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COMMON BEAN (*PHASEOLUS VULGARIS* L.) LANDRACES REACTION TO FIELD AND STORAGE INSECT PESTS: BASELINE DATA FOR INSECT RESISTANT AND HIGH YIELDING COMMON BEAN VARIETY DEVELOPMENT

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ABSTRACT: Common bean is a lowland legume crop that contributes for food security and poverty reduction in Ethiopia. A number of constraints are associated with common bean production in Ethiopia including drought, insect pests, diseases, low number of improved variety, storage practices, storage insect pest management and seed systems among others. Therefore, this study was conducted to investigate the interaction of selected common bean landraces against field and storage insect pests. The field experiment was done at Arsi-Negele in the West-Arsi zone at the sub-center of Melkasa Research Centre (MRC) in Oromia Regional State of Ethiopia. Ten common bean landraces and one improved variety (Beshebeshe) were collected from MRC and evaluated under field and storage conditions. The field experiment was designed in a randomized complete block design in three replications, while the storage experiment was designed in a completely randomized design in three replications. Highly significant variations were observed in the tested common bean landraces in terms of field and storage insect pests. The landraces were not consistent in terms of insect pest reaction across the different plant growth stages and in the storage. This study demonstrated the high potential that existed in common bean landraces in terms of insect pest resistance. Hence, the result of this study calls for a strong collaborative work between common bean breeders and entomologists to develop high yielding and insect resistant common bean varieties.

Key words/phrases: Common bean, insect pest, landraces, resistance

INTRODUCTION

Legume crops are among the most important crops grown in Ethiopia for food, feed, soil restoration and income generation (Tesdeke Abate and Ampofo, 1996). Legume crops can be categorized into highland and lowland crops (Emana Getu *et al*., 2018). Common bean is among the most popular and important lowland legume crop worldwide mainly grown for human consumption (Endeshaw Habte et *al*., 2018). It is the second most important source of human dietary protein after maize and it is the third most important source of calories after maize and cassava worldwide (Emana Getu *et al.*, 2018). In Africa, common bean is highly cultivated in low, mid to high altitude areas (Mulatwa Wondimu *et al*., 2017; Endeshaw Habte *et al*., 2018). It is produced in Ethiopia mainly for food, feed and income generation (Endeshaw Habte *et al*., 2018). The production and productivity of common beans are constrained by several environmental stresses such as drought, insect pests and diseases both under field and storage conditions. Insect pests such as bean stem maggot under field conditions and bean bruchids under storage conditions are significantly limiting the production and productivity of common bean in Ethiopia (Tsedeke Abate, 1984, 1996; Mulatwa Wendimu *et al*., 2017; Emana Getu *et al*., 2018). A number of management strategies have been developed to minimize the effect of insect pests on common bean including resistant varieties (Mohamed Yuesuf, 2005; Mulatwa Wendimu *et al*., 2017; Emana Getu *et al*., 2018). However, some of the varieties which were resistant to insect pests are moderately resistant which do not keep the losses due to insect pests below 10%. Moreover, varieties like Melkae which was released two decades ago as a resistant variety to bean stem maggots became susceptible (Mulatwa Wendimu *et al*., 2017). On the other hand there are large

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number of common bean landraces in Ethiopia which are both in the hands of farmers and researchers which are not yet tested for their potential against insect pests (Emana Getu *et al*., 2018). Thus, looking for more gene sources from landraces is a crucial step to develop insect pest resistant and high yielding common bean varieties. Therefore, this study was carried out to investigate the potential of 10 common bean landraces against field and storage insect pests which serve as a preliminary information that can help in developing insect resistant and high yielding common bean varieties.

MATERIALS AND METHODS

Description of the study area:

The field experiment was conducted at Arsi-Negele in west Arsi zone at the sub center of Melkasa Research Centre (MRC). Arsi- Negele is located at 7°21′N 38°42′E and at an elevation of 1950 m. a s l. It has a chromic and pellic vertisols with PH of 5-7. The annual rainfall of the location is 915 mm with 27±0.30°C mean daily temperature.

