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Research Article

Farmers' Perceptions of Mexican Bean Weevil, *Zabrotes subfasciatus* (Boheman), and Pest Management Practices in Southern Ethiopia

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The common bean, *Phaseolus vulgaris* L., is one of the most important sources of protein in Ethiopia and other developing countries. However, the Mexican bean weevil, *Zabrotes subfasciatus* (Boheman), is a major constraint of stored common bean that causes qualitative and quantitative losses. This study was conducted to assess farmers' knowledge and perceptions of Mexican bean weevil, to examine farmers' pest management practices, and to identify challenges of pest management practices to develop integrated pest management (IPM) strategies. A survey of 148 smallholder common bean farmers was conducted at Mareka and Loma districts in southern Ethiopia. The majority (75%) of the farmers stored common bean in polypropylene bags while less than 10% of the farmers stored beans in '*Diya*' (a traditional storage structure). Most (60.8%) farmers stored their beans in seed (threshed) form, and the majority (63.5%) of them stored their beans for 3-5 months. The majority of the farmers had knowledge about the Mexican bean weevil; they could identify damaged seeds based on the 'holes' on the seed (72.3%) and circular 'windows' on the seed (20.0%). About 45% of the farmers mentioned the high amount of loss at the time of storage. In addition, most farmers (53.4%) estimated 26-50% loss in storage. Most farmers reported the use of pesticidal plants for control of Mexican bean weevil, while only a few farmers reported they had applied insecticide in their store. Education level and family size had a positive and statistically significant impact on the use of pesticidal plants for the control of Mexican bean weevil. Furthermore, education level also influences the use of chemical insecticide. Results highlighted the need to use improved storage technology and to train farmers in postharvest handling practices as a component to develop IPM approach in order to minimize losses occurring along the value chains of the common bean.

1. Introduction

Common bean, *Phaseolus vulgaris* L., is a very important legume crop worldwide due to its nutritional value as a good source of protein, vitamins, minerals, and fiber for millions of people in developing countries [1, 2]. In addition, common bean serves as a source of income for smallholder farmers and of foreign currency earnings in developing countries [3–5]. In Ethiopia, common bean is ranked as the second major pulse crop in terms of production and volume with a share of 19% and 21% next to faba bean. Production increases more than twofold from 138 to 513 thousand tones between 2005 and 2014 [6]. The two major common bean producing regions in the country are Oromia Region and Southern Nations Nationalities and People's Region (SNNPR), which produce 70 and 60 thousand tons annually, respectively, accounting for up to 85% of the total production of the country [6].

Consumption of common bean is common in the major producing areas of Ethiopia; however, for the past many years, this type of grain was traditionally considered as a "poor man's food" by the medium to high income urban and rural consumers, and, thus, urban demand has been low. For instance, pulse retailers in many major town centers do not want to keep common bean, implying that the customers are less interested in these products [4]. Nowadays with the increasing food price and increasing awareness of its nutritional value, the perception about consumption of common bean is changing rapidly in urban areas. As a result, the production and supply increased due to increasing demand in local, national, and international markets, thus enhancing smallholder farmers' income [4].

Bean bruchids (Coleoptera: Bruchidae) are one of the main constraints of common bean production that cause heavy losses in terms of both quality and quantity of stored beans. In addition, damaged beans have a poor germination rate and have low market value [5, 7]. Two species of bean bruchids, namely, the bean weevil, *Acanthoscelides obtectus* (Say), and the Mexican bean weevil, *Zabrotes subfasciatus* (Boheman) (Coleoptera: Bruchidae), were reported as the major pests of common bean in Ethiopia and other common bean growing regions of the world. The former species infests common beans in the field and storage, whilst the latter species infests only harvested beans in the storage [8]. Mallqui et al. [9] observed cooccurrence of the two species without negative interactions in bean storage facilities.

In eastern Africa, Karel and Autrique [10] reported an estimated grain loss between 30% and 73%. In Ethiopia, Bruchid caused up to 38% damage, with corresponding bean weight losses of about 3.2% [11]. Although Mexican bean weevil is causing a considerable amount of losses in stored common bean, there is little information available regarding farmers' perceptions, knowledge, and current management practices in the region. Nevertheless, understanding farmers' knowledge and their practices is essential in developing integrated pest management (IPM) strategy that fits smallholder farmers setting [12, 13]. Therefore, the objective of this study is to assess farmers' knowledge and perceptions of Mexican bean weevil, to examine farmers' pest management practices, and to identify challenges of Mexican bean weevil control in order to develop participatory IPM for smallholder farmers in southern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area. The study was conducted in Dawuro zone, Mareka and Loma districts (Figure 1). Dawuro zone is found in SNNPR of Ethiopia, which is located about 500 km South West of Addis Ababa, the capital city of Ethiopia. Loma is one of the administrative districts in Dawuro zone of SNNPR. The total surface area was 116,320 ha. The agroecology of the district comprises 45.6% Lowland (altitude less than, 1500 m.a.s.l), 41.4% Midland (altitude, between 1500 and 2300 m.a.s.l), and 13% Highland (altitude greater than 2300 m.a.s.l). The annual mean temperature ranges between 15.1 and 29.5°C and the annual mean rainfall ranges between 900 and 1800 mm. The land use pattern followed is 50,701 ha cultivated; 36,172.17 ha covered by bush shrubs; 16, 202 ha under settlement; 120, 60 ha for grazing; 852.33 ha covered with forest; and the remaining 332.50 ha covered by others. The district comprises 34 rural and 5 urban *kebeles* (the lowest administrative region). From these 22 *Kebeles* have high common bean production potential.

