Ovipositional Antixenosis in Some Barley Accessions to Barley Shoot Fly

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Abstract

Ovipositional antixenosis to Barley shoot fly *Delia flavibasis* was studied using five resistant accessions and one susceptible variety (control) both in the field and pot culture experiments. The study was undertaken at the Sinana Agricultural Research Center in *bona* season (August–December, 2002) under natural infestation in the field and artificial infestation in the pot culture. In the single choice tests (pot culture experiment), the result was not consistent as to whether the susceptible HB-42, or the resistant accessions were more preferred. PGRCE/E 1799 and PGRCE/E 4409 accessions were significantly more preferred to HB-42 whereas PGRCE/E 4414, PGRCE/E 4282 accessions and Arusso were significantly less preferred to HB-42. In the multiple choice test (field experiment), statistically significant variation was revealed among the treatments in terms of average number of eggs per plant, per centage of plants with eggs and main shoot and tiller infestation. HB-42 was the most preferred for oviposition to all the entries as it had the highest mean values for all these parameters. But PGRCE/E 1799 and PGRCE/E 4409 were in contrast the least preferred. Hence, antixenosis mechanism of resistance was confirmed to prominently function in the resistance of barley against *D. flavibasis*.

Key words: *Delia flavibasis*, anti-xenosis, non-preference

Introduction

Barley shoot fly, *Delia flavibasis* Stein, belongs to the family Anthomyiidae of order Diptera. It is a major pest of barley in Kenya (Macharia and Mueke 1986). In Ethiopia, the first record of the barley shoot fly as major pest of barley was made by Davidson (1969) at Holetta, and the species had been identified to be *D. arambourgi* Seguy. The species that is widely occurring and has attained major pest status in Bale, however, has recently been identified as *D. flavibasis* Stein while it was referred to as *D. arambourgi* Seguy, for a long time. The identification was undertaken at the University Museum of Natural History, Oxford, UK in 2003 while conducting current study. So far, *D. flavibasis* is reported only from these two countries as a major pest of barley. *D. flavibasis* inflicts significant yield loss and is becoming an important constraint to barley-growing farmers in Bale since all improved varieties are highly susceptible (Amare 1993, SARC 2001). Because of its devastating effect on improved varieties and exotic germplasm, the pest has become a major constraint to barley research activities at Sinana, as the affected crops are often lost before sufficient data were collected. As a result, it is an obstacle, both to release and to introduce improved barley varieties for the region.

Barley varieties showing relative tolerance to *D. flavibasis* have been reported from Kenya (Macharia and Mueke 1986, Macharia 1992). Because of wide differences in infestation levels among barley genotypes, it has been established that resistance sources of barley to the pest may exist among Ethiopian barley landraces (SARC 2001). The local barley cultivar Arusso, due to its co-existence with the pest for long, is apparently resistant/tolerant to barley shoot fly infestation (SARC 2001). Besides, a number of Ethiopian barley landraces, obtained through the Institute of Biodiversity Conservation and Research (IBCR), were found to be either resistant or tolerant at Sinana (SARC 2001). But the mechanisms of resistance in these varieties have not been investigated yet.

The expression of resistance to pests in crops is often the result of a combination of resistance categories (Van Emden 1987), and it is important to identify the contribution of each such category to the overall expression of resistance. The classification on mechanisms of host plant resistance to specific insect pest species is usually the first step in developing an insect-resistant variety as the information generated from such studies lay the foundation for breeding resistant varieties. Hence, the present investigation was initiated with the specific objective of assessing the presence of antixenosis mechanism of resistance in barley accessions to *D. flavibasis*.

Materials and Methods

Six barley accessions were evaluated in the study (Table 1). They were identified at Sinana Agricultural Research Center in previous screening studies. Similarly, HB-42 was confirmed for its susceptibility to barley shoot fly and was used as a susceptible check (SARC 2001).

