphis gossypii*), *Thrips* sp. and Whitefly (*Bemisia tabaci*) are the major (Ermias *et al.*, 2009).

While the cotton growers are suffering from the severe damage of these previously exiting insect pests; a new insect pest, cotton mealybug appeared in Melka Sadi locality in July 2010. In this year the infestation was at isolated spots and the damage the pest inflicted was insignificant. In 2011, however, the pest heavily infested wide area of cotton fields in different localities of Awash Valley. With this the economic importance of the pest was recognized and designing of control strategy was found necessary. In order to develop sound control strategies knowing the identity of the pest, degree of infestation and its geographical distribution in the country were lacking. Therefore, this study was conducted to fill these gaps.

Materials and Methods

The first field survey was conducted in August, 2011. It covered different localities of Awash River basin, Arbaminch areas (Arbaminch and Sile) and Omo valley (Wayto). At each specific locality three cotton fields, located at the entrance to the farm, in the middle ground and at the end were selected in diagonal way and one hectares of each field were sampled. For each hectare, about 40 sample plants were randomly selected for mealybug assessment by crisscrossing cotton fields. Then, incidence of mealybug was scored as either infested or not infested and percent infestation was calculated (Abbas *et al.*, 2010). Severity of infestation based on presence of mealybugs on cotton plants was recorded in the scale of 1 to 4 ranges according to Nagrare *et al.*, 2011; where 1- stood for scattered appearance of few mealybugs on the plant; 2- for severe infestation of mealybug on any one branches of the plant; 3-for infestation of mealybugs on more than one branch or half portion of the plant and 4- for severe infestation of mealybugs on the whole plant. Then, severity index (**SI**) was calculated using the formula $\frac{\sum_{g=1}^{4} m}{Pio}$ where **g** is grade points (1-4 for infestation grade $g_{=1}$ to $g_{=4}$, respectively) of infested plants and p_{io} is total number of infested plants observed. At the same time (August, 2011) samples of adult mealybugs were collected from cotton fields in Awash Valley and placed in vials half filled with 70% alcohol. About 30 to 50 mealybugs were collected per vial and the samples were sent to plant pest diagnostic center, USA, for species identification by experts.

The second survey which covered Awash valley (Afambo, Assayita, Gewane, Amibara, Nuar-Eera, Merti-Jeju and Tibila), Arbaminch areas (Arbamich and Sile), Omo valley (Waito, Omorate and Gnangatom), Gambella, North and Northwest Ethiopia (Humera, Tsegade, Merab-Armachiho, Metema, Quara, Metekel and Benishanul gumz) was conducted in February 2013. During this survey geographic coordinates of all sites were recorded using GPS. The incidence, percent infestation, and severity whenever possible were determined in similar fashion as in the case of first field survey. In areas where cotton mealybugs were intercepted, group discussion were made with develop agents, farm managers and crop protection personnel to identify possible sources of mealybug infestation.

During both surveys, other plants (crop and non crop plants) within or at the border of cotton fields were also checked for cotton mealybug infestation. Samples of major weeds hosting cotton mealybugs were collected, mounted and

identified to species at Holota Agricultural Research Center, Ethiopian Institute of Agricultural Research. Visual observations were also made on plants infested by the cotton mealybug for any morphological change as compared to uninfested plants. At the same time, the presence of predators was checked on the colonies of the mealybug.

Result and Discussion

Species identity confirmation

The identification results of mealybug samples were received in January 2012. It was identified by Dr. Gillian W. Watson, Senior insect biosystematist, Plant pest Diagnostic Center, USA. All samples were identified as cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). This insect is a serious pest of many crops which is distributing to different part of the world with initial reports from Texas, USA (Tinsley, 1898). It was reported from Ecuador in 1992 (Williams and Willink, 1992) and Caribbean region in 2000 (Watson and Chandler, 2000). Then it was recognized as a pest on Papino (*Solanum muricatum*) in Chile (Patricia, 2002) and Argentina (Granara de Willink, 2003). In 2005, *P. solenopsis* appeared as pest of tomato and cotton in Brazil and Pakistan, respectively (Culik and Gullan, 2005; Govpk, 2005). It has also been reported as a serious pest of cotton in India (Nagrare *et al.*, 2009) and as a potential threat in China (Wang *et al.*, 2010) and Australia (Admin 2010). In Africa, it has been reported from Nigeria (Akintola and Ande, 2008), Benin (Germain *et al.*, 2010), Cameron and Egypt (Abd-Rabou *et al.*, 2010). In African countries the level of infestation of the pest has not been stated clearly, yet the global scenario tells that the introduction of the pest to Ethiopia is a great threat to the cotton sector unless organized nationwide control stagey is in place.

