International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 9 Issue 12 December - 2025, Pages: 337-350

Cotton Farmers' Perceptions of Bio-ecology and Management of Cotton Flea Beetle (*Podagrica puncticollis* Weise) in Metema District, Northwestern Ethiopia

Eshetu Agegnehu Abebe[1], Bayeh Mulatu Aregay[2], Tebkew Damte Belete[3] and Mulatu Wakgari Amenta[4]
[1]College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia
[2]Food and Agriculture Organization, Ethiopia (FAO Et.), Addis Ababa, Ethiopia
[3]Debre Zeit Agricultural Research Center, EIAR, Debre Zeit, Ethiopia
[4]School of Plant Sciences, Haramaya University, Dire Dawa, Ethiopia
Corresponding author; Eshetu Agegnehu Abebe; College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia; email; agegnehueshetu70@gmail.com ; Tel; +2510918786450

Abstract: *Cotton production in Northwestern Ethiopia is severely affected by cotton flea beetle, Podagrica puncticollis Weise (Coleoptera: Chrysomelidae), resulting in low yields in spite of the rising demand for the commodity. Although this beetle is known to cause significant crop losses, information on its bio-ecology and management aspects has not been adequately identified and documented. This study aims to assess farmers' opinions regarding cotton pests and constraints to cotton pest management, to know farmers' perceptions and understanding on cotton flea beetle and examine farmers' current practices in managing cotton flea beetle. A total of 200 cotton farmers from ten administration divisions were interviewed using structured questionnaire during the main cropping season of 2020 in Metema district. The data were analyzed through descriptive statistics (frequencies, percentages, and means) to generate summaries and tables. The chi-square (χ2) test was conducted to compare some qualitative characteristics or opinions based on the percentages of responses for various questions by using SPSS computer software. The results showed that farmers were well aware of cotton flea beetle and other cotton pests and considered them the main constraints to cotton production in the district, causing significant economic damage. Cotton flea beetle, different bollworm species, aphids and termites were identified by the interviews as the most important insect pests of cotton, with cotton flea beetle ranked (89.9%) as the most damaging insect pest during the main cotton cropping season. This study revealed that farmers had little to moderate knowledge of cotton flea beetle and other insect pests as a whole. The majority of the farmers were, however, only able to identify pests descriptively while a few mentioned them by their local names. Cotton flea beetle and bollworm were mentioned by local names as "Workit" and "Gui-Til" or "Argif", respectively, and were considered the most important pests in the district. The current findings demonstrated that farmers have sound knowhow on the cotton flea beetle identity, host plants, infestation time as well as the threat it has been posing on cotton. Damage level due to cotton flea beetle was considered high by the majority of the farmers and they believed that on average up to 50% yield loss occurs in years of high infestation. About 75.5% of the farmers indicated that they protected their crops against cotton flea beetle using insecticides, weeding, late sowing, burning of cotton stumps, using high seed rate and insecticide dressed seeds, farm sanitation and adopting fallow. Pest management, where practiced, relied mainly on pesticides although the majority of the farmers did not effectively apply them due to high costs and shortage of appropriate pesticides and limited knowledge on all pest management approaches, including integrated pest management (IPM) and pests' natural enemies. Therefore, it is essential to train cotton producers to advance their knowledge towards cotton flea beetle bio-ecology and management as well as supporting them to obtain general knowledge of cotton pests as a whole through farmers' field schools.*

Keywords: *Podagrica puncticollis*, opinions, alternative hosts, insect infestation, crop damage, pest control

1. INTRODUCTION

Cotton (*Gossypium* spp.) is an important cash and agro-industrial crop grown under diverse agro-climatic conditions around the world [1]. It is an important cash crop especially for a number of developing countries at local and national levels [2]. Cotton is both a domestic and export crop in about 111 countries hence called "Queen of fibers" or "white gold" [3]. It is the most essential natural fiber crop in the world for textile produce, accounting for about 50% of all fibers used in the textile industry [4]. Cotton fibers are used in clothing and household furnishings [5], the seeds are used to obtain edible oil and its seed by-products also useful for livestock feed and provide income for hundreds of millions of people [6].

Cotton is the most key cash crop in Ethiopia and plays a vital role in the agricultural and industrial development of the country's economy as well as provides livelihood to hundreds of thousands of people engaged in farming, processing, trade and marketing [7]. It is extensively grown in the lowland areas under large-scale irrigation schemes and also in small-scale level under rain fed agriculture [8]. Ethiopia has a very good cotton-growing condition and a large amount of land potentially suitable for cotton production [9]. However, the amount of cotton produced in the country is small and the current domestic cotton production is much lower than the potential [10]. The main challenges in all aspects of cotton production and processing is the lack of new and continuous

generation/development/promotion of cotton production and processing technologies in Ethiopia. Biotic factors coupled with climatic and edaphic factors are hindering normal growth, boll formation and productivity of the crop mainly fiber or lint [11].

In Ethiopia, a pest complex of 57 species of insects and mite has been reported by Ermias *et al*. [12]. There are three (*Podagrica pallidicolor* Pic., *P. puncticollis* Weise and *P. uniformis* Jac.) species of flea beetles on cotton [12], however it is only *P. puncticollis*, which is the dominant species recorded as economic pest on cotton in Ethiopia and the neighboring countries [12]. Smallholder cotton production and marketing in Metema area, northwestern Ethiopia, is significantly affected both in quantity and quality of production due to multiple constraints, which include cotton flea beetle, *Podagrica puncticollis* Weise, locally known as *Workit*, which feeds on cotton leaf especially at germination stage, and which leads to losses of seedlings and poor crop establishment. The problem is worsened due to unavailability of research generated management options [13].

