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Farmers' indigenous knowledge, perception and management practices of American fall army worm *(Spodoptera frugiperda* J. E. Smith) in maize crop productions in West Hararghe Zone, Ethiopia

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ABSTRACT: The study was carried out to determine the farmers' indigenous knowledge, perceptions on the infestation and damage level of American Fall Army Worm (AFAW) *(Spodoptera frugiperda* J. E. Smith) in maize cultivated fields at Chiro and Darolebu districts of West Hararghe zone, Ethiopia during the main cropping season of 20l8 to 2019 and also to assesses the indigenous knowledge and how the farmers manage AFAW in maize crop fields to further design and improve appropriate control mechanisms for the study areas. Sampling technique was purposive for identifying districts that had high maize crop production potential from both districts. From each district, three localities were selected purposively. A total of 207 respondents (51 Key Informants (KI) and 26 Focus Group Discussions (FGDs) per each locality from both study districts were interviewed and generated both qualitative and quantitative data on AFAW insect pest and its local management practices and losses in maize crops. All the respondents were reported that AFAW was caused damage and yield losses on maize fields at both study districts. They also reported that AFAW was in general feeders which attack many crop species. In the farmers' opinion, maize (76% and 72.88%), sorghum (13% and 18.56%), and millet (11% and 8.56%) were considered as the most susceptible at Chiro and Darolebu districts, respectively. On average, more than 25.90 % of the controls against this pest in all the study areas were often done through chemical and cultural control methods. The main control methods were used both insecticides and cultural at Darolebu (55.6%**)** and insecticides only at Chiro (20.8%) districts, respectively. From traditional management options, most of the discussants reported and used various particles like ash, urea, soils and botanical extracts such as tobacco, garlic, datura (banji), green pepper and also soap particles (66.6% and 18.5% from Darolebu and 29.7% and 4.7% Chiro districts, respectively. From all the study areas, 26.40% respondents reported that the mechanical methods were used by the removal of infested plants in the fields. But 14.35 % of respondents said did not use any traditional methods in the study areas. The FGD respondents suggested that it is better to have resistance and adaptable varieties that released for such agro-ecologies the same to our area. Also, they have emphasized that the government should be supplied fertilizers and different effective insecticides timely by affordable prices.

KEYWORDS*:* maize, farmers perception, American fall army worm, management practices, yield losses.

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INTRODUCTION

The agricultural sector is mainly based on small holder farms and the livelihoods of more than 80% of the citizens in Ethiopia. The agricultural development is vital for sustainable growth and poverty reduction in the country. Maize (*Zea mays* L.) can be grown in the wide range of environmental conditions ranging between 500 and 2400 m. a. s. l and are the primary and co-staple food materials in Ethiopia and occupies more land than any other cereal crop after teff and accounts for 36 percent of all grain production and it grows from low rainfall areas to high rainfall areas (Twumasi *et al*., 2001). It is one of the high priority crops to feed the increasing human population of the country due to its adaptation and total yield (Sahito *et al*., 2010). Approximately 88 % of maize produced in Ethiopia is consumed as food, both as green and dry grains. The total grain crop production area, maize is second next to teff and first in productivity which comprises 21114876 hectares (16.91/%) of land and 71508354.11 (26.80%) quintals productivity with average yield of 3 tons/ha, respectively as compared to sub-Saharan Africa that estimated to 1.8 tons/ha which is still far below the global average yield of maize 5 tons/ha (CSA, 2016). Farmers get lower yield mainly due to insect pests, diseases and sub-optimal fertilization and also inadequate quarantine measures along with climate change have contributed to the occurrence of new pests which kept on emerging almost regularly.

In Ethiopia, West Hararghe zone is a well-known potential area for cereal crops production particularly sorghum and maize crops, among, Chiro and Darolebu districts are famous in maize productions, out of total crop cultivated land 13,215 and 7,247 hectares in Chiro and 11,076 and 6,612 hectares in Darolebu districts of land covered by maize crops. Despite its vital importance, the yield and production potential of this crop is under pressure due to different constraints, especially insect pests. Farmers in the area of study produced maize crops on a small scale and usually small-scale producers are resource of very poor and consequently risk aversive. In the study areas, farmers have various forms of indigenous knowledge to solve pest problems of maize crops which are generally adapted to the existing economic, social and climatic conditions. Such indigenous knowledge forms the concept of cultural control: which includes field hygiene, using local available different particles and botanical control options. In Africa, the majority of farmers still depend on indigenous pest management approaches to manage pest problem (Abate *et al*., 2000).

American fall army worm (AFAW) *(Spodoptera frugiperda* J. E. Smith) is a migratory insect pest known to cause serious damage to maize crops under warm and humid conditions in the Americas (Ayala *et al.,* 2013; Clark *et al*., 2007). Despite the huge amounts of damage to crops, very little information is known on farmers' perceptions of AFAW pest and their management practices. The first step towards the development of successful pest management strategies adapted to farmers' needs is an understanding of farmers' perceptions of the pests and their control methods (Debelo and Degaga, 2015). Furthermore, information about indigenous perception and management practices of fall armyworm pest is scarce in the literature, indicating the need for appropriate documentation of such invaluable information from a different part of the world.