Mareka is one of the administrative districts in Dawuro zone. The total area of the district is 478, 98 km square. It consists of Highland > 2500 m (36%), Midland 1500-2500 (51%), and Lowland < 1500 m (13%). Mareka is located at an altitude between 1200 and 2400 m.a.s.l. Mean annual rainfall is 1400–1800 mm and the mean temperature is 18–27.5°C [14]. From the total 34 rural and 3 urban *kebeles*, 19 of them have high common bean production potential.

2.2. Sampling Procedures. In order to select a representative sample, a three-stage sampling procedure was implemented to select farmer household respondents for the survey. In the first stage, two districts, namely, Loma and Mareka, were purposively selected based on the production status of common bean. In the second stage, six *kebeles*, namely, Zima Waruma, Danaba Bola, Dissa Kera, Gozo Shasho, Tarcha Zuria, and Aselli-Mendida, were selected purposively from each selected district based on common bean production and a problem of Mexican bean weevil. Finally, simple random sampling was employed and a total of 148 representative farmers were selected randomly from each of the selected *kebele* using Yamane [15] sample size determination formula as indicated in the formula given below:

$$\mathrm{n} = \frac{N}{1 + N\left(e^2\right)} \tag{1}$$

where N= total number of common bean produces, n = sample size, and e= the accepted sampling error; hence 8% in this study are with 92% confidence interval level and N=2651; hence

$$\mathrm{n} = \frac{2651}{1 + 2651\left(0.08^2\right)} = 148 \tag{2}$$

2.3. Survey Data Collection. The survey was conducted from December 2016 to February 2017. Individual interviews were conducted using semistructured questionnaires. The questionnaires had focused on collecting and identifying information on socioeconomic characteristics, common bean production status, farm experience, storage systems, storage pest problem, farmers' knowledge of storage pest, and pest management practices. To measure farmers' knowledge of Mexican bean weevil, farmers were asked whether they were able to identify the pest by local/common name, description of the pest, and the type of damage they caused on the bean seed. The questionnaires were first prepared in English and then translated into the Amharic language. Six enumerators (development agents), that is, one from each selected *kebeles*, were recruited and trained to collect the data from respondents. The questionnaire was pretested on six common bean producing farmers and three agricultural experts for clarity of the study.

2.4. Data Analysis. Survey data were summarized and descriptive statistics (means and percentages) were calculated using the Statistical Package for Social Sciences (SPSS). Comparative statistical tools, such as Chi-square and t-test, were conducted to assess differences regarding sociodemographic and farm characteristics, knowledge and perceptions

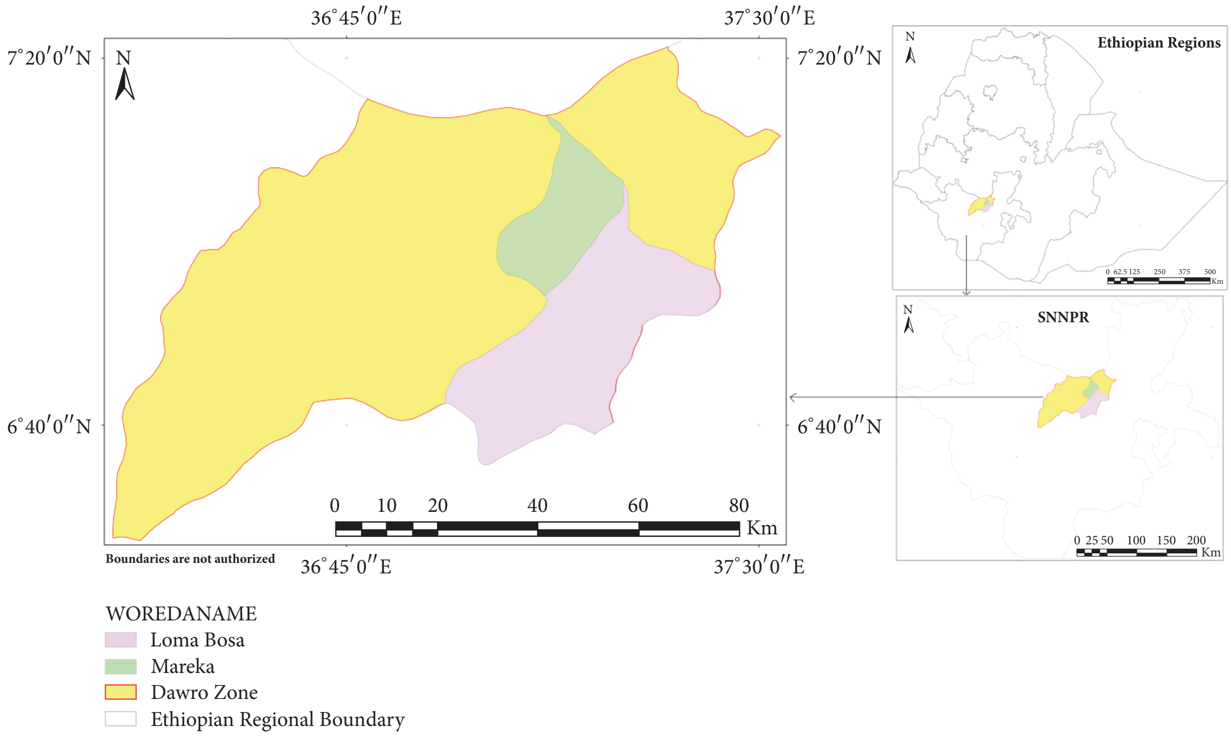


Figure 1: Map showing study districts in southern Ethiopia.

