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Infestation Status and Farmers' Knowledge on Yellow Sugarcane Aphid (*Sipha flava*) in Tanzania

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Abstract

A survey was conducted to determine the infestation status of Yellow Sugarcane Aphid (YSA) from June to August 2019 in Manyara, Kilombero and TPC plantations and small scale farms in central and northern Tanzania. All farmers interviewed confirmed the occurrence of Yellow Sugarcane aphid in their farms and field survey data indicated the high level of incidence both in sugarcane plantations (79.07%) and small-scale farms (88.2%) and the yield loss due to Yellow Sugarcane aphid was estimated to be 8.9 tons/ha. There was no difference in the level of infestation between plantations and small-scale farms in Manyara ($F = 1.007$, $P > 0.05$) and Morogoro ($F = 1.676$, $P > 0.05$). Less than half of all interviewed farmers (39%) reported using chemical pesticides against Yellow sugarcane aphid while more than half (61%) did not use any kind of management approach in controlling Yellow sugarcane aphid. We recommend more monitoring exercises and information gathering about Yellow sugarcane aphid to be undertaken to properly establish the status of this pest all over the country.

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Introduction

Sugarcane (*Saccharum spp.)* is an important cash crop in terms of sugar and ethanol production worldwide (Verheye, 2009; Friedrich *et al.*, 2010; Mary and Sujata, 2016). In Tanzania, the sugar industry is considered one of the largest agro-economic sectors which contributes to about 35% of the growth in output of the food manufacturing sector (Nkonya and Barreiro-Hurle, 2012). Sugarcane cultivation in Tanzania is concentrated in three regions, Morogoro, Kilimanjaro and Kagera (Tarimo and Takamura, 1998) where there are large plantations as well as small-scale sugarcane farmers under the out-grower schemes (Rabobank, 2013; Sulle, 2017). Average annual cane production is about 2.7 million tonnes which contribute about 12.4 billion Tanzanian Shillings (TZS) to the Government's revenue through sugar-related activities (FAO,2012) and provides the farmers with total earning of more than TZS 45 billion (Sulle, 2017)

However, sugarcane cultivation is faced with many challenges. Prevalence of pests and diseases has been identified as one of the challenges facing sugarcane production, which result in a considerable loss in term of sugarcane yield, quality and recovery (Hussnain *et al.*, 1997). Throughout the world, about 1500 species of insects have been identified to feed on sugarcane such as stem bores, shoot borers, mealy bugs, scale insects, white grubs and aphids (Ahad *et al.*, 2016). For example, it was reported in India that pests and diseases contribute to about 20% and 19% decline in cane production, respectively (Directorate of Sugarcane Development, 2013).

Stem borers and Root borers are considered the major pests of sugarcane (Ahad *et al.*, 2016). However, various species of aphids have also been identified to cause considerable damage to sugarcane plants such as Sugarcane aphid, *Melaniphis sacchari*, Yellow sugarcane aphid, *Sipha flava* (White *et al.*, 2001; Akbar *et al.*, 2010) and Sugarcane wooly aphids, *Ceratovacuna lanigera* (Srikanth *et al.*, 2008). Yellow sugarcane aphid (YSA), *Sipha flava* (Forbes) is thought to have originated from temperate and subtropical regions of North America, but it has also been reported in central and South America (Regan, 1994). In Africa, the first occurrence was reported in Morocco in 2006 (Abdelmajid, 2008), then in the South African sugarcane industry in 2013 (Way *et al.*, 2014) and recently in Kenya in 2016 (KARLO-SRI, 2018). It has been considered as a common pest to various economic important crops such as sorghum and sugarcane (Nuessly, 2014), and also they have been found on several host plants including corn, rice, wheat, barley, oat (Nuessly, 2014; Way *et al.*, 2014).

The infestation of YSA has been reported to cause significant damage to sugarcane plants resulting to yield loss (Hall, 2001). Through their way of feeding, YSA cause leaf chlorosis and necrosis (Hall and Bennett, 1994), reduced tillering, premature leaves, stalk and whole plant senescence (Hall, 2001) and even death of plants in case of severe infestation (Cherry *et al.*, 2015), which altogether may contribute to yield reduction up to about 19% (Hall, 2001). Apart from the damage caused by feeding, YSA has also been reported to spread sugarcane mosaic potyvirus (Blackman and Eastop, 2000).

Despite several reports on YSA in various countries, little is known about YSA infestation status in Tanzania and how it affects sugarcane cultivation. Therefore, this paper reports on the infestation of YSA in Sugarcane Estates and Small scale farms and knowledge of farmers on the pest and management.

Materials and methods

Description of the study area

The study was conducted in three regions, Manyara, Morogoro and Kilimanjaro, which were selected due to the presence of sugarcane plantations. In each region, one estate/plantation was selected for the study (See figure 1). Estates at Kilombero Sugarcane Company, Tanganyika Planting Company (TPC) and Manyara Sugarcane Company were selected for the study. Five small scale farms around Kilombero sugarcane plantation and Manyara sugarcane plantations were randomly selected for the survey.