Single choice test for oviposition

Two pots, one with the test accession and the other with the susceptible control (HB-42), were placed side by side in a screen cage of size 41 cm × 50 cm × 60 cm following the procedure of Raina et al. (1984). The experiment was laid in completely randomized design (CRD) with four replications. The replication consisted of a pair of pots, one with test accession and the other with the control in one cage. Eight mated female *D. flavibasis* collected from field were released into each cage before the seedlings

Table 1. Accessions used for the experiment

Accession	Origin	Reaction to barley shoot fly
PGRCE/E 1799*	Ethiopia	R/T**
PGRCE/E 4414	Ethiopia	R/T
PGRCE/E 4409	Ethiopia	R/T
PGRCE/E 4282	Ethiopia	R/T
Arusso	Ethiopia	R/T
HB-42	Ethiopia	S

*PGRCE/E: Plant Genetic Resource Conservation of Ethiopia

**R/T: resistant/tolerant; S: susceptible attained the 1.1 (first leaf unfolded) growth stage scale of Zadoks et al. (1974). The flies were provided with diet consisting of brewers' yeast, glucose and water and were kept in the cage to oviposit for four days after which they were removed and the number of eggs laid per plant were recorded. The plants with the eggs were left in the cages for the development of deadhearts and data were collected 18 days after the adults were removed.

Multiple choice test for oviposition

The occurrence of antixenosis mechanism of resistance among the six accessions was studied in the field in multiple choice test experiment, where six varieties were planted on a 1.2 m × 2 m plot where the pest was prevalent. The experimental design used was randomized complete block (RCBD)- with four replications. Fishmeal was uniformly spread over the experimental plots at the rate of 1 kg/plot to attract the pest and thereby ensure high and uniform infestation (Sharma et al. 1992, Sileshi 1994). The oviposition non-preference was evaluated based on the relative number of eggs laid per plant, the percentage of plants with eggs, extent of infestation and deadheart formation as well as tiller infestation. Eggs were located first by carefully looking around the collar region of each plant and then by gently excavating the soil close to the seedlings until all the available eggs were exposed. The number of eggs per plant was counted from 20 randomly selected sample plants per plot and the average number of eggs per plant as well as percentage of plants with eggs were calculated. The number of seedlings showing infestation were counted from among a total of 50 random plants within 50 cm × 50 cm quadrat at 18 days after sowing and then converted to per cent infestation. Tiller infestation was counted after tillering commenced and deadhearts were counted by the same method. Infestations were considered as range of symptoms from mild and early leaf 'mining' symptoms to damage as severe as deadhearts and 'deadheart' referred to only seedlings attacked by *D. flavibasis*, reading to central shoot drying or starting wilting.

Statistical analysis

All data were analyzed using analysis of variance (ANOVA) and MSTATC statistical package (MSTU 1988). Wherever F-test statistics was significant ($p < 0.01$ or 0.05), least significant difference (LSD) was used for treatment mean separation and comparison (Gomez and Gomez 1984).

Results

Single choice test for oviposition (pot culture)

The average number of eggs laid per plant ranged from 0.56 on HB-42 to 8.26 on PGRCE/E 4409. While two accessions, PGRCE/E 1799 and PGRCE/E 4409 recorded significantly ($p < 0.01$) more number of eggs per plant than HB-42, each of the remaining three accessions had significantly less number of eggs oviposited as compared to HB-42 (Table 2). Among the latter group, PGRCE/E 4414 was apparently less preferred by the shoot fly for laying the eggs and few number of plants with eggs, infestation and deadhearts were recorded in comparison to susceptible variety HB-42. Accession PGRCE/E 4282 and Arusso were also less preferred as compared to HB-42 for the number of eggs laid, but were at par with HB-42 in terms of infestation, deadhearts and number of plants with eggs. On the other hand, PGRCE/E 1799 was apparently more preferred than HB-42 in terms of number of eggs laid, infestation, deadhearts and number of plants with eggs. Significantly more number of eggs (8.26) were also laid on accession PGRCE/E 4409 as compared to HB-42 (4.68), while infestation, deadhearts and number of plants with eggs were found to be at par in both entries.