Materials used:

Ten common bean landraces collected from different parts of Ethiopia and deposited at MRC and bean stem maggot resistant variety named as Beshbesha (treatments) obtained from MRC (Table 1) were planted at Arsi-Negele Research Sub-Station to evaluate against field insect pests at different plant growth stages during the main cropping seasons of 2018.

Experimental Design and the treatments:

The experiment was laid out in a randomized complete block design in three replications. The landraces (10) together with Beshebeshe (1) were the treatments tested. The plot size was 2.4 m x 4.0 m and spacing between plants, between plots and block were 10 cm, 40 cm and 1 m, respectively. All agronomic practices including weeding and fertilizer application were done per the recommendation for the study site.

Data Collection and Identification:

Data collected include plant stand count, bean stem maggot percent infestation, percent cutworm infestation, status and types of foliage beetles, percent pod infestation by African bollworm and percent pod infestation by sucking bugs. The insect pests' encountered were identified by senior entomologist from Addis Ababa University using morphological charters such as tarsi formula, wing venation, wing coupling structure, antennal segment, mouth characters and head orientation among others.

Data Analysis

The data were organized and analyzed using different computer software such as Microsoft excel and SPSS (IBM Corp, 2017). One-way ANOVA were performed using General Linear Model (Madsen and Thregod, 2011) and significant means ($P<0.05$) were separated using LSD at 0.05 significance level.

Table 1. Description of common bean landraces used for the experiments (field and storage)

Code	Acc.no	Color	Size	Region	Zone	Woreda
34	NC-50	Carioca	Medium	Amhara	Debub Welo	Kombolcha
50	NC-30	Carioca	Small	Amhara	Debub Welo	Gaynet
75	211305	Yellow	Medium	Oromiya	Mirab Hararge	Tulo
93	211546	Pinto	Medium	SNNPR	Semen Omo	Damot Gale
99	214675	Black	Medium	SNNPR	Semen omo	Damot Wayde
108	211280	Cream	Small	SNNPR	Debub Omo	Bako Gazer
110	211286	Carioca	Small	SNNPR	Debub Omo	Bako Gazer
112	215051	White	Small	SNNPR	Bench Maji	
114	241756	Pink	Small	SNNPR	Bench Maji	
115	241757	Red	Medium	SNNPR	Bench Maji	
Beshebeshe	-	Mosaic	Medium	-	-	

Storage experiment:

The storage experiment was carried out at MRC where the mean daily temperature and relative humidity ranged from 26-30°C and 60-80%, respectively. Seeds of 10 landraces and 1 improved variety (Beshbeshe) harvested from field experiment were tested against the Mexican bean wevvil, *Zabrotes subfasciatus* Boheman in three methods: free-choice test, no-choice test and natural infestation. The tests were conducted following Emana Getu et al. (2018) procedures. The natural infestation and free-choice test were non-replicated experiments because of insufficient seeds, while the no-choice test was laid out in a completely randomized design in three replications. The bruchid species used for this test was *Z. subfasciatus* which is known as a leaf beetle in the family Chrysomelidae. The data collected includes number of eggs per seed, number of seeds infested, number of holes per seed, number of F_1 progenies, alive and dead parent *Z. subfasciatus* and number of egg batch. Identifications of the insect pests were done by senior entomologist from Addis Ababa University using morphological characters.

RESULTS AND DISCUSSION

Common bean landraces reaction to field insect pests

Seedling stage common bean pests:

Data on cutworms, bean stem maggots and defoliators were recorded one month after planting. The data recorded showed that the infestation by bean stem maggots and cutworm were 0.2% and 0.01%, respectively which were not statistically significant among the landraces. Data were not presented in the form of table and/or figure because of many zero values. However, significant ($df_{10.22}$ F=5.285; P= 0.001) differences were observed with regard to defoliators among the genotypes. The highest percent infestation due to defoliators (*Ootheca bennigseni* (Weise), *O. mutabilis* (Sahlberg) and *Medythia quaterna* (Fairmaire) were recorded with common bean landrace named NC-30, while the lowest was with the landrace 241756 (Table 2). At seedling stage cutworm and bean stem magot (*Ophiomyia phaseoli (Tryon)*) were found to be non-economic pests on all landraces. However, the defoliators were found to be economically important as some of the landraces showed over 50% infestation. The current result is in contrary to Tesedek Abate and Ampofo (1996), Mulatwa Wendimu *et al*. (2017) and Emana Getu *et al*. (2018) who reported that bean stem maggot at seedling stage is the most important insect pest limiting the production of common bean in Africa in general and East Africa in particular including Ethiopia.