of Mexican bean weevil, and management practices. Binary logistic regression analysis was used to identify the key socioeconomic variables influencing farmers' control practices (pesticidal plants and chemical insecticides) of Mexican bean weevil, which was dichotomous. Binary variables were with a score of "1" for farmers who applied control measures against Mexican bean weevil in the store and a score "0" for farmers who did not apply control measures. The "Enter" method was followed to select the best predicting variables. In the "Enter" method, all the variables in the model are selected and a 5% significance level was adopted.

3. Results and Discussion

3.1. Socioeconomic Characteristics of the Farmers. The majority (87.5%) of the farmers in the study area were male. Farmers' age averaged 49.8 years with significant ($P < 0.05$) variations among study districts. The level of education of farmers did not show a significant difference between the districts. Over half of the farmers had attended primary education, whilst 21.6% of them had attended secondary school, with only 17.1% of farmers who did not receive formal education. On average, the family size of the farmers consists of about six individuals (Table 1).

The average household landholding was 3.1 ha of which 0.7 ha of the land was allocated for common bean. There was a significant ($P< 0.05$) difference in the farming experience of common bean among surveyed farmers in the two districts. It was noted that common bean production was introduced to the area about 15 years ago; however, on average, the farmers had only about seven years of common bean farming experience in the study area (Table 1). Majority of the farmers (87.2%) practiced mixed farming, that is, both crop production and animal husbandry, whereas only a small number of farmers (12.8%) engaged only in crop production. In the study areas, the main crops grown include cereals, pulses, and fruits. Most (59.2%) farmers grew common bean for home consumption, whereas 33.3% for both home consumption and selling, and only 7.4% produced common bean solely for selling (Table 1).

3.2. Farmer's Storage Practices. The present study showed that farmers stored their beans in different types of storage; however, farmers' storage practices did not vary significantly among the study districts (Table 2). Storing bean seed is one of the important postharvest operations where farmers store bean seeds for different reasons such as for home consumption, as a source of seed for next planting, and to speculate the selling price [5]. In this study, polypropylene bag was the major storage container for common bean (75%), followed by Jute or hessian sacks (15.5%) and '*Diya*' (6.8%), a traditional storage structure, which is constructed from bamboo split and the outer part plastered with cow dung (Figure 2(a)). Nevertheless, high common bean seed damage by Mexican bean weevil has been observed in those traditional storage structures (Figure 2(b)).

In Ethiopia and other African countries, the use of bag has been reported as the main storage container [16, 17], which might be due to availability in the local market and cost. In addition, in the present study, farmers perceived that bean seeds stored in polypropylene bag were less susceptible to

Table 1: Socioeconomic and farm characteristics of the respondents in Loma and Mareka districts in southern Ethiopia.

Characteristics	Districts		Mean N=148	χ^2	T-test
	Loma N=75	Mareka N=73			
Gender (%)					
Male	84.1	90.9	87.5	0.257^{ns}	
Female	15.9	9.1	12.5		
Level of education (%)				4.254^{ns}	
Illiterate	18.1	16.1	17.1		
Primary school	54.2	56	55.1		
Secondary school	21.4	21.8	21.6		
College diploma	6.4	4.2	5.3		
Degree and above	0.0	1.8	0.9		
Age of the farmer (years)	47.8	51.8	49.8		-2.357*
Number of family size	5.8	5.8	5.8		0.045^{ns}
Common bean farming experience (years)	6.4	7.0	6.7		-2.023*
Type of farming system				1.363^{ns}	
Mixed farming	89.2	85.1	87.2		
Crop production	10.8	14.9	12.8		
Total land (ha)	3.0	3.1	3.1		0.050^{ns}
Land allocated for common bean (ha)	0.5	0.8	0.7		1.186^{ns}
Purpose of production				0.561^{ns}	
For selling	6.4	8.4	7.4		
Consumption	59.8	58.5	59.2		
Both	33.8	32.7	33.3		

Note: statistically significant at $*P < 0.05$; ns = not significant.

Table 2: Storage types, forms of storage, and storage duration of common bean in Loma and Mareka districts in southern Ethiopia.

Variables	Districts		Mean N=148	χ^2
	Loma N=75	Mareka N=73		
Storage type (%)				
Polypropylene bags	80.0	70.0	75.0	2.321^{ns}
Jute/hessian sacks	16.5	14.5	15.5	
'*Diya*'/Traditional storage	7.6	6.0	6.8	
Forms of common bean storage (%)				
Pod (unthreshed)	14.5	16.5	15.5	2.321^{ns}
Seed (threshed)	55.6	66.0	60.8	
Both (threshed and unthreshed)	20.0	27.2	23.6	
Storage period (%)				
1 to 2 Months	34.2	32.0	33.1	
3 to 5 Months	67.0	60.0	63.5	5.630^{ns}
6 to 8 Months	4.4	2.4	3.4	

Note: ns = not significant.

storage insect pests. Farmers in the study area indicated that they reuse storage containers for common bean storage. This might serve as a source of bruchid infestation and increased the possibility of damage to the stored grain. Negasi and Abate [11] observed a different type of storage used to store common bean in central Ethiopia such as '*dibiginit,*' '*gotera,*' bag and clay pot. In addition, in recent studies, Bachewe et al. [17] and Befikadu [18] reported a different type of traditional storage structures used to store different types of grains in different areas of Ethiopia. As is common with

(a) (b)

Figure 2: '*Diya,*' a traditional storage structure in the study area (A) and common bean seeds damaged by Mexican bean weevil (B).

other developing countries [19], farmers' traditional storage structures are poorly constructed and do not protect the stored grain from pest infestation.

