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Review Article

PROGRESSES IN LOWLAND PULSE INSECT PEST MANAGEMENT IN ETHIOPIA

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ABSTRACT

Grain legumes are one of the important cash crops for Ethiopian smallholder farmers and a significant agricultural commodity contributing to export earnings. Lowland pulses are comparatively inexpensive sources of protein in Ethiopia. However, these economically important crops are affected by various pests. Among the most damaging in storage are bruchids (*Acanthoscelides obtectus*, *Zabrotes subfasciatus*, and *Callosobruchus* spp.), while in production fields, the primary pests include the bean stem maggot (*Ophiomyia* spp.), African bollworm (*Helicoverpa armigera*), and aphids (*Aphis craccivora* Koch). Estimated yield losses due to bean stem maggot and African bollworm range from 11-100% and 12-16%, respectively. Various pest control strategies have been employed, including the use of resistant varieties, biological control, botanical treatments, and chemical control. This review summarizes relevant scientific studies on these economically important crops, the associated insect pests, the aggravating factors in Ethiopia, and available management options.

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INTRODUCTION

Grain legumes, particularly lowland pulses, are vital components of food and agricultural systems worldwide. They complement cereal crops (Graham and Vance, 2003). In Ethiopia, lowland pulses serve as affordable sources of protein and play a significant role in the export market, notably the small-white (navy) beans. According to the report of CSA (2014), white-colored beans are referred to as "white gold" due to their high demand in the export market. The most cultivated lowland pulses in Ethiopia include the common bean (*Phaseolus vulgaris*), soybean (*Glycine max*), cowpea (*Vigna unguiculata*), pigeon pea (*Cajanus cajan*), and mung bean (*Phaseolus mungo*).

However, their production is constrained by various pathogens and insect pests (Iqbal and Mukhtar, 2014). In the field, bean stem maggot (*Ophiomyia* spp.), African bollworm (*Helicoverpa armigera*), and aphids (*Aphis craccivora* Koch) pose significant threats. In storage, bruchids (*Acanthoscelides obtectus*, *Zabrotes subfasciatus*, and *Callosobruchus* spp.) are the most economically important pests of lowland pulses.

Yield losses due to bean stem maggot and African bollworm are estimated to range from 11% to 100% and 12% to 16%, respectively. A population dynamics study of pulse crops, primarily focusing on bean stem maggot, was conducted at Awassa and Areka locations from 1991 to 1993 (Tadesse, 2006). This study is crucial for designing management strategies. At Areka, the infestation rate of *O. spencerella* ranged from 73% to

100% in 1992 and 57% to 100% in 1993 (Tadesse, 2006). The ecology of bean stem maggot in Ethiopia has been documented (Abate et al., 1998), identifying where this specific insect pest is prevalent based on ecological diversity.

As a result, efforts have been made to develop integrated insect pest management through the combination of resistant varieties, biological control, botanical control, and chemical control methods for both field and storage insect pests (Getu et al., 2003). Planting date and plant density have a significant effect on bean stem maggot (BSM) intensity, crop damage, and yield (Abate, 1990). These efforts led to the registration of two common bean varieties, Melke and Beshbesh, for BSM resistance (MOA, 2014). Additionally, the screening of 48 cowpea lines for resistance to cowpea aphids was conducted at the Mekelle Research Center over three consecutive years (1995-1997). The results from this research are promising for resistant breeding. Research activities concerning each insect pest is presented below. This paper discusses the major insect pests of lowland pulses, including their population dynamics, distribution, management options, and prospects for improving research methods for economically important selected pests.

Bean stem maggot (*Ophiomyia* spp.)

Distribution in pulse production areas of Ethiopia

Getu et al. (2018) reported that over 40 different insect species were recorded on five different lowland pulses across Ethiopia. The importance of these species varied, though most are either minor pests or pests of unknown significance. The major pests include two species of bean stem maggot (*Ophiomyia phaseoli* and *O. spencerella*), bean bruchid (*Callosobruchus* spp.), and African bollworm (*Helicoverpa armigera*) on haricot bean; bean pod weevil (*Apion* sp.) on mung bean; and bean bruchid (*Callosobruchus* spp.) and African bollworm (*H. armigera*) on cowpea. Moreover, the non-insect spider mite, *Tetranychus* sp., was also identified as a major pest on haricot bean.

A recent survey on soybean identified about 34 insect pests belonging to 8 insect orders and 18 families (Table 1). Among the insect orders recorded on soybean, the highest number of species belonged to the order Homoptera, followed by Lepidoptera and Coleoptera. Homoptera also had the highest total number of insects counted, density of insects per plant, and number of insect families recorded. The plant parts attacked by these insects included leaves, stems, and roots.

