Resistance in Ethiopian Barley Landraces to the Russian Wheat Aphid (*Diuraphis noxia* Mordvilko)

Adisu Berhan
Sheno Research Center
P. O. Box 112, Debre Berhan, Ethiopia

Bayeh Mulatu
Ethiopian Agricultural Research Organisation
Holetta Research Center
P.O.Box 2003, Addis Ababa, Ethiopia

Tadesse Gebremedhin
Ethiopian Agricultural Research Organisation
P.O.Box 2003, Addis Ababa, Ethiopia

Abstract

The Russian Wheat Aphid, RWA, (*Diuraphis noxia* Mordvilko) is an important pest of barley in Ethiopia. Chemical control of RWA with spray and seed dressing could give limited protection because of the leaf enrolling behaviour of the insect which reduces the effect of the former and the limited efficacy the latter method has with plant growth stages. The alternative, which requires less investment, no special skill and which is sustainable and friendly to the environment is the use of resistant cultivar. Based on this fact, screening of land races of barley was carried out at Holetta and Sheno (Ethiopia) by selecting more than 1400 lines from land races. A total of 29 lines were found to have good level of resistance. With further evaluation, among these lines 3379-17, 3296-03, 1671-06, and 1726-17 were found to have better plant stand and good level of resistance to the pest. But, it was 3296-15, which had acceptable agronomic merits and expressed high level of tolerance to the pest, though it supported more aphids than the accessions mentioned above. From this study it was confirmed that there is a possibility of getting barley accessions with good level of resistance to the pest if more Ethiopian collections are screened.

Introduction

In Ethiopia, more than 38 species of insect pests have been recorded on barley. Out of which, eight are aphid species and the most important is the Russian Wheat Aphid (RWA) (*Diuraphis noxia* Mordvilko) (Adugna & Kemal, 1985). It has been reported as an indigenous aphid in southern Russia, Iran, Afghanistan, and countries that border the Mediterranean (Hewett *and Grifiths 1978*). To date, it is found distributed both in the old and New World threatening mainly the production of barley followed by wheat (Robinson, 1992; Webster *et al.*, 1987).

RWA was first recorded on barley in northern parts of Ethiopia in the early 1970's drought period. At present, it is found in all barley growing areas of the country with varying degrees of importance (Adugna & Tessema, 1987; Bayeh & Tadesse, 1994). Damage symptoms caused by the pest include: chloroplast breakdown caused by stylet injected toxins, rolling of leaves including the flag leaves

which results in a contorted "goose neck" grain heads which are sterile (Smith et al., 1991). RWA infestation starts at early seedling stage and damage progresses thereof as a result, the aphid pressure increases and the infestation may even persists after heading and results in sever crop damage or total crop failure. This is mainly the case in *"Belg"* (February-May) season with low rainfall. A yield loss in barley due to RWA damage in North Shewa at Chacha was estimated to be 41-79 % in years of shortage of rainfall, which favours the pest population development (Adugna & Kemal, 1985).

The present RWA, situation in the country has become very serious in places, which have been facing cyclical drought over years and/or erratic rainfall distribution within a growing season. The farmers because of the subsistent nature of the farming system did not adopt use of insecticides. Spray insecticide may not be effective on RWA due to the enrolled leaves, which prevent direct contact. Seed dressing with systemic insecticides could reduce or prevent early crop stage infestation, but the available ones are costly to use. The alternative, which requires less investment from the farmers, does not need special skill to implement and is sustainable and friendly to the environment, is the use of RWA resistant barley cultivars.

Host resistant study to the RWA has relatively a longer history on wheat than on barley (Du Toit (1987). Identification of RWA resistance sources in barley was a success in the United States (Webster *et al*, 1987) and Mexico (Robinson, 1994). Robinson (1994) in CIMMYT selected two resistant lines S12 and S13 and both were found to have antibiosis resistance against the RWA. In the United States, line PI366449 (Afghanistan) was identified to have highest level of antibiosis and reduced RWA reproduction by 50 % when compared with the control Wintermalt (Webster *et al.*, 1993). Study on the effect of resistance on RWA feeding was conducted on a number of barley lines and PI366450 (Afghanistan) and CI 1412 (Spain) were found to be the most resistant lines (Webster *et al.*, 1993).

