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Research Article

Incidence of a New Pest, the Cotton Mealybug *Phenacoccus solenopsis* Tinsley, on Sesame in North Ethiopia

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Sesame *(Sesamum indicum)* is one of the most important cash crops grown extensively for its seeds in Ethiopia. Production of sesame in the country is very crucial in many aspects, but the invasion of the cotton mealybug, *Phenacoccus solenopsis* Tinsley, is becoming a big deal in its production. A survey for mealybug infestation was conducted during 2016 production season in 15 localities of "Kafta Humera" district so as to assess the incidence and severity of the pest. In each locality 2 sesame farms have been selected and 6 samples per farm (2 samples from the road sides, 2 from camp surrounding, and 2 from the central part of the farms) have been checked. During the survey, "Bowal" and "Sherif Hamad" have scored the higher incidence and severity of mealybugs. Road sides and camp surrounding of the farms were shown to have severe infestation. Stony and oxen plowed farms were also intensively invaded with cotton mealybugs. The pest has different natural means to infest new areas; thus its control measure has to be developing timely.

1. Introduction

Sesame *(Sesamum indicum)* is the most important cash crop grown extensively for its seeds in western and south western Tigray. Ethiopia stands at 6th position amongst 76 sesame growing countries of the world [1]. And sesame is the second largest agricultural commodity for the source of foreign currency and good source of cooking oil through local extraction. Despite its importance as source of cooking oil and foreign currency earning, sesame productivity is very low especially in dry land area like in Tigray [2]. Production of sesame in the country is very crucial in many aspects, but there are many hurdles for its production and productivity, like pest infestation, seasonal delay, low yielding, postharvest loss, poor storage facility, difference in capsule maturity, shattering, and so on. Insect pests such as sesame webworm *(Antigastra catalaunalis)*, sesame seed bug *(Elasmolomus sordidus)*, and gall midge *(Asphondylia sesami)* are the most important insects that affect production of sesame during its different growing stages [3]. But now *Phenacoccus solenopsis* Tinsley, has been found as a new and invasive pest of sesame. It has been described as a serious and invasive pest of cotton in Pakistan and India [4]. Mealybugs (Hemiptera: Pseudococcidae) are small, soft-bodied insects that suck plant saps. Mealybugs are severe agricultural pests which reach up to 350 species but only 158 (about 35 are polyphagous) species are identified as pests worldwide [5]. The pest was reported for the first time in 1991 as a severe pest from Texas, America, which later on spread throughout the world. During the first decade of 21st century mealybugs emerged as the most devastating pest of agricultural crops [4]. *P. solenopsis* is a polyphagous insect feeding on about 200 plants but it causes economic damage mainly to cotton, brinjal, okra, tomato, sesame, sunflower, and China rose [6]. Mealybugs feed on all parts of plants, particularly on leaves and branches that join stems. According to Hodgson et al. [7], there is a striking difference in the mealybug's distribution on the plant between southwestern USA and Mexico populations and the Indian subcontinent populations. That is, "in the hot, dry conditions of the Mexican and Californian summer, *P. solenopsis* occurs mainly on roots or on the underside of foliage and stems very close to the soil, whereas in India and Pakistan it is found almost exclusively on the upper parts of the plant, well above soil level. This difference in the distribution on the plant maybe due to differences in humidity, which is much higher in India and Pakistan" [7]. Same is true in

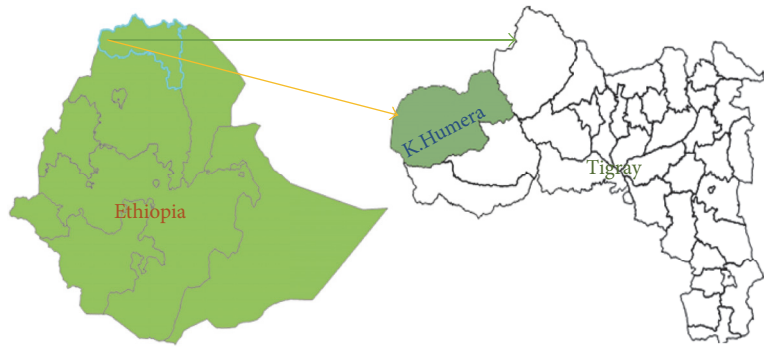


Figure 1: Map of the study area.

Ethiopia; the pest occurs on the upper parts of the plant. But in the hot dry period (Hagay) the pest was observed in the roots of perennial weeds, that is, *Taraxacum* spp., "Demaito," and *Sida cordifolia* "Ezni Tel" (personal observation). Perhaps this could be a mechanism to escape the harsh condition.

