Varietal resistance in haricot beans (*Phaseolus vulgaris* L.) to postharvest infestation by *Zabrotes subfasciatus* Boheman

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Abstract

Fifty-six, 32, and 65 indigenous and exotic haricot bean genotypes were screened for their resistance against Mexican Bean Weevil *Zabrotes subfasciatus* (Boheman) (**Coleoptera: Bruchidae**) damage in 1996, 1997 and 1998, respectively, in the laboratory at Bako Agricultural Research Center, Western Ethiopia. Thirty of the genotypes were received from the International Center for Tropical Agriculture (CIAT) whereas the rest were obtained from Bako and Melkassa Research Centers. Data on the number of eggs laid per seed, median development time (MDT), number of progeny developing successfully into adults, percentage grain damage (%gd) and susceptibility index were considered for evaluation. Variations were observed among the genotypes tested against attack by *Zabrotes*. All of the 25 CIAT accessions (RAZ coded lines) were resistant (with low progeny emergence, low percentage of grain damage and longer MDT) to *Zabrotes*. From the commercial bean varieties, only Roba-1 exhibited resistance to the pest. The rest of the genotypes including bean progenies from the Bean Improvement Programme as well as materials from the bean stem maggot resistance breeding had high progeny weevil emergence, percent grain damage and indices of susceptibility. The overall result of this experiment indicated that except RAZ lines and Roba-1, all the other bean genotypes tested were found to be susceptible to attack by Zabrotes.

Introduction

Beans (*Phaseolus vulgaris* L.) form an important food and cash crop in Africa, particularly in the Eastern, Southern, and Great Lakes of the continent (Abate & Ampofo 1996). Ethiopia is the third principal producer of bean in Eastern African countries next to Kenya and Uganda (Kirkby 1993). Damage by insect pests, inter alia, is considered the limiting factor of bean production in Africa (Abate & Ampofo 1996). Although numerous pests attack all parts of beans, bean stem maggot (*Ophiomia* species) and bruchids are the most important field and storage pests, respectively (Abate & Ampofo 1996, Giga & Chinwada 1993).

Bruchids, *Zabrotes subfasciatus* (Boheman) also known as Mexican bean weevil, and *Acanthoscelides obtectus* (Say), the common bean weevil, are the two important pests of stored beans in the world causing the average losses 13% (Cardona, nd.). Negasi & Abate (1992), reported that these two species are the major pests of stored beans in Ethiopia. *Z. subfasciatus* is the only bruchid species reported on haricot beans in the Bako area (Abraham 1996).

Insecticides are the most publicized methods of bruchid control but they are mostly unavailable to or unaffordable by the subsistence farmers. In addition, dust formulations have limited shelf life and are prone to user abuse (Silim 1993). Exploring alternatives like selecting the less susceptible bean cultivars (genotypes) was started long ago in which *Zabrotes* resistant accessions were obtained (Cardona, nd.).
The objective of this study was to screen indigenous and exotic haricot bean genotypes for their resistance to *Z. subfasciatus*.

Materials and methods

Different haricot bean genotypes obtained from national bean breeding programs and from international sources were evaluated for their resistance to *Z. subfasciatus* damage between 1996 and 1998, for three years in the laboratory at room temperature at Bako Agricultural Research Center, western Ethiopia. The genotypes tested were received from Bako and Melkassa Research Centers and from the International Center for Tropical Agriculture (CIAT), Cali, Colombia. Most of the accessions received from CIAT (30 in number) were known for their arcelin content which is a toxin and affects the survival and development of *Zabrotes*. One susceptible check, Diacol Calm was also included in the trial. Indigenous genotypes include: progenies from bean improvement program as well as materials from bean stem maggot (*Ophiomia phaseoli*) resistance breeding nursery coded as cr- and nur- at Melkassa Research Center. The rest were commercial varieties and local cultivar.

The number of entries were 56, 32 and 65 local and foreign genotypes in 1996, 1997 and 1998, respectively. Completely randomized design was used for the experiment in all the years. In 1996, fifty seeds and seven pairs of sexed adults of *Z. subfasciatus* were introduced into each glass jar containing 50 seeds of each genotype, while the number of weevils and the amount of seeds per jar were increased for the other two years. Fifteen sexed adults of *Z. subfasciatus* were introduced to each jar containing 50 grams of each genotype in 1997 and 1998.