Table 2. Mean (±SE) percent common bean landraces infestation by defoliators at seedling stage at Arsi Negele, 2018

Acc.no	Code	Stand count	Mean % infestation by defoliators
NC-50	34	102.6	36.45±3.97abcd
211286	110	101.0	31.32±1.25ab
211546	93	100.3	46.03±1.29fg
NC-30	50	103.3	52.02±2.19g
211305	75	100.0	45.35±3.54efg
211280	108	99.3	39.32±3.31bcde
241756	114	110.3	30.91±0.89a
215051	112	106.0	42.62ab±1.55def
214675	99	106.6	31.87±5.59ab
241757	115	99.6	32.57±3.70abc
Standard check (Beshebeshe)	-	105.3	40.12±2.79 cdef
LSD		-	19.40 CV

Means followed by the same letter (s) within a column are not statistically different from each other, LSD (0.05).

Vegetative stage common bean insect pests:

Bean stem maggot, aphids and red spider mites were recorded at vegetative growth stage of common bean genotypes. However, data for aphids and red spider mites were found to be very low, while the tiny wasps which their status was not known occurred in heavy population on all plots. As shown in Table 3, plant damage (loss) due to bean stem maggot ranged from 0.00 to 2.09% which was significantly ($df_{10,22}$; F=6.7; P= 0.024) different. The highest mean percent damage was recorded with common bean landrace named as NC-50, while the lowest was with landrace 214675. The bean stem maggot species involved in the infestation were *O. phaseoli* and *O. spencerella*. Out of 60 pupae collected from all plots, *O. phaseoli* were 8 (13.33%) and *O. spencerella* 52 (86.67%).

The highest mean percent bean stem maggot plant damage was 2.09 the figure which put bean stem maggot at Arsi-Negele under unimportant insect pest, because for high value crop such as common bean an economically important insect pest should cause >5% loss to be considered as economically important insect pest. However, variations among the genotypes explain the existence of genes in common bean genotypes responsible for resistance which could be valuable information for both entomologists and breeders to develop both bean stem maggot resistant and at the same time high yielding varieties. Tsedeke Abate (1992) released two common bean varieties: Melkae and Beshebshe as bean stem maggot resistant varieties in early 90's. After two decades Melkae became susceptible, but Beshebeshe remained resistant (Mulatwa Wendimu *et al*., 2017; Emana Getu *et al*., 2018). In the present study, significantly better common bean landraces resistant to bean stem maggot were found in comparison to Beshebeshe. Tsedeke Abate (1992) identified hot spot areas of bean stem maggot in Ethiopia and Arsi Negele, the current study location was not in the list. Hence, the variation could be due to low level of infestation of bean stem maggot at Arsi Negele. Three species of bean stem maggot were reported from Africa which includes *O. phaseoli*, *O. spencerella* and *O. centrosematis*. The species that were involved in the present study area were *O. spencerella* and *O. phaseoli* with the former dominating the species composition. Previous researchers in Ethiopia entirely claim that the bean stem maggot infestation in Ethiopia was due to *O. phaseoli* which is in contrary with the present findings. Tsedeke Abate and Ampofo (1996) reported many members of the family *Chrysomelideae* from the insect order Coleoptera as defoliators of common bean plants at seedling stage which is in agreement with the present findings as *O. bennigseni*, *O. mutabilis* and *M. quaterna* were found defoliating common bean genotypes tested in the present study.