The crawlers disperse from the ovisac by way of walking, wind, or ants. The nymphs feed and develop into adults in approximately 30 days. The female mealybug produces 10–15 generations per year in colonies of 500–600 eggs [8]. Mealybug was the biggest threat of cotton from 2005 to 2007 with a potential to destroy the crop over its whole range resulting in complete failure in Pakistan [4].

Cotton mealybug was introduced via mango seedlings to "Humera" in 2012. According to the Western Tigray Bureau of Agriculture [9] the pest was introduced from Awash area through mango seedlings. And through different management practices (destruction of infested plants, burning, burying, and chemical spraying) it was successfully kept from expansion and spread but in 2016 cropping season (Kiremti) an eruption of mealybug invasion was observed in some sesame fields of Kafta Humera. The purpose of this study was to assess the incidence and severity of the cotton mealybug in Kafta Humera.

2. Materials and Methods

A survey for mealybug infestation was conducted during 2016 production season in the major sesame growing areas of "Kafta Humera" district (Figure 1). Therefore, Adebay, Maikadira, Centeral, Bowal, Niguara, Sherif Hammad, Sherif Gola, Kaftamesil, Lugdi, Banat, Maisegen, Redem, Kebabo, Rawian, and Bereket have been assessed for the pest incidence along the accessible roads. In each locality two different farms (2–5 km far) were selected and 1 × 1 m sized quadrant was thrown twice in the center of the farm, twice in the road side of the farm, and twice near the kitchen in the farm (camp) for sampling. Generally, a total of 6 samples were taken in a single farm for recording mealybug incidence and severity during the capsule development stage of the crop. Mealybug specimens were collected from infested sesame plants and identified at Humera Agricultural Research Center. Mealybug specimens were slide-mounted for identification using the method outlined in Williams and de Willink [10].

Percent of Incidence. It was worked out by counting infested plants and dividing to the total number of plants in the quadrant. Data for plant damage severity, plant growth stage, farm stoniness, and tillage device have been recorded also.

Growth Stage. The plant was at capsule developmental stage while the survey was being conducted.

Farm Stoniness. A sesame field with few or more stones (>1 stone per m^2) was classified as a stony farm and stone free farm if there are no or very few stones (one or <1 stone per m^2).

Tillage. Each farm was classified under tractor or oxen plowed.

Level of Plant Damage/Severity. As already given by Nagrare et al. [11] it was assessed based on presence of mealybugs using one to four scales (Figures 4(a)–4(d)) of mealybug infestation from the five infested plants within the quadrant.

Grade I: scattered appearance of few mealybugs on the plant (<25%).

Grade II: severe infestation of mealybug on any one branch or on less than half of the plant (25–49%).

Grade III: severe infestation of mealybug on more than one branch or half portion of the plant (50–75%).

Grade IV: severe infestation of mealybug on the whole plant (>75%).

3. Results and Discussion

The analysis of survey showed that an average incidence of cotton mealybug was 29.5% in the surveying areas. Amongst all the locations "Sherif Hamad" scored higher incidence of cotton mealybug (91.3%) followed by "Bowal" (88.2%), while in "Kebabo" and "Bereket" the pest appeared in a scattered form (Table 1). The pest was seen first in "Maikadira" (near to "Bowal" and "Sherif Hamad") in 2012 [9], and its infestation might get spread through animals/oxen, laborers, farm machineries (tractor, disc harrow), and wind to different localities year after year; in 2016 especially production season cotton mealybug infestation was higher in "Bowal" and "Sherif Hamad" sesame farms. And the other reason that might aggravate infestation of mealybug in the above-mentioned localities was poor farm sanitation such as leaving

Table 1: Means of cotton mealybug incidence for the different localities with 95% confidence limits.

Location	n	Incidence (%)	s.e.	CV	95% confidence limits	
					Lower	Upper
Adebay	12	20.7	2.66	12.8	15.5	25.9
Banat	12	11.3	1.45	12.85	8.43	14.2
Bereket	12	6.57	1.62	24.6	3.37	9.76
Bowal	12	88.1	5.84	6.62	76.6	99.7
Centeral	12	30.6	2.35	7.67	26.0	35.3
Kafta Mesil	12	85.6	4.92	5.75	75.9	95.3
Kebabo	12	6.46	0.41	6.27	5.66	7.26
Lugdi	12	14.8	1.56	10.6	11.7	17.9
Maikadira	12	44.6	5.52	12.4	33.7	55.5
Maisegen	12	52.2	4.77	9.15	42.8	61.6
Niguara	12	85.3	3.73	4.38	77.9	92.6
Rawian	12	16.6	1.94	11.7	12.8	20.5
Redem	12	16.7	1.79	10.7	13.1	20.2
Sherif Gola	12	76.4	3.86	5.05	68.8	84.1
Sherif Hamad	12	91.3	4.07	4.39	83.4	99.2
Total	180					

Table 2: Means of cotton mealybug incidences in different parts of the farm with 95% confidence limits.