Both smallholder and commercial cotton farmers in Ethiopia use synthetic organic insecticides, including organophosphates, carbamates and organochlorins to manage insect pests [14] without consideration for the negative impacts of synthetic organic pesticides on human health and the environment. This because of their limited knowledge on safe use of pesticides and the lack of appropriate and easily accessible alternatives [15], thus, require to be improved by addressing the major constraints. This needs making a realistic assessment of their on-farm crop protection practices [16]. It is, thus, necessary to conduct surveys that can provide farmers' alternative viewpoint on the crop protection constraints facing them in their efforts to increase and sustain crop production [17]. The existing indigenous knowledge base of the farming community on pest management could serve as a guide for further improvement of management approach based on the assessment output [18].

Getting reliable information on cotton producers' practices to know the available opportunities to build on and constraints faced in pest management decision making at the farm level are crucial to device appropriate cotton flea beetle management approach acceptable to the producers. Currently, there is a limitation of information on farmers' awareness of insect pests including cotton flea beetle of cotton and their management practices in Ethiopia. Therefore, it is necessary to evaluate farmers' knowledge and perceptions on cotton flea beetle and its management as a baseline data to devise sustainable management tactics. It is important to assess farmers' knowledge and perceptions of cotton insect pests and their management practices as base to design approaches to strength them as independent decision-makers of their farm operations [16]. This is because pest management effort will be more effective when farmers' perceptions and practices are taken into consideration [19]. Also, Tefera [20] mentioned that an understanding of farmers' indigenous knowledge and the strategies they adopt in solving problems helps in conducting research that involves farmers' participation that will lead to adoptable and effective pest management option which meet farmers' needs. To improve cotton production, it is essential that producers actively participate as true partners in the development of pest management programs [21] through consideration of their socio-economic realities. The results obtained were supposed to single out the main research priority areas for intervention in the development of IPM programs proper to the interests and situations of cotton growers for managing cotton flea beetle and other cotton pests as whole.

General objective

This study aims to assess farmers' perceptions and knowledge of bio-ecology and management of cotton flea beetle as well as farmers' opinions about cotton pests and constraints to cotton pest management in Metema district, Northwestern Ethiopia.

Specific objectives

i) to assess farmers' ideas regarding cotton pests and constraints to cotton pest management
ii) to evaluate farmers' understanding on cotton flea beetle identity, host plants and natural enemies
iii) to assess farmers' views on cotton flea beetle infestation time, damage and factors affecting its outbreak
iv) to examine farmers' current practices in managing cotton flea beetle

2. MATERIALS AND METHODS

2.1. Description of the study area

The study was conducted in Metema district in North Gondar Zone of the Amhara National Regional State. Metema is located at about 900 km northwest of Addis Ababa and about 180 km West of Gondar town. It is situated at 12°58′ N and 36°12′ E. The district has a long international boundary of more than 60 km with the Sudan and is found in East of the Sudan border [22]. The altitude of Metema ranges from 550 to1608 meter above sea level. The daily maximum temperature can reach as high as 43degree centigrade from March to May, while the mean annual temperature is about 31 degree centigrade. The total annual rainfall ranges from about 850 to 1100 mm [23]. The soil in the district is predominantly black with vertic properties, such as characterized by excessive cracks, which could be as deep as 0.75 m in some places during the dry season [23]. According to CSA [24], the district covers an area of 6,969.97 km^2 and hosts a total population of 110,231 (58,734 males and 51,497 females), out of which 29,685 live in urban and the rest 80,546 in rural areas. The economy of Metema district depends predominantly on agricultural production. Settlers and commercial framers in the district extensively cultivate cotton, sesame and sorghum and raise goats and cattle [25].

2.2. Survey design and procedures

A survey was conducted in the main cotton growing season that spanned from July to December 2020. From 20 cotton producer administration divisions, 10 divisions viz. Agam Wuha, Das, Genda Wuha, Gubay, Kokit, Kumer-Aftit, Meka, Mender 7, Metema Yohannes and Shenfa were purposively selected since they were known to have cotton flea beetle problem. Based on the proportion of cotton growers in the selected ten divisions, 20 farmers were randomly taken and interviewed in each sample divisions. The purpose of the study and objectives of the survey was explained to participants beforehand. Structured questionnaire consisting of closed- and open-ended questions were prepared, pre-tested, revised and administered.

Farmers' knowledge of cotton flea beetle was investigated through simple dichotomy statements (i.e. Yes/No), while their perceptions and practices were measured using frequency determination statements to indicate the strength of responses to the questions. To ease communication between the researcher and the respondents, the questionnaires were translated from English to Amharic, which is the common language of the district. Each interview on average took about 30 minutes.

2.3. Data collection

Through questionnaire and field observation, data were collected on constraints to cotton production; cotton insect pests; perception of farmers about cotton flea beetle; common/local names of host plants of cotton flea beetle; soil type and land-use system that favor cotton flea beetle incidence; initial time of cotton flea beetle infestation; length of infestation; preferred part of the hosts for the flea beetle; economical important stage of cotton flea beetle; the symptoms of damage by the cotton flea beetle damaged; when cotton flea beetle feeds on alternative hosts; survival strategies of cotton flea beetle during off-season; management measures to cotton flea beetle and other pests; and other similar or related aspects.

2.4. Data analysis

Data were analyzed through descriptive statistics (frequencies, percentages, and means) to generate summaries and tables. The chi-square ($\chi 2$) test was performed to compare some qualitative characteristics or opinions based on the percentages of responses for various questions by using SPSS computer software version 16.