Although pulses are very important for the human diet and income generation in Ethiopia, a few insect species limit their production and storage shelf life (Getu et al., 2003; Gram and Vance, 2003; Ali et al., 2006; CSA, 2014). The history of pests associated with pulses has not changed significantly, but changes are expected as minor pests could become major pests, and exotic pests might also invade the country.

Table 1. Summary of insects recorded on soya bean in Metekel zone in 2021-2022.

Order	No. of families	Total no. of insects	No. of species
Coleoptera	2	80	5
Diptera	1	1	1
Hemiptera	1	29	2
Homoptera	6	666	11
Isoptera	1	390	2
Lepidoptera	3	39	8
Orthoptera	3	29	3
Thysanoptera	1	710	2

Population dynamics study

A study on the population dynamics of the bean stem maggot was conducted at the Awassa and Areka locations from 1991 to 1993, (Tadesse, 2006) *Ophiomyia phaseoli* was the dominant species in bean plots sown between early May and mid-June. In contrast, *O. spencerella* constituted 60% to 100% of the populations in plots sown during the cool and wet months of July and August. At Areka, *O. spencerella* ranged from 73% to 100% in 1992 and 57% to 100% in 1993. Here, *O. phaseoli* was found in considerable numbers only in plots sown during the warmer and relatively drier months of February to May. Host range studies have shown that BSMs are restricted to the Leguminosae plant family, affecting common bean, cowpea, wild host (*Crotalaria laburnifolia*), and soybean in ascending order (Abate, 1990).

Ecological studies

The ecology of the bean stem maggot in Ethiopia has been reported by Abate et al. (1998). Three species of BSM have been recorded: *O. phaseoli*, *O. spencerella*, and *O. centrosematis*. *O. phaseoli* and *O. centrosematis* are more prevalent at altitudes below 1800 m in warmer climatic conditions, whereas *O. spencerella* is dominant at higher altitudes and cooler environments. These species are predominant in the southern parts of Ethiopia, such as Hawassa, Shalla, and Wolaita Sodo, where common bean production is concentrated at altitudes ranging from 1700 to 1900 m above sea level (Abate, 1995).

O. phaseoli was the dominant species in beans planted before July and August, accounting for 93% to 100% of the species in bean plots sown between early May and mid-June at Hawassa. *O. phaseoli* was more abundant in early sown beans, whereas *O. spencerella* became more common later in the season. Within the same sowing date, the proportions of *O. centrosematis* and *O. spencerella* declined, and those of *O. phaseoli* increased as the host plant's growth stage progressed (Abate et al., 1998).

Management studies

Several studies on the control methods of bean stem maggots, including cultural control, host plant resistance, and biological and chemical control, have been undertaken. The biological control efforts are mainly limited to the identification of parasitoids associated with the insect (Abate, 1995) and will not be discussed further here.

Cultural practices

The management of bean stem maggot incorporates several cultural methods such as determining sowing dates, plant density, and habitat management. Planting date and plant density have significant effects on bean stem maggot intensity, crop damage, and yield (Abate, 1990) As shown in Table 2 and 3 the effect of sowing date is location-specific. Seedling mortality and the resulting yield did not follow any specific trend among sowing dates at Awassa, while at Melkassa, seedling mortality increased, and seed yield decreased with delays in sowing (Table 3).

Table 2. Effect of planting density on seed yield at two growing locations.

Plant density	Locations				Mean
	Awassa		Melkassa		
	1987	1988	1987	1988	
100,000 ha^{-1}	1943 b	2526 c	428 a	1476 c	1602 c
200,000 ha^{-1}	2562 a	3107 b	486 a	1842 bc	1999 b
300,000 ha^{-1}	2860 a	3401 a	617 a	2213 ab	2273 a
400,000 ha^{-1}	2838 a	3449 a	635 a	2593 a	2379 a
500,000 ha^{-1}	2776 a	3224 ab	641 a	2616 a	2314 a

Host plant resistance

Since the early 1980s, bean genotypes introduced by the national bean breeding program have been evaluated for their resistance to the bean stem maggot by entomologists. Abate (1995) reviewed progress in this area up until the mid-1990s. This effort led to the registration of two common bean varieties, Melke and Beshbesh, for BSM resistance (MOA, 2014). However, there is no information available on the extent to which these bean varieties have been adopted by farmers.

Table 3. Effect of sowing date on seed yield at two growing locations.