Farm part	n	Incidence (%)	s.e.	CV	95% confidence limits	
					Lower	Upper
Center	60	13.1	1.31	9.99	10.5	15.7
Kitchen surrounding	60	75.5	3.23	4.28	69.1	81.8
Road side	60	68.6	3.88	5.65	60.9	76.3
Total	180					

infested plant residues, presence of perennial weeds (*Taraxacum* spp., "Demaito," and *Sida cordifolia* "Ezni Tel"), and low awareness of farmers (they believe that the presence of mealybug is a condemnation from god). Cotton mealybug has the propensity to spread through many natural carriers such as raw plant seeds, wind, rain water, birds, human beings, and farm animals [12]. Severe *P. solenopsis* infestation in Pakistan was recorded for the first time in 3000 acres (1214 ha) but later on (2007/08) it was observed throughout the major cotton growing areas of the country [13]. This indicates that the pest can spread from the center/source of infestation to other new areas easily. Moreover, Noureen et al. [4] stated that weeds should be eradicated as these provide alternate hosts for cotton mealybug and severely damaged plants should be immediately removed also.

There were higher mealybug incidences in the road sides (68.6%) and near the kitchens of the farms (camp) (75.5%) and lower incidence in the central part of the farms (13.1%) (Table 2). In most of the surveyed sesame farms, mealybug incidence was observed to be higher in areas more vulnerable to contact with humans and animals (road sides and kitchen surrounding of the farms). This clearly indicated that the pest could be disseminated by agricultural laborers, animals, and farm machineries (tractors), because these factors have frequent contact with road sides and camps of the different sesame fields. Nagrare et al. [11] noted that mealybugs have the tendency to spread through wind, water, rain, birds, human beings, ants, and farm animals. Although the laborers have more contact with all parts of the sesame fields throughout the growth stage of the plant in the study area, fortunately the severe infestation was limited to road sides and kitchen surroundings (camp) of the farms. This could be directly associated with late occurrence of the pest.

When incidence of the pest is investigated across stone free and stony sesame farms, the later one was found to be infested more with cotton mealybugs. About 85.8% of incidence was recorded in stony farm, while 50.5% was in stone free sesame filed (Table 3). The pest was observed and it can persist underneath stones within the infested farms and this could be the possible reason for higher incidence of cotton mealybug in the stony farms (Figures 2(a) and 2(c)). In addition, most of the stony farms were plowed using oxen, while the stone free (Figures 2(b) and 2(d)) was plowed by tractors. As Nagrare et al. [11] stated that oxen by themselves are means of cotton mealybug dissemination because animals can carry and transfer the crawlers of cotton mealybug from an infested area to new noninfested area, same authors noted that mealybugs have the ability to hide in cracks and crevices

Table 3: Means of cotton mealybug incidence in stony and stone free sesame farms with 95% confidence limits.

Farm stoniness	*n*	Incidence (%)	s.e.	CV	95% confidence limits	
					Lower	Upper
Stone free	132	50.5	3.91	7.75	42.8	58.3
Stony/few stones	48	85.8	2.55	2.98	80.7	90.8
Total	180					

(a) (b) (c) (d)

Figure 2: Cotton mealybug incidences in stony (a, c) and stone free (b, d) sesame fields.

in soil and corners of plant parts. Hodgson et al. [7] noted that, under the hot, dry climate of southwestern USA, *P. solenopsis* occurs primarily on the roots and underside of the foliage and stems, where in the higher humid regions of India and Pakistan it is found almost entirely on the upper portions of the foliage. Therefore, under harsh condition it is clear that the pests can hide themselves underneath the stones just like they did in the cracks and crevices in the soil.

The analysis of the survey revealed that cotton mealybug incidence in sesame was higher (82.7%) in oxen plowed farms compared to tractor plowed farms. Oxen plowed fields have had about 32.6% invasion by cotton mealybug in comparison to tractor plowed sesame farms (Table 4). Most of the oxen plowed sesame fields were near to hilly areas and grazing lands. Therefore the pest might get scattered to nearby farms via animals and winds easily. And most of the oxen plowed sesame fields were stony (Figures 2(a) and 2(c)); in a sense the pest could hide itself underneath the stones to escape from harsh conditions like heavy rain, flood, and other natural enemies.