The environmental temperature rises from September onwards until April/May for Bako area. This experiment was conducted at different times starting from December, October, and February in 1996, 1997 and 1998, respectively. The corresponding mean laboratory temperatures during the experiments were 20.5°c, 19.8°c and 22.3°c, for 1996, 1997 and 1998, respectively.

The adult infestation (egg laying) period was seven days after weevil introduction. Data such as number of eggs per seed, median development time (MDT) (i.e. the time at which 50% of the progenies will emerge), number of progeny weevils emerged and percentage of grain damage were taken where needed. The data were subjected to one way analysis of variance using an MSTAT-C computer program.

Results

Higher degree of variability existed among the genotypes tested against *Zabrotes* damage. The mean number of eggs laid per 50 seeds ranged between zero (for Roba-1) and 75 (for RAZ-44 and MX-2500-19). But non of the 75 egg masses hatched into larvae and emerged as adult weevils from RAZ-44. Out of the 75 eggs laid 50 seeds of MX-2500-19, 46 of them were hatched into larvae and gave adult progeny weevils (Table 1).

The mean number of adult weevils emerged ranged for zero (for RAZs) to a maximum of 46 weevils on MX-2500-19. Bean genotypes such as cr-10, Cr-2, ICA PIJAO, Beshbesh, Mexican-142 and susceptible check (Diacol calm) resulted in highly significant ($P < 0.001$) mean number of weevil emergence. Out of the 25 RAZ lines, very few number of adult weevils were emerged from RAZ-50, RAZ-1, RAZ-20, RAZ-33 and RAZ-6. No adult weevil was emerged from the rest of RAZ lines (Table 1). Similarly, no progeny weevil was emerged from two released varieties Roba-1 and Brown speckled.

There were highly significant differences in percentage grain damage among the genotypes. Percent grain damage ranged from zero for most of RAZ lines to 50% on Cr-10. High percentage damage was recorded for genotypes such as Cr-10, Diacol calm, MX-2500-19, Cr-2, Cr-1, Cr-4, Beshbesh, Mexican-142, G-1954, ILA-PIJAO, MX-1309-3, G12888, Cr-9, Red welaita, A-262 and the local variety (Table 1). The other genotypes showed intermediate reactions.

Table 2 shows the relative response of 32 haricot bean genotypes to attack by Zabrotes in 1997. The result indicated that although recorded damage is high there was no significant difference in progeny emergence among the genotypes. The number of emerged weevils ranged was between 59 in Diacol calm and 129 in Cr-13. The percentage grain damage ranged between 7.5 and 50.3%.

Table 3 depicts, the mean number of adult F1 *Zabrotes* emerged and the corresponding percentage of grain damage for 1998 experiment. Out of the 65 genotypes, almost all the RAZ -coded lines were with zero progeny emergence and free of grain damage. These lines performed exactly in a similar manner as in 1996. There was statistically significant difference ($p<0.05$) in progeny emergence and percent grain damage. Zero progeny emergence was recorded for nearly all of the RAZ lines and the figure ranged between zero for RAZs and a maximum of 58 progeny weevils per 50 g of grain in other genotypes. High mean number of weevils were emerged from Diacol calm, Cr-3, Awash-1, nur-5, and nur-8.

Bean genotypes coded as Cr-1, Cr-2, Cr-11, Cr-16, nur-1 and nur-6 showed lower rate of susceptibility (Table 3). Progeny emergence was low for these genotypes. Generally, bean genotypes of local sources showed susceptible nature.

Median development time ranged between 0 day in most RAZ lines and in Roba-1 to a maximum of 51 days in 1996 (Table 1). In susceptible check, Diacol calm, MDT was attained in 46 days. In 1997, however, the figure was almost similar for all the genotypes and the range was very narrow (51 to 54 days) (Table 2). In 1998, on the other hand, MDT was reduced to up to less than 38 days and the range was between 0 and 38 days both in RAZ lines (Table 3).