Recently improved storage technologies have been developed and are being promoted in Africa for the control of postharvest pests of cereals and grain legumes. This includes metal silo and storage bags such as PICS bag, SuperGrain, and ZeroFly bags [20]. Those improved storage facilities are hermetic or airtight storage, which deprives oxygen and enhances accumulation of carbon dioxide, thereby suppressing the development of insect pests and fungal pathogens in the storage [21]. Various research results showed the effectiveness of hermetic storage bags in controlling the common bean weevil in stored common bean, for example, PICS bag in Kenya [22] and different hermetic storages as a method of controlling the common bean weevil in Brazil [23]. Although there have been some efforts in using improved storage technologies including metal silo and PICS bag in Ethiopia, in the present study areas, farmers did not use improved storage technologies suggesting the need to introduce those improved storage technologies for the control of Mexican bean weevil.

Farmers in the study area stored their beans in different forms, with the majority (60.8%) of the farmers reporting they stored their beans in seed (threshed) form, whereas 23.6% of the farmers stored their beans in both threshed and unthreshed form. Only about 15.5% of the farmers stored their beans in pods (Table 2). As shown in Table 2, the majority (63.5%) of the farmers stored their beans for 3 to 5 months. Recent surveys in Rwanda showed that 63.8% of the farmers stored common bean for 6 to 12 months [24]. In general, smallholder farmers usually store beans for less than 6 months [5]. Mainly due to bean bruchid infestation farmers are unable to store beans for a long time and are forced to sell with available price in the local market.

Different varieties of common bean were grown in the study areas. The majority (70.3%) of the farmers grew red color common bean followed by white color (22.3%) and mottled type (7.4%) (Figure 3). The choice of red common bean by most farmers was due to its high local market value as compared to the other types of common beans, which corroborate earlier report of Asfaw et al. [25] who observed

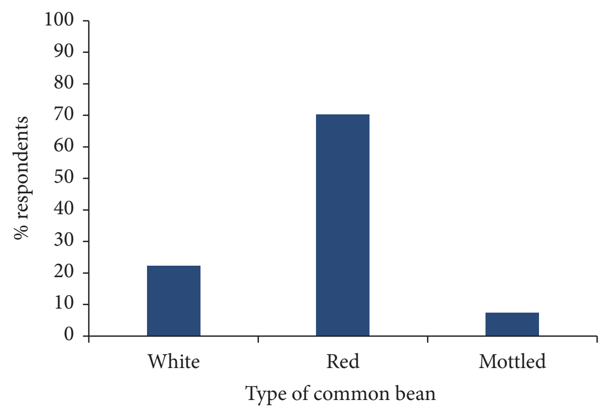


Figure 3: Types of common bean produced in Loma and Mareka districts in southern Ethiopia.

that small-red seeded beans were preferred by farmers in southern Ethiopia for consumption, marketability, and other desirable traits. Farmers also perceived that red common bean type is less susceptible to bruchid damage.

3.3. Postharvest Loss Estimation. Postharvest losses take place at a different stage of postharvest chains. Farmers reported postharvest losses of common bean from harvesting until the consumption stage. However, the extent of loss may vary from farmers to farmers depending on various factors such as farmers postharvest practices. In this study, the majority of the farmers mentioned that postharvest loss of common bean occurred at the time of storage (44.6%) followed by harvesting (18.2%), drying (16.8%), and threshing (10.7%) stage, while less than ten percent of the farmers reported loss during transportation (Figure 4(a)). Various studies reported that among losses which occur at different stages of postharvest chains, storage loss was very high mainly due to lack of adequate infrastructure that needs intervention to reduce storage losses [19, 26].

In the present study, farmers reported that the Mexican bean weevil was the major challenge during storage period and infestation was starting after two months of storage and was more severe between three to five months of storage