Field survey

During the first survey the distribution of cotton mealybug was limited only to upper and middle Awash (Table 1). The cotton fields of lower Awash (Afambo and Asayita areas) and southern refit valley i.e. Weyito, Sile and Arbaminch were free from mealybug infestation. In infested areas of Upper and Middle Awash, the degrees of severity and percentage of incidence were very variable between the localities (Table 1). In the middle Awash, the highest percentage of incidence and severity index was recorded from Kabt beret farm at Werer; where the whole cotton plants in the field were dead. In other fields of the area, the percentage incidences were 10, 25 and 95 at Melka Sadi, Werer farm and Shelako, respectively. The severity indices were also inclined from 1.37 at Melka Sadi to 2.3 at Werer farm and 3.79 at Shelako. Cotton fields of Werer Agricultural Research Center (WARC); had relatively less percentage incidence than other infested fields excepting Amasaburi and Melka sadi farms. However, the severity index at Werer Agricultural Research Center farms was higher than both Amasaburi and Melka sadi farms. Comparing level of infestation of two cotton fields at Gewane, Gefrem field had more percent incidence and severity index than Amasaburi field.

Areas inspected during the January 2013 included southern Ethiopia, northern and North West of the country and the Awash Valley (Fig 1). In southern Ethiopia cotton fields in Omo valley (Weyto, Omorate, and Ghangatom), Sile, Arbaminch and Merab Abaya were surveyed and cotton mealybug was intercepted at Weyto, Sile, Armbaminch, and Merab Abaya. The infestation was the highest at Arbaminch with percent incidence and severity index of 45.5 and 1.98, respectively. Cotton fields at Merab Abaya and Sile had relatively less infestation than those in Arbaminch areas (Table 1). At Weyto level infestation was not determined as cotton plants on infested fields were removed and burned prior to survey work. Yet, heavy infestation of mealybug was evident on weeds left unattended in cotton grown fields. In the remaining cotton growing areas of Southern Ethiopia (Omorate, and Ghangatom), there was no cotton mealybug infestation.

In North and northwest Ethiopia, cotton fields at Humera (places between Mickadra and Lugdi), Metema, Metekel, Tsegede, Quara, and Merab-Armachiho were inspected (Table 1). Mealybug was found in four of the eight farms visited at Mickadra locality. In this village cotton was being picked and stalks were removed, thus level of infestation couldn't be determined.

Nevertheless; heavy infestation of cotton mealybug was observed on different weed species which provided food source for the pest. Other cotton fields in this part of the country were not infested by the cotton mealybug.

In cotton farms in Gambella and Benishangul gunz were surveyed. In Gambella region fields at Abobo, Bazen farm, Gambella zuria, Abol and Etang were inspected but cotton mealybug was recorded only at one field of Bazen farm. At this field percent incidence was 10.83 and severity index was 0.49. In Benishangul gumuz region places visited include Dangur, Guba and Sharkole. In this region none of the farms was infested by the cotton mealybug. Similar survey was also conducted in whole cotton growing areas of Awash Valley which included Tibila, Merti-Jeju, Nura-Eera, Amibara, Gewane, Assayita and Afanbo. This survey was focused on identification of overwintering niches of mealybugs in dry season. The pest was prevalent throughout the whole valley feeding on weeds grown at the border of cotton grown fields. Being grown on adages of irrigation canals which had moist soil during the dry season, the weeds remained green providing excellent feeding and reproductive niche for the pest.

Figure 1. Female colony, crawlers emerging from ovisacks and male adults (pictures accessed from Google in May 2012).