Multiple-choice test for oviposition (field experiment)

The entries showed significant differences with respect to all the parameters used to measure ovipositional antixenosis indicating that the shoot fly exhibited detectable preference/non-preference for oviposition in multiple-choice situation (T3). Average number of eggs laid per plant and percentage of plants with eggs ranged from 0.54 to 1.36 and 43.75 to 71.25, respectively, the highest figures being for the susceptible control HB-42. The highest figure of average number of eggs per plant (1.36) and per cent deadhearts (50.50) were both recorded from the susceptible control, followed by Arusso, (0.71 and 36.50 respectively.) The highest percentage of infestation (60.50) was registered from the susceptible control followed by PGRCE/E 4282.

The lowest average number of eggs per plant (0.54) and deadhearts (14.50) were all from PGRCE/E 1799, whereas the lowest percentage of plants with eggs (43.75) was from PGRCE/E 4409. Hence, the two accessions appeared to be the least preferred to all for oviposition by *D. flavibasis*, though PGRCE/E 1799 ranked

Table 2. Number of eggs per plant, infestation, deadhearts and number of plants with eggs of *Delia flavibasis* on resistant/tolerant accessions under single choice test

Accession	Average number of eggs per plant	Number of plants with eggs*	Mean number of infested plants *	Mean number of plants with deadhearts*
PGRCE/E 1799	2.65a	4.00a	4.00a	4.00a
HB-42	0.56b	2.25b	3.00b	3.25b
CV(%)	6.68	11.31	0.00	5.88
SE	0.05	0.18	0.00	0.11
PGRCE/E 4414	0.80a	2.75b	2.75b	2.75b
HB-42	1.38b	4.00a	4.00a	4.00a
CV(%)	10.63	10.48	10.48	10.48
SE	0.06	0.18	0.18	0.18
PGRCE/E 4409	8.26a	4.00	4.00	4.00
HB-42	4.68b	4.00	4.00	4.00
CV(%)	7.72	0.00	0.00	0.00
SE	0.25	0.00	0.00	0.00
PGRCE/E 4282	3.38a	4.00	4.00	4.00
HB-42	4.51b	4.00	4.00	4.00
CV(%)	16.17	0.00	0.00	0.00
SE	0.32	0.00	0.00	0.00
Arusso	2.98a	4.00	4.00	4.00
HB-42	3.93b	4.00	4.00	4.00
CV(%)	14.48	0.00	0.00	0.00
SE	0.25	0.00	0.00	0.00

Means within a column followed by the same letter are not significantly different at $P < 0.01$

SE = standard error of means

* = Counted from among total of four plants per pot

Table 3. Response of barley shoot fly to the resistant/tolerant accessions for oviposition and infestation in the field.

Accession	Average number of eggs per plant*	% number of plants with eggs**	% infestation*	% deadheart *	% tiller infestation*
PGRCE/E 1799	0.54 b	63.75 ab	31.00 b	14.50 c	18.00 c
PGRCE/E 4414	0.69 b	53.75 bc	29.00 b	24.00 bc	24.00 bc
PGRCE/E 4409	0.65 b	43.75 c	26.00 b	20.00 bc	11.00 c
PGRCE/E 4282	0.68 b	52.50 bc	33.00 b	22.50 bc	20.00 c
Arusso	0.71 b	55.00 abc	26.00 b	36.50 ab	34.50 b
HB-42	1.36 a	71.25 a	60.50 a	50.50 a	85.50 a
CV%	31.38	19.47	37.36	32.99	20.41
SE	0.12	5.52	6.40	19.25	3.28
LSD value	0.29	16.62	19.28	4.62	13.68

Numbers within a column followed by the same letter are not significantly different at * = $p < 0.01$; ** = $p < 0.05$

the second highest, next to HB-42 in terms of percentage of plants with eggs. The remaining four accessions had their mean values in between the two extremes and thus were moderately preferred for oviposition.

The average number of eggs laid per plant on the susceptible control (HB-42) was significantly ($p < 0.01$) higher than the other five accessions, but there was no significant difference among the five accessions. Arusso, HB-42 and PGRCE/E 1799 did not differ significantly ($p < 0.05$) in terms of percentage of plants with eggs. On the other hand, HB-42 had significantly higher percentage of plants with eggs than PGRCE/E 4414, PGRCE/E 4282 and PGRCE/E 4409. Similarly, PGRCE/E 1799 had significantly ($p < 0.05$) higher percentage of plants with eggs than PGRCE/E 4409.