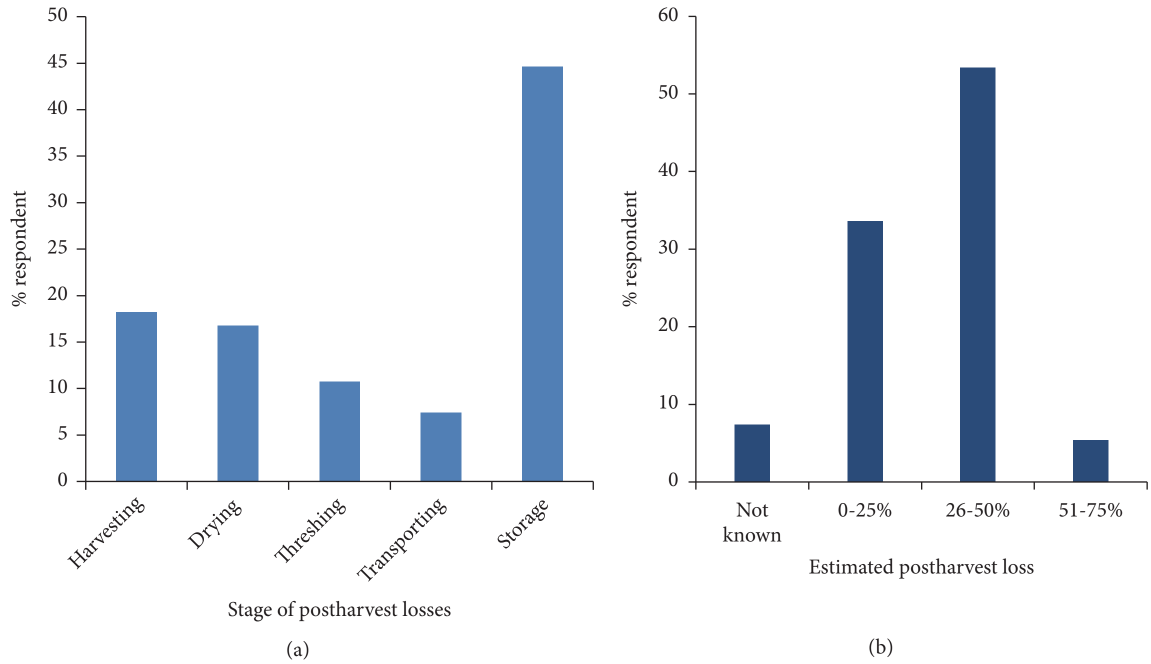


Figure 4: Loss occurring at different postharvest stages of common bean (a) and estimated percentage loss of common bean by Mexican bean weevil in Loma and Mareka districts in southern Ethiopia (b).

period. Over half of surveyed farmers estimated a loss of 26-50%, whereas about 5.4% of the farmers reported 51-75% of loss due to the Mexican bean weevil (Figure 4(b)). In earlier studies, up to 38% damage and bean weight loss of about 3.2% due to Bruchid were been reported in central parts of Ethiopia [11]. In a recent survey conducted in Rwanda, Umubyeyi and Rukazambuga [24] observed that 37.4% of surveyed farmers reported an estimated loss of 30% due to bean bruchids infestation. In another study in Rwanda and Burundi, bruchids caused about 30% of losses to stored beans [27]. In general, in eastern Africa grain losses between 30% and 73% have been reported [10]. Damage caused by Mexican bean weevil result in not only quantitative and qualitative losses but also price reduction of insect-damaged beans [28].

3.4. Farmers' Knowledge of the Mexican Bean Weevil. Most (93.2%) of the farmers had knowledge about storage pests. However, there was a difference in farmer's knowledge of storage pest and the Mexican bean weevil. For example, some of the farmers in the study area mentioned maize weevils as a pest of stored beans whereas other farmers mentioned bruchids as pests of both maize and common bean (Table 3). Even though most (85.9%) of the farmers had knowledge about the Mexican bean weevil, there was a considerable gap in identifying its symptoms. About 72% of them recognized the symptoms of this pest by observing the 'holes' on the seed followed by circular 'windows' on the seed (20%), which are the main evidence of damage. On the other hand, only less than one percent of the farmers reported early damage symptoms such as the presence of bruchids eggs on the surface of the bean, indicating that most of the farmers were aware of late damage symptoms of the Mexican bean weevil. Nevertheless, once the Mexican bean weevil caused a significant amount of damage it is too late to apply control measures. Hence, early detection and identification of symptoms of infestation are very important to apply pest control methods and to reduce the damage caused by bruchids [29]. This study also showed that the majority (73.6%) of the farmers perceived the Mexican bean weevil as a severe problem in their area, whereas a quarter of the farmers perceived this pest as a moderate problem (Table 3).

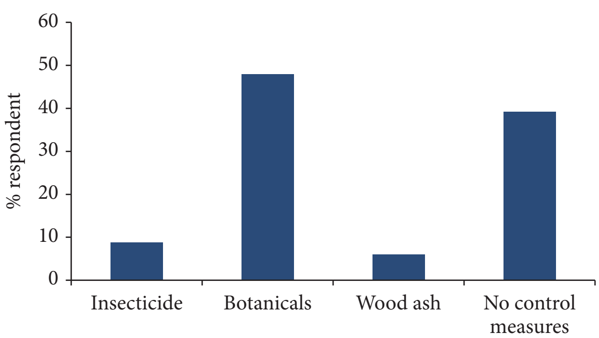
3.5. Mexican Bean Weevil Control Practices. Farmers reported that they applied different control methods of the Mexican bean weevil. Most (48%) of the farmers reported that they were using different traditional practices which includes pesticidal plants such as neem (*Azadirachta indica* A. Juss), eucalyptus (*Eucalyptus globulus* Labill) leaf, and hot pepper (*Capsicum annuum* L.). On average, 6 % of the farmers used wood ash for control of the Mexican bean weevil. On the other hand, less than ten percent of the farmers reported they had applied chemical insecticide against the Mexican bean weevil, which was less than the proportion of farmers in Rwanda (53.9%) who used insecticides to control this pest [24]. On the other hand, about 39% of the farmers reported that they did not apply any control measures against this pest (Figure 5(a)).