Table 4 shows the agronomic characteristics of the RAZ lines and other bean genotypes at Bako condition in 1998 season. RAZ lines with numbers -36, -34, -38, -52 and –44 had comparable grain yields with the standard check, Roba-1. Moreover, they are resistant to the major bean diseases, anthracnose and common bacterial blight (CBB), which are prevalent in the Bako area (Table 4).

Discussion

High number of eggs were laid on some bean genotypes but failed to hatch into larvae and then to adult. This indicates that oviposition could not be used as an indicator of varietal resistance for *Zabrotes* on beans in no choice tests. On the other hand, few to many eggs were observed being laid on the layer of glass jars. For faba bean, Kemal and Smith (1996), observed that ovipositional preference is not an indication of susceptibility of the host. From the results of their work Giga and Chinwada (1993) also reported that the majority of the eggs on the RAZ lines hatched and penetrated the seed coat, as indicated by the white coloration of the egg shells left behind but very few larvae were developed successfully into adults.

There was no weevil emergence from RAZ lines. Larvae failed to develop on the resistant (RAZ) lines or larval development took a much longer time than on the susceptible. Zero MDT as indicated for most of the RAZs was used to designate no weevil emergence. Hence, resistant varieties had either 0 or longer MDT, indicating that the resistant varieties can retard progeny weevil emergence by lengthening the life cycle of an insect. Giga and Chinwada (1993) indicated that the development periods of those adults that emerged from the RAZ lines were significantly longer (39.6-69.0 days) than those from the susceptible check (31.4 days). These authors also indicated that although a few adults had emerged from most RAZ lines, they were small and "unfit".

Variations existed among the test varieties in terms of their MDT in all the three years' experiments (1996-1998). This may be due to the effect of temperature on the *Zabrotes* development. *Z. subfasciatus* prefers warmer temperatures for its reproduction as compared to *A. obtectus* which is the more prevalent in cooler areas (Abate and Ampofo, 1996). The mean laboratory temperatures during the experiments were 20.5°c, 19.8°c and 22.3°c, for 1996, 1997 and 1998, respectively. The environmental temperature rises from September onwards until April /May for Bako area. The length of MDT can be reduced as temperature rises up to 30-32°c for *Zabrotes*.

Silim (1993) recommended the use of RAZ-2 in situations where conventional pest control procedures cannot be utilized as this variety provides adequate protection against *Z. subfasciatus*. Previous studies in Ethiopia, indicated that varieties such as RAZ-8, brown speckled, RAZ-20-1, RAZ-20, RAZ-13-5, RAZ-6, RAZ-21, RAZ-33, RAZ-11, RAZ-7-3, RAZ-18-1, RAZ-17-1, RAZ-22 and RAZ-1 are the most resistant genotypes to the pest (Negasi and Abate, 1992). However, almost all bean genotypes from Melkassa Bean Breeding Program were found to be susceptible and from the commercial varieties Awash-1 was with high level of susceptibility (Negasi and Abate, 1992). In general, the results of this experiment indicated that except CIAT bean accessions (RAZ lines) and Roba-1, all the bean genotypes tested were susceptible to attack by *Zabrotes*.

Table 1. Response of haricot bean genotypes against *Zabrotes* damage in the laboratory, Bako, 1996.

Trt. No.	Entries	Eggs laid	progeny emerged	MDT (days)	% of grain damaged
1	RAZ- 1	54	5f-k	47	2.0g-j
2	RAZ- 6	23	1jk	47	0.0j
3	RAZ-7	38	0k	0	0.0j
4	RAZ-8	29	0k	0	0.0j
5	RAZ-11	42	0k	0	1.0j
6	RAZ-13.5	52	0k	0	2.0hij
7	RAZ-13.6	44	0k	0	0.0j
8	RAZ-17.1	28	0k	0	0.0j
9	RAZ-17.3	74	0k	0	1.0ij
10	RAZ-18.1	24	0k	0	0.0j
11	RAZ-20	50	3h-k	47	4.1f-j
12	RAZ-20.1	37	0k	0	1.0ij
13	RAZ-21	20	0k	0	0.0i
14	RAZ-22	32	0k	0	1.0ij
15	RAZ-30	35	0k	0	0.0j
16	RAZ-33	22	4 g-k	46	0.0j
17	RAZ-34	38	Ok	0	0.0j
18	RAZ-36	40	Ok	0	0.0j
19	RAZ-38	38	Ok	0	0.0j
20	RAZ-39	50	Ok	0	0.0j
21	RAZ-40	9	Ok	0	0.0j
22	RAZ-41	60	Ok	0	0.0j
23	RAZ-44	75	Ok	0	0.0j
24	RAZ-50	43	9d-k	46	12.2c-j
25	RAZ-52	22	Ok	0	0.0j