Understanding of farmer's indigenous knowledge and the strategies they adopt in management of insect pests helps in conducting research which involves farmers' participation and that will lead to adoptable and effective pest control option which meet farmers' needs (Nyeko *et al.*, 2002). Additionally, small scale agriculture is characterized by small land holdings (Aheto *et al.,* 2013) and most of the farmers may be unwilling to invest on pest management tactics (Morris and Thomson, 2014). Farmers' knowledge of fall armyworm pests and its management practices has not received as such attention in Ethiopia and there is only negligible information. Such study helps to assess any gap in the small-scale producer system in order to enable the provision of information necessary to promote development of sustainable control strategies in the maize crop ecosystems. Therefore, this study was carried out to determine the farmers' indigenous knowledge perceptions on the incidence and infestation/damage level of AFAW in maize cultivated fields at Chiro and Darolebu districts of West Hararghe zone, Ethiopia and also to assesses the indigenous knowledge and how the farmers manage American fall army worm in their maize crop production fields to further design and improve appropriate control mechanisms for the study areas.

MATERIALS AND METHODS

Description of the study areas.

Survey was carried out in West Hararghe Zone of Oromia Regional State in two selected districts (SPIR/DFSA Program) namely Chiro and Darolebu during the main cropping season in 2018/19, to investigate the farmers' indigenous knowledge and their management practices of fall armyworm in maize fields.

The district Chiro is located in West Hararghe Zone of the Oromia Regional state at about 324 km East of Finfine, the capital city of Oromia Regional state and is found at an average altitude of 1800 m. a. s. l. The topography of the district 45% is plain and 55% steep slopes. The district is mainly characterized as steep slopes and mountains with rugged topography, which is highly vulnerable to erosion problems. It has a maximum and minimum temperature of 23^{o}C and 12^{o}C, respectively and the maximum and minimum rainfall of 1800 mm and 900 mm, respectively. Soil type is sandy, clay (black soil) and loamy soil types covering 25.5, 32, and 42.5%, respectively.

The district Darolebu is situated between 7^{0}52'10" and 8^{0}42'30" N and 40^{0}23'57" and 41^{0}9'14" E and characterized mostly by flat and undulating land features with altitude ranging from 1350 up to 2450 m. a. s. l. The temperature of the district ranges from 10 to 28°C. Rainfall is ranging from 800 up to 1200 mm/year. The pattern of rain fall is bimodal and its distribution is mostly uneven. The topographic areas of the district have plain areas 80%, mountains /hilly 10%, rugged terrain 5% and others 5%. Soil types of the district includes sandy 48%, loam 10%, clay (Black soil) 27%, red 15%, and others 3%.

Sampling techniques and data collection

Totally, the samples were taken from 207 respondents (including 26 FGDs per each kebele and 51 KIs) from both study districts. The research employed using Focus Group Discussion (FGD) and Key Informant interviews (KIIs) to assess the farmer's indigenous knowledge of management practices of American fall army worm in maize field in the study areas. Selections of households

for group discussion and key informants were based on sex and representativeness of participants from different direction of the kebeles. Therefore, 26 FGDs (8 elder men, 8 youth men and 10 female) from each kebele and 51 KIs (respondents) were participated from both districts during the discussions. (Tables 1 & 2; Figure 1).

Table 1: Participant list on the Focus Group Discussions (FGD) from the study areas

District	Kebele	List of participants			Total respondents
		Focus Group Discussions			
		Elder Male	Youth Male	Female	
Darolebu	Matagudesa	8	8	10	
	Kortu	8	8	10	
	Sakina	8	8	10	
Chiro	Arberekete	8	8	10	
	Waculimaye	8	8	10	
	FugnanDimo	8	8	10	
Grand total		48	48	60	156

Table 2: Participants list of KIs from the study areas

District	Kebele	Lists of Participants	Total Respondents
		Key Informants	
		Number of respondents	
Darolebu	Matagudesa	11	27
	Kortu	8	
	Sakina	8	
Chiro	FugnanDimo	8	24
	Waculimaye	8	
	Arberekete	8	
Grand total		51	51

Samples were collected using purposive data sampling methods based on local producer's experience of agricultural production. Three kebeles in each district was selected by consulting district agricultural office based on potential areas of selected maize crop. Depending on the study areas, both quantitative and qualitative information's were collected. Qualitative surveys were aimed at confirming the presence or absence of insect pest of AFAW in an area. Quantitative surveys were used to estimate the proportion of plants infested and expected maize crop losses or injury levels. Primary data was obtained through questionnaires. For the confirmation of the discussant's response, the information was also obtained through sampling of plant. Purposively, more experienced model elder and young house hold farmers (male and female) were selected for key informants' interview (KII). Samples sizes were determined based on saturation theory or until newly collected data no longer provides additional insights. Appropriate tools were used to obtain information about farmers' indigenous knowledge related to maize crop American fall armyworm management options. Semi-structured interview was used to gather data in the farmers' cultural context. Ten farmers were participated in the pre-study (Pre-test) to ensure farmer comprehension

of typical questions and the ability of enumerators to administer it. The pre-test was used to improve the final interview schedules. To minimize bias questions were communicating and farmers were allowed to indicate other answers in case the stated option does not meet their response(s). Basic information on social economic status, which includes farmers' age, educational level, gender, religion, and marital status were collected. Information was also collected on farmers' perception of AFAW as pests, other crops attacked by AFAW and their management practices. Secondary data also collected from zone and districts Agricultural Office Crop Protection and Agronomy Service Experts and villages development agents from documented and reported materials.