Polyphagus nature of cotton mealybug

In addition to cotton the pest infested different field crops grown in Awash Valley such as kenaf, sesame, sweet potato, tomato, water melon, okra and green pepper. This shows that the pest is a threat to many valuable crops of the country. The pest was also hosted by many weed species of which the major one include *Paratherium hysterophorous*, *Xanthium strumarium*, *Datura stramonium*, *Amranthus hybridus*, *Abutilon indicum*, *Hibiscus mutabilis*, *Corechorus trilocularis*, *Solanum melongena*, *Portulaca sp.* and *Prosopis julifilora*. Some non weed higher plants like *Azardectin indicum* which is supposed to be poison to many insects was also found heavily infested by the cotton mealybug. So far, it has been reported from 183 plant species in 52 families (Ben-Dov *et al.*, 2013). Therefore, the introduction of this extremely polyphagous insect to Sothern Ethiopia and Gambella region where there is high plant diversity the threat to the production of cotton and other crops in the regions is under real threat.

Causes of cotton mealybug distribution in Ethiopia

Through group discussions four different possible causes of cotton mealybug dispersion were identified. Firstly there is high exchange of farm machineries (tractors, plowing discs, lilliston, cultivator, planters, pesticide spray machines etc.) between farms of Middle Awash Valley, previously infested part of the country, and the southern Ethiopia and Gambella areas. This might have introduced mealybug to new places (Abaya, Arbaminch, Sile, Weyto and Gambella) since crawlers can be taken to distant places by farm machines. Secondly Middle Awash remained the sole source of cotton seeds for most cotton growers in the country. In fact cotton seed purchased from this area is sulfuric acid delinted one. Unlike fuzzy seed, sulfuric acid treated seed may not be directly infested by the mealybug, however, the chance that crawlers could stick to seed bags and get transported to new places is a possibility. Thirdly most cotton growers in the country use common gentries at Mojo, Dukem, Debre Zeit and Akaki where there is unintended exchange of jut bags. This might have created a chance for cotton mealybug contaminated sacks to enter new

places and introduce the pest. The importance of juts sacks in introducing cotton mealybug was evident at two newly infested farms, Weyto and Bazen, where heavy infestations of the pest on weeds around storage structures were seen. Fourthly there is high movement of laborers between Awash Valley, southern Ethiopia and Gambella areas. The picking time of cotton is earlier in Awash Valley than in Gambella and southern Ethiopia. Therefore, the laborers who have picked cotton in Awash Valley move to southern Ethiopia and Gambella areas. Since crawlers of cotton mealybug can stick to human clothing; this is one of the possible routes of its introduction to southern Ethiopia and Gambella areas. Source of infestation of cotton mealybug in Humera areas was not clear since there was no evidence showing any possible route that can take the pest from Awash Valley to this part of the country. Therefore, infestation in Humera areas needs to be investigated further.

Damage to cotton crops by cotton mealybug

In our observations, mealybug were mainly found on the young parts of the cotton plant, including twigs, leaves, flower buds, petioles and young bolls of the cotton plants. In heavy infestations it was also found on the stems of the plant forming continuous single layered colony. The infested plants were stunted, growth appears to stop and most plants look dehydrated. In severe cases, defoliation, loss of flower buds, flowers and immature bolls has occurred. A similar observation was also reported by Abbas *et al.* (2010) and Mark and Gullan (2005).

Figure 2. Cotton mealybug damage on developing flowers, stems and bolls of cotton plants (Pictures by Bayeh Mulatu, 2011)

Some of infested cotton plants were found covered with a dense mat of sooty moulds grown on the large amount of exuded honeydew. It was stated that the insect releases large quantity of honeydew through orifices on its back side. This allows sooty mold growth which fouls plant surfaces, blocks stomata, impedes respiration and photosynthesis, and consequently reduce yield (Saeed *et al.*, 2007). Therefore, cotton mealybug causes quantitative yield loss through direct feeding and by disrupting physiological function of the plant. In some localities for example Gewane; seed cotton picked from late infested field was heavily stained with sooty mold fungi that grew on honeydew excreted by mealybug. This indicates that honeydew of mealybug coming from late infestation results in significant lint quality degradation.