26	G-1954	14	Ok	0	1.1ij
27	G-12888	33	14c-i	51	26.3a-d
28	G-12891	50	Ok	0	7.0d-j
29	G-11051	35	1ijk	49	3.0g-j
30	ICA-PIJAO	55	26a-d	45	22.6a-f
31	Cr-1	29	14c-h	46	25.2a-i
32	Cr-2	16	31abc	48	33.0abc
33	Cr-3	5	2h-k	46	2.0hij
34	Cr-4	54	31abc	46	27.8abc
35	Beshbesh	25	21.5a-e	45	26.8a-e
36	Cr-6	23	5e-k	47	8.3c-j
37	Cr-7	25	12d-k	46	9.0c-j
38	Cr-8	14	9d-k	47	15.1b-i
39	Cr-9	29	19a-f	47	21.0a-g
40	Cr-10	28	38ab	43	49.8a
41	Cr-11	31	3h-k	43	17.0a-i
42	Cr-12	40	9d-k	45	10.0c-j
43	Cr-13	30	7e-k	48	8.0c-j
44	Melkie	16	12c-j	46	5.1e-j
45	Cr-15	14	8d-k	45	9.0c-j
46	Cr-16	28	10c-j	45	5.0e-j
47	Diacol Calm	56	41a	46	45.5ab
48	Roba-1	0	Ok	0	0.0j
49	Awash-1	23	10d-k	46	9.9c-j
50	Red Wolita	9	16c-j	43	20.0c-j
51	Mexican-142	31	19a-g	45	26.1a-e
52	Brown speckled	7	Ok	0	0.0j
53	MX-2500-19	75	46a	45	17.0b-i
54	MX-1309-3	19	16d-h	45	16.0a-i
55	A-262	28	12c-j	46	19.9a-h
56	Local	47	13c-i	43	21.3a-g
	Mean	33.20	8.35	26.25	9.50
	SE(±)	-	5.8	-	9.94

Table 2. Response of haricot bean genotypes against *Zabrotes* damage in the laboratory, Bako, 1997.

Trt. No.	Entries	Progeny emerged	MDT (days)	% grain damaged	Index of susceptibility
1	Cr-1	63.0	54	12.5	3.3
2	Cr-2	70.7	54	7.5	3.4
3	Cr-3	80.0	53	12.4	3.6
4	Cr-4	127.0	53	16.3	3.9
5	Beshbesh	114.7	51	13.3	4.0
6	Cr-6	82.7	53	10.0	3.0
7	Cr-7	79.7	52	8.6	3.6
8	Cr-8	84.3	52	11.6	3.7
9	Cr-9	65.7	53	10.4	3.4
10	Cr-10	83.3	52	12.2	3.6
11	Cr- 11	110.3	53	30.8	3.8
12	Cr-12	119.0	53	26.5	3.8
13	Cr-13	129.3	53	33.0	3.9
14	Melkie	267.3	53	50.3	4.2
15	Cr-15	146.7	53	27.8	4.1
16	Cr-16	81.3	52	23.6	3.6
17	Nur-1	114.7	53	42.5	3.9
18	Nur-2	96.7	53	12.9	3.7
19	Nur-3	128.3	52	20.5	4.1
20	Nur-4	93.7	52	47.8	3.7
21	Nur-5	155.3	52	20.2	4.0
22	Nur-6	104.3	52	43.0	3.8
23	Nur-7	118.0	53	14.5	3.9
24	Nur-8	113.0	53	21.7	3.8
25	Nur-9	91.7	53	12.9	3.6
26	Nur-10	97.7	52	11.5	3.8
27	Nur-11	106.7	53	14.4	3.8
28	Nur-12	94.3	53	9.2	3.7
29	Nur-13	125.3	52	23.1	4.0
30	Nur-14	104.7	52	23.5	3.9
31	Roba-1	115.0	51	10.0	4.1
32	Diacol calm	58.0	53	9.3	3.1
	Mean	106.95	52.59	20.12	3.9
	SE(±)	41.0	-	7.5	-

Table 3. Response of haricot bean genotypes against *Zabrotes* damage in the laboratory, Bako, 1998.