3. RESULTS AND DISCUSSION

3.1. Background of cotton growers

In the case of sex distribution, the proportion of males (81%) cotton producers was highly significantly ($\chi 2 = 76.88$; df = 3; N= 200; $P \leq 0.01$) greater than the proportion of females (19%) cotton producers (Table 1). In western Kenya, and indeed Sub-Saharan Africa (SSA), cotton is a cash crop that is more often treated as a man's crop. Thus, it is likely that men spend more time tending the crop than women and, therefore, gain more knowledge on pest and other constraints affecting the crop [26]. The age varied highly and significantly ($\chi 2 = 31.84$; df = 3; N= 200; $P \leq 0.01$) among cotton producers. Farmers with ages ranging from 32-40, 41-50 and 51-60 were 84 (42%), 44 (22%) and 34 (17%), respectively. Nineteen percent (19%) of the respondents were over 60 years of age (Table 1).

In educational background of the framers, the Chi-square test ($\chi 2 = 236.12$; df = 3; N= 200) revealed a statistically and highly significant ($P \leq 0.01$) difference in the level of education among farmers. It was found that about a quarter of the respondents had no formal education. A total of 138 (69%) of them had primary level education, while 3.5% reported that they have attended secondary level education. Only 1.5% of the cotton growers had attended college/university (Table 1). Improved crop production requires high level of expertise from farmers to implement effectively the recommended practices [27]. Madisa *et al*. [17] believed that educated farmers are generally more open to innovative ideas and new technologies that promote positive change.

Data on the cotton production experience of the framers indicated that 68 (34%) farmers had been in the cotton production business for 5-10 years, while 55 (27.5%) grown cotton for 16-20 years. Farmers producing cotton for 11-15 years were 51 (25.5%). Only 26 (13%) of farmers had been in production for over 20 years (Table 1). The Chi-square test ($\chi 2 = 18.52$; df = 3; N= 200) revealed a highly significant ($P \leq 0.01$) difference in the cotton production experience of the framers. Generally, most of the farmers had between 5–10 years of experience in cotton farming. Clearly, farmers in Metema had the longest history of cotton cultivation as indicated by their relatively higher response percentage in the 11-15 and 16–20 years' experience-categories. The cotton growers of 32 to 40 years age 84 (42%) dominated the study area. In decision making process on agriculture, age and farming experience of the farmer plays major role as well as develop positive attitude towards the adoption behavior that helps in decision-making and technological diffusion with appropriate thinking [28].

Cotton growers were also asked whether they obtained training or not on cotton insect pests and management. The Chi-square test ($\chi 2 = 14.58$; df = 1; N = 200) revealed that significantly ($P \leq 0.01$) higher number of farmers had not taken any training related to cotton pests. A total of 73 (36.5%) of them said they obtained formal training, while 127 (63.5%) respondent farmers told that they had not obtained any formal training on cotton insect pests and management (Table 1). Also, according to the reports indicated by

respondents on responsible organization for the training, 61.5, 42.5, 19 and 8.5% of the farmers, who were interviewed, obtained training on cotton pests from agricultural offices, research centers, NGO and others, such as cotton traders and relatives, respectively.

With respect to landholding of the households, an average size of land owned per household was found to be 6.46 hectares, which was by far greater than the regional average. Land allocation for different crops grown significantly varied among households and on the average was 2.80, 1.70 and 1.49 ha were allocated for sesame, cotton and sorghum, respectively, and constituted 95% of the production in the district.

3.2. Cotton production constraints

Farmers mentioned technical, institutional and socio-economic production constraints. When the farmers were asked to rank the most important factor(s) that mostly affect cotton production from the total 200 respondents, about 139 (69.5%), 127 (63.5%), 94 (47%), 87 (43.5%), 82 (41%) and 78 (39%), indicated that pest damage, limited access to improved cotton seed, market constraints (cotton price fluctuation), unavailability of appropriate pesticides, reduction in soil fertility and lack of information on improved practices, respectively, were listed as the major problems. This current finding is considerably similar to what was reported by IPMS [22] on Metema, which included use of low yielder local variety, lack of knowhow on improved practices, pest damage particularly caused by flea beetle and shortage of appropriate chemicals, in the list of factors that contributed for low productivity of cotton in the study area. It was also reported that the problems of insects were also exacerbated due to shortage of insecticide, particularly during the peak times of infestation [13].

3.3. Farmers' perceptions of cotton productivity and cotton pest as a threat to cotton yield

3.3.1. Farmers' perceptions of cotton productivity

With respect to the trends regarding the cotton yield and productivity of the area, in the years of 2014 up to 2019, almost all the farmers were involved in cotton cultivation; however, the productivity was not satisfactory. About 22% of the 200 respondent believed that there was increase in cotton productivity, while 39.5% indicated that their cotton production was declining. The rest 12.5% said no change in productivity, while 26% had no idea about it (Table 2). The Chi-square test ($\chi 2 = 30.12$; df = 3; N = 200) reveals a statistically highly ($P \leq 0.01$) significant difference in the level of farmers perception of the trends regarding the cotton productivity of the area. The standardized residuals (R for increase = -6, R for decrease = 29, R for no change = -25, R for No idea = 2) indicated that the majority 79 (39.5%) of the respondents who said that there was a decrease in productivity of cotton (Table 2). Farmers who reported an increase in production mentioned the following as reasons for the increase: use of agricultural inputs (improved seed, pesticides and fertilizer), good handling of their farmlands (before sowing they used non-selected herbicides) and increasing cotton land coverage, which was the result of some market opportunities and expansion of textile industry in Metema in particular and in the country at large. On the other hand, the majority of the respondents who said that there was a decrease in productivity mentioned different limiting factors, such as an increase in pest prevalence, soil fertility problems, unavailability of agricultural inputs (improved seeds, pesticides) and fluctuation of cotton market prices.