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to the laboratory. Field collected larvae were taken to laboratory for rearing and identification. Morphological characters were used to determine the species identity. The insect pest, AFAW on maize crops were identified using manuals protocols and based on morphological characteristics of the larvae collected: larval forms, body and head pigmentation, damage symptoms related to each insect species. American Fall armyworm identification was used by Jeger *et al*. (2017), to support farmers for their timely actions.

Data analysis

The Survey Data Processing System software was imported into Statistical Package of SAS software (SAS version 9.4) used for analysis. Qualitative data were subjected to analyses using SAS computer software (SAS, 2020). Excel was also used to produce figures. Descriptive statistics were used to determine mean frequencies and percentage of responses.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents in Chiro and Darolebu districts

In this study, totally 51 respondents (24 from Chiro district and 27 from Darolebu district) were selected and interviewed. The demographic characteristics of the farmers interviewed in the survey indicated that maize crop production in the study area is gender biased with 70.6% male and 29.4% female headed households. This is in contrary to Assefa *et al.,* (2008) and Lewu and Assefa (2009) who observed farming in Africa is gender sensitive. The age group of respondents were totally varied; 31 - 40; 41 - 50; 51 - 60 and above 60. Below 30 years age group of respondents were not selected. Among 51 respondents, 57% of the respondents come under the young age group 31 to

40; 31.5% were middle aged group (41 to 50) and 11.5% were the remaining come under the age group 51 to 60 and above 60 (Table 3). In relation to the level of education 33.3% were illiterate; 21.6% were primary; 31.3% under secondary; 11.8 % were diploma and degree holders and 2.0 % at higher secondary level (Table 3). With regard to religion, the Muslims were dominant (70.6%) and followed by Orthodox (27.4%) and Wakefeta (2.0%). The family size was also varied among the 51 respondents. About 37.4% of the respondents has 1 to 5 and 33.3% of the respondents has 6 to 7 and the remaining 33.3% respondents has 8 to 12 (Table 3). The family size includes unmarried respondents who are living with their parents, brothers and sisters.

Table 3: Socio-economic characteristics of the respondents in both Chiro and Darolebu districts

Chiro district*				Darolebu District*			Total	
Sampled Kebeles*	S1	S2	S3	S1	S2	S3		Percentage (%)
Number of Respondents	8	8	8	8	8	11	51	
Gender								
Male	6	5	4	4	8	9	36	70.6
Female	2	3	4	4	--	2	15	29.4
Total	8	8	8	8	8	11	51	100.0
Age group								
Below 30 years	--	--	--	--	--	--	--	--
31 – 40 years	4	3	4	4	5	9	29	57.0
41 – 50 years	3	2	4	3	2	2	16	31.5
51 – 60 years	--	2	-	--	1	-	3	
Above 60 years	1	1	-	1	--	-	3	11.5
Total	8	8	8	8	8	11	51	100.0
Education								
Illiterate	2	3	4	4	3	1	17	33.3
Primary	2	3	-	2	3	1	11	21.6
Secondary	4	2	3	2	2	3	16	31.3
Higher secondary	--	--	1	-	-	-	1	11.8
Degree/Diploma	--	--	--	-	-	6	6	2.0
Total	8	8	8	8	8	11	51	100.0
Religion								
Orthodox	1	3	1	3	2	4	14	27.4
Muslim	7	5	7	5	5	7	36	70.6
Wakefeta	--	-	-	-	1	-	01	2.0
Total	8	8	8	8	8	11	51	100.0
Family size								
1-5	4	3	3	2	1	6	19	37.4
6-7	4	2	4	3	2	1	16	33.3
8-12	--	3	1	3	5	4	16	33.3
Total	8	8	8	8	8	11	51	100.0

*Chiro district
S1 -- Waculimaye
S2 -- FugnanDimo
S3 – Arberekete

*Darolebu District
S1–Matagudesa
S2 -- Kortu
S3 – Sakina

Farmers' perception about American fall armyworm

All the respondents similarly reported that AFAW was caused more damage and yield losses on maize cultivated fields at both study districts. They also reported that AFAW was in general feeders which attack many crop species. In the farmers' opinion, maize (76% and 72.88%), sorghum (13% and 18.56%), and millet (11% and 8.56%) were considered as the most susceptible at Chiro and Darolebu districts, respectively (Figure. 2). Different morphological appearances and damaging syptoms of insect pests were identified and considered initially on the informations obtained from local farmers producing maize crop. In both districts, the local name of AFAW was Geri America and its morphological appearance is with dafferent colors at larvae stage, green and grey with different strip and the damaging symptoms mainly eat the growing point and widowing the leaf parts and its margin in maize cultivated fields.