In Ethiopia, barley has been in production in diverse ecologies across the country since thousands of years and its genetic diversity is very high. Engels (1991) did diversity analysis on barley land races of Ethiopia and confirmed that Ethiopia is the center of diversity for barley and the diversity is evenly distributed over the barley growing areas of the country, although there is some concentration for individual characters. Though the pest has short history in the country as a major pest, considering the diversity of the crop genetic base, evaluation of land races of barley with the objective to identify genotypes with inherent resistance against the RWA was started with mass screening program. The screening was initiated together with the breeders and the pathologists in 1991. 1400 single head selections were evaluated for their resistance against RWA in Holetta and Sheno research centers from 1991-1995

Materials and Methods

First stage Screening

In the first cycle, mass screening was carried out by dividing the 1400 pure lines into two. Each part was evaluated for two consecutive years under field condition at Holetta in the off-season using irrigation. The lines were sown unreplicated on two rows of a ridge with the local cultivar "Baleme" included as a susceptible check after every sixty lines. Then after all the plots were artificially infested at about four leaf stage by spreading RWA infested leaves of the susceptible local cultivar "Baleme" which were cut into small pieces for ease of spreading. Supplemental infestation was never required in the four years experimental period. From two weeks after infestation, scoring of the degree of seedling leaf chlorosis and rolling had been recorded three times on weekly intervals using the scoring scales of 0-9 adopted but improved at Holetta for visually assessing whole plot (Table 1) (Webster et al., 1993). The recorded score data were then stored in Lotus 123 file and sorted by the same software to select the lines which showed good level of resistance which was determined mainly by the lower scores they had for the two RWA damage symptom measuring parameters.

Second Stage Screening

In this stage of the screening which was carried out only for one season, the 29 lines selected

from the first cycle of the selection were further evaluated by sowing them on larger plots of size 2 m x 3 m with six rows contained in each plot. There were three replications per line. At Holetta, Infestation was done in the way it was carried out in the first stage of the experiment. At Chacha, the screening was done under natural infestation and no supplemental infestation was required. The comparison of the lines was made on the basis of percent-infested tillers by counting infested and healthy seedlings contained within a 50-cm long area per row. The rows were taken at random in the six rows. Aphid count was done by removing randomly ten seedlings from each plot at a time (destructive sampling), visual assessment and scoring of the leaf chlorosis and rolling manifested by each line and the number of days taken by each and every line to head. Data on these parameters except the last one were collected three times on weekly intervals. In counting the aphids, particularly in the last two days of data recording, only the dominant tiller was taken. This was done with the assumption that it was the mother plant, which was infested at the four leaf-stage of the test seedlings as the tillers were infested by the aphids reproduced in the mother plant. All the recorded data on the parameters considered at this stage of the screening were then stored in lotus123 file and later transferred to SPSS/PC+ software for computation of the parameters means, analysis of variance and group mean comparison. The results obtained from both stages of screening are described below.

Table 1. Scales used for the visual rating of the damage levels inflicted on the different barley lines

Scale	Damage description
0	plants are healthy
1	few isolated chlorotic spots and slightly folded leaves
2	slight increase in isolated chlorotic spots and slightly folded leaves
3	Chlorotic spots larger and more numerous with slightly enfolded leaves
4	Chlorosis in about 25 % of the leaves and increased level of enfolding of leaves
5	merging of chlorotic spots with apparent streaking parallel to and on either sides of the midribs and pronounced enrolling of leaves
6	distinct streaking parallel to and on either sides of the midrib and enrolled leaves with leaf die back symptoms from tips
7	Extensive leaf streaking and enrolled leaves with leaf die back
8	> 80 % chlorotic and enrolled leaves with leaf die back and stunted growth
9	plants are already dead or dying.