Table 1: Demographic information, education levels and cotton farming experience of the farmers

Factors (N=200)	Frequency	%	Chi-square ($\chi 2$)
Sex:			76.88*
Female	38	19.0	
Male	162	81.0	
Age (years):			31.84*
32–40	84	42.0	
41–50	44	22.0	
51–60	34	17.0	
>60	38	19.0	
Level of Education:			236.12*
No Education	52	26.0	
Primary	138	69.0	
Secondary	7	3.5	
College/University	3	1.5	
Years in cotton crop production:			18.52*
5-10	68	34.0	
11-15	51	25.5	
16-20	55	27.5	
>20	26	13.0	
Had you obtained training on cotton pests?			14.58*

Yes	73	36.5
No	127	63.5

*Means statistically and significantly different at P≤0.01.

3.3.2. Farmers' perceptions of cotton pest threat

Concerning farmers' perceptions of cotton pest problem, a total of 187 (93.5%) farmers responded in affirmative, while 13 (6.5%) of them said they had never considered the negative effects of pests. The Chi-square test ($\chi2 = 151.38$; df = 1; N = 200) revealed a statistically highly significant (P≤0.01) difference in the level of farmers' perceptions of the cotton pest problem. The standardized residuals (R for knowhow = 87; R for no consider = - 87) indicated that most 187 (93.5%) of the respondents perceived that pests as the main constraint to enhance production of cotton on their farms (Table 2). The results confirmed that farmers encountered problem with insect pests, weed and disease on their cotton farms, resulting in reduced quantity and quality of produce. From a total of 200 farmer respondents, 167 (83.5%) reported that insect pests problem was ranked high among the other biotic constraints. Significant 112 (56%) number of farmers indicated that weeds were second important production constraints. Only 33 (16.5%) of the respondents identified disease as the major constraints to cotton production in the study area. These results correspond with those of other studies that have identified insect pests of cotton as key constraints in different parts of the world, including Cameroon [29], China [30] and Pakistan [31]. Additionally, insect pests are considered as one of the most important biotic constraints to cotton production in all areas where cotton is grown [32], with their management easily accounting for at least 30% of the total cost of cotton production.

When respondents were asked to list and rank cotton insect pests according to their importance, among the 200 farmers, 188 respondents provided usable data. They described insect pests mostly as related to a particular symptom or by the plant part under attack. The association of insect pest names by farmers with the crop or the damage caused has also been reported for insect pests of yam and cotton in Benin [33, 34]. The majority of farmers identified insects by generic or descriptive names in the local languages, for example in most surveyed areas, *Workit* (based on golden color of their elytra) was used to refer for cotton flea beetle and *Gui-Til* or *Argif* (related with damaged part of cotton plant and dropping of bolls) for Africa bollworm. The description of local names of insect pests is expected to help entomologists, extension workers, and others who work with rural communities to better understand pest occurrence and appreciate local knowledge [35]. For instance, farmers had difficulties to distinguish different sucking insects and only were able to describe their damage (wilting, drying, leaf damage and others) reported by Velay *et al.* [36]. Moreover, smallholder farmers have been reported to have difficulties in pest recognition and understanding pest ecology [37]. The result of this study revealed that cotton flea beetle and Africa bollworm dominated over the other pests as reported by 89.9 and 82.4%, respectively of the respondents. Aphid came third in importance and was mentioned by 58.5% of farmers, while termite was considered the least important insect pest mentioned by 5.8% of the respondents. Bosena *et al*. [10] reported that low productivity of cotton in Metema is attributed to attack by flea beetle and water-logging problem. This present study also confirmed that cotton flea beetle was also recognized by farmers as key problem in the production of cotton in Metema area.

The 180 respondents indicated that they received information on cotton pests from various sources, including their own experiences (22.2%), fellow farmers (62.7%), cotton traders (20.5%), extension worker (61.6%), researchers (30%), radio/television (18.8%) and others, such as friends and relatives (11.6%).

3.3.3. Farmers' perceptions of cotton flea beetle threat

With respect to the degree of damage caused by the cotton flea beetle, 64.97% of the respondents believed that the damage was high; 6.09% rated the damage low, while the rest (28.93%) labeled it a medium threat to cotton production (Table 2). The Chi-square test ($\chi2 = 104.17$; df = 2; N = 197) revealed a statistically highly significant (P≤0.01) difference in the level of farmers perception of the threat of the flea beetle. The standardized residuals (R for high = 53.7; R for medium = - 8.7; R for low = -53.7) indicated that most (64.97%) of the respondents perceived that the threat caused by the flea beetle was high (Table 2). Yield losses due to cotton flea beetle, majority (46.8%) of the farmers perceived losses of about 50%; about 25% of the respondents said they lost about 25% of their crop; 23.93% of the respondents mentioned about 75% loss of the crop, while 4.5% of the respondents said they experienced no losses due to cotton flea beetle (Table 2). The Chi-square test ($\chi2 = 73.83$; df = 3; N = 188) revealed a statistically highly significant (P≤0.01) difference in the level of farmers perception of yield loss caused by cotton flea beetle. The standardized residuals (R for 25% = -3; R for 50 = 44; R for 75 = -2, R for no loss = -39) indicated that most (40.8%) of the respondents perceived that the yield loss caused by the flea beetle reached up to 50% during high infestation periods (Table 2). Odebiyi [38] reported that *Podagrica uniformis* and *P. sjostedti* (Coleoptera: Chrysomelidae) major species responsible for heavy defoliation of okra in West Africa. The adult flea beetles eat the leaves and make numerous holes resulting in yellowing, drying and falling of the leaves [39, 40]. Thus, the results of this present study also are similar with findings of other studies [41, 42] have demonstrated that *Podagrica* spp. is the most important pest of okra in Ghana. The pest's feeding habits, which cause perforations on the leaves, reduce the photosynthetic surface area of the leaves, leading to a great reduction of yield in okra [43]. Likewise, *Podagrica* species have been also reported to have caused economic damage on okra [44].