Sowing date	Locations				
	Awassa		Melkassa		Mean
	1987	1988	1987	1988	
1st	2488 b	3657 a	867 a	2592 a	2388 a
2nd	2738 b	3028 b	547 ab	2364 a	2176 b
3rd	2885 a	3165 b	482 bc	2294 a	2195 b
4th	2322 c	2746 c	323 c	1386 b	1694 c

The search for BSM-resistant bean varieties has continued. Between 2016 and 2018, two groups of bean genotypes viz. Red mottled and Sugar bean were tested in the Arsi Negelle and Shalla districts. The Red mottled group comprised 56 genotypes (DAB 344 to DAB 472), and the Sugar bean group comprised 55 genotypes (DAB 481 to DAB 539), totaling 111 genotypes. In 2016, twelve genotypes from the Sugar bean group (DAB-365, 366, 447, 355, 449, 331, 423, 380, 388, 393, 398, and 402) and eleven from the Red mottled group (DAB-500, 515, 506, 512, 483, 520, 539, 525, 528, 541, and 545) exhibited lower seedling mortality and less damage severity from the pest. Evaluations of these selected genotypes in the 2017 and 2018 cropping seasons identified 36 genotypes for further evaluation in the 2019 cropping season. The best-performing materials were recommended as sources of resistance to BSM for future breedingpurposes (Wondimu, 2024).

Chemical control

In the 1980s, the insecticides aldrin and carbosulfan (35% liquid formulation) were used as seed dressings for BSM control in beans (Abate, 1995). Later, endosulfan at a rate of 5 g a.i. per kg of seed was recommended based on experiments conducted at Hawassa and Melkassa (Abate, 1991). Currently, the recommended insecticide for seed treatment against BSM in beans is imidacloprid, known by the trade name Imdalem 70% WS, at a rate of 100 g per 100 kg of seeds. However, insecticides are not commonly used by bean growers in Ethiopia for BSM control, partly due to the sporadic nature of the pest (Wondimu et al., 2017).

On-farm validation of BSM management components

In 2014 and 2015, the IPM components identified from previous studies, including resistance sources, high seed rates, and chemical seed treatments, were validated on farms in Jimma and Shalla. Based on plant vigor and seed yield, the variety Beshbesh outperformed Melke. Furthermore, high seed rates and seed treatment with Imdalem 70% WS showed good performance in both vigor and yield (Wondimu et al., 2017).

Aphids (*Aphis Craccivora* Koch)

Loss assessment studies

According to the report by Negasi and Abate (1987), who studied loss assessment due to common insect pests of cowpea over two seasons at Melkassa, the application of endosulfan at both the seedling and flowering stages resulted in relatively higher yields. The estimated crop yield loss was 9.5%. Similarly, a loss assessment study on aphids conducted at Miesso during the 2017 main cropping season demonstrated that spraying Dimethoate 400g/l at 3, 12, 6+9, 3+9, and a combination of 3+6+9+12 weeks after crop emergence produced better results on the Bole Cowpea variety. The estimated yield loss ranged from 11.12% to 17.12% (Table 4).

Table 4. Effect of dimethoate 400g/L spraying 3, 6, 9 and 12 weeks after crop emergence on the number of infested plants due to aphids on Bole variety of cowpea in 2017.

Time of spraying (Dimethoate 400g/L)	No. of infested plant due to Aphids	Severity (1-5)	Grain Yield kg/ha	Yield loss (%)
3 WAE*	6.32abc	1.33ab	3033bc	17.12
6 WAE	8.67abc	0.33bc	2917bc	22.21
9 WAE	2.47bcd	0.00c	3333bc	33.33
12 WAE	9.67ab	0.33bc	2500c	11.12
3+6 WAE	2.33bcd	0.67abc	2500c	33.33
6+9 WAE	1.33cd	0.67abc	3350abc	12,67
3+9 WAE	2.12abcd	1.67a	3333bc	11.12
3+6+9+12 WAE	2.57bcd	0.33bc	3483a	10.78
control	10.23a	033bc	2000abc	46.66
CV (%)	16.23	17.12	34.0	

*WAE= Weeks After crop emergence.

Host plant resistance

A preliminary screening of 48 cowpea lines for resistance to cowpea aphids was conducted at the Mekelle Research Center over three consecutive years (1995-1997). As a result, twenty-three lines were identified as having moderate resistance or tolerance. These lines were then advanced to a replicated trial and tested over two seasons under natural infestation. Overall, the results from these two seasons indicated that the cowpea lines IT86D-400, IT87-D-1010, IITA VAR-91-12, TVU 1977ODI, IT85F-26-87, IT82-889, IT84D-666, and White Wonder Trail had low levels of infestation, better grain yields, and early maturation (MARC, 1998).

Bruchids

Currently, *Zabrotes subfasciatus* and *Callosobruchus maculatus* are the major storage pests of common beans and cowpeas, respectively.