Table 3. Mean percent bean stem maggot infestation at vegetative stage to different common bean landraces at Arsi Negele, 2018

Acc.no	Code	Stand count	Mean % plant damaged (lost)
NC-50	34	102.6	2.09±0.30g
211286	110	101.0	1.43±0.21defg
211546	93	100.3	1.45±0.25efg
NC-30	50	103.3	1.10±0.57cdefg
211305	75	100.0	2.00±0.29fg
211280	108	99.3	0.40±0.20ab
241756	114	110.3	0.57±0.37abcde
215051	112	106.0	0.60±0.30abcde
214675	99	106.6	0.0±0.0a
241757	115	99.6	1.00±0.53abcdef
Standard check (Beshebeshe)		105.3	1.44±0.13defg
LSD	-	-	0.35

Means followed by the same letter (s) within a column are not statistically different from each other, LSD (0.05)

Common bean flower insect pests:

Bean flower thrips including *Taenothrips nigricornis* (Uzel) and *Frankliniella dampfi* Priesner were found feeding on the flowers of some genotypes at very low (0.01) density per plant. This finding is in line with Emana Getu *et al*. (2018) and Tsedeke Abate and Ampofo (1996) who reported these species of thrips as common pests of beans in Africa at flowering stage. Moreover, pollen beetles including *Coryna* spp. and *Mylabris* spp. were recorded on few genotypes at flowering stage.

Common bean maturity stage insect pests:

Mean percent common bean pods infested with African Bollworm (ABW) and different plant bugs are shown in Table 4. Common bean landraces showed statistically no variation in terms of both ABW ($df_{10,22}$; F= 0.719; p= 0.699) and plant bugs ($df_{10,22}$; F= 0.22; p= 0.991) infestation. Mean percent ABW pod infestation ranged from 1.64% to 2.82%, while the range for plant bugs was between 8.1% and 19.2%. On the pods of few landraces legume pod borer, *Maruca testulalis* (Geyer) were recorded at low percentage (0.7%). Pod sucking bugs recorded were *Clavigralla tomentosicollis* (Stal), *Anoplocnemis curvipes* (Fabricius) and *Nezara viridula (L.)*. The first two species commonly occurred, while the last species occurred rarely. A number of researchers demonstrated that legume pod borer (*M. testulalis*), African bollworm (*Helicoverpa armigera* (Hubner)) as common bean pod borers and *C. tomentosicollis*, *A. curvipes* and *N. viridula* as pod sucking bugs which is in line with the present findings (Tsedeke Abate and Ampofo, 1996; Mulatwa Wendimu *et al*., 2017; Emana Getu *et al*., 2018).

Table 4. Mean percent ABW and plant bugs infested common bean pods on different common bean landraces grown at Arsi Negele, 2018.

Acc.no	Code	Total number of pods/plant	Mean % pod damage by ABW	Mean % pod damage by plant bugs
NC-50	34	80.0	2.08±0.58a	15.31±4.91a
211286	110	77.3	2.37±0.07a	16.8±8.43a
211546	93	92.0	1.95±0.84a	13.3±4.54a
NC-30	50	65.6	2.82±0.23a	17.3±6.98a
211305	75	78.3	2.04±0.72a	17.2±4.58a
211280	108	67.6	3.04±0.53a	13.4±7.13a
241756	114	68.0	1.86±0.61a	16.9±2.19a
215051	112	74.6	1.64±0.67a	8.1±4.32a
214675	99	96.0	2.42±0.62a	18.0±2.04a
241757	115	73.6	2.76±0.18a	15.7±5.96a
Standard Check (Beshebeshe)	-	74.0	2.76±0.16a	19.2±13.07a
LSD			0.33	6.50

***Means followed by the same letter within a column are not statistically different from each other,* LSD (0.05)**

Severity of bean stem maggot at seedling and vegetative stages is shown in Figure 1. Mean percent bean stem maggot damage was higher at vegetative stage than seedling stage. The mean percent damage recorded at vegetative stage was 2.09, while it was 0.2% at seedling stage. Tsedeke Abate and Ampofo, (1996) considered as common bean insect pest at seedling stage, but the present study demonstrated that bean stem maggot is more important at vegetative stage than at seedling stage.