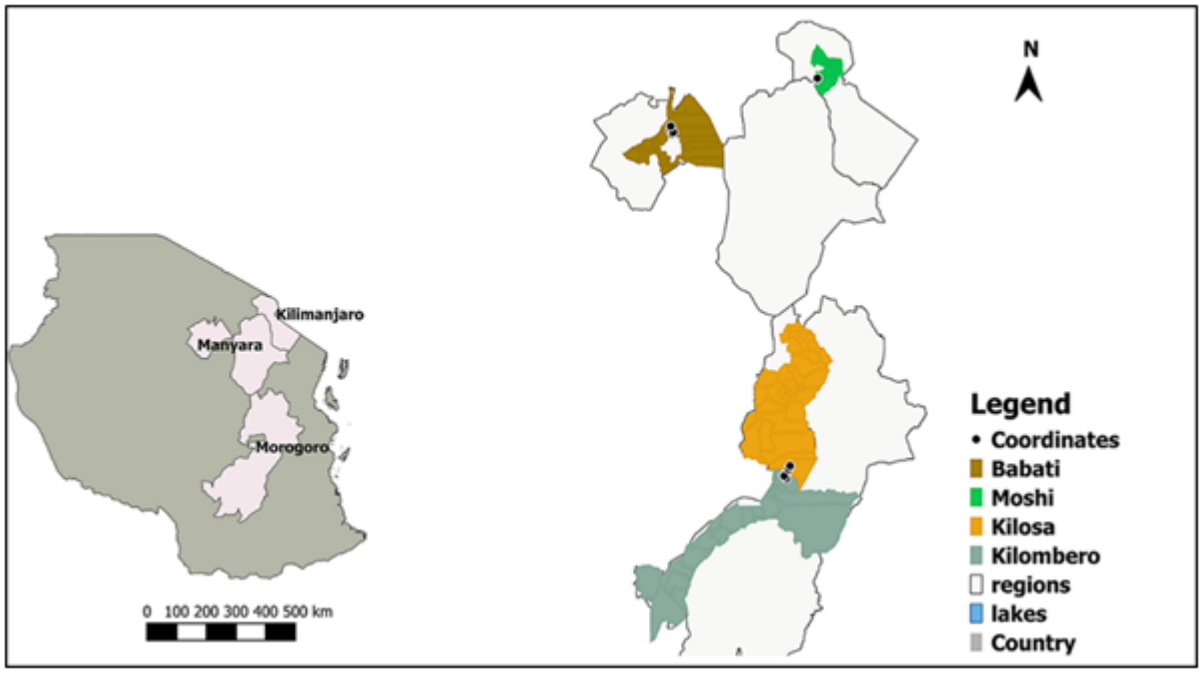

Fig. 1. A map of Tanzania showing surveyed districts.

Kilombero Sugarcane Company which covers about 13,000 ha of which 7,900 ha are under cane cultivation (Nkonya and Barreiro-Hurle, 2012) is located at Kilombero and Kilosa districts along the Kilombero valley (Kamuzora, 2011; Lucas *et al.*, 2016), which lies East of the Udzungwa Mountains and extends to the north and south of the Great Ruaha River in Kilosa District (Landesa, 2017).

Tanganyika Planting Company (TPC) is one of the largest sugar estates located in Northern Tanzania, Moshi district with about 8,000 ha under cane cultivation. Manyara Sugarcane Company is a medium-sized sugarcane company located in Babati District in Manyara region with about 1,000 ha under cane cultivation.

Sampling methods

For each of the three plantations purposely five (5) plantation officers in each plantation who are involved in monitoring the health of sugarcane plants were interviewed and sixty (60) small-scale sugarcane farmers around Kilombero and Manyara Sugarcane Estates were randomly selected for interview. There were no small-scale sugarcane farmers around TPC Plantations, so it was left out of the survey for farmers. Five colonies of aphids were randomly collected from each surveyed regions and stored in 80% ethanol.

Field survey for aphid infestation

In each plantation, five (5) plots of 3m x 3m were randomly marked for observation. In each plot, all sugarcane plants were carefully observed for the presence or absence of aphids. The infestation scale of 0 to 4 was used to rate the size of aphid infestation on each of the observed plants.

0 – No aphid observed
1 – The scattered appearance of few aphids on the sugarcane plant
2 – Aphids present on any one branch of the sugarcane plant
3 – Aphids present on more than one branch of the sugarcane plant
4 – Severe infestation of aphids on the whole sugarcane plant

Percentage incidence was calculated by the incidence formula as outlines by Kataria and Kumar, (2012) with minor correction;

$$\text{Percentage Incidence} = \frac{\text{Number of infested plants}}{\text{Number of plants observed}} \times 100$$

The severity index was calculated by the severity formula outlines by Kataria and Kumar, (2012) with minor correction;

$$\text{Percentage Incidence} = \frac{\text{Sum of total infestation scale points of infested plants}}{\text{Total number of infested plants observed}}$$

Survey for small scale farmers

A total of 120 small scale farmers (60 in each region) around Kilombero and Manyara Sugarcane Plantations were interviewed face-to-face using guided questionnaires.

The questionnaire addressed information on farmers' socio-economic profile (e.g. age, gender, and education, farm size, whether sugarcane is their main source crop and how much they depend on it to support their daily livelihood), whether they have seen aphids or not, the first time they saw aphids in their farms, estimated yield loss due to aphid infestation. Farmers were also asked about management practices undertaken to address the aphid infestation and the effectiveness of those management practices. They were also asked to rate aphids among other pests.

Identification of aphids

A total of 15 sample colonies of aphids (five from each region) were taken to Tropical Pesticides Research Institute (TPRI) for identification.

Data analysis

Survey data were summarized and descriptive statistics (means and percentages) were calculated using Statistical Package for Social Science (SPSS).

One way ANOVA and Chi-square tests were used to compare responses of farmers between the villages and regions regarding their knowledge about YSA and Turkey's HSD was used to separate the mean.

Results

Aphid sample identification

All the 15 samples taken to TPRI were identified as Yellow sugarcane aphid based on their morphological traits. Figure 2 below show a wingless yellow sugarcane aphid.

Table 1. Incidence and Severity at Manyara, Kilombero and TPC.