Source: Webster et al. (1993)

Results and Discussion

First stage of Screening

In the first stage of the screening (1991-1994), 29 lines were identified to have good level of resistance to the RWA damage which was manifested by the lower scores they had for both parameters (leaf chlorosis and rolling) among the 1400 land race pure line selections. However, none of the tested lines were neither immune nor killed by the pest attack, although it was not expected that a host plant would be immune from infestation. Line 3296-15 (from the 1993-94 selection) had better stand despite higher mean scores for seedling leaf chlorosis 4 and leaf rolling 3, *i.e.*, it was found being tolerant to the RWA population at Holetta. Line 1659-07, too, was found at this stage of the screening to be a good tolerant material despite the high degree of leaf chlorosis it

expressed which was worse than even the susceptible cultivar Baleme. Three accessions: 3293-15, 3296-03, 3296-13 scored 3 on both parameters whereas Baleme scored 6 and 5 in the first set and 5 and 5 in the second set for leaf chlorosis and rolling respectively (Table 2a and 2b). As described in Table 1, lines which scored 3 on both parameters had larger and more numerous isolated chlorotic spots without any streaking but with slightly enfolded leaves. This shows the possibility of integrating host plant resistance with biological control agents for the control of the RWA. This is because, unlike susceptible lines, which give protective cover for the infesting aphids as a result of the pronounced enrolling their leaves have, the resistant lines expose the aphids which resided on their leaves to the predators or natural enemies. These selected lines besides the good level of resistance they have to RWA, they also give the forementioned associated benefits. Because of the promising results they gave, these lines were further evaluated for one more year in 1995 at Holetta and Chacha in the second stage of the screening.

Table 2a. Barley land race lines with good level of resistance against the RWA (*D. noxia* Mord.) Damage (1991-92).

Line No.	Mean Scores (1-9)	
	Leaf Chlorosis	Leaf Rolling
1639-02	4	3
1642-19	4	2
1647-10	4	3
1667-04	4	3
1667-16	4	4
1667-18	4	3
1671-08	4	3
1726-17	4	3
1726-20	4	2
3285-14	4	4
3333-05	4	1
3357-04	4	1
3410-03	4	4
3379-17	4	3
Baleme	6	5

Table 2b. Barley land race lines with good level of resistance against the RWA (*D. noxia* Mord.) damage (1993-94).

Line No.	Mean scores (1-9)	
	Leaf Chlorosis	Leaf Rolling
3305-12	4	3
3293-15	3	3
3296-03	3	3
3369-03	4	4
1659-07	6	4
1725-07	4	4
3379-12	4	3
1725-11	4	4
1671-06	4	3
3297-11	4	4
3296-15	4	3
3379-16	4	3
3297-12	4	3
3296-13	3	3
3379-10	4	3
Balemo	5	5