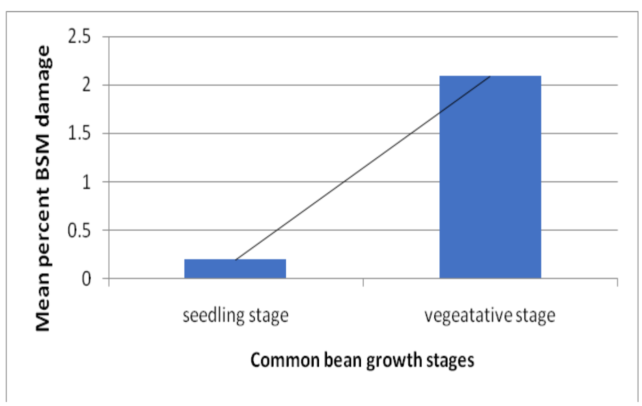

Figure 1. Comparison of common bean landraces reaction to bean stem maggot at seedling (0.20±0.02a) and vegetative stage (2.09±0.11b).

Mean percent ABW and plant bugs infestation is shown in Figure 2. Mean ABW percent infestation is 2.34 and that of plant bugs is 15.56. Tsedeke Abate and Ampofo (1996) reported that ABW is more important than pod sucking bugs which are in contrary with the present findings which demonstrated that pod sucking bugs are more important than ABW alone and also pod borers all together.

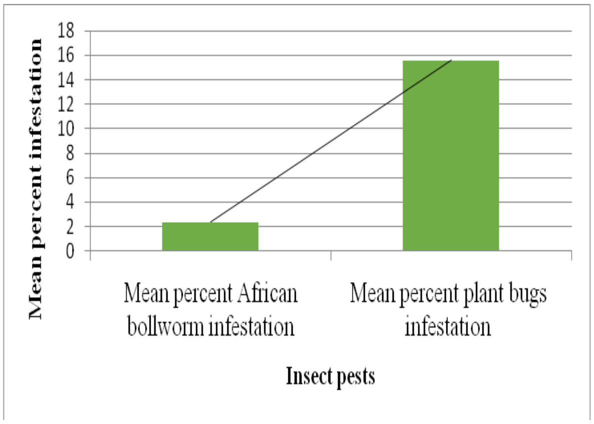

Figure 2. Comparison of African Bollworm (2.34 ±0.2a) and plant bugs (15.56±2.3b) infestation on common bean.

Common bean genotypes reaction to storage insect pests at Melkasa

No-choice test:

Results of no-choice experiments are shown in Tables 5 and 6. As shown in Table 5, the landraces and the improved variety of common bean showed significant variations in terms of total number of eggs, number of seeds with eggs and percent seed damage. The highest total number of eggs, number of seeds with eggs and percent seed damage was recorded with the landraces 211546, while the lowest was recorded with 241756. The present findings demonstrated that the existence of tremendous variabilities among common bean genotypes in terms of insect pest reaction which is in line with the findings of a number of scientists (Mulatwa Wendimu et al., 2017; Emana Getu et al., 2018).

Table 5. Mean (±SE) total number of eggs, number of seeds with eggs and percent seed damage by *Z. subfasciatus*.

Treatments	Total number of eggs	Number seeds with eggs	Percent seeds damages
NC-50	16.33 ± 6.35gh	13.33 ± 5.84fg	6.66 ± 2.92efg
211286	16.67 ± 4.07fg	14.00 ± 4.04ef	7.00 ± 2.02efg
211546	37.00 ± 13.31a	27.66 ± 9.38a	13.83 ± 4.69a
NC-30	19.00 ± 6.50ef	15.66 ± 5.45e	7.83 ± 2.72ef
211305	12.00 ± 7.50k	9.33 ± 5.33h	4.66 ± 2.66h
211280	33.00 ± 8.71c	24.67 ± 8.08c	12.33 ± 4.04abc
241756	10.33 ± 3.28k	8.66 ± 2.60h	4.33 ± 1.30h
215051	36.33 ± 22.84ab	27.33 ± 16.34ab	13.33 ± 8.17ab
214675	22.00 ± 8.62d	16.00 ± 3.46e	8.00 ± 1.73e
241757	19.33 ± 9.82e	16.00 ± 7.21e	8.00 ± 3.60e
Standard check (Beshebeshe)	22.33 ± 2.02d	20.00 ± 3.00d	10.00 ± 1.50d
LSD (5%)	2.49	2.14	1.52

Means followed by the same letter (s) with in the column are not significantly different from each other, LSD (0.05).