The analysis of survey showed that severity of cotton mealybug in the study area was observed from scattered infestation to severe infestation of mealybug on the whole sesame plant. Higher sesame severity (severe infestation of mealybug on the whole plant) due to cotton mealybug was recorded in "Bowal" and "Sherif Hamad" while in "Lugdi,"

Table 4: Means of cotton mealybug in oxen and tractor plowed sesame farms with 95% confidence limits.

Tillage device	*n*	Incidence (%)	s.e.	CV	95% confidence limits	
					Lower	Upper
Oxen	48	82.7	3.01	3.64	76.8	88.7
Tractor	132	55.7	3.98	7.14	47.9	63.6
Total	180					

Table 5: Means of cotton mealybug severity for the different localities with 95% confidence limits.

Location	*n*	Severity (Grades 1–4)	s.e.	CV	95% confidence limits	
					Lower	Upper
Adebay	12	1.30	0.18	13.58	0.95	1.65
Banat	12	1.00	0.00	0.00	1.00	1.00
Bereket	12	1.00	0.00	0.00	1.00	1.00
Bowal	12	3.68	0.19	5.21	3.30	4.00
Centeral	12	1.73	0.15	8.36	1.45	2.02
Kafta Mesil	12	3.28	0.23	7.01	2.83	3.73
Kebabo	12	1.00	0.00	0.00	1.00	1.00
Lugdi	12	1.00	0.00	0.00	1.00	1.00
Maikadira	12	2.32	0.20	8.56	1.93	2.71
Maisegen	12	2.70	0.33	12.06	2.06	3.35
Niguara	12	3.14	0.25	7.92	2.65	3.63
Rawian	12	1.54	0.18	11.6	1.18	1.89
Redem	12	1.00	0.00	0.00	1.00	1.00
Sherif Gola	12	2.67	0.17	6.29	2.34	3.00
Sherif Hamad	12	3.64	0.18	4.88	3.29	3.99
Total	180					

"Redem," "Kebabo," "Bereket," "Banat," and "Adebay" only scattered appearance of the pest was observed (Table 5). The later mentioned areas/localities are huge investment areas of sesame and are partially mechanized farms (farmers use machines for plowing and planting). They are not as such stony and somehow far from primary source of cotton mealybug infestations and most of them have no vast grazing lands. These reasons might keep the later described localities with low incidence and severity of the pest.

The overall average severity of cotton mealybug in the study area was **1.6** (severe infestation of mealybug on any one branch of sesame or on less than half of the plant). The potential reduction in yield levels in respect of Grade 1, Grade 2, Grade 3, and Grade 4 severity of mealybug infestation in cotton was estimated to be 2.4, 31.5, 39.9, and 43.9% for *P. solenopsis* [14]. Similarly, Nagrare et al. [11] reported that reduction in cotton yield was estimated to be 15.7% and 52.7% for Grade 1 and Grade 4 mealybug infestation levels, respectively. According to the previous works on cotton, the potential reduction of yield in respect to Grade 4 is about 50% but in sesame 100% yield loss has been observed in respect to Grade 4 mealybug severities (Figure 3). Infested plants become stunted and weak, turned yellow, produced only a few capsules, and eventually dried out. Heavy infestation of mealybug resulted in the complete damage and death of the balls and entire cotton plants [12, 15]. The same authors noted that mealybug excretes honey dew resulting in sooty mold growth, which hinders photosynthesis and reduces the marketability of the products. In addition, the sooty mold development attracts ants that carry crawlers from one plant to another [8, 15].