Table 2: Farmers' perceptions of cotton productivity and cotton pest as a threat to cotton yield

Factors	Frequency	%	Chi-square ($\chi 2$)
Farmers' perceptions of cotton productivity (N=200):			
Increase	44	22	30.12*
Decrease	79	39.5	
No change	25	12.5	
No idea	52	26	
Farmers' awareness of cotton pest problem (N=200):			
Knowhow	187	93.5	151.38*
Not consider	13	6.5	
Farmers' perceptions of flea beetle threat (N=197):			
High	128	64.97	104.17*
Medium	57	28.93	
Low	12	6.09	
Farmers' perceptions of yield loss due to flea beetle (N=188):			
75%	45	23.93	73.83*
50%	88	46.8	
25%	47	25	
No loss	8	4.25	

*Means statistically different at P≤ 0.01

3.4. Farmers' perceptions on cotton insect pests control methods

Farmers of Metema used pesticides for minimizing the damage caused by cotton insect pests. Among the 200 farmer respondents, 143 (71.5%) of the farmers reported that they protected cotton crop against cotton insect pests attack. However, 57 (28.5%) of the farmers indicated that they had not taken any measure to manage cotton insect pests in their farms. Although pests were reported as major constraints of cotton production, the majority of the farmers did not effectively manage them. Where practical, the most common pest management method was the use of synthetic chemical insecticides, mentioned by the majority (79%) of the farmers applied. The proportion of farmers who said they practiced weeding, farm sanitation, burning of cotton stumps and adjust sowing time as means of cotton insect pests control were 53.4, 52.4, 42.6 and 41.2%, respectively. Similar findings have been reported among cotton farmers in Kenya [26]. Even if the use of chemical pesticides tactic is the least chosen, due to its side effects, it has remained the primary choice of the farmers to manage cotton pests. Comparable results have been reported among cotton farmers in Kenya [26] and tomato and cabbage farmers in Zambia [45].

Reasons mentioned by some of the farmers for not protecting insect pests on cotton included lack of knowledge on pest control methods (68.4%), shortage of proper insecticides (54.3%) and high price of insecticides (50.8%). The higher percentage of farmers indicating lack of knowledge on control methods is a major concern that requires serious attention. Lack of knowledge on pest management measures among okra farmers have been reported in southern Sierra Leone [46]. Farmers who actively manage pests rely primarily on chemical insecticides, but can be constrained by the cost and availability of insecticides [47]. Moreover, this study investigated a knowledge gap in chemical pesticide use against cotton pests. Most farmers in developing countries generally lack knowledge in handling and application of chemical insecticides [48] which might cause health and environmental effects and pollution [49]. This implies the need to provide training for farmers on the safe application of insecticides.

3.5. Farmers' perceptions and knowledge on cotton flea beetle descriptions, bio-ecology and management

3.5.1. Farmers' perceptions of cotton flea beetle identity and economic importance

Among the 200 respondents, 197 (98.5%) know cotton flea beetle effect on cotton. There are specific local names given to the cotton flea beetle. The most common name identified was *Workit* (n=187), followed by *Tenziza* (n=151). The majority (n=179) easily identified the cotton flea beetle by its morphology (mainly the golden elytra), behavior (jumping) and the feeding damage symptoms [(shot-holed, wilted (dried) and defoliated leaves)] (Table 3). As indicated (Table 3); 97.2, 54.7 and 16% of the farmers reported that leaf, flower and root, respectively, were the plant parts attacked by cotton flea beetle.

Most (94.6%) respondents reported that cotton flea beetle mostly occurred at early growth stages of cotton, and existed in cotton fields at early cropping season. Moreover, most (n=175) of the interviewed farmers reported significant reduction in plant stands forcing re-sowing (n=160). Majority (98.3%) of the respondents indicated that adult stage that feeds on cotton plants, while 13.5% said the larval stage feeds on cotton plants (Table 3). Most (94.7%) of the interviewees said that cotton flea beetle is widely distributed

in their areas. The majority (58.3%) of the respondents (n=115) indicated that the cotton flea beetle problem was very serious, while 63 (31.9%) farmers said that the cotton flea beetle problem was serious. The proportion of farmers who said the cotton flea beetle problem was not serious was 6 (3%), while 13 (6.5%) had no opinion about the nature of the cotton flea beetle situation in their localities (Table 3).

