Revue Marocaine de Protection des Plantes, 2016, N° 9: 61-67

Sources of resistance in durum wheat and its wild relatives to Russian wheat aphid (Hemiptea: Aphididae)

Sources de résistance chez le blé dur et ses espèces sauvages apparentées pour le Puceron russe (Hemiptera: Aphididae)

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ABSTRACT

Russian wheat aphid (RWA), *Diuraphis noxia* (Kurdjumov), is a serious pest of cereals in many parts of the world, particularly in dry areas. As limited resistance sources to this pest were previously identified in durum wheat, 144 accessions of *Aegilops* spp. and 72 advanced durum wheat lines were evaluated for resistance to RWA in the field and in the plastic house at Tel Hadya, Syria. Ten *Aegilops* accessions and 14 advanced durum wheat lines showed good level of resistance to RWA. The best five lines were studied for categories of resistance, and the results showed that antibiosis, antixenosis and tolerance are involved in various combinations.

Key words: Russian wheat aphid, durum wheat, *Aegilops*, resistance

RESUME

Le Puceron russe, *Diuraphis noxia* (Kurdjumov), est un ravageur important des céréales dans plusieurs coins du monde, et plus particulièrement dans les régions arides. Comme seulement un nombre limité de sources de résistance à ce ravageur ont été identifiées auparavant chez le blé dur, 144 accessions d'*Aegilops* spp. et 72 lignées avancées de blé dur ont été évaluées sous serre et au champ à Tel Hadya, Syrie, pour la résistance au puceron russe. Dix accessions d'*Aegilops* et 14 lignées de blé dur ont montré un bon niveau de résistance à ce puceron. Les cinq meilleures lignées ont été étudiées pour leurs catégories de résistance. Les résultats ont montré que les trois catégories de résistance (antibiosis, antixenosis et tolérance) sont impliquées avec des niveaux de combinaison différents.

Mots clés: Puceron russe, blé dur, *Aegilops*, résistance

INTRODUCTION

Russian wheat aphid (RWA), *Diuraphis noxia* (Kurdjumov), is one of the most important insect pests of cereals in many parts of the world: North America, North Africa, Ethiopia, Yemen and South Africa. In Ethiopia yield losses due to this pest have been estimated at 41 to 71% in barley and 60% in wheat, while in South Africa the wheat losses due to this pest vary between 21 to 92% (Miller and Haile, 1988; Aalbersberg et *al*., 1989). Economic losses from the RWA in the United States were estimated at more than 200 million US$ (Burd et *al*., 1993).

Host plant resistance is the most sustainable, cost-effective and environmentally safe way of controlling RWA. More than ten resistance genes have been identified from *Aegilops tauschii*, rye or wheat (Liu et al., 2001; Smith et *al*., 2004; Lapitan et al., 2007; Peng et *al*., 2007) and used to develop varieties with RWA resistance (Souza et al., 2002; Haley et al., 2004; El Bouhssini et *al*., 2011). However, in North Africa and West Asia (WANA) few sources of resistance to RWA have been identified in durum wheat. Therefore, the objective of this study was to identify sources of resistance to RWA in durum wheat and its wild relatives.

MATERIALS AND METHODS

Initial evaluation

Field test. One hundred and forty four accessions of *Aegilops* spp. and 72 durum wheat lines were evaluated in the field at Tel Hadya, Syria. The genotypes tested were evaluated in two separate experiments using a Lattice design. Five seeds of each entry were planted in hill plots, 50 cm apart. The experiment was repeated three times. Plants were infested at GS 11 (one-leaf stage) on the Zadoks scale, with 50 to 60 insects per hill in two applications using an aphid's pazoka; this corresponds to about 10 aphids per plant. Scoring was done three times during the season: at tillering (GS 20), jointing (GS 30), and post-heading (GS 60), using an ascending damage rating scale from one to six as described by Du Toit (1987):

Du Toit scoring damage scale

Scale	Damage
1	Small isolated chlorotic spots on the leaves.
2	Larger chlorotic spots on the leaves.
3	Chlorotic spots tend to become streaky.
4	Mild streaks visible and leaves tend to roll lengthwise.
5	Prominent white / yellow streaks present, leaves tightly rolled.
6	Severe white / yellow streaks, leaves tightly rolled and starting to die.

Plastic house test. The same germplasm was planted in a plastic house at ICARDA. The same infestation and evaluation procedure for the field test was used, except that only two aphids per plant were used.