Total number of *Z. subfasciatus* progeny, total number of holes, and percent damage seeds are shown in Table 6. The highest total number of progenies was recorded on 211546, while the lowest was recorded on 241756. The total number of holes and percent damaged seeds was the highest in 211546, while the lowest was recorded in 241756. Similarly, great variability was recorded on common bean genotypes in terms of total progeny, total number of holes and percent damage seeds. Emana Getu *et al.* (2018) reported the existence of genes responsible in common bean genotypes which protect the crop from storage insect pests.

Table 6. Mean (±SE) total number of Z. *subfasciatus* progeny, total number of holes and percent damaged seeds by Z. *subfasciatus*

Treatments	Total progeny	Total no. of holes	% damaged seeds
NC-50	15.33± 6.33[ab]	15.33 ± 6.33[ab]	7.5 ± 3.75[cd]
211286	13.67 ± 3.52[ab]	13.66 ± 3.52[ab]	5.5 ± 1.15[cde]
211546	30.33 ± 9.20[a]	30.66 ± 9.33[a]	12.67 ± 3.34[a]
NC-30	17.00 ± 5.13[ab]	17.00 ± 5.13[ab]	5.5 ± 1.60[cde]
211305	11.00 ± 2.88[b]	11.00 ± 3.21[b]	4.33 ± 1.48[de]
211280	22.33 ± 6.83[ab]	22.33 ± 6.83[ab]	8.5 ± 3.75[bc]
241756	8.67 ± 3.75[b]	8.66 ± 3.75[b]	3.5 ± 1.60[e]
215051	22.33 ±9.40[ab]	22.66 ± 13.71[ab]	11.67 ± 6.16[ab]
214675	10.33 ± 2.66[b]	14.00 ± 5.50[ab]	6.16 ± 2.33[cde]
241757	18.33 ± 12.81[ab]	14.66 ± 9.13[ab]	6.00 ± 3.32[cde]
Standard check (Beshebeshe)	21.33 ± 3.48[ab]	17.66 ± 2.18 [ab]	7.16 ± 0.33[cde]
LSD	17.05	17.77	4.13

Means followed by the same letter (s) with in the column are not significantly different from each other, LSD (0.05).

Free choice test:

Table 7 demonstrated results of an observation made on 11 genotypes of common bean in terms of number of seeds with eggs, number of eggs, number of seeds with holes and number of Z. *subfasciatus* adults. The observation indicated that there were variations in all parameters measured. This result demonstrated the existence of variability among common bean genotypes. Tsedeke Abate and Ampofo (1996) reported similar results on free choice experiment.

Table 7. Number of seeds with eggs, number of eggs, number of seeds with holes and total number of adults of Z. *subfasciatus* per each treatment.

Treatments	No. of seeds with eggs	No. of eggs	No. of seeds with holes	No. of *Z. subfasciatus* adult
NC-50	2	3	0	59
211286	4	9	2	48
211546	5	8	1	45
NC-30	9	14	5	83
211305	5	11	3	39
211280	5	13	2	36
241756	6	11	1	59
215051	4	8	2	36
214675	8	11	1	49
241757	9	17	5	44
Standard check (Beshebeshe)	2	5	0	43

Natural infestation:

Natural infestation experiment was set between October 2018 and April 2019 for almost 6 months, but no infestation, no egg, no holes on seeds and no adult bruchids were recorded due to the absence of common bean store nearby, where the experiment was conducted to serve as source of infestation for our experiment. Araya Gebreselase and Emana Getu (2009), Tesfu Fekenesa and Emana Getu (2013), and Emana Getu *et al.* (2018) demonstrated the need of infested stores for the infestation to occur.

CONCLUSION

Common bean genotypes demonstrated very great variability in terms of field insect pest infestation at all phenological growth stages of the crop such as seedling, vegetative, flowering and maturity stages. The tested genotypes were also demonstrated variability for storage insect pests.

Therefore, the present work calls for firm collaboration of breeders and entomologist to embark on intensive and extensive screening of common bean genotypes to come up with both insect resistant and high yielding common bean variety (ies).

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