3.5.2. Farmers' perceptions on occurrences and conditions affecting prevalence of cotton flea beetle

In many situations, an individual farmer confirmed two or more identified factors or conditions in related with cotton flea beetle bio-ecology. About 45.1% (n=155) farmers believed that the pest existed in their fields, while 54.8% (n=155) of the farmers did not observe the pest in their fields before cotton crop is established (Table 4). About 84.2% (n=70) of the respondents believed that the pest was observed emerging from the soil after enough rainfall was received and alternative host plants emerged in the fields. About 42.8% (n=70) of the farmers replied that they observed the pest with the onset of the first rain and the emergence of alternative host plants. Only 22.8% (n=70) of the respondents did not know about the factors favoring the pest in their fields. About 95.2% (n=167) supposed that the population of cotton flea beetle was favored by low rainfall, while 89.8% (n=167) said minimum rainfall coupled with high temperature. Only 18.5% (n=167) respondent said they had no idea about weather elements in relation to cotton flea beetle incidence (Table 4). On the other hand, out of 170 farmers, 94.7% reported that the population of cotton flea beetle was disfavored by continuous and high rainfall, whereas 87.6% of them replied that cool damp situation negatively affected the pest population, while 15.8% had no view about this issue (Table 4). About 97.8% (n=185) supposed that the population of cotton flea beetle would be high at seedling stage of cotton, while 72.9% (n=185) indicated that when cotton plants are moisture stressed, the flea beetle population reaches peaks. Also 67.5% (n=185) of the farmers stated that the flea beetle population peaks in early sown cotton crops. About 98.1% (n=185) of the respondents reported that cotton flea beetle population decreased after seedling stage passed, whereas 74% (n=185) of them replied that when late sown, cotton escapes cotton flea beetle attack (Table 4).

Table 3: Farmers' perceptions and knowledge on cotton flea beetle identity and economic importance

Factor	Frequency	%
Do you know cotton flea beetle? (N = 200):		
Yes	197	98.5
No	3	1.5
Local name as given by farmers (N=197):		
Workit	187	94.9
Tenziza	151	76.6
Morphology and particular behavior as indicated (N=179):		
Golden or shining color of elytra	155	86.6
Habit of jumping when disturbed	147	82.1
Plant part under attack as identified (N=181):		
Leaf	176	97.2
Flowers	99	54.7
Root	29	16
Particular feeding symptom observed on plants as indicated (N=190):		
Shot-holes on leaf	173	91.1
Wilting and drying of leaf	150	78.9
Defoliate	127	66.8
Time of occurrence in field as indicated (N=188):		
Early season insect	168	89.3
Occur mostly when crops at early stages	178	94.6
Final effect of incidence (N=183):		
Reduction of plant stands	175	95.6
Re-sowing common	160	87.4
Damaging stage of cotton flea beetle (N=185):		
Larval stage	25	13.5
Adult stage	182	98.3
Is cotton flea beetle widely distributed in your areas? (N=190):		
Yes	180	94.7
No	11	5.7
Self-perceived nature of cotton flea beetle problem (N = 197):		
Very serious	115	58.3
Serious	63	31.9

Not serious	6	3
No idea	13	6.5

About 45.6% (n=160) of the interviewees said that cotton flea beetle showed preference for soil type, while 54.3% (n=160) of the respondents said they had not observed soil type preference. The 45.6% (n=160) also indicated the preference level of cotton flea beetle among different soil types. Most (90.4%) of them said that heavy black clay soil is preferred to friable black clay soil and red soil (Table 4).

About 86.3% (n=161) farmers supposed that cotton flea beetle leaves cotton fields when there are no fresh succulent leaves, while 75.7% (n=161) pointed out that it is after the alternative host dried. Also, 30.4% (n=161) farmers reported no idea about this aspect. The season end movement behaviors of cotton flea beetle was reported to be migrating to wetlands 80.9% (n=126), while 77.7% (n=126) of the respondents said that it moves into cracked soil in the cotton farms. Also, 43.6% (n=126) of the farmers reported no idea about this issue (Table 4).

About 45.8% (n=120) responded that cotton flea beetle is present even after cotton plants have dried up, while 54.1% (n=120) said they did not observe cotton flea beetle in the field after cotton was harvested. The farmers were then asked to mention areas and plants preferred after cotton plants fully were dried. Majority (89%) (n= 55) of the respondents mentioned that the cotton flea beetle commonly moves to irrigated areas, while 76.3% (n= 55) mentioned succulent perennial plants as alternative hosts. Meanwhile, 36.3% (n= 55) of them said they had no idea about this issue (Table 4).

Table 4: Farmers' perceptions on occurrences and conditions affecting prevalence of cotton flea beetle

Factor	Frequency	%
Does cotton flea beetle exist before cotton established in field? (N=155):		
Yes	70	45.1
No	85	54.8
Conditions as identified by farmers (N=70):		
First rain shower with emerged alternative host	30	42.8
After enough rainfall with emerged alternative host	59	84.2
No opinion	16	22.8
Weather elements favor cotton flea beetle density and attack (N=167):		
High temperature with low amount rainfall	150	89.8
Low amount of rainfall	159	95.2
No opinion	31	18.5
Weather elements disfavor cotton flea beetle density and attack (N=170):		
Low temperature and cool situation	149	87.6
High amount of rainfall exist consistently	161	94.7
No opinion	27	15.8
Conditions increase number and problem of cotton flea beetle (N=185):		
When cotton crops at seedling stage	181	97.8
When early sown cotton crops	125	67.5
When plants under moisture stress	135	72.9
Conditions decrease number and problem of cotton flea beetle (N=185):		
When crop escape seedling stage	183	98.1
When planting time delay	137	74
Does cotton flea beetle prefer soil type for its survival? (N=160):		
Yes	73	45.6
No	87	54.3
Type of soil prefer by cotton flea beetle as identified by farmers (N=73):		
Heavy cracked black clay soil	66	90.4
Friable black clay soil	47	64.3
Red soil	23	31.5
Situations initiate cotton flea beetle to leave cotton field (N=161):		
No enough fresh succulent leaves/food	139	86.3
Alternative host plants starting to dry	122	75.7
No idea	49	30.4