Second Stage of Screening

The results on the 29 selected accessions are described in Table 3 and 4. The percent infestation data taken on the three subsequent scoring dates were not found statistically significant ($P<0.05$). On the other hand for the parameters mentioned in Table 3, the variations were found significantly different even at $p<0.01$ in both locations. The Duncan's Multiple Range Test showed that for the aphid count data, the majority of the lines were grouped in one with 1667-04 and 3285-14 hosting more aphids in the first day of scoring. 3357-04 had the highest infestation in day two and in day three, the infestation level was higher on 1659-07, 3285-14, 3297-11, 3305-12, and 3357-04. On the most important parameter, leaf chlorosis, in day one there were four groups each containing 15, 8, 5 and 1 lines with scores between 1-2, and 2-3, 3 and 4 respectively. On the second day, there were 23, 2, 1 and 3 lines with scores between 2 and 4, 4, 5 and above 5 respectively. On the last day there were 10, 13, 4 and 2 lines with scores of 2-3, 3-4, and 5 and above 5 respectively. For leaf rolling, there were 23, 1, and 5 lines with scores of 1-2, 3, and above 3 respectively. On the second day there were 23, 3, 4, 1 lines with scores of 2-3, 4, and above 4 respectively. on the last day there were 23, 4, 1, 1 lines with scores of 3-4, above 4, 5 and above 5 respectively. These results showed that lines which sustained higher level of RWA infestation, scored higher for leaf chlorosis and rolling. When one sees the changes over the scoring days particularly the data on aphid count, 1671-06, 1762-17, 3293-15, 3296-03, 3296-13, 3379-10, 3379-12 and 3379-17 had lower aphid counts and the corresponding scores on leaf chlorosis and rolling were also lower. However, among these lines those, which had better plant stand with good level of tolerance to the pest though not comparable with 3296-15, were 3379-17, 3296-3, 1671-6 and 1726-17. 3296-15 is a very good tolerant material with acceptable agronomic merits, but it hosted more aphids and sustained more damage indicating the high level of tolerance the line has to the pest. The other lines, which had more aphids recorded on them than 3296-15 were 1659-07, 3357-04, and 3285-14. Line 1659-07 was included in the second stage of the screening considering its seemingly good agronomic performance during the first phase of the screening, but in the second stage it was found being more susceptible and had relatively poor crop stand. The results from both locations were found to be consistent.

These results do suggest that in the Ethiopian barley

gene pool, there is a possibility of getting materials with good level of tolerance to the RWA population under Ethiopian condition. This particular screening work has shown that there is variability in the reaction of land race barley collections to the RWA. For instance lines 3296-03, 3296-13 and 3296-15 which are selections from the population 3296 from Kofele (Arsi region) reacted differently to the pest attack. Among the three as indicated earlier, line 3296-15 had the combined advantages of good level of tolerance to the pest attack and acceptable agronomic merits. This line can be tested further in farmers' fields in areas of hot spot to the pest. In the "Meher" season by early planting in late May on larger plots one can test it to verify its performance against this pest.

Table 3. Response of the selected barley lines to the RWA *(Diuraphis noxia* Mordv.), Holetta.

Line No.	Mean aphid count			Mean leaf chlorosis			Mean leaf rolling			Days to heading
	D-I	D-II	D-III	D-I	D-II	D-III	D-I	D-II	D-III	
1639-02	46a	79a	34a	1a	5d	4b	2a	4c	4a	87b
1642-19	39a	88a	23a	3b	4b	5d	3c	3a	4a	96e
1647-10	51a	108a	15a	4d	4a	5c	2a	3a	4b	93c
1659-07	51a	158a	62e	3b	4b	4b	3c	4c	5c	95d
1667-04	108b	73a	27a	2b	3a	3a	2a	2a	3a	84b
1667-16	55a	106a	43a	3b	4a	4b	2a	3a	4a	85b
1667-18	40a	133a	19a	2a	3a	3a	1a	2a	2a	85b
1671-06	35a	44a	10a	2a	4a	4b	1a	3a	3a	100i
1671-08	57a	56a	25a	2a	2a	3b	1a	2a	3a	96e
1725-07	43a	60a	28a	3a	3a	4a	2a	2a	3a	99g
1725-11	56a	67a	38a	2b	5d	3b	2a	4b	4a	103i
1726-17	73a	57a	17a	3c	3a	4a	2a	2a	4a	90c
1726-20	42a	108a	10a	3c	4a	5b	3c	3a	3a	101i
3285-14	127c	164a	50c	2a	5d	5c	2a	4c	4a	103i
3293-15	26a	56a	18a	1a	3a	2a	1a	2a	3a	97f
3296-03	40a	80a	42a	1a	2a	4a	1a	2a	3a	87b
3296-13	24a	62a	16a	2a	3a	4b	2a	3a	4a	98g
3296-15	65a	136a	42a	2a	3a	2a	1a	2a	3a	101i
3297-11	36a	109a	46b	3c	5c	5c	3c	4d	4b	98g
3297-12	50a	54a	31a	2b	4a	4b	2a	3a	4a	100h
3305-12	75a	98a	47b	3b	4a	4b	2a	3a	5b	89c
3333-05	70a	50a	18a	3c	4a	4b	2a	3a	4b	102i
3357-04	90a	197b	54d	2a	4a	5d	2a	4b	4a	74a
3369-03	47a	101a	30a	3b	4a	4b	3b	4c	5d	101i
3379-10	39a	49a	16a	1a	3a	4b	1a	2a	4a	98g
3379-12	37a	38a	21a	2a	3a	3a	1a	2a	2a	97e
3379-16	56a	72a	37a	1a	3a	4a	1a	3a	4a	101i
3379-17	63a	42a	14a	1a	2a	3a	2a	2a	3a	94d
3410-03	83a	76a	24a	3c	4a	5c	3c	4b	4a	102i