The present study demonstrated that most of the farmers in the study area used different pesticidal plants for the control of Mexican bean weevil. In Africa, smallholder farmers have used different forms of traditional practices which include various pesticidal plants and wood ashes

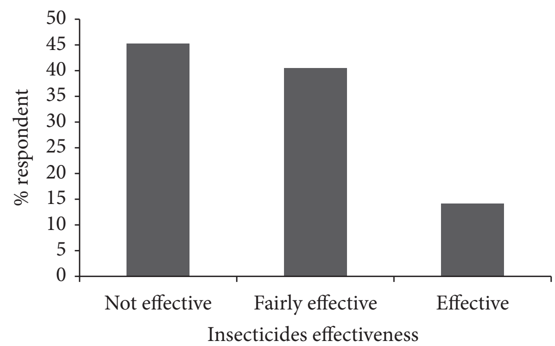
Table 3: Farmers' knowledge of Mexican bean weevil in Loma and Mareka districts in southern Ethiopia.

Variables	District: Loma N=75	District: Mareka N=73	Mean N=148	χ^2
Knowledge of storage pest (%)				0.002^{ns}
No	6.3	7.3	6.8	
Yes	93.7	92.7	93.2	
Knowledge of Mexican bean weevil (%)				0.001^{ns}
No	12.4	14.4	13.4	
Yes	87.6	84.2	85.9	
Symptoms of Mexican bean weevil (%)				1.559^{ns}
Never seen	2.5	1.5	2.0	
Presence of the eggs	0.7	0.7	0.7	
Circular 'windows' on the seed	21.5	18.5	20.0	
'Holes' on the seed	74.4	70.2	72.3	
The extent of the Mexican bean weevil problem (%)				0.083^{ns}
Severe	76.2	71.0	73.6	
Moderate	23.7	26.3	25.0	
Minor	1.3	1.4	1.4	

Note: ns = not significant



(a)



(b)

Figure 5: Mexican bean weevil control methods (a) and the effectiveness of chemical insecticides to control the Mexican bean weevil in Loma and Mareka districts in southern Ethiopia (b).

for the control of storage pests [30]. Pesticidal plants and traditional pest management practices are alternatives to synthetic insecticides for postharvest pest management. They are ecofriendly, economical, and usually target specific and most are essentially nontoxic to animals and humans [30, 31].

The present study also showed that only 8.8% of the farmers interviewed indicated they were applying chemical insecticides for the control of Mexican bean weevil in storage. Most (45.3%) farmers perceived that the insecticides they applied were not effective in controlling the Mexican bean weevil and only about 14% of the farmers perceived that insecticide was effective (Figure 5(b)). This might be due to different reasons such as knowledge gap about insecticides application and use of unregistered and/expired insecticides. Most farmers in developing countries generally lack knowledge in the handling and application of chemical insecticides [32], which might cause health and environmental effects [19]. This suggests the need to offer training for farmers on the safe use of insecticides.

3.6. Factors Affecting the Use of Pest Management Practices. The results on Logit regression analysis for the socioeconomic factors influencing the use of pesticidal plants (botanicals) are presented in Table 4. The model applied had a log likelihood value of 61.976 and a chi-squared value of 12.355, which was significant at p = 0.030. The result showed that the Nagelkerke R^2 value was = 0.228 which indicated that there was a 22.8% variation in the use of pesticidal plants, as explained by the variables selected for the analysis. Among the socioeconomic variables, two variables, the education level of the farmer and family size, had a positive and statistically significant impact on farmers' use of pesticidal plants, indicating that

Table 4: Factors affecting farmers' pesticidal plants use decision for control of Mexican bean weevil (binary regression).

Variable	Coefficient (B)	SE	Wald	p-value
Age of the farmers	-0.17	0.43	0.164	0.686
Gender	17.206	11.0	0.130	0.999
Education level	0.554	0.227	5.963	0.015
Family size	0.604	0.309	3.836	0.050
Common bean farming experience	-0.164	0.284	0.333	0.564
Constant	-24.864	1.070	0.110	0.998

R^2= 0.228; observations = 148; Chi-square= 12.355; p=0.030; -2 log likelihood = 61.976

Table 5: Factors affecting farmers' chemical insecticides use decision for control of Mexican bean weevil (binary regression).

Variable	Coefficient (B)	S.E	Wald	p-value
Age of the farmers	-0.32	0.021	2.335	0.127
Gender	-1.222	0.654	3.495	0.062
Education level	0.288	0.084	11.706	0.001
Family size	0.158	0.115	1.882	0.170
Common bean farming experience	0.119	0.142	0.709	0.400
Constant	-0.548	1.219	0.202	0.578

R^2= 0.171; observations = 148; Chi-square= 20.238; p=0.001; -2 log likelihood = 184.690

educated farmers had more knowledge of pest management practices and were likely to apply control measures against Mexican bean weevil in the storage. Kamanula et al. [30] observed a significant association between knowledge of pesticidal plants and level of education. Furthermore, family size determined the use of pesticidal plants for the control of Mexican bean weevil, where larger family size may have a diverse knowledge of pest management among the household members [33].

The logit regression analysis also showed that, among the socioeconomic variables selected for the analysis, only education level significantly affected farmers' insecticide use decision. The model was significant at 0.001. The R^2 value of 0.171 indicated that there was a 17.1% variation in insecticide application, explained by the variables captured for the study (Table 5).

Table 6: Access of extension services provided to farmers in Loma and Mareka districts in southern Ethiopia.