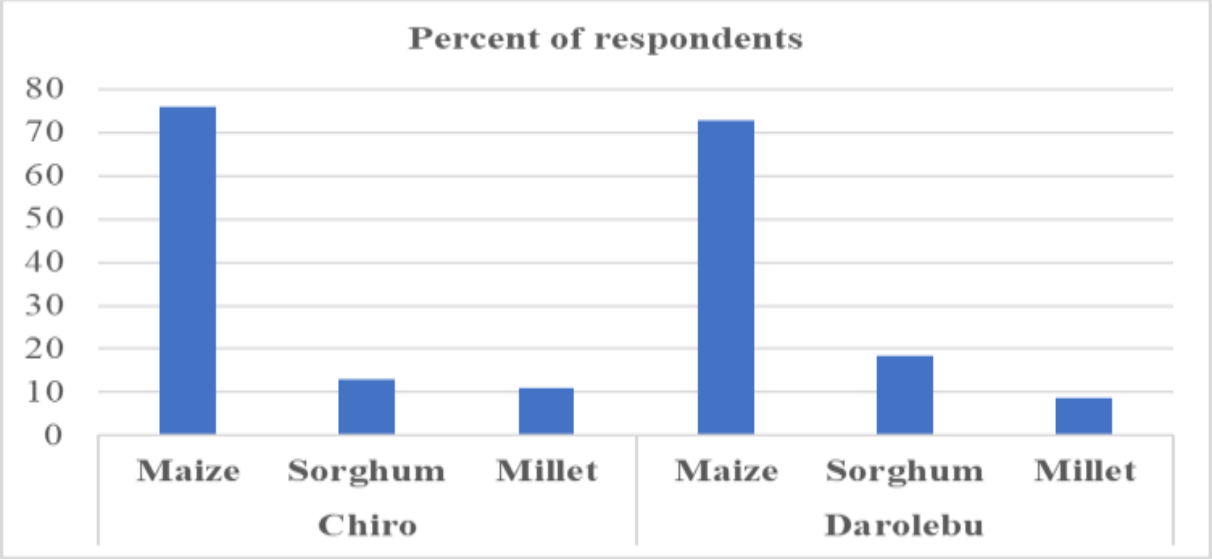

Fig. 2: Crops reported by farmers as susceptible to American fall army worm attacks
Source: from FGD, KI and Experts survey results of 2018/19.

New insect pest, AFAW problem encountered recently in the study areas

As far as concerning the new type of insect pests encountered in the study areas, all 51 respondents from both districts, responded, the American fall army worm was only encountered new insect pest on maize cultivated fields but the percentage of frequency was differed at the stage of the crops encountered. At Chiro district, among 24 respondents, the AFAW encountered after one month at the stage of the crop was by about 37.5% farmers but after one month and half, the percentage of frequency was very high by about 58.3% farmers and after one month up to 2 months stage the percentage of frequency was only by about 4.2% farmers (Table 4). At Darolebu district, among 27 respondents, the AFAW encountered after one month at the stage of the crop was just by about 3.7 % farmers but after one month and half, the percentage of frequency was very high by about 74.1% farmers and after one month up to 2 months stage the percentage of frequency was only by about 22.2% farmers (Table 4).

As reported on the above results, the production of maize is threatened by the AFAW and confirmed the occurrence of the same in 28 countries in Africa (Cock *et al.,* 2017; Day *et al.,* 2017) indicating the rapid spread of the pest in the African continent, threatening the food security of millions of people. In Ethiopia AFAW was reported for the first time in Bench Maji zones of Southern Nations, Nationalities and Peoples State in January 2017 (Teshome *et al.,* 2018). Now it is distributed throughout different areas of the studied areas.

Table 4: New insect pest AFAW problems encountered recently in the study areas of both districts

District	Kebele	Name of the Crop	Name of the new insect pest	Stage of the crops encountered on maize crop			
				After one month	After one month and half	After one month up to 2 months	Total frequency
Chiro	Waculimaye	Maize	American Fall armyworm	7	-	1	24
	Fugnan Dimo			2	6	-	
	Arberekete			-	8	-	
Frequency				9	14	1	
Percentage				37.5	58.3	4.2	
Darolabu	Matagudesa	Maize	American Fall Armyworm	-	8	-	27
	Kortu			1	7	-	
	Sakina			-	5	6	
Frequency				1	20	6	
Percentage				3.7	74.1	22.2	

Source: FGD, Expert and KIs survey results of 2018/19

Factors that may have brought AFAW problems in the study areas

In relation to what factors may have brought AFAW insect pest problems and which weather conditions may play a great role in prevailing the new pest, AFAW in the study areas were also discussed with all respondents. So that, at Darolebu district from all discussants, the main reason for encountered the AFAW insect pest due to drought by about 25.0%of respondents; lack of rain by about 20.8% of respondents; climate change by about 16.7% of respondents and about 4.2% of respondents raised the routes of enter through commodities exchange between Ethiopia and neighboring countries and about 41.7% of respondents replied they don't know the cause of entry of AFAW (Table 5; Figure. 3). At Chiro district, among from all respondents, the main reason for encountered AFAW insect pest due to drought 22.2%; lack of rain 18.5%; and climate change for about 7.4% of respondents and some of the respondents said they don't know (11.1%) and about 18.5% of respondents replied the routes of enter through commodities exchange between Ethiopia and neighboring countries (Table 5; Figure.4). These results similar with the report of Goergen *et al*. (2016) the possible routes of entry of fall army worm to Africa likely the adults and/or egg

masses transported on direct commercial flights between the Americas and West Africa, followed by dispersal by adult flight within the African continent.