NB. Values followed by same letter were not statistically different from one another (P<0.05)

Table 4. Response of the selected barley lines to the RWA *(Diuraphis noxia* Mordv.), Chacha.

Line No.	Mean aphid count			Mean leaf chlorosis			Mean leaf rolling			Days to Heading
	D-I	D-II	D-III	D-I	D-II	D-III	D-I	D-II	D-III	
1639-02	45a	87c	41c	2a	5c	6c	2a	3b	5c	92b
1642-19	47a	96c	18a	3b	5c	5c	2a	3b	4b	100c
1647-10	61b	118d	24b	4d	3b	5c	1a	3b	4b	98c
1659-07	63b	203f	51d	3b	6d	6c	2a	3b	6c	97d
1667-04	118d	81c	23b	3b	4b	5c	2a	2a	3a	86b
1667-16	73c	126d	41c	3b	3b	5c	2a	3b	4b	88b
1667-18	37a	141e	10a	1a	2a	4b	1a	1a	2a	90b
1671-06	44a	58b	7a	1a	5c	4b	1a	3b	4b	106f
1671-08	55b	51b	29b	2a	1a	3b	2a	2a	4b	102d
1725-07	41a	56b	36c	2a	2a	4b	2a	2a	3a	104e
1725-11	56b	62b	42c	2b	6d	4b	2a	3b	5c	102d
1726-17	85c	50b	13a	4c	2a	5c	2a	2a	4b	93b
1726-20	51b	110c	27b	4c	4b	5c	2a	3b	4b	106f
3285-14	143e	194f	43c	1a	6d	7d	2a	3b	5c	108g
3293-15	31a	63b	12a	2a	2a	2a	2a	2a	3a	101c
3296-03	47a	88c	39c	1a	1a	4b	1a	2a	3a	91b
3296-13	33a	70b	23b	2a	4b	4b	2a	3b	3a	102d
3296-15	60b	146e	34c	1a	3b	2a	2a	2a	3a	105e
3297-11	40a	119d	59d	2c	5c	4b	2a	3b	3a	100c
3297-12	43a	49a	37c	1b	3b	3b	2a	3b	4b	101c
3305-12	89c	101c	56d	2b	5c	4b	2a	3b	5c	92b
3333-05	67b	56b	9a	3c	4b	5c	1a	2a	4b	103d
3357-04	112d	156e	63d	2a	3b	6c	2a	3b	4a	80a
3369-03	53b	96c	45c	4b	5c	4b	3b	4c	5c	103d
3379-10	37a	54b	26b	1a	2a	4b	2a	2a	6c	102d
3379-12	44a	30a	17a	2a	3b	2a	1a	2a	4b	99c
3379-16	61b	81c	47c	2a	4b	3b	1a	3b	3a	106f
3379-17	61b	40a	8a	1a	1a	3b	2a	1a	3a	99c
3410-03	91c	66a	29b	4c	5c	6c	3b	3b	5c	105e
Kessele	196f	183f	184e	5d	6d	8e	4c	5c	7d	104e

NB. Values followed by same letter were not statistically different from one another (P<0.05)

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