Figure 3. Cotton leaves and lint contaminated with sooty mold after honeydew deposition (Pictures by Miesso Hemba, 2012)

Natural enemies of cotton mealybug

In principle, when a new pest like the cotton mealybug invades a new geographical area, the local natural enemies (predators and parasitoids) take some time before they get adapted to feed on it. In contrary to this fact, significant number of predatory coccinelides (larvae and adults) and larvae of green lacewing were found actively preying on the cotton mealybug in most of the infested cotton fields mainly after cotton was picked. Therefore, species composition and preying efficiency of these potential biocontrol agents need to be determined. In addition, a large number of ants were observed roaming around on plants infested with cotton mealybug and attending them. They were also observed taking the mealybugs to new areas and help establish new mealybug colony. The ants were safeguarding the mealybug from predators and in return collect honeydews exuded by the mealybug (Personal observation).

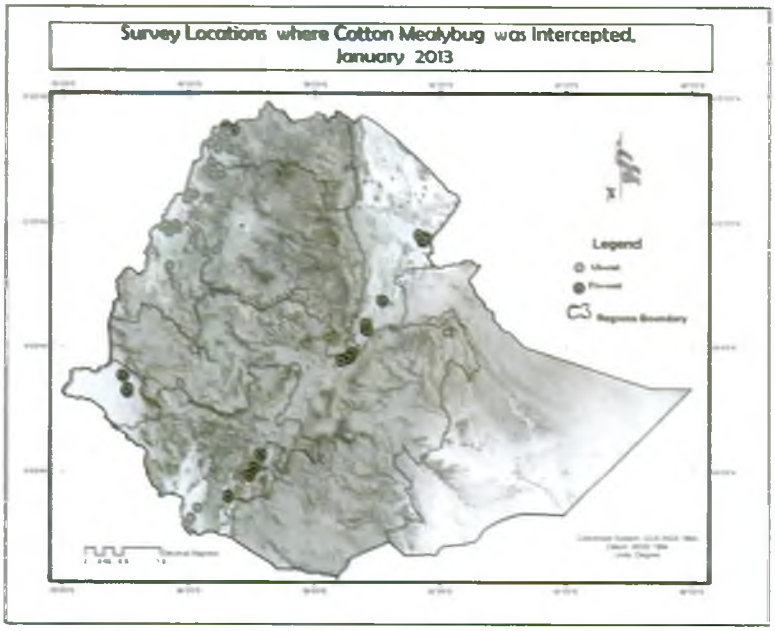

Figure 4. Survey locations where the Cotton Mealybug was intercepted, January 2013

Table 1. Incidence and severity of cotton mealybug in some cotton agro-ecologies of Ethiopia

August 2011					January 2013			
Localities	Incidence	PI	SI		Localities	Incidence	PI	SI
Weyto	Absent	---	---		Omorate	Absent	---	---
Sile	Absent	---	---		Gnangatom	Absent	---	---
Arbaminch	Absent	---	---		Weyito	Present	ND	--
Upper Awash	Present	25	1.0		Sile	Present	6.25	0.25
Melka Sadi	Present	10	1.37		Arbaminch	Present	45.83	1.98
Werer farm	Present	25	2.3		Merab Abaya	Present	15.25	0.37
Shelako	Present	95	3.79		Tibila	Present	ND	--
WARC	Present	10	2.13		Merti-Jeju	Present	ND	--
Kabt beret farm	Present	100	4.0		Nuar- Eera	Present	ND	--
Gefrem	Present	67.50	2.21		Amibara	Present	ND	--
Amasaburi	Present	2.50	1.0		Gewane	Present	ND	--
Afambo	Absent	---	---		Assayita	Present	ND	--
Asayta		---	---		Afanbo	Present	ND	--

Mikadara	Present	ND	--
Lugdi	Absent	---	---
Merab-Armachiho	Absent	--	---
Quara	Absent	--	---
Tsegade	Absent	--	---
Metekel	Absent	--	---
Metema	Absent	--	---
Benishangul gumz	Absent	--	---
Bazen farm	Present	10.83	0.49
Abobo	Absent	--	---
Etang	Absent	--	---
Abol	Absent	--	---

* ND= Not determined

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