Table 5 Factors that may have brought insect problems in the study areas

District	Kebele	Drought	Lack of Rain	Climate change	Enter through commodities exchange between Ethiopia and neighboring countries	Don't know
Darolebu	Matagudesa	1	3	1	1	2
	Kortu	2	1	1	-	4
	Sakina	3	1	2	-	4
Frequency		6	5	4	1	10
Percentage		**25.0**	**20.8**	**16.7**	**4.2**	**41.7**
Chiro	Waculimaye	-	4	2	1	-
	Fugnan Dimo	1	1	-	3	1
	Arberekete	5	-	-	1	2
Frequency		6	5	2	5	3
Percentage		**22.2**	**18.5**	**7.4**	**18.5**	**11.1**

Source: FGD, Experts and KIs discussants survey results of 2018/19

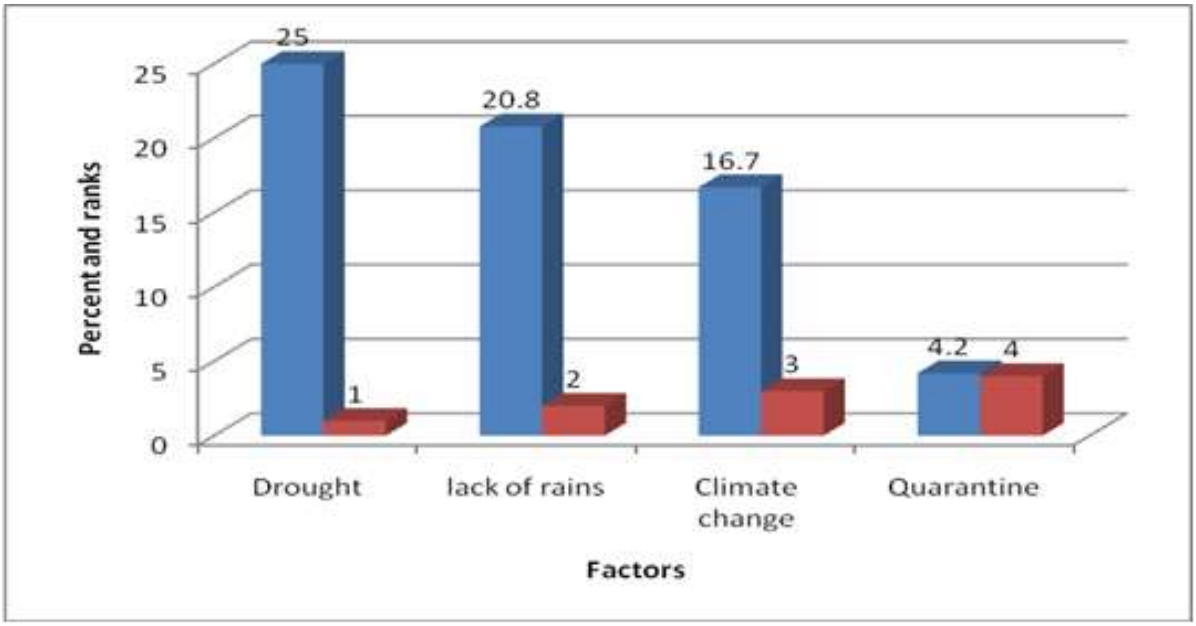

Fig.3: Factors influencing the occurrence of AFAW problems in Darolebu study areas

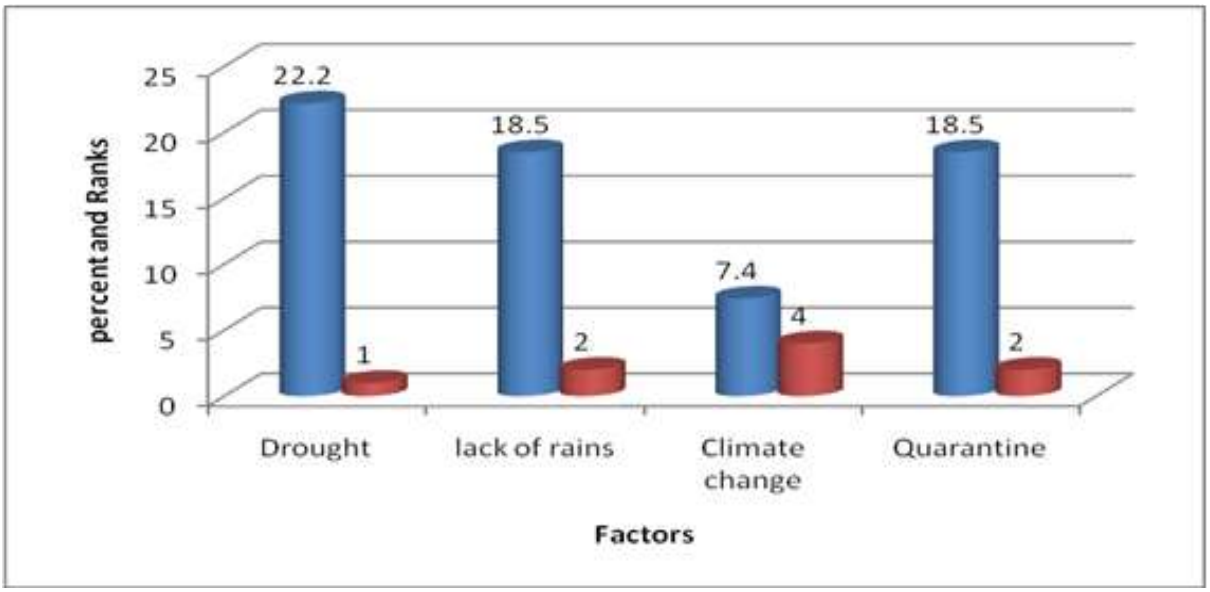

Fig. 4: Factors influencing the occurrence of AFAW problems in Chiro study areas.