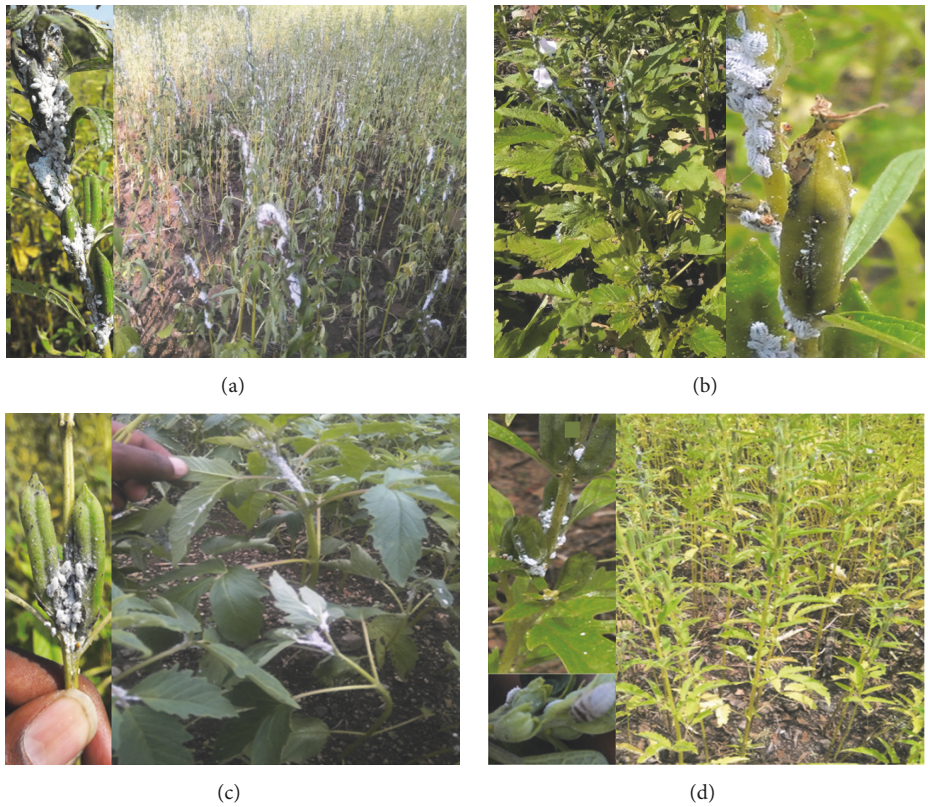
The result indicated that there was higher mealybug severity in the road sides and kitchens surrounding of the farms (severe infestation of mealybug on half portion of the plant) and lower severity in the central part of the farms (scattered appearance) (Table 6). In the surveyed sesame farms mealybug severity was observed to be severe in areas more vulnerable to contact with humans and animals (road sides and kitchens surrounding of the farms). This clearly indicates that the pest might be disseminated by agricultural laborers, farm animals, and farm machineries (tractors). Because these elements have numerous dealings with road sides and kitchens surroundings of the sesame fields, mealybugs have the propensity to spread through natural carriers such as raw cotton, wind, water, rain, birds, human beings, ants, and farm animals [11, 12].

Analysis of the survey showed that cotton mealybug severity in sesame was higher (severe infestation of mealybug on half portion of the plant) in oxen plowed farms compared to tractor plowed farms (Table 7). Most of the oxen plowed sesame fields were near to hilly areas and grazing lands. Therefore the pest might get disseminated to the nearby farms

Table 6: Means of cotton mealybug severity for the different sesame field parts with 95% confidence limits.

Farm part	n	Severity (Grades 1–4)	s.e.	CV	95% confidence limits	
					Lower	Upper
Center	60	1.42	0.37	25.7	0.69	2.13
Kitchen surrounding	60	2.99	0.14	4.70	2.71	3.26
Road side	60	2.89	0.13	4.48	2.63	3.14
Total	180					

Figure 3: Totally damaged (Grade 4) sesame plants by heavy cotton mealybug infestation.



(a) (b) (c) (d)

Figure 4: Mealybug damage levels/severity ((a) = Grade 4, (b) = grad 3, (c) = Grade 2, and (d) = Grade 1).

Table 7: Means of cotton mealybug severity for oxen and tractor plowed sesame fields with 95% confidence limits.

Tillage device	*n*	Severity (Grades 1–4)	s.e.	CV	95% confidence limits	
					Lower	Upper
Oxen	48	3.24	0.14	4.35	2.96	3.51
Tractor	132	2.49	0.14	5.64	2.21	2.77
Total	180					

via animals and winds easily. Winds and farm animals are one of the natural agents for mealybug spreading [11, 12, 14]. And most of the oxen plowed sesame fields were stony; in a sense the pest could hide itself under the stones (Figure 2(c)) to escape some harsh conditions like heavy rain, flood, and other natural enemies, while tractor plowed farms could not.

4. Conclusion

The results of the studies showed that cotton mealybug infestation was detected at all the localities that the study has conducted. The pest was observed attacking the whole sesame plant in all the infestation areas. During the study, road sides and camp surrounding of the sesame farms were severely infested. Stony and oxen plowed farms were also intensively invaded with cotton mealybugs in comparison to stone free and tractor plowed sesame farms. The mealybug excretes honeydew on the plant that promotes sooty mold disease that suppresses plant growth and eventually kills the plant. During the survey, mealybug infestation was observed to reduce when the crop was dried out completely. Generally, the pest can spread through different natural carriers such as wind, water, rain, birds, human beings, ants, farm animals, and farm equipment to new noninfested areas/farms; therefore its control measure has to be developed.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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