	Plantation/Estates				
Variable	Manyara	Kilombero	TPC	Mean	F-test
% Incidence	83.5	70.9	82.82	79.07	1.028^{ns}
Severity index	1.43	1.65	1.28	1.45	0.630^{ns}

Incidence was calculated as % of sugarcane plants infested in each plot and Severity was scored as 0 = no aphids observed, 1 = scattered appearance of few aphids on sugarcane plant, 2 = Aphids present on any one branch of sugarcane plants, 3 = Aphids present on more than one branch, 4 = severe appearance of aphids in the whole sugarcane plant (Note: ns = not significant, $P > 0.05$).

Table 2. Incidence and Severity of YSA in Manyara and Morogoro Region.

Vaiable	Manyara region			Morogoro region		
	Sugarcane Estates	Farms	F-Test	Sugarcane Estates	Farms	F-Test
% Incidence	83.18	92.22	1.007^{ns}	74.06	84.24	1.676^{ns}
Severity Index	1.44	2.14	2.456^{ns}	1.64	1.52	0.126^{ns}

Incidence was calculated as % of sugarcane plants infested in each plot and Severity was scored as 0 = no aphids observed, 1 = scattered appearance of few aphids in sugarcane plant, 2 = Aphids present on any one branch of sugarcane plants, 3 = Aphids present on more than one branch, 4 = severe appearance of aphids in the whole sugarcane plant (Note: ns = not significant, $P > 0.05$).

Infestation status

The % incidence was observed to be high in all plantations surveyed, Manyara Sugarcane Estates (83.5%), TPC Sugarcane Estates (82.82%) and Kilombero Sugarcane Estate (74.65%) (Table 1). Analysis of variance test shows that there is no statistically significant difference in the incidence level between Manyara, Kilombero and TPC plantations ($F = 1.028$, $P > 0.05$) as well as severity level between Manyara, Kilombero and TPC

plantations (F = 0.630, P > 0.05). The incidence and severity in the small scale farms surveyed were observed to be high both at Manyara (Incidence = 92.22 %,) and Kilombero (Incidence = 84.24%). However, the ANOVA test indicates that there was no difference in the level of incidence between plantations and small-scale farms in Manyara region (F = 1.007, P > 0.05) and Morogoro region (F = 1.676, P > 0.05) (Table 2). The same applies to the level of severity between plantations and Small scale farms in Manyara and Morogoro region (Table 2).

Table 3. Socio-economic data of Small Scale Farmers around Sugarcane Estates in Manyara and Morogoro.

Variables		Manyara (*Manyara Sugarcane Estates*)			Morogoro (*Kilombero Sugarcane Estates*)		
		Matufa n = 20	Mawemairo n = 20	Villages Gichameda n = 20	Kidatu n = 20	Kidogobasi n = 20	Ruhembe n = 20
Average Age (years)		50.6	49.9	51.4	48.2	46.9	51.2
Gender	Male	16	17	16	16	13	15
	Female	4	3	4	4	7	5
Education Level	Primary	19	16	15	14	14	16
	Secondary	1	4	4	6	6	4
	Tertiary	0	0	1	0	0	0
Average Farm size (Acre)		4.7	4.3	8.7	6.5	5.9	6.4
Experience (years)		4.1	4.6	8.6	9.2	7.5	8.4
Main crop	(Yes)	20	19	20	20	20	20
Dependence on Sugarcane	(Yes)	20	19	20	20	20	20

Table 4. Responses of Plantation officers about YSA infestation in Manyara, TPC and Kilombero Sugarcane Estates.

Variables	Sugarcane Estates				
	Manyara N = 5	Kilombero N = 5	TPC N = 5	Mean N = 15	X^2
Age (years)	47	36	44	42	
Sex (Male %)	100	100	100	100	
Experience (Years)	12	5	13	10	
Know aphid (Yes %)	100	100	100	100	
How often (Very often %)	100	100	100	100	
Recognition					
Colour (%)	100	100	100	100	4.060^{ns}
Size (%)	100	100	100	100	
Others (%)	0	100	60	53.3	
Infestation rate					
Severe (%)	100	0	20	40	11.667*
Moderate (%)	0	100	80	60	
Low (%)	0	0	0	0	
Season (Dry hot %)	100	100	100	100	
Effect on yield					
Low (%)	0	0	0	0	4.615^{ns}
Moderate (%)	100	60	100	86.7	
High (%)	0	40	0	13.3	
Quality of Sugarcane (Infested vs Not infested					
No difference (%)	0	0	0	0	4.200^{ns}
Moderate (%)	60	40	0	33.3	
Low (%)	40	60	100	66.7	
Management					
Chemical Pesticide (%)	100	100	100	100	7.778^{ns}
Bio-control (%)	0	100	100	66.7	
Cultural method (%)	0	100	100	66.7	
Effectiveness of Pesticides					
Effective (%)	0	20	40	20	2.500^{ns}
Moderate (%)	100	80	60	80	
Not effective (%)	0	0	0	0	
Effectiveness of Biocontrol					
Effective (%)		40	0	20	
Moderate (%)		60	100	80	
Not effective (%)		0	0	0	
Major pest (YSA %)	100	100	80	93.3	

Note: Statistically significant at $^{*}P$ < 0.05; ns = not significant (P > 0.05).

Knowledge and perception of Farmers about YSA infestation

Socio-economic profile of Small scale farmers at Manyara and Morogoro

Table 3 above shows the socio-economic profile of the Small Scale Farmers in the villages surrounding Manyara Sugarcane Estates in Manyara region and Kilombero Sugarcane Estates in Morogoro region. As illustrated in Fig. 3 below, half of the farmers interviewed in Manyara and Morogoro were above the age of 50 years. Also in both villages surrounding Sugarcane estates in Manyara and Morogoro region, most of the farmers interviewed were males as illustrated in Fig. 4 below. In terms of education level, most farmers in villages surrounding Sugarcane Estates in Manyara and Morogoro had primary education, few had secondary education as illustrated in Fig. 5.