Advanced evaluation

After the initial evaluation, the accessions that showed low level (less than 3 in the Du Toit scoring damage scale), 14 durum wheat lines and 5 *Aegilops* accessions, were selected for advanced evaluation. Seeds of each entry and a susceptible check were planted in flats, using a Randomized Complete Block (RCB) design with 10 replications. Five seeds were planted per hill, and upon emergence the number of plants was thinned to three. The evaluation procedure was the same as described above. The data were analyzed using GenStat Ed. 14 (Payne et *al*., 2011).

Categories of resistance

The entries that showed good level of resistance (less than 3 in the Du Toit scoring damage scale) were studied for categories of resistance. Those lines were the following:

Name/Species	Origin/Source
1. *Aegilops biuncialis* 400004	Syria
2. Haucan/Aeg. 400020//omtel-1/3/omlahn	DPT96 314
3. RSP car	DPT96 204
4. *Aegilops ovata* 401650	Morroco
5. *Aegilops ovata* 401650	Tifelt, Morocco
6. Korifla	Susceptible check

Antibiosis (reproduction). Five seeds of each genotype were sown in a standard greenhouse soil mixture, in plastic pots (17 cm in diameter). Randomized Complete Block (RCB) design was used with 10 replications. After emergence, plants were thinned to one seedling per pot. At one leaf stage, each individual leaf seedling was infested with five adult aphids from the plastic house culture. The plants were covered with a plastic cage (30 cm high and 15 cm in diameter) with a cloth screen on the top and screened ventilation holes on the sides. The plants and aphids were observed daily. The adults were removed shortly after five nymphs were present. The nymphs were held on the test plant until they matured and began to reproduce. At this time, all the aphids, except one, were removed from the plant, and the number of nymphs recorded daily until the adults stopped reproducing.

Antixenosis (non-preference). In this test, the six genotypes were planted in a standard plastic house soil mixture in plastic pots (17 cm in diameter). Three seeds of each genotype were planted on the edge of the pots and thinned to one plant per genotype. The experimental design used was an RCB with 10 replications. At the one-leaf stage, when the plants were 5-6 cm high, 60 apterous RWA adults were released in the center of each pot. The number of aphids per plant was recorded at 24, 48 and 72h intervals.

Tolerance (plant damage). Three seeds from each entry were planted in a plastic pot. Upon emergence, seedlings were thinned to one per pot. The plant height from the soil surface of each seedling was recorded before infestation, and plants with similar heights were paired together. For every pair, each plant was infested with 10 apterous RWA adults, and one plant served as a control. All plants were covered with ventilated plastic cages (15 cm in diameter and 35 cm long). The experimental design was a Randomized Complete Block with three replications. Plants were monitored at 48h intervals. Aphids were removed or added to maintain the level of 10 adults per plant. The experiment was terminated 21 days after infestation. Plant height was recorded for both infested and control plants. Damage rates were assigned to infested plants using the DuToit scale. The infested and control plants were cut at soil level, oven-dried (70-75^{o}C) for 3 days, then weighed.

RESULTS AND DISCUSSION

Initial and advanced evaluation tests. Of the 144 accessions of *Aegilops* and 72 lines of durum wheat screened in the initial tests, five *Aegilops* accessions (Table 1) and 14 durum wheat lines (Table 2) were found resistant to RWA. The selected accessions showed various levels of resistance in the advanced screening test based on the DuToit scale; the average damage ranged from 2.25 to 3.0. The highest levels of resistance were found in *Aegilops biuncialis, Aegilops ovata* (Table 1) and durum wheat lines Haucan/Aeg.//Omtel-1/3/Omlahn-3, RSP Car (Table2).

Table 1. Reaction of selected accessions of *Aegilops* spp. for resistance to Russian wheat aphid (plastic house test).

Species/cultivar	**Origin**	**Damage**
Aegilops biuncialis	Syria	2.25
Aegilops ovata	Morocco	2.75
Aegilops ovata	Tifelt, Morocco	2.75
Aegilops ovata	Sefrou, Morocco	3
Aegilops biuncialis	Syria	3
Cham 5 (susceptible check)	APCB 95-10	5
LSD value at (0.05)	2.13	

Table 2. Reaction of selected accessions of durum wheat for resistance to Russian wheat aphid (plastic house test).