Mexican bean weevil

Studies on host plant resistance, botanical control, and chemical control have been carried out.

Host plant resistance

Approximately 100 bean accessions introduced from

CIAT were screened, and the RAZ series was identified as highly resistant to the pest (Negasi, 1994). This series includes RAZ 1, RAZ 7, RAZ 8, and RAZ 11. Additionally, Tigist et al. (2018) screened about 300 common bean lines against the Mexican bean weevil, comprising 204 landraces, 34 released varieties, 27 breeding lines, and 35 genotypes with known resistance to the weevil. The results indicated that the most resistant genotypes with no adult emergence were the MAZ and RAZ lines, including MAZ-203, RAZ-2, RAZ-36, RAZ-44, RAZ-11, RAZ-120, and RAZ-40. A few others, such as MAZ-217, NC-20, Acc. No. 214678, NC-18, and SCR-28, had the lowest number of eggs but the highest proportion of emerged adults. All RAZ lines, without exception, and some MAZ lines, extended the period of adult emergence to over 40 days, indicating the presence of certain inhibiting factors (Tigist et al., 2018).

A total of 101 bean materials (64 MAZ lines, 15 released varieties, and 22 candidate lines) obtained from CIAT and the national lowland pulse breeding program were screened between 2016 and 2018 at MARC. The results showed low levels of egg infestation and adult emergence on MAZ-2, MAZ-7, MAZ-17, MAZ-21, MAZ-26, MAZ-68, GLP-2, MLRB, NLRB, SW (N1), LRB, and Hawassa Dume. Additionally, the lowest percentage weight loss was recorded on MAZ-16 and Hawassa Dume (Wondimu and Amsalu, 2018).

Botanical and inert material control

Seeds of various plant species such as neem (*Azadirachta indica*), pepper tree (*Schinus molle*), and Persian lilac (*Melia azedarach*) have been reported to provide effective control for up to 90 days when mixed with the seed at a rate of 10 g/kg seed (Negasi, 1994). Attempts to verify some botanical controls against bruchids on farmer's storage in 2011-12 around Melkassa failed due to very low infestation levels of the pest (Tigist Shiferaw, Personal communication). Furthermore, the potential of filter-cake (Melkabam), a byproduct of aluminum sulfate, was tested at eight different rates (T1=0.03 % w/w, T2=0.05 % w/w, T3=0.08 % w/w, T4=0.09 % w/w, T5=0.188 % w/w, T6=0.37 % w/w, T7=0.75 % w/w) against *Z. subfasciatus* at the MARC entomology laboratory. The results revealed that all the rates caused complete mortality of bruchid adults (100%) within three days after infestation (Wondimu et al., 2020).

Chemical Control

Between 1981 and 1983, an experiment at MARC reported that the organophosphate insecticide pirimiphos-methyl, applied at 4 to 8 ppm a.i, was effective in controlling C*. chinensis* (Abate, 1995).

CONCLUSION

Lowland pulses are crucial food security crops in Ethiopia, produced on both small and large scales for income generation and as export commodities. However, these high-value crops are significantly affected by various insect pests. Among the reported pests, bruchids, bean stem maggot, African bollworm, and aphids are the most problematic in production fields. Yield losses caused by bean stem maggot and African bollworm have been estimated at 11-100% and 12-16%, respectively.

Insect pest management strategies have prioritized the most economically important pests using various approaches. Research findings have demonstrated that planting date and plant density effectively control bean stem maggot. Screening germplasm is the best approach to evaluate the resistance potential of legumes, with nine genotypes identified as the most resistant to bruchids. In the 1980s, aldrin and carbosulfan (35% liquid formulation) were used as seed dressings for chemical control of bean stem maggot in beans. Currently, the insecticide/fungicide Imdalem 70% WS (Imidacloprid) at a rate of 100g/100kg of seeds is recommended. For chemical control, the organophosphate insecticide pirimiphos-methyl at 4 to 8 ppm a.i has been reported as effective against *C. chinensis*. In terms of botanical and inert material control, neem, pepper tree, and Persian lilac have been found effective in controlling bruchids for up to 90 days when mixed with seeds at a rate of 10g/kg seed.

In conclusion, research activities regarding lowland pulse entomology over the past 50 years have been encouraging. To further advance this field, it is recommended to strengthen existing activities and incorporate enabling technologies such as GIS, AI, and molecular methods to modernize entomology research, particularly in the context of lowland pulse crops.

AUTHORS' CONTRIBUTIONS

The authors collected, sorted out, and arranged the literature into different sections, drew conclusions, made suggestions for future directions, and wrote and proofread the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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