Table 5. Farmers knowledge and management practices used against YSA in Manyara region.

	Villages around Manyara Sugarcane Estates				
Variables	Matufa N = 20	Mawemairo N = 20	Gichameda N = 20	Mean N = 60	X^2
Seen Aphids (Yes %)	100	100	100	100	
When first sighted					
2000 – 2019	20	20	20	20	
Recognition (Colour)	20	20	20	20	
Rate of infestation					
Severe	11	13	15	13	1.758^{ns}
Moderate	9	7	5	7	
Low	0	0	0	0	
Estimated yield (tons/acre)					
No YSA infestation	41.2	42.4	40.8	41.4	
Infested with YSA	30.1	34.9	32.2	32.4	
Yield loss	10.9	7.5	8.6	9	
Pest Control method					
Chemical pesticides	0	3	4	2.3	4.205^{ns}
Cultural methods	0	0	0	0	
Biological control	0	0	0	0	
None	20	17	16	17.7	
Effectiveness of chemical pesticides					
Effective		0	0	0	5.714^{ns}
Moderate		20	15	17	
Not effective		0	5	3	
Major pest (YSA %)	20	20	20	20	

Note: ns = not significant, $P > 0.05$.

The farm size of more than half of farmers (60%) in Manyara is below 5 acres while in Morogoro, about 52% of farmers had about 6 – 10 acres as illustrated in Fig. 6.

In term of experience in sugarcane cultivation, it was established that 48% of farmers both at Manyara and Morogoro had the experience of below 5 years in sugarcane cultivation, while some had the experience of about 5 – 10 years in sugarcane cultivation and only a few farmers had the experience of more than ten years in sugarcane cultivation as illustrated in Fig. 7 below. Although small-scale farmers in villages surrounding sugarcane estates in manyara and Morogoro cultivate other crops such as rice, sorghum, millet, maize, vegetables, etc., they have pointed out that sugarcane is their main cash crop as noted in Table 3 above. Most farmers in Manyara and Morogoro depend on sugarcane cultivation for their daily livelihood as illustrated in Fig. 8 below. Correlation analysis indicates that there is an association between the dependence on sugarcane and the type of the main crop that farmers cultivate in Manyara ($r = 1.000$, $P < 0.01$).

Table 6. Farmers knowledge and management practices used against YSA in Morogoro region.

Variables	Villages around Kilombero Sugarcane Estates				
	Kidatu N = 20	Kidogobasi N = 20	Ruhembe N = 20	Mean N = 60	X^2
Seen Aphids (Yes)	20	20	20	20	
When first sighted					
2000 – 2019	20	20	20	20	
Recognition (Colour)	20	20	20	20	
Rate of infestation					
Severe	15	14	10	13	3.077^{ns}
Moderate	5	6	10	7	
Low	0	0	0	0	
Estimated yield (tons/acre)					
Not infested by YSA	39.4	40.3	41.1	40.3	
Infested with YSA	29.2	32.5	32.9	31.5	
Yield loss	10.2	7.8	8.2	8.7	
Management method					
Chemical pesticides	15	12	11	12.7	1.866^{ns}
Cultural methods	0	0	0	0	
Biological control	0	0	0	0	
None	5	8	9	7.3	
Effectiveness of chemical pesticides					
Effective	0	0	0	0	2.727^{ns}
Moderate	16	12	16	14.7	
Not effective	4	8	4	5.3	
Major pest (YSA %)	20	20	20	20	

Note: Statistically significant at $^{*}P < 0.05$; ns = not significant.

The response of farmers and plantation officers on YSA infestation

Both Plantation officers and small-scale farmers interviewed confirmed that they have seen YSA in their plantations/farms as shown in Tables 4, 6 and 7. Similarly, all small-scale farmers reported having seen YSA for the first time in the 2000s mostly between 2016 and 2018. All farmers in Manyara and Morogoro were able to identify and differentiate YSA from other pests according to its yellow color. Most farmers in Manyara and Morogoro rated the YSA infestation as severe while few farmers in Manyara and Morogoro said that the YSA infestation is moderate as shown in Tables 5 and 6. Similarly, plantation officers have shown the same concern for the infestation rate of YSA as 40% of plantation officers interviewed claimed YSA infestation as severe, while 60% reported a moderate level of infestation. According to the plantation officers interviewed, the YSA infestation becomes more severe during the dry hot season as shown in Table 4.

Fig. 2. The colony of Yellow sugarcane aphid on sugarcane leaf (A). A wingless Yellow Sugarcane Aphid (B).

As Table 5 and 6 indicate, farmers in surveyed villages have shown that YSA infestation could result in yield reduction, with farmers at Manyara reported an estimated yield loss of about 9 tons/acre while those in Morogoro reported an estimated yield loss of about 8.7 tons/acre. These estimations were merely based on farmers' experience on sugarcane yield from year to year. Plantation officers interviewed reported that YSA infestation has effects both on yield and quality of sugarcane, where most reported on moderate effects on yield while few reported that the effect on yield is high as indicated in Table 4.

In comparing the quality of sugarcane infested with YSA with those not infested, most plantation officers interviewed responded that the sugarcane infested with YSA has low quality compared to those not infested while 33% claimed that the infested sugarcane has moderate quality compared to those not infested as indicated in Table 4.