3.4. Estimated of percent infestation and losses of maize by respondents from study areas.

Farmers were asked to estimate the percentage of estimated infestation level and yield loss of maize crops that was lost or affected by AFAW insect pest. As far as concerned, the percent yield losses caused by AFAW were estimated from maize cultivated fields. In Darolebu district, from discussant respondents, due to infestation of AFAW, about 77.8% of respondents were responded for the estimated infestation level of 20 -50 % and also 51- 81%, of the of infestation level estimated by about 22.2% of respondents whereas in Chiro district, due to AFAW infestation on maize cultivated fields, about 87.5% of respondents were responded for the estimated infestation level of 20 -50% and about 4.7% of respondents were responded for the estimation of infestation level of 51- 81% (Table 6). In Darolebu district, from all respondents, due to AFAW, the estimation losses of about 92.6% respondents responded at 10 - 30% and also 31- 70%, the estimation of losses % was nil only whereas in Chiro district, due to AFAW infestation on maize cultivated fields, about 87.5% of respondents responded for the estimated losses at 10 -30%, and about 4.7% of respondents responded for the estimation of losses of 31- 70%.About 7.4% from Darolebu district and 8.3% of respondents from Chiro district were no responses about the of yield losses percent due to infestation of AFAW. Averagely almost all of the discussants (about 92.6% and 77.8% of respondents from Darolebu and 87.5% and 87.5% from Chiro districts respectively) responded the estimation losses level from 10-30% and estimated infestation from 20-50 % were listed on maize crop by AFAW, which is similar to previous damage evaluated by Hruska and Gould, (1997) have shown that infestations during mid-to-late maize growth stages can result in yield losses of 15–73% (as 55-100% of the plants are infested).Similarly, an evaluation in Ethiopia indicated that FAW caused up to 30% loss at the late whorl stage unless the pest is timely controlled (Fentahun, 2017).

Table 6: Estimated of percent infestation and losses of maize by respondents from study areas.

District	Kebele	Name of the crop	Name of the insect pest	Estimated infestation level (%)		Estimated losses (%)		None respondents (they do not know)	
				20-50	51-80	10-30	31-70	Infestation	Losses
Darolebu	Matagudesa	Maize	AFAW	8	-	7	-	-	1
	Kortu			8	-	7	-	-	1
	Sakina			5	6	11	-	-	-
	Frequency			21	6	25	-	-	2
	Percentage			77.8	22.2	92.6	-	-	7.4
Chiro	Waculimaye			7	1	7	1	-	
	Fugnan Dimo			8	-	8	-	-	
	Arberekete			6	-	6		2	2
	Frequency			21	1	21	1	2	2
	Percentage			87.5	4.7	87.5	4.7	8.3	8.3
Grand total				42	7	46	1	4	4

Source: FGD, Experts and KIs discussants survey results of 2018/19

Different m**anagement options practiced to control AFAW by respondents in both study areas.**

The different management options viz. chemical control, cultural control, removal of infested crops by mechanical and both chemical and cultural control were practiced by respondents in both study areas on maize cultivated crop fields (Table 7). At Chiro district, the main management options were practiced maximum of about 55.6% farmers using both chemical and cultural control methods followed by cultural control of 18.5%, chemical control 7.4% and also mechanical methods used by 7.4% farmers. At Darolebu district, the main management options were practiced maximum of about 33.3% farmers using Cultural control method followed by both chemical and cultural control methods 20.8%, chemical control 16.7% and mechanical method used by 4.2% farmers (Table 8). In both districts, the few respondents (11.1% in Chiro and in Darolebu districts) did not use any management options (Table 7).

Table 7: Different Management options practiced by respondents in both study areas.

District	Kebele	Different management options practiced by respondents				
		Cultural control	Chemical control *	Removal of infested crops by mechanical	Both chemical and cultural	No management options
Darolebu	Matagudesa	1	1	1	4	1
	Kortu	-	-	1	5	2
	Sakina	4	1		6	-
	Frequency	5	2	2	15	3
	Percentage	18.5	7.4	7.4	55.6	11.1
Chiro	Waculimaye	3	3	-	1	1
	FugnanDimo	1	-	1	1	2
	Arberekete	4	1	-	3	-
	Frequency	8	4	1	5	3
	Percentage	33.3	16.7	4.2	20.8	11.1
Grand total		13	6	3	20	6

*Common chemicals used in the area are: Malathion 50% EC; Etilotine and Filitrotine

Averagely, 38.2% of the respondents in the study areas were used both chemical and cultural control methods. As reported below the farmers traditionally used botanical extracts, wood ashes and soils particles for control of AFAW. However, they don't know the quantity of those botanical, they simply added by approximation. But if they used effectively, botanical extracts have long been proposed as attractive alternatives to synthetic insecticides for pest management. Botanical extracts are eco-friendly, economical, usually target-specific, and bio-degradable. As reported, the greatest strength of botanical extracts is their specificity, as most are essentially nontoxic and non-pathogenic to animals and humans (Stevenson, 2017). Some of the farmers depend on the use of chemical control; this is in agreement with the reports of the growing dependence on synthetic insecticides for the control of crop pests (Orr and Ritchie, 2004, Obopile *et al*., 2008, Grzywacz *et al*., 2010). Most of the pesticides applied are potent toxins and their intensive use poses potential hazards to humans, livestock, and the environment (Chambers *et al*., 2001, Ngowi *et al*., 2007)

Traditional management options used against AFAW in study areas.