Variables	Frequency	Percent (%)
Types of services		
Crop production	111	75.0
Crop protection	29	19.6
Both (crop production and protection)	8	5.4
The frequency of extension contact		
Once within two weeks	74	33.3
Once a week	50	49.3
Two times a week	15	10.0
Once a month	1	0.7
Twice a month	7	4.8

3.7. Extension Services Provided to Farmers. Extension service and the communication between the extension agent and the farmers are very important in the dissemination of agricultural information to the farmers, thereby enhancing farmers' knowledge and practices of postharvest pest management. The majority (75%) of the farmers reported that they had received extension support during the crop production period, whereas 19.6% of the respondents received extension support in crop protection, and 5.4% of them received during both crop production and protection period. In addition, most (49.3%) of the farmers had contact with extension agent once a week, whereas about 33.3% of the farmers had contact once within two-week period and 10% of farmers had contact two times a week (Table 6). Training is one of the ways in which farmers obtain new knowledge and skills in postharvest pest management methods and it is measured by the frequency of training given to the farmers annually. In the study area, about 70% of the farmers reported that they did not receive any training on the application of pesticides. Nevertheless, farmers mentioned that they have got information about insecticides from other farmers and pesticide sellers, whereas 29.7% of them received training on pesticide usage and application, which was organized by agriculture extension office. Hence, in the study areas, it was noted that farmers were applying pesticide without following proper safety regulations.

4. Conclusion

The present study demonstrated that the Mexican bean weevil was the main postharvest pest in the study areas causing a significant amount of losses in stored beans. Farmers' traditional storage facilities were unable to protect stored beans from insect pest damage; thus farmers were unable to store common bean seeds for a long duration. Furthermore, farmers perceived that traditional pest management practices such as pesticidal plants and wood ash were not effective in reducing losses caused by Mexican bean weevil. This suggests the need to improve the existing traditional storage structure and to use improved storage technologies such as PICS bags and metal silo that has been effective in controlling different storage pests without insecticide application in various developing countries [21, 22, 34]. In addition, from the present study, it is evident that the majority of farmers were unable to recognize early damage symptom of Mexican bean weevil that affects early intervention in order to minimize losses in bean storage. Thus, in order to bridge the knowledge gap identified in this study, it is very important to provide training for local farmers using extension program such as demonstration and Farmer Field School (FFS) approach. It is also important to develop an integrated pest management approach for Mexican bean weevil in order to reduce postharvest losses and to enhance common bean productivity of smallholder farmers.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] W. J. Broughton, G. Hernández, M. Blair, S. Beebe, P. Gepts, and J. Vanderleyden, "Beans (*Phaseolus* spp.) – model food legumes," *Plant and Soil*, vol. 252, no. 1, pp. 55–128, 2003.

[2] N. A. Castro-Guerrero, M. C. Isidra-Arellano, D. G. Mendoza-Cozatl, and O. Valdés-López, "Common bean: a legume model on the rise for unraveling responses and adaptations to iron, zinc, and phosphate deficiencies," *Frontiers in Plant Science*, vol. 7, article 600, 2016.

[3] S. Ferris and E. Kaganzi, "Evaluating marketing opportunities for haricot beans in Ethiopia. Improving productivity and Market access (IPMS) of Ethiopian Farmers Project," Working paper 7, 2008.

[4] IFPRI, "Pulses value chain in Ethiopia constraints and opportunities for enhancing exports," Working Paper, July 2010.

[5] A. L. Jones, *Phaseolus Bean: Post-Harvest Operations. INPhO-Post-Harvest Compendium*, CIAT & FAO, 1999.

[6] Central Statistical Agency, *Agricultural Sample Survey 2013/2014 Area and Production of Major Crops*, Statistical Bulletin, May 2012, Addis Ababa, 2014.

[7] T. Abate and J. K. O. Ampofo, "Insect pests of beans in Africa: their ecology and management," *Annual Review of Entomology*, vol. 41, no. 1, pp. 45–73, 1996.

[8] C. Cardona, "Insects and other invertebrate bean pests in Latin America," in *Bean Production Problems in the Tropics*, H. F. Schwartz and M. A. Pastor-Corrales, Eds., pp. 505–570, CIAT, Cali, Colombia, 2nd edition, 1989.

[9] K. S. V. Vilca Mallqui, E. E. Oliveira, and R. N. C. Guedes, "Competition between the bean weevils *Acanthoscelides obtectus* and *Zabrotes subfasciatus* in common beans," *Journal of Stored Products Research*, vol. 55, pp. 32–35, 2013.

[10] A. K. Karel and A. Autrique, "Insects and other pests in Africa," in *Bean Production Problems in The Tropics*, H. F. Schwartz and M. A. Pastor-Corrales, Eds., pp. 455–504, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, 1989.

[11] F. Negasi and T. Abate, "Progress in bean bruchid management," in *Proceedings of the Third SADC/CIAT Bean Research Workshop, Mbabane, Swaziland, 5-7 October 1992*, O. J. Allen, Ed., vol. 27 of *Network on Bean Research in Africa, Workshop series*, No.27. CIAT, Dar es Salaam, Tanzania, 1992.

[12] A. Van Huis and F. Meerman, "Can we make IPM work for resource-poor farmers in sub-Saharan Africa?" *International Journal of Pest Management*, vol. 43, no. 4, pp. 313–320, 1997.