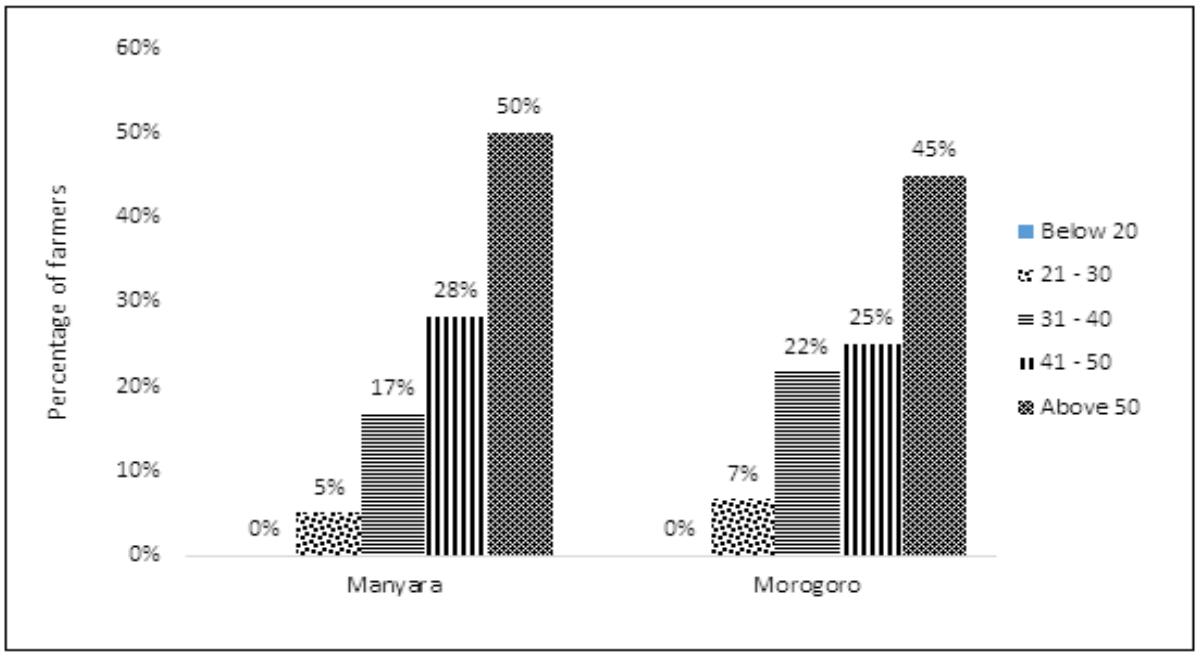

Fig. 3. Age group (years) of Small scale Farmers surrounding Sugarcane Estates in Manyara and Morogoro.

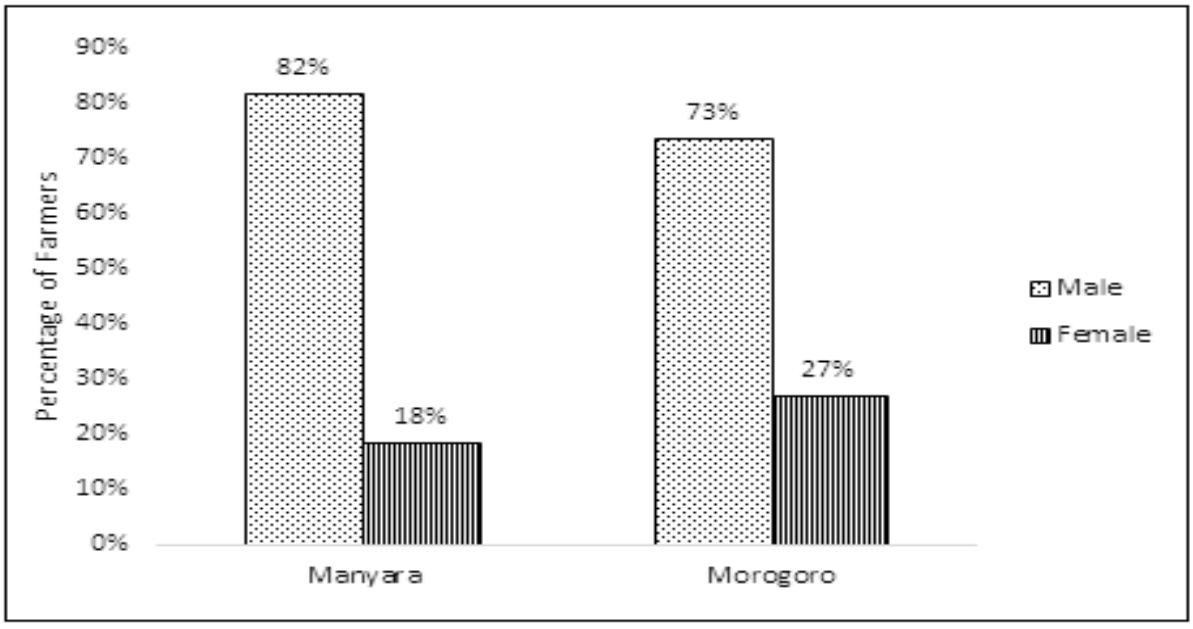

Fig. 4. Gender of Small Scale Farmers surrounding Sugarcane Estates in Manyara and Morogoro.

Only a few farmers in the surveyed villages in Manyara reported having used chemical pesticides as the means to control YSA infestation, while most farmers said that they did not use any kind of management practice against YSA as shown in Table 5. For those farmers who have used chemical pesticides, most reported that the chemical pesticides used had a moderate effect in controlling YSA while few said that the chemical pesticides are not effective in controlling YSA. Similarly, more than half of the interviewed farmers in Morogoro reported having used chemical pesticides as their means to control YSA infestation while few of the farmers did not use any kind of management practice against YSA.