About the traditional management of AFAW insect pest control in cultivated maize crop field's, among 27 respondents from Darolebu district, 66.6% respondents used only traditional methods and adding various particles like ash, urea soils, while 18.5% used botanical extracts such as tobacco, garlic, datura (banji), green pepper and also soap particles. 11.1% respondents used mechanically by the removal of infested plants in the fields. But 3.7 % of respondents did not use any traditional methods in Darolebu district (Table 8). At Chiro district, among 24 respondents, 41.7% respondents used directly the removal of infested plants and 29.7% used the traditional methods and adding various particles like ash, urea soils. While 4.7% of respondents used botanical extracts such as tobacco, garlic, datura (banji), green pepper and also soap particles. Moreover, 25 % of respondents did not use any traditional methods in Chiro district (Table 8).

As an emergency response, governments in Africa, including in Ethiopia, deployed massive use of pesticides to the affected areas to saving the crops and halt further expansion of the pest. The invasive nature of the most insect pests and the lengthy process of pesticide registration forced farmers to use non-registered pesticides. This highlights the need for emergency registration of pesticides in exceptional cases. Most subsistence farmers in Africa do not apply pesticides to maize to control pests; nevertheless, they do practice cultural control methods which deter or kill pests, such as maize intercropping with common beans, handpicking and killing of caterpillars, application of tobacco extracts, wood ashes and soils to leaf whorls (Abate *et al*., 2000). It is specifically noted that none of the farmers had an awareness of host plant resistance and biological control. Following the sudden invasion of the fall armyworm, farmers were supplied with pesticides by governments, often for free, to spray this pest without proper training and adequate spray equipment. However, besides supplying pesticides, it is important to train farmers on the proper methods of pesticide application to circumvent in efficacy of pesticides, health risks, and cases of resistance development. The plants used for pest control varied considerably. Generally, most farmers consistently used the similar plant parts from particular species such as leaves, roots, fruits, husks etc. The main differences were in the mixtures applied by each individual farmer. Their availability, safety, and effectiveness might have contributed towards the use of botanical pesticides among farmers in the study area.

Table 8: Traditional management options used against AFAW in study areas

District	Kebele	Traditional fall armyworm management options				Frequency
		Plant extracts **	Using traditional methods and adding Various particles*	Removal of infested plants	Not practiced any traditional approaches	
Darolebu	Matagudesa	4	1	2	1	8
	Kortu	-	7	1	-	8
	Sakina	1	10	-	-	11
	Frequency	5	18	3	1	27
	Percentage	**18.5**	**66.7**	**11.1**	**3.7**	**100**
Chiro	Waculimaye	-	6	2	-	8
	FugnanDimo	-	1	4	3	8
	Arberekete	1	-	4	3	8
	Frequency	1	7	10	6	24
	Percentage	**4.7**	**29.7**	**41.7**	**25**	**100**
Grand total		6	25	13	7	51

***** Particles used: Ash, Urea, soils, green pepper; ** Plant extracts: tobacco, garlic, datura (banji) & green pepper

As reported, most subsistence farmers in Africa do not apply pesticides to maize to control pests; nevertheless, they do practice cultural control methods which deter or kill pests, such as maize intercropping with common beans, handpicking and killing of caterpillars, application of tobacco extracts, wood ashes and soils to leaf whorls (Abate *et al*., 2000)

Time of management options practiced by local farmers

At Chiro district, from the discussant respondents, the maximum percentage of 70.8%, were replied, the management options were practiced, when the insect, AFAW was observed on the maize cultivated fields, immediately, whereas in Darolebu district, among 27 respondents, the maximum 96.3% respondents replied the same, when the insect pest, AFAW was observed on the cultivated fields. In Chiro district, 4.7% respondents replied using the economic threshold level after that the management of AFAW insect pest control was practiced (Table 10) but 16.7% in Chiro district respondents and 3.7% respondents in Darolebu district did not use any management practices in both cultivated crop fields (Table 9).

Table 9: Time of management options practiced by local farmers

District	Kebele	Time of management				Frequency
		When insects first observed	By considering economic threshold level	No practiced at all	By consulting experts of the area	
Darolebu	Matagudesa	7	-	1	-	8
	Kortu	8	-	-	-	8
	Sakina	11	-	-	-	11
	Frequency	26	-	1		27
	Percentage	**96.3**		**3.7**		**100**
Chiro	Waculimaye	5	1	-	-	8
	F/Dimo	4	-	4	-	8
	Arberekete	8	-	-	-	8
	Frequency	17	1	4	-	24
	Percentage	**70.8**	**4.7**	**16.7**	**-**	**100**
Grand total		43	1	5		51

Source: FGD, Experts and KIs discussants survey results of 2018/19

Farmers awareness in differentiation (identification) of natural enemies and insect pest, AFAW at the time of spray

All 51 respondents from both districts discussed and reflected their idea about the conditions that could influence the establishment of helpful/beneficiary/ insects which occurred in the area or not. The Chiro district, 24 respondents replied 100%as they have no experience to identify between beneficiary or harmful insect pests whereas 21 respondents (77.8%) from Darolebu district, were accepted for the same, as they have no experience to identify between beneficiary or harmful insect pests. Only 6 (22.2%) from Darolebu district respondents used to spray at late afternoon and morning for controlling the insect pests (Table 10).