Cultivar	**Damage**
Haucan/Aeg.400020//Omtel-1/3/Omlahn-3	2.5
RSP car	2.75
Sbl1/Aeg.	3
Sbl1/Aeg.	3
Krf/BaladiaHamra//Krf/3/T.mon5566/4/Carzio	3
Rufom-5/*T.Araraticum* 500140//Carzio	3
RSP mono	3
RSP mono	3
Waha	3
Mrb5/T.mon5221//Chah88/3/Omguer-1	3
Haucan/Aeg.400020//Omtel-1/3/Omlahn-3	3
Haucan/Aeg.400020//Omtel-1/3/Omlahn-3	3
Haucan/Aeg.400020//Omtel-1/3/Omlahn-3	3
Haucan/Aeg.400020//Omtel-1/3/Omlahn-3	3
Korifla (susceptible check)	5
LSD value at (0.05)	2.28

Categories of resistance

Antibiosis: Significant differences ($P<0.05$) were found among genotypes in antibiosis as measured by the number of nymphs produced per adult, which ranged from 4.2 nymphs from adults feeding on the *Aegilops biuncialis* 400004 to 54.1 nymphs feeding on the susceptible control, Korifla (Table 3). Resistance to RWA is most commonly expressed through antibiosis (DuToit, 1989; Formusoh et al., 1994; Khan et *al*., 2010). The highest level of antibiosis was expressed in *A. biuncialis 400004*, which only produced 4.2 nymphs on average.

Table 3. Russian wheat aphid antibiosis levels of three *Aegilops* accessions, two durum wheat lines and Korifla, the susceptible durum wheat check.

Entry	Number of *D. noxia* nymphs/adult
Aegilops biuncialis 400004	4.2 a
Haucan/Aeg.400020//omtel-1/3/omlahn-3	26.6 b
RSP car	33.0 bc
Aegilops ovata 401650-Tifelt	41.0 bc
Aegilops ovata 401650-Sefrou	29.5 b
Korifla (susceptible check)	54.1 c
LSD value at (0.05)	16.26

Antixenosis: There was a significant difference ($P<0.05$) among genotypes of the number of aphids per plant at 24h, 48h and 72h after aphid release. However, there was only one line (Haucan/Aeg.400020//Omtel -1/3/Omlahn-3) that showed a strong antixenosis effect, with about four aphids per plant across all three period tests; this is 2/3 less than that of the susceptible check (Table 4).

Table 4. Russian wheat aphid antixenosis test of three *Aegilops* accessions, two durum wheat lines and Korifla, the susceptible check.

Entry	Number of aphids/plant		
	24h	48h	72h
Aegilops biuncialis 400004	11.7b	9.0b	4.9 ab
Haucan/Aeg.400020//omtel-1/3/omlahn-3	4.6a	4.2a	4.3a
RSP car	10.3b	9.7b	8.9 bc
Aegilops ovata 401650-Tifelt	10b	10.7b	10.1c
Aegilops ovata 401650-Sefrou	7. ab	7.6ab	7.5 abc
Korifla (susceptible check)	11.2b	10.7b	11.8 c
LSD value at (0.05)	4.34	4.65	4.34

Tolerance: Significant differences ($p<0.05$) were detected between infested and non-infested entries in plant height and dry weight at the end of the test. Percent loss in plant height of infested accessions ranged from 9.2% for *Aegilops ovata* 401650, to 30.4 % for the durum line, RSP car. Similarly, dry weight loss of infested entries ranged from 19.8% for *A.ovata* 401650 to 78% for the durum wheat line, RSP car. The most tolerant entry was *A.ovata* 401650, which had the least loss in dry weight and plant height. Tolerance as category of resistance may provide more stable resistance than antibiosis and antixenosis (Khan et *al*; 2010).

Table 5. Percentage loss in dry weight and plant height of durum wheat lines and *Aegilops* accessions due to Russian wheat aphid feeding.

Entry	Dry weight	Plant height
Aegilops biuncialis 400004	30.2 b	13.3 ab
Haucan/Aeg.400020//omtel-1/3/omlahn-3	54.6 cd	22.7 bc
RSP car	78 d	30.4 c
Aegilops ovata 401650-Tiflet	19.8 a	9.2 a
Aegilops ovata 401650-Sefrou	30.0 b	10.5 ab
(Korifla)	46.6 c	21.6 b
LSD value at (0.05)	14.9	2.88

This study showed that the accessions tested have different categories of resistance to Russian wheat aphid. It is also interesting to note that lines like Haucan/Aeg.400020//omtel-1/3/omlahn-3 have high levels of antibiosis but, at the same time, have a moderate level of antixenosis. Combining different categories should be sought in breeding for resistance to insects, as this will slow down biotype development.

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