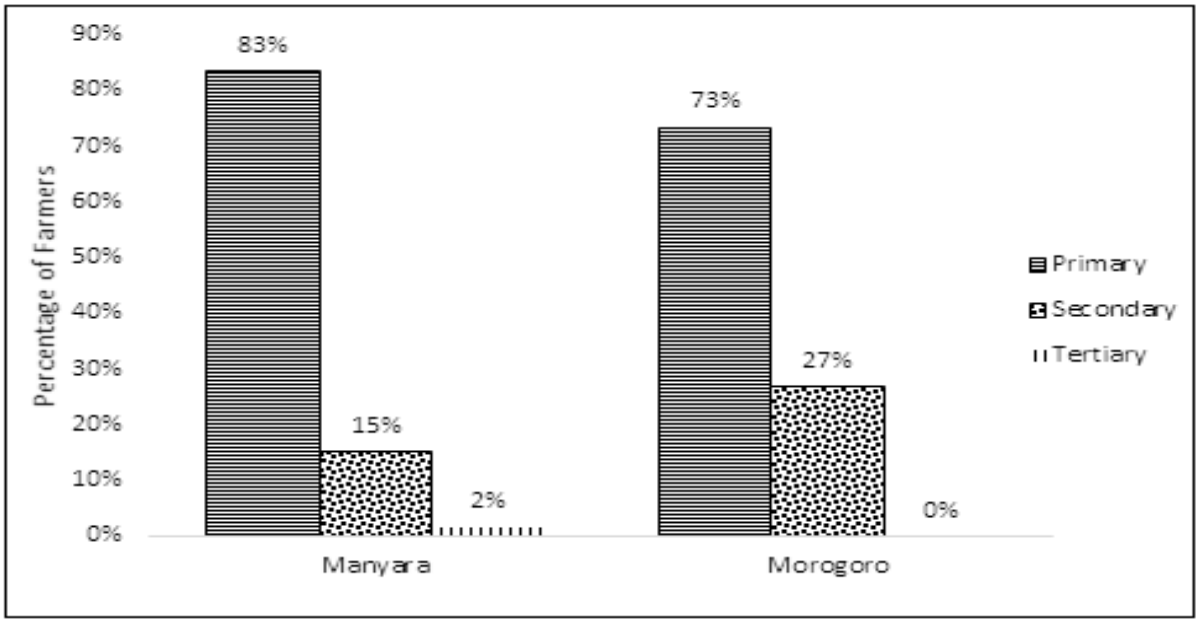

Fig. 5. Education Level of Small Scale Farmers surrounding Sugarcane Plantations in Manyara and Morogoro.

The chemical pesticides used were perceived to have a moderate effect on controlling YSA by most farmers in Morogoro as shown in Table 6. The chemical pesticides that were mentioned to be used include Imidacloprid (Septer 2000 SL), Acetameprid (GOLAN SL), Thoxam and Neonicotides. In addition to the use of chemical pesticides in controlling YSA, plantation officers in Kilombero and TPC reported on the use of natural enemies such as ladybird beetles (*Coccinellidae spp*) as a bio-control method against YSA and the use of irrigation (spraying water) as the cultural method.

The chemical pesticides were perceived to have a moderate effect in controlling YSA by most plantation officers interviewed as shown in Table 4.Even though other pests were mentioned to affect sugarcane such as white grubs, *Phyllophaga spp* (Coleoptera: Scarabaeidae), white scale, *Ceroplastes destructor* (Hemiptera: Coccoidea), black beetles, *Heteronychus arator* (Coleoptera: Scarabaeidae), stalk borers, *Papaipema nebris* (Lepidoptera: Noctuidae), yellow sugarcane aphid was reported to be the major pests affecting sugarcane by all small scale farmers interviewed and nearly all plantation officers.

Discussion

It is apparent from the survey data that the level of incidence of YSA in Tanzania is high as observed in surveyed plantations. High incidence was recorded in all surveyed plantations, 83.5% in Manyara, 82.82% in TPC and slightly lower in Kilombero 70.9%. Similarly, the incidence level was observed to be high in small-scale farms surveyed both in Manyara (92.22%) region and Kilombero region 84.24%. However, the data indicate that there is not much difference in the level of occurrence and severity of YSA between plantations and small-scale farms as well as among surveyed plantations. This lack of difference in infestation level might be attributed to

the dispersal ability of YSA as they can move from one location to another, so YSA can move between plantations and small-scale farms and vice versa. YSA infestation and its effects on sugarcane cultivation have been reported in various countries. In Tanzania, most farmers in surveyed regions reported having seen YSA in their farms and were able to differentiate YSA from other pests due to its yellow color.