Table 10: Farmers awareness in differentiation (identification) Natural enemies and insect pests at the time spray

District	Kebele	Experienced	Not experienced	Used to spray at late afternoon and morning time	Frequency
Darolebu	Matagudesa	-	8	-	8
	Kortu	-	8	-	8
	Sakina	-	5	6	11
	Frequency		21	6	27
	Percentage		**77.8**	**22.2**	**100**
Chiro	Waculimaye	-	8	-	8
	FugnanDimo	-	8	-	8
	Arberekete	-	8	-	8
	Frequency		24	-	24
	Percentage		**100**		**100**
Grand total			45	6	51

Farmers recommendations for possible solution to solve AFAW problems

About 91.7% and 66.7% respondents from Chiro and Darolebu districts, respectively responded the possible solutions to solve the production problems of AFAW in maize cultivated fields, they insisted particularly, the Government should facilitate the irrigation of water supply for local farmers and supply improved varieties of crops, insecticides, and fertilizers on time (Table 11). About 18.5% respondents from Darolebu district and 8.3% respondents from Chiro district were insisted the use of improved techniques to solve the insect problem in cultivated maize crop fields. About 3.7% of respondents from Darolebu district recommended training programs and awareness creation to the farmers about fall armyworm control (Table 11).

Table 11: Farmers recommendations for possible solution to solve AFAW insect pest problems

District	Kebele	Government supports in facilitating improved technologies and input supplies	Researchers and expert supports	Use of improved techniques	Training and awareness creation for farmers and other stakeholders	Frequency
Darolebu	Matagudesa	6	1	1	-	8
	Kortu	7	1		-	8
	Sakina	5	1	4	1	11
	Frequency	**18**	**3**	**5**	**1**	**27**
	Percentage	**66.7**	**11.1**	**18.5**	**3.7**	**100**
Chiro	Waculimaye	6	-	2	-	8
	Fugnan Dimo	8	-	-	-	8
	Arberekete	8	-	-	-	8
	Frequency	**22**	**-**	**2**	**-**	**24**
	Percentage	**91.7**	**-**	**8.3**	**-**	**100**
Grand total		**40**	**3**	**7**	**1**	**51**

The FGD respondents suggested that it is better to have resistance and adaptable varieties that released for such agro-ecologies the same to our area. Also, they have emphasized that the government should be supplied fertilizers and different effective insecticides timely by affordable prices. In general, the community practiced different adaptation strategies towards maize crop production constraints of which the following are the major in the study area:.

- ✓ Planting of drought tolerant and early maturing maize variety
- ✓ Shifting from maize production to sorghum and groundnut
- ✓ Pond construction and water harvesting during rainy season
- ✓ Adjusting cropping time (from April to June)

Though the community practiced the above mention strategies to cope with fall army worm impact and other insect pests, access to agricultural technologies and information on different constrants were reported as major problems by the participants for example drought tolerant and early maturing improved maize crop varieties. Additionally, lack of awareness and training on how to adapt to this shock indicated as constraints hindering their capacity to response.

CONCLUSIONS

Purposive sampling was employed to assess the farmer's perceptions, indigenous of AFAW insect pest and their management in Chiro and Darolebu districts. All the surveyed farmers reported that AFAW, which caused an important yield loss, attacked their maize fields. They also reported that fall army worm is general feeders which attack many crop species. Among them, maize (76% &72.88% of responses), sorghum (13% & 18.56% of responses), and millet (11% & 8.56% of responses) are considered the most susceptible at Chiro and Darolebu districts, respectively. From different management options, averagely from all study areas, more than 25.90 % of the farmers make use of cultural control method when comparing with chemical insecticides. Only 12.05 % had access to chemical insecticides for controlling AFAW in maize crops in cultivated fields. The predominant control methods were used both insecticides and cultural practices at Darolebu (55.6%) and insecticides only at Chiro (20.8%) districts. From traditional management options, most of the discussants used by adding various particles like ash, urea, soils and botanical extracts such as tobacco, garlic, datura (banji), green pepper and also soap particles (66.6% and 18.5% from Darolebu and 29.7% and 4.7% Chiro districts) respectively. From both study areas, 26.40% respondents used mechanically by the removal of infested plants in the fields. On average, in districts, the few respondents (11.1%) in Chiro and 12.5% in Darolebu districts) did not use any management options.

Farmers' perceptions have contributed to the understanding of the pest status of AFAW in the two districts of West Hararghe zone of oromia region. The current study revealed that Farmers rate of AFAW as an important polyphagous pest on food crops that warrants urgent management or control. The pest incidence has increased because of host availability and farmers' low awareness to prevent and control it. It is therefore, necessary to consider this pest among the major pests in the West Hararghe zone. Integrated Pest Management (IPM) strategy is a comprehensive approach that combines all rational strategies to reduce pest densities to tolerable levels while maintaining

a safe quality environment. These farmers' perceptions are in general similar to the results of most experimental studies but may stimulate researchers to identify new research areas. Both farmers and scientific knowledge have strengths and weaknesses. Most of the farmers in the study area were not aware of the currently available AFAW management options which improve crop health and productivity. This is deficient in knowledge and information calls for training and awareness creation of both farmers and extension workers in fall armyworm identification and control. Therefore, it is recommended to provide practical training and awareness creation for farmers, DAs and extension workers on AFAW diagnosis, monitoring and currently available management options to prevent and control the high quantitative and qualitative maize crop losses incurred so as to contribute towards family food security in West Hararghe Zone of Ethiopia. This study was fulfilled the information gabs and all information of insect pests which lead production and improve house hold nutrition of all age. This information was also the fundamental importance to the local communities and the country as it seeks to prevent actual and potential losses by developing effective and sustainable insect pest management strategies for the future.

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