[13] C. A. O. Midega, A. W. Murage, J. O. Pittchar, and Z. R. Khan, "Managing storage pests of maize: farmers' knowledge, perceptions, and practices in western Kenya," *Crop Protection*, vol. 90, pp. 142–149, 2016.

[14] SNNPRS-BoFED, "Bureau of finance and economic development," Tech. Rep. 2011-2012, Hawassa, Ethiopia, 2012.

[15] T. Yamane, *Statistics: An Introductory Analysis*, Harper and Row, New York, USA, 2nd edition, 1967.

[16] J. K. Mwangi, C. M. Mutungi, S. G. Midingoyi, A. K. Faraj, and H. D. Affognon, "An assessment of the magnitudes and factors associated with postharvest losses in off-farm grain stores in Kenya," *Journal of Stored Products Research*, vol. 73, pp. 7–20, 2017.

[17] F. Bachewe, B. Minten, A. S. Taffesse, K. Pauw, A. Cameron, and T. G. Endaylalu, *Farmers' Grain Storage And Losses in Ethiopia. Strategy Support Program*, Working Paper 115, IFPRI and EDRI, Addis Ababa, 2018.

[18] D. Befikadu, "Factors affecting quality of grain stored in Ethiopian traditional storage structures and opportunities for improvement," *International Journal of Sciences: Basic and Applied Research*, vol. 18, pp. 235–257, 2014.

[19] A. Manandhar, P. Milindi, and A. Shah, "An overview of the post-harvest grain storage practices of smallholder farmers in developing countries," *Agriculture*, vol. 8, no. 4, p. 57, 2018.

[20] D. Kumar and P. Kalita, "Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries," *Foods*, vol. 6, no. 1, p. 8, 2017.

[21] L. Murdock and I. Baoua, "On Purdue Improved Cowpea Storage (PICS) technology: Background, mode of action, future prospects," *Journal of Stored Products Research*, vol. 58, pp. 3–11, 2014.

[22] C. Mutungi, H. D. Affognon, A. W. Njoroge, J. Manono, D. Baributsa, and L. L. Murdock, "Triple-Layer plastic bags protect dry common beans (*Phaseolus vulgaris*) against damage by *Acanthoscelides obtectus* (Coleoptera: Chrysomelidae) during storage," *Journal of Economic Entomology*, vol. 108, no. 5, pp. 2479–2488, 2015.

[23] R. S. Freitas, L. R. A. Faroni, and A. H. Sousa, "Hermetic storage for control of common bean weevil, *Acanthoscelides obtectus* (Say)," *Journal of Stored Products Research*, vol. 66, pp. 1–5, 2016.

[24] S. Umubyeyi and N. D. T. M. Rukazambuga, “Small scale farmers’ knowledge on grain losses from bean bruchid, pesticides safe use and implication on food security and safety in Huye District, Rwanda,” *Rwanda Journal*, vol. 1, 2016, Life and Natural Sciences: Special issue II.

[25] A. Asfaw, C. J. Almekinders, M. W. Blair, and P. C. Struik, “Participatory approach in common bean (*Phaseolus vulgaris* L.) breeding for drought tolerance for southern Ethiopia,” *Plant Breeding*, vol. 131, no. 1, pp. 125–134, 2012.

[26] H. Affognon, C. Mutungi, P. Sanginga, and C. Borgemeister, “Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis,” *World Development*, vol. 66, pp. 49–68, 2015.

[27] M. Nahimana, “Highlights of bruchid research in the great lakes region,” in *Proceedings of the Third SADC/CIAT Bean Research Workshop, Mbabane, Swaziland, 5-7 October 1992*, O. J. Allen, Ed., Network on Bean Research in Africa, Workshop series, pp. 153–163, No.27. CIAT, Dar es Salaam, Tanzania, 1992.

[28] M. S. Jones, C. E. Alexander, and B. Smith, “Economic consequences of post-harvest insect damage in Rwandan common bean markets,” *Crop Protection*, vol. 104, pp. 92–100, 2018.

[29] E. Mendesil, Z. Shumeta, P. Anderson, and B. Rämert, “Smallholder farmers’ knowledge, perceptions and management of pea weevil in north and north-western Ethiopia,” *Crop Protection*, vol. 81, pp. 30–37, 2016.

[30] J. K. Kamanula, G. W. Sileshi, S. R. Belmain et al., “Farmers’ insect pest management practices and pesticidal plant use in the protection of stored maize and beans in Southern Africa,” *International Journal of Pest Management*, vol. 57, pp. 41–49, 2011.

[31] P. C. Stevenson, M. B. Isman, and S. R. Belmain, “Pesticidal plants in Africa: a global vision of new biological control products from local uses,” *Industrial Crops and Products*, vol. 110, pp. 2–9, 2017.

[32] K. Atreya, B. K. Sitaula, F. H. Johnsen, and R. M. Bajracharya, “Continuing issues in the limitations of pesticide use in developing countries,” *Journal of Agricultural and Environmental Ethics*, vol. 24, no. 1, pp. 49–62, 2011.

[33] C. A. O. Midega, I. M. Nyang’au, J. Pittchar et al., “Farmers’ perceptions of cotton pests and their management in western Kenya,” *Crop Protection*, vol. 42, pp. 193–201, 2012.

[34] A. B. Abass, M. Fischler, K. Schneider et al., “On-farm comparison of different postharvest storage technologies in a maize farming system of Tanzania Central Corridor,” *Journal of Stored Products Research*, vol. 77, pp. 55–65, 2018.