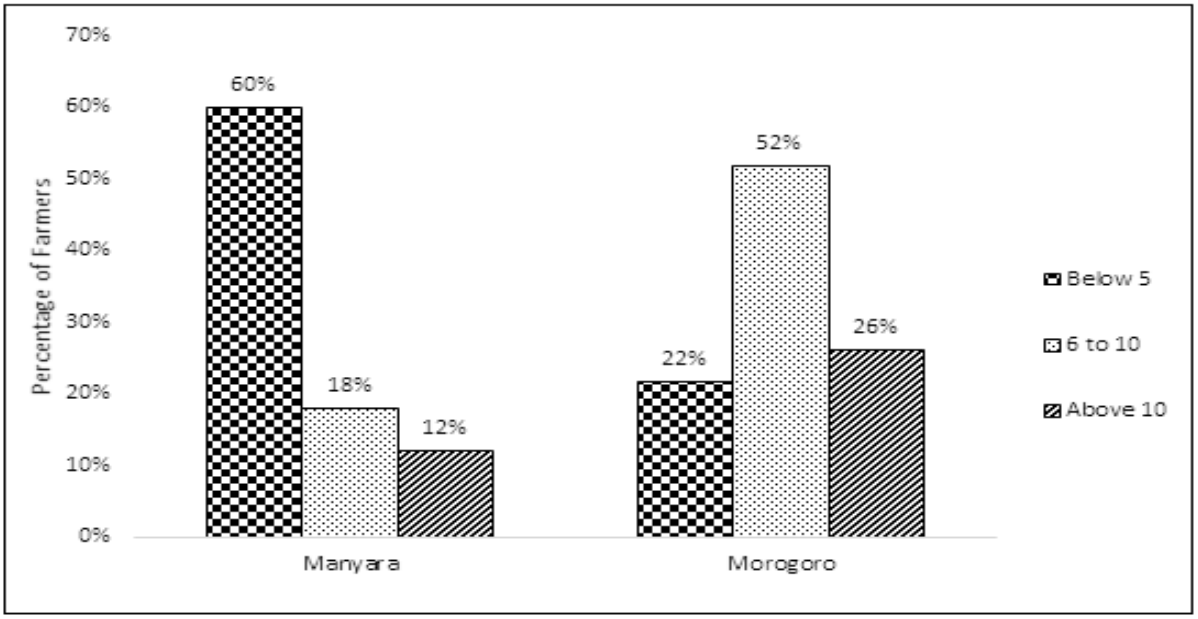

Fig. 6. Farm size (acres) of farmers around Sugarcane Estates in Manyara and Morogoro.

This might be attributed to the fact that being near to the large plantations, they get information from pest experts from large sugarcane estates. As in some African countries such as Morocco (Abdelmajid, 2008), South Africa (Way *et al.*, 2014) and Kenya (KARLO-SRI, 2018; Mutonyi and Babikhas, 2019), farmers in Tanzania reported having seen YSA for the first time in the years the 2000s mostly between 2016 and 2018. Being a North American native (Nuessly, 2014), YSA has since then spread to other continents (Hentz and Nuessly, 2004; Hernandez and Perez, 2014; Way *et al.*, 2014).

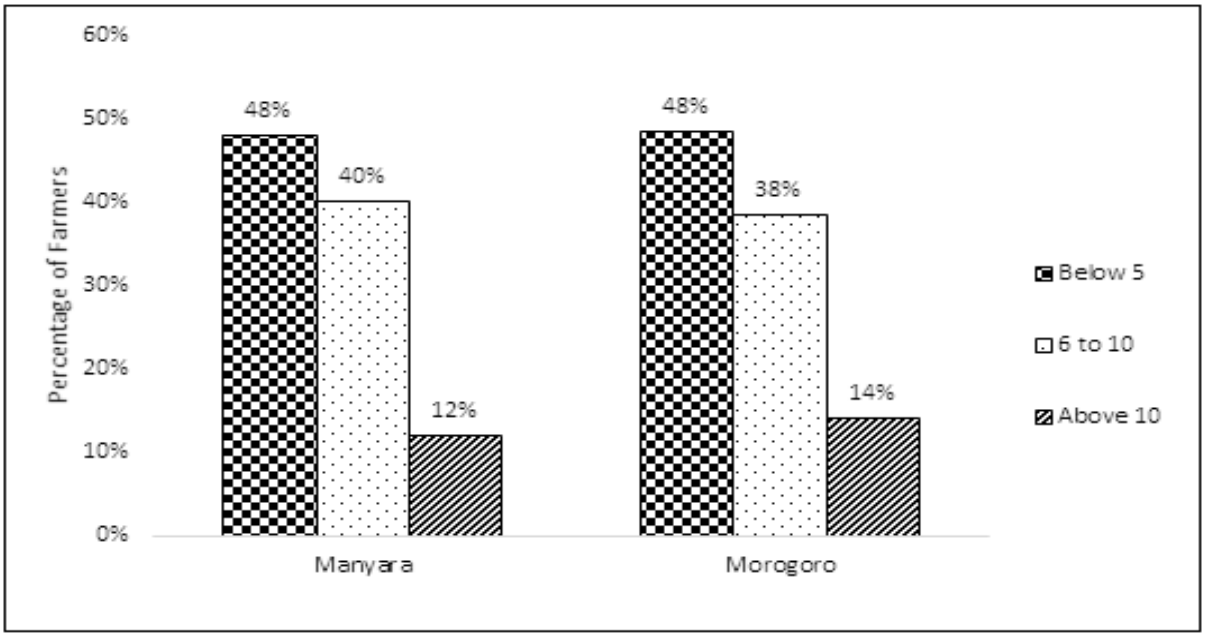

Fig. 7. Farmers experience (years) in sugarcane cultivation in Manyara and Morogoro region.

The deteriorating effects of YSA on sugarcane production were also evident in Tanzania with reports from farmers indicated an estimated yield loss of about 9 tons/acre and 8.7 tons/acres respectively due to aphid infestation. Response from farmers in Manyara indicated that when their farms are not infested with YSA, the estimated yield is high (Mean = 42.89, Standard deviation = 2.439) and the same applies in Morogoro (Mean = 40.16, Standard deviation = 3.152). The exact yield reduction could be high or low compared to those given by the farmers because the estimations made by farmers were merely based on their experience rather than measured and recorded data. Nevertheless, these findings coincide with various reports by authors such as Hall, (2001) who reported on yield loss of about 19% due to YSA infestation, Grisham *et al.* (2001) who reported on about 11% and 14% sugarcane yield loss due to sugarcane yellow virus spread by aphids. Also, Patil *et al.* (2007) reported on the reduction of cane yield of about 25-36 tons/ha and loss in sugarcane recovery in the range of 1.20% - 3.43% in India.