Behavior of cotton flea beetle at the end of cotton cropping season (N=126):		
Move to cracked soil	98	77.7
Move to wet lands	102	80.9
No idea	55	43.6
Is cotton flea beetle exists in the field after cotton harvest? (N=120):		
Yes	55	45.8
No	65	54.1
Areas and plants prefer by cotton flea beetle as indicated by farmers (N=55):		
Irrigation areas	49	89
Succulent perennial alternative host plants	42	76.3
No idea	20	36.3

3.5.3. Farmers' perceptions on infestation levels of cotton flea beetle at each growth stage of cotton plant

About 48.8% (n=178) of the farmers responded that cotton flea beetle is present at all growth stages of cotton plants, while 51.1% (n=178) of the respondents said that they did not observe cotton flea beetle in all growth stages of cotton plant. Those farmers who reported its presence at all growth stages of cotton plant stated that high infestation occurred at primordial leaf (cotyledon) and seedling stages, medium at late seedling and flowering stages and least at late flowering and a few during boll setting (Table 5).

Table 5: Farmers' perceptions of infestation levels of cotton flea beetle at each growth stage of cotton plant

Factor	Frequency	%
Does cotton flea beetle is present at all growth stages of cotton plants? (N=178):		
Yes	87	48.8
No	91	51.1
Cotton flea beetle infestation levels at all growth stages of cotton plant (N =87):		
High infestation at cotyledon stage	84	96.5
High infestation at seedling stage	79	90.8
Medium at late seedling stage	49	56.3
Medium at flowering stages	60	68.9
Least at late flowering stage	53	60.9
Few during boll setting stage	87	100

3.5.4. Farmers' perceptions on alternative hosts and natural enemies of cotton flea beetle

Farmers' perceptions and knowledge have been summarized on alternative hosts of cotton flea beetle and its natural enemies (Table 6). About 97.4% (n=200) farmers indicated the presence of alternative plants as hosts of cotton flea beetle in and around cotton fields. The local names of some of the plant species are *Gimel waika* (*Hibiscus vitifolius*), *Yebereha Bamia* (*H. cannabinus*), *Kudra* (*Corchorus olitorius*) and *Amirra* (*C. trilocularis*). Most (97.2%) of the interviewees also said that *Hibiscus vitifolius* is the most preferred alternative host plant species, closely followed by *H. cannabinus* (94.4%), and also *Corchorus olitorius* (84.4%) and *C. trilocularis* (81.6%). The different host plants reported by the farmers have been already previously documented as alternative hosts for cotton flea beetle by researchers [50, 51].

A total of 53 (24.5%) of the respondents observed natural enemies to the cotton flea beetle, including crickets, praying mantis, big-eyed ants and birds (Table 6). Knowledge about natural enemies was acquired through training and personal efforts. Most of the farmers commonly regard natural enemies as pests and applied insecticides on them. Knowledge about natural enemies is usually low among farmers, as was observed also in Benin [33] and China [30]. Research findings in western Kenya also reported a majority of the cotton farmers were not aware of any arthropod predators and parasitic wasps [26]. Natural enemies of the beetle are least 13 (24.5%) recognized by the farmers in this study.

The cotton flea beetle was seen feeding on the young leaves of alternative host plants during field visiting with farmers to validate their information provided during interview about host plants of cotton flea beetle (Fig. 1). This entails the importance of indigenous technical knowledge of farmers for procuring information about ecological aspects of crop pests as well as to design sustainable management options against them.

3.5.5. Farmers' perceptions on cotton flea beetle management practices

Among the 200 farmer respondents, 151 (75.5%) of the farmers protected cotton against cotton flea beetle attack, while 49 (24.5%) indicated adopting no control against this insect pest. The result from the study (Fig. 2) indicates that the majority (74.8%)

of farmers sprayed synthetic organic insecticides for the management of cotton flea beetle. The farmers practiced weeding, late sowing, farm sanitation, burning of cotton stumps, high seed rate and used insecticide dressed seeds to manage cotton flea beetle (Fig. 2). The farmers used a combination of cultural and chemical methods of pest control, which they developed without support from the extension system. In this regard, many farmers claimed that they have defined their own control strategies in the absence of good supervision by extension or research services [52]. But they were not aware of the significance of host plant resistance, botanical and biological control agents in managing the beetle. Similar findings have been reported among fruit vegetables farmers in Nigeria [53]. Application of chemical insecticides is the first choice of the farmers in controlling cotton flea beetle in Ethiopia. In Nigeria, control of *Podagrica* spp. is based largely on the use of synthetic insecticides [54]. According to the World Bank report, the main reason for unnecessary pesticide use is lack of knowledge and information among farmers about other pest management practices and the true costs and benefits of pesticide use [55].

