Reaction of Durum and Bread Wheat Varieties to Russian Wheat Aphid, *Diuraphis noxia* Attack under Irrigated Condition

Tebkew Damte
Ethiopian Institute of Agricultural Research, DebreZeit Center, P. O. Box 32, DebreZeit Email: tebkew@yahoo.com, damteb@gmail.com

Abstract

The reaction of wheat varieties to Russian wheat aphid (RWA) attack was assessed under field and glasshouse condition at DebreZeit center. In glasshouse test wheat varieties were evaluated in two replications in wooden seedboxes of 60 x 40 x 10cm. The boxes were filled with Vertisoland 20 seeds of each variety were sown in 10cm row spaced at 5cm. In each seedbox unknown number of field collected RWA were introduced at one leaf stage. Degree of leaf chlorosis was scored following 1 to 9 scale and leaf rolling either as flat or rolled. In the field screening, seeds (20 to 25 seeds) of each variety were planted in single row of 1m. Plants were inspected weekly from seedling to ear emergence stage and degree of leaf chlorosis and leaf rolling was scored as described in the glasshouse experiment. In all experiments irrigation water was given at weekly interval. In the glasshouse test, only the durum wheat variety Quamy and the bread wheat varieties Galama and Pavon-76 had chlorotic score of 6.0 and were categorized as moderately resistant/ susceptible to RWA, whereas the rest varieties of both wheat types fell in the susceptible category. Under field conditions the durum wheat varieties Asassa, Bichena, Cocorit 71, Hitosa, Kilinto, Werer, Quamy, Robe and Ude and among the bread wheat varieties Bobicho, Danda'a, Dashen, Enseno, Lackech, Tay and Tosa were moderately resistant/ susceptible to RWA, while the rest wheat varieties were susceptible to RWA. All the tested durum and bread wheat varieties rolled their leaves when attacked by RWA.

Keywords: Russian wheat aphid, resistance, wheat, irrigation, Ethiopia

Introduction

Wheat is produced mainly as rainfed and to a lesser extent as irrigated crop in different regions of Ethiopia. In 2012/13 cropping season nearly 4.6 million households grow wheat on 1.68 million hectare of land and produce more than 3.4 million tons (CSA 2013). However, because of the huge gap between the amount produced and demand for wheat, Ethiopia annually imports large volume of wheat from several countries. For instance, between 2003 and 2012 the average annual import of durum wheat alone was1.98 million tons which worth more than5.9 billion Birr (Ethiopian Revenues and Custom Authority, unpublished report).

Expansion of irrigated wheat land is one way of increasing wheat production in the country. The estimated total irrigable area in eight river basins is more than 3.5 million hectares but currently only about 5% of this potential irrigable area is in use (Makombe et al. 2007). Between 2004/05 and 2011/12 cropping seasons an average of 6,543ha of wheat was grown under irrigation (CSA reports for the respective years). Hagos et al. (2009) indicate that under Ethiopian condition the gross margin from irrigated wheat is twice the gross margin of rainfed wheat. Moreover, wheat variety development for irrigated area has been going on intermittently since the mid-1970s and the varieties pavon76 in 1982, werer in 2009 and Gambo in 2011 were released.

The Russian wheat aphid (RWA), *Diuraphisnoxia* (Hemiptera: Aphididae) assumed pest status in wheat in Ethiopia around 1978 (DZARC 1984) and yield loss assessment in rainfed wheat reveal that it causes complete crop failure in late planted wheat in certain years and locations (Birhanu 1983), whereas in irrigated wheat at DebreZeit a yield loss of 69-93% was reported (Tebkew 2012), which suggest that developing sustainable RWA management method is inevitable. Both contact insecticides and natural enemies are not effective against the RWA as it feeds within leaf whorls and rolled leaves. The use of host plant resistance is economically and socially acceptable, environmentally friendly and sustainable method of RWA management. Consequently, many RWA resistant wheat genotypes have been identified in different countries where RWA is key pest of wheat (Botha et al. 2005, El Bouhssini et al. 2011a). About ten resistance genes (Dn1 to Dn9 and Dnx) were identified and their locations on chromosomes in different cereals including wheat have been determined (El Bouhssini et al. 2011b). Information on wheat resistance to RWA under Ethiopian condition is lacking. The objective of this experiment was to determine the reaction of wheat varieties released for rainfed production to RWA infestation under irrigated condition.

Material and Method

Glasshouse screening

Seedbox screening method was used to evaluate18 durum- and 30 bread – wheat varieties in separate sets for RWA resistance under glasshouse condition. Wooden seedboxes of 60cm long, 40 cm wide and 10cm deep were prepared and filled with black soil (Vertisol). About 20 seeds of each variety were sown in 10cm long row spaced 5cm apart. The space between blocks within a box was 5cm. Water was given once a week. Varieties were set in completely randomized design with two replications. In each seedbox unknown number of field collected RWA were introduced at one leaf stage. Degree of leaf chlorosis on the entire row of plants was scored following 1 to 9 scale of Webster et al. (1991) as:

1= plants appeared healthy, may have few isolated chlorotic spots
2= chlorotic spots become more noticeable, up to 5% of total area
3= chlorotic spots larger and more numerous, up to 15% of the total area
4= chlorosis covers up to 25% of the leaf area. Some streaking may become apparent, especially along the midrib
5=chlorotic spots begin to coalesce, or definite streaking may occur. Chlorosis covers up to 40% of the leaf area
6= larger chlorotic areas from coalesced spots; leaves starting to "dieback" from tips
7= further symptom development; chlorosis covers up to 70% leaf area
8= extensive chlorosis and necrosis; up to 85% of the leaf area affected
9= plant death or no recovery possible

Moreover, leaf rolling was recorded either as flat (F) or rolled (R). Classification of variety's chlorotic score and leaf rolling was as chlorotic score of 1-3 = resistant, 4-6 = moderately resistant/susceptible and 7-9 = susceptible. The last date score (30 days after infestation) was used for categorizing varieties as resistant or susceptible to RWA. Because scores are discrete and not normally distributed, Friedman test was used to test if there were chlorotic scores differences among varieties.

Field screening

The field screening consisted of two sets of experiment. In set I 18 released durum wheat varieties and in set II 45 bread wheat varieties were evaluated under field condition at DebreZeit Center for RWA resistance between January and May in 2012 and 2013 off seasons. Seeds (20 to 25 seeds) of each variety were planted in single row of 1m long. Varieties were arranged in completely randomized block design with three replications. The spacing between rows and blocks was 40cm and 1.5m, respectively. Irrigation water was given at weekly interval. Sprinkler was used to spray water over the experimental field from sowing to crop establishment and flood irrigation was used thereafter. DAP was broadcasted at the time of planting at the rate of 100kg/ha. All plants in a were inspected at weekly interval from seedling to ear emergence stage and degree of leaf

chlorosis and leaf rolling was scored and analyzed as described in the glasshouse experiment. In addition, at maturity grain size was assed as plump or shriveled.

Result and Discussion

Glasshouse response

In Tables 1 and 2 the reaction of durum and bread wheat varieties, respectively, to