Trt. No.	Entries	Progeny emerged	MDT (days)	% grain damaged
1	RAZ- 1	0.0h	0	0.0h
2	RAZ- 6	0.0h	0	0.0h
3	RAZ-7	0.0h	0	0.0h
4	RAZ-8	0.0h	0	0.0h
5	RAZ-11	0.0h	0	0.0h
6	RAZ-13.5	0.0h	0	0.0h
7	RAZ-13.6	0.0h	0	0.0h
8	RAZ-17.1	0.0h	0	0.0h
9	RAZ-17.3	0.0h	0	0.0h
10	RAZ-18.1	0.0h	0	0.0h
11	RAZ-20	0.0h	0	0.0h
12	RAZ-201	0.0h	0	0.0h
13	RAZ-21	1.0f	38	1.1fgh
14	RAZ-22	0.0h	0	0.0h
15	RAZ-30	0.0h	38	2.5e-h
16	RAZ-33	0.0h	0	0.8h
17	RAZ-34	0.0h	0	0.2h
18	RAZ-36	2.0e-h	36	0.5h
19	RAZ-38	0.0h	0	0.0h
20	RAZ-39	0.0h	0	0.3h
21	RAZ-40	0.5h	0	0.0h
22	RAZ-41	0.0h	0	0.6h
23	RAZ-44	0.0h	0	0.0h
24	RAZ-50	0.0h	0	0.0h
25	RAZ-52	0.0h	0	0.0h
26	Cr-1	8.5c-h	32	2.2fgh
27	Cr-2	7.5c-h	34	2.5e-h
28	Cr-3	44.5ab	32	9.0b-h
29	Cr-4	25.5a-f	30	5.1c-h
30	Beshbesh	30.0a-e	32	7.0b-h
31	Cr-6	24.5a-e	33	4.9c-h
32	Cr-7	11.0d-h	31	2.2fgh
33	Cr-8	33.0a-d	31	6.9b-h
34	Cr-9	15.0b-h	30	4.5c-h
35	Cr-10	14.5b-h	31	4.1c-h
36	Cr-11	1.5fgh	34	0.6h
37	Cr-12	6.5d-h	32	1.3fgh
38	Cr-13	15.0b-h	31	4.8c-h
39	Melkie	34.0a-d	30	11.4bc

40	Cr-15	19.0a-g	30	9.1b-f
41	Cr-16	26.5a-e	33	10.3b-e
42	Diacol Calm	57.5a	32	24.7a
43	Roba-1	20.0a-g	30	6.3c-h
44	Awash-1	40.5abc	30	7.4b-h
45	Red Wolita	16.0a-h	30	6.4c-h
46	Mexican-142	19.0a-g	31	5.3c-h
47	Brown speckled	25.5a-e	29	14.4b
48	MX-2500-19	15.0b-h	30	4.8c-h
49	MX-1309-3	6.0e-h	30	2.9e-h
50	A-262	15.0b-h	35	6.8b-h
51	Local	24.0a-e	29	11.0bcd
52	Nur-1	1.5fgh	33	0.0h
53	Nur-2	15.0b-h	29	3.4d-h
54	Nur-3	12.0c-h	29	2.9e-h
55	Nur-4	7.0d-h	31	1.3fgh
56	Nur-5	33.5a-d	32	8.9b-g
57	Nur-6	10.5b-h	32	0.9gh
58	Nur-7	18.0b-h	30	5.4c-h
59	Nur-8	30.0a-e	33	7.6b-h
60	Nur-9	12.0c-h	30	2.2fgh
61	Nur-10	4.5a-d	30	7.2b-h
62	Nur-11	9.5c-h	34	4.0c-h
63	Nur-12	17.5a-h	31	4.4c-h
64	Nur-13	18.5a-h	31	7.4b-h
65	Nur-14	12.5b-h	31	7.3b-h
	Mean	11.71	20.92	3.77
	SE(±)	50.7	-	37.4

Table 4. Field performance of the genotypes tested for resistance to *Zabrotes*,Bako, 1998.

Trt. No.	Entries	Anthracnose	CBB	Maturity (Days)	Pods per plants (Mean of 5 plants)	Yield (Kg/ha)
1	RAZ- 1	1	1	100	19	599.5
2	RAZ- 6	5	1	92	9	303.1
3	RAZ-7	1	1	92	16	479.8
4	RAZ-8	1	1	100	15	929.2
5	RAZ-11	3	1	92	17	861.8
6	RAZ-13.5	9	1	92	4	19.0
7	RAZ-13.6	9	1	92	5	24.6
8	RAZ-17.1	7	1	100	7	164.0
9	RAZ-17.3	7	1	100	5	156.5
10	RAZ-18.1	2	1	100	11	771.4
11	RAZ-20	5	1	92	12	435.6
12	RAZ-201	6	1	92	6	292.9
13	RAZ-21	7	1	100	3	69.0
14	RAZ-22	2	1	92	9	142.1
15	RAZ-30	5	1	92	5	236.7
16	RAZ-33	6	1	106	10	595.9
17	RAZ-34	1	1	100	22	1220.6
18	RAZ-36	1	1	100	19	1415.0
19	RAZ-38	2	1	100	16	1150.8
20	RAZ-39	3	1	92	13	761.3
21	RAZ-40	2	1	93	14	729.0
22	RAZ-41	5	1	92	15	590.5
23	RAZ-44	1	1	100	13	1046.0
24	RAZ-50	1	1	100	16	892.7
25	RAZ-52	1	1	106	14	1135.5
26	Cr-1	3	1	100	12	629.3
27	Cr-2	2	1	101	9	685.2
28	Cr-3	1	1	101	10	905.0
29	Cr-4	1	1	101	11	715.2
30	Beshbesh	1	1	92	17	722.5
31	Cr-6	3	1	101	16	393.2
32	Cr-7	5	1	101	6	339.0
33	Cr-8	5	1	101	13	188.2
34	Cr-9	6	1	101	9	361.0
35	Cr-10	1	1	101	12	930.3
36	Cr-11	1	2	106	7	901.1
37	Cr-12	1	2	101	7	801.4
38	Cr-13	1	1	101	9	905.5
39	Melkie	1	3	101	7	686.5
40	Cr-15	1	1	101	12	1132.6
41	Cr-16	1	1	101	7	1053.9

42	Diacol Calm	1	1	101	11	944.0
43	Roba-1	1	1	101	11	1368.3
44	Awash-1	2	1	106	19	813.0
45	Red Wolita	2	5	101	12	632.9
46	Mexican-142	5	1	106	28	879.0
47	Brown speckled	1	1	101	12	1310.4
48	MX-2500-19	6	1	106	10	1068.1
49	MX-1309-3	3	1	106	14	1221.0
50	A-262	1	3	92	9	1192.9
51	Local	1	1	92	9	660.0
52	Nur-1	1	1	101	7	537.5
53	Nur-2	1	1	101	12	729.0
54	Nur-3	1	1	101	8	626.8
55	Nur-4	1	1	101	6	560.0
56	Nur-5	1	1	101	14	1080.8
57	Nur-6	1	1	101	3	511.4
58	Nur-7	3	1	101	10	755.6
59	Nur-8	3	1	106	21	832.5
60	Nur-9	4	1	106	8	325.5
61	Nur-10	2	1	106	21	964.4
62	Nur-11	1	1	101	8	664.6
63	Nur-12	1	1	101	10	788.2
64	Nur-13	2	1	101	7	421.8
65	Nur-14	1	1	101	12	1388.1

Note: For disease score 1-9 scale, 1 is used to indicate leaves with out any disease symptom while 9 is used to mean 100% (severe plant damage) leading to a yield nearer to zero; CBB = Common bacterial blight

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