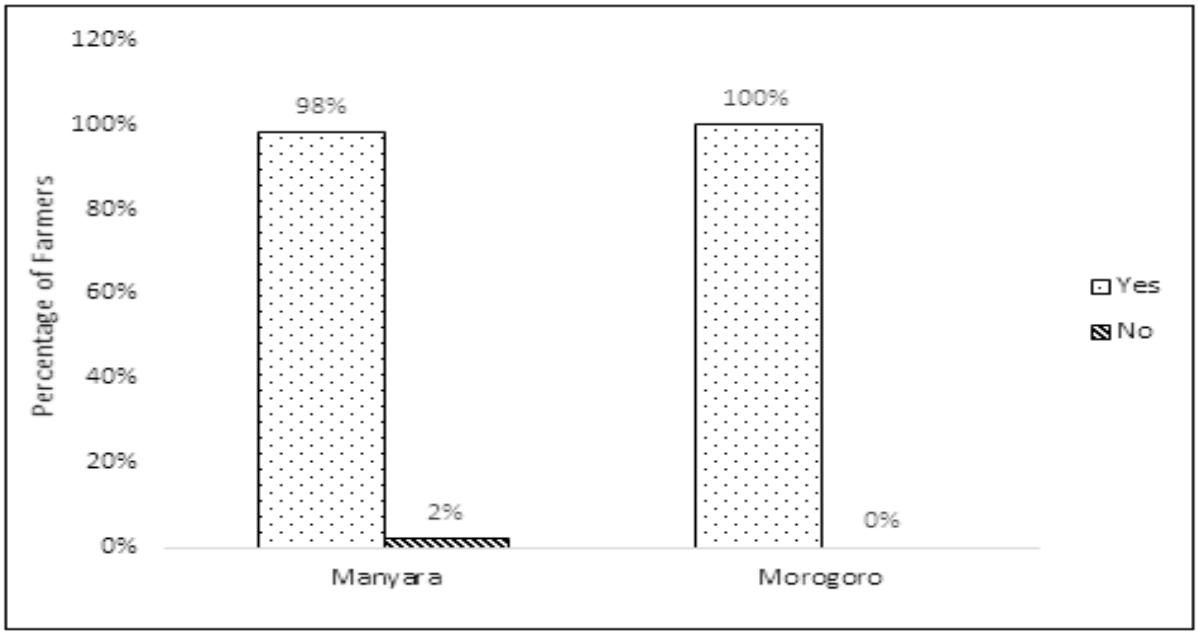

Fig. 8. Farmers' dependence on sugarcane cultivation for their daily livelihood in Manyara and Morogoro region.

The yield loss is brought by the feedings habits of YSA on sugarcane which results in leaf necrosis and chlorosis, reduced tillering, premature senescence and death of plants (Hall and Bennett, 1994; Hall, 2001; Cherry *et al.*, 2015) which all together impair the ability of the plants to manufacture their own food. Figure 9 below show the damage to sugarcane crops by YSA in one of surveyed small scale farm in Manyara region. The YSA infestation was rated from moderate to severe by farmers both in Manyara and Morogoro with Plantation officers explaining that the infestation rate becomes more severe during the dry hot season. This was supported by survey data from sugarcane plantations and small-scale farms which indicated the high level of incidence (occurrence) both in Plantations (83.5% incidence in Manyara and 74.06% incidence in Morogoro) and small-scale farms (92.22% incidence in Manyara and 84.245 incidences in Morogoro). Not only does the YSA infestation has effects on yield but also affects the quality of sugarcane plants as reports from interviewed plantation officers indicated that the infested sugarcane has low quality in term of height, weight, even sucrose content compared to non-infested sugarcane.

The effects of aphids on growth parameters of sugarcane have also been reported by Gupta and Goswami, (1995) and Patil *et al.* (2003) which reported on reduced cane height, weight and brix of infested sugarcane plants compared to healthy sugarcane plants.

Fig. 9. Damage to Sugarcane crops by Yellow sugarcane aphid in one of the small scale farm in Manyara; image by Ally Shabani, NM-AIST, Tanzania.

Chemical pesticides have always been the ultimate method in controlling pests despite their drawbacks. However, most farmers in surveyed regions did not use chemical pesticides or any other management control methods against YSA. This might due to a lack of information about proper management methods against YSA or the cost of buying chemical pesticides or the post-application negative impacts of chemical pesticides to farmers (Elena *et al.*, 2011). On the other hand, the farmers who use chemical pesticides pointed out that chemical pesticides had a moderate effect in controlling YSA. Most farmers pointed out that even the use of pesticides does not provide much help so, it was economically unwise to spend money on chemical pesticides when they do not help.

The main challenge raised by farmers and plantation officers on the use of the chemical pesticides is the cost for buying pesticides and the need to spray pesticides on regular basis mostly about every 7-14 days which becomes very costly to them. Difficulty in the application of pesticides especially to matured sugarcane plants and re-occurrence of aphids 2-3 weeks post-application present major drawbacks to the use of chemical pesticides (Patil *et al.*, 2007). YSA is not the only pest affecting sugarcane in Tanzania as some other pests such as white grubs, white scale, black beetles, stalk borers were also mentioned to affect sugarcane production. However, among all other mentioned pests, YSA was named as the major pests by all the small scale farmers interviewed and by 97% of all plantation officers interviewed.

This might be attributed to the reproductive ability of females (parthenogenesis) and the ability of the winged female to easily disperse by wind (Nuessly, 2014) hence they can easily be distributed to a large area. The present study shows that indeed there is a high level of YSA infestation in Tanzania and its effects on cane yield were significant as the present study indicates an estimated yield loss of about 9 tons/ha due to YSA infestation, so there is a need to put more efforts in coming up with strategies to minimize yield loss due to aphids infestation.

The use of chemical pesticides to control YSA was perceived as inadequate, so there is a need for the government and other stakeholders in agriculture to come up and try other ways of controlling aphids. We suggest that monitoring exercises and information gathering about Yellow sugarcane aphid should continue.

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Discloser statement

The authors report no conflict of interest.

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