HB-42 and Arusso did not show significant differences ($p < 0.05$) in deadhearts formed, whereas the other four accessions had significantly lower per cent deadhearts than the susceptible control. Arusso had significantly higher per cent deadhearts ($p < 0.05$) than PGRCE/E 1799. HB-42 was significantly ($p < 0.01$) more infested than the rest five accessions, which did not differ significantly for the same parameter.

In addition to the main shoot infestation scored at the earlier crop growth stage, per cent tiller infestation was significantly ($p < 0.01$) higher for HB-42 as compared to the remaining five entries. The highest tiller infestation (85.50%t) was scored from this same variety, followed by *Arusso* that had tiller infestation of 34.50%. There was no significant difference among the resistant accessions (PGRCE/E 1799 (18.00), PGRCE/E 4414 (24.00), PGRCE/E 4409 (11.00) and PGRCE/E 4282 (20.00)) in this respect, but all of them except PGRCE/E 4414 had significantly ($p < 0.01$) less tillers infested than those of Arusso. Two accessions, PGRCE/E 1799 and PGRCE/E 4409, had comparatively lower tiller infestation, providing further evidence that they were the least preferred to all. In general, barley shoot fly showed marked preference/non preference for oviposition under multiple-choice situation. HB-42 was apparently the most preferred variety and PGRCE/E 1799 and PGRCE/E 4409 were the least preferred among the entries.

Discussion

The average number of eggs oviposited per plant in the single choice experiment was higher relative to the multiple-choice situation. This is most likely because of either the reduced number of choices available to the pest for oviposition or due to heavier pest population within the cage relative to the field condition, and that confirms the existence of ovipositional antixenosis under multiple-choice conditions. Multiple-choice test appeared to be a more sound approach than single choice test in assessing the antixenosis mechanism of resistance. It also reflected a consistent relationship between the resistant accessions and the susceptible variety. Taneja and Leuschner (1985) reported similar results for *Atherigona soccata* on sorghum. Ovipositional non-preference is the major component of antixenotic resistance mechanism also in sorghum to *A. soccata* (Blum 1967, Blum 1969, Singh and Jotwani 1980, Sileshi 1994) and many other crops.

Barley shoot fly has apparently shown good potential for preference in oviposition. Average number of eggs oviposited per plant by the barley shoot fly was, however, relatively low as compared to 2.22 to 5.48 per plant by *A. soccata* on sorghum (Singh and Jotwani 1980) and up to a maximum of 170 by *D. radicum* on crucifers (Jyoti et al. 2001). This may indicate that the resistant accessions used for the study were not preferred by the barley shoot fly for oviposition and the pest oviposited perhaps much less than it could do on ideally suitable varieties. Apparently, barley shoot fly has good potential for infestation which, however, is counteracted by the adapted and resistant landraces of Ethiopian origin that deter oviposition. Another implication is that the flies have to test the suitability of all the existing varieties for oviposition and distribute the eggs rather than laying them all at a time on a single variety, another possible cause for ovipositional preference non-preference.

The infestation level of tillers which results from either secondary infestation by larvae quitting the main shoot (Bullock 1965, Davidson 1969) or due to oviposition on newly formed tillers or combination of both may suggest the possibility of larval antixenosis as is the case for *Chilo partellus* larvae on sorghum seedlings (Van den Berg and Van der Westhuizen 1997), whereas the latter strengthens the evidence of the existence of ovipositional preference/ non-preference in the test host of barley in the present study.

The basis of oviposition preference has not been addressed in the current study and needs further investigation. If the trait responsible for antixenosis is identified, it could be transferred to elite barley varieties to improve resistance to *D. flavibasis*.

Acknowledgements

The authors thank Michael Ackland, University Museum of Natural History, Oxford, UK, for identifying the species of the pest under study. Dr. S. Sithanantham of International Center for Insect Physiology and Ecology (ICIPE), Nairobi, Kenya, is also acknowledged for his kind cooperation in facilitating the species identification.

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