Table 6: Farmers' perceptions on alternative hosts and natural enemies of cotton flea beetle

Factors	Frequency	%
Is there any plants attack by cotton flea beetle beside cotton? (N=195):		
Yes	190	97.4
No	5	2.5
Plant species identified as alternative host (N =190):		
Hibiscus vitifolius	178	94.2
Hibiscus cannabinus	172	90.5
Corchorus olitorius	168	88.4
Corchorus trilocularis	153	80.5
Plant species most time preferred by cotton flea beetle (N=180):		
Hibiscus vitifolius	175	97.2
Hibiscus cannabinus	170	94.4
Corchorus olitorius	152	84.4
Corchorus trilocularis	147	81.6
For what purpose cotton flea beetle using alternative hosts? (N=183):		
Food	159	86.8
Reproduction	120	65.5
Have you seen natural enemies attacking cotton flea beetle? (N=53):		
Yes	13	24.5
No	40	75.4
Type of natural enemies as mentioned (N=13):		
Praying mantis	5	38.4
Field crickets	3	23
Big eyed ant	7	53.8
Bird	4	30.7

Fig. 1. *Cotton flea beetle feeding on young leaves of alternative host plants.*

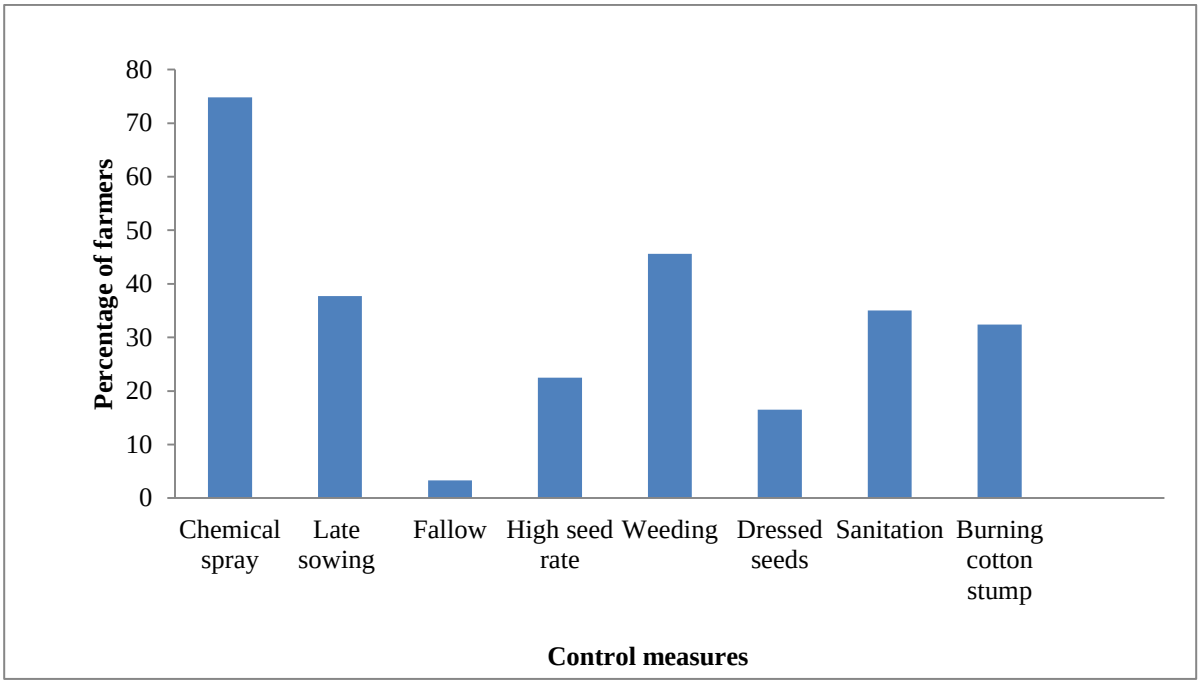

Fig. 2. *Practices adopted by farmers in the management of cotton flea beetle.*

4. CONCLUSION

The interviewed farmers have a good knowledge of cotton ecosystem, agronomic practices, and the constraints that limit cotton production, which can be grouped into technical, institutional and socio-economic production constraints. The most important factor(s) limiting cotton production included pest damage, limited access to improved cotton seed, market constraints, shortage of appropriate pesticides, soil fertility problem (depletion) and lack of information on improved practices. Based on the findings of the study, it can concluded that cotton farmers in Metema, recognized pest problems as major constraint to cotton production and ranked insect pests as the most important. Farmers identified various economically important insect pests of which cotton flea beetle was reported as the major insect pest followed by bollworm and aphids. The interviewed farmers easily identified cotton flea beetle morphologically and by its damage and given local names based on its morphological features, the types of damage it causes, and time of occurrence in the fields. However, the survival strategies of cotton flea beetle is least known. But the environmental factors that may influence the behavior of cotton flea beetle are well understood including alternative hosts, temperature and rainfall. Natural enemies of the beetle are least recognized by the farmers. The farmers used a combination of chemical and cultural method of pest

control, which they developed without support from the extension system. The cotton flea beetle management measures taken by farmers include: chemical insecticides, weeding, late sowing, burning of cotton stumps, high seed rate, use of seeds dressed with chemical, farm sanitation and adopting fallow. But they were not aware of the significance of host plant resistance, botanical and biological control agents in managing the beetle. Therefore, this gap of knowledge on cotton flea beetle calls for training of farmers in related with insect pest identification, bio-ecology, and management. The cotton flea beetle is a threat to cotton supply at the country level; hence, it requires a sustainable and effective integrated pest management strategy. So, this study also suggests the need to develop management strategies for this insect pest based on farmers' needs and priorities as well as consider farmers' knowledge of the pest, socioeconomic status, and current pest management practices.

5. ACKNOWLEDGEMENTS

Authors express their profound indebtedness to University of Gondar, particularly College of Agriculture and Environmental Sciences for providing all the needed materials and logistic support during the survey study. Authors also recognize the staffs of the District Agricultural Office for hospitalities and assistance by providing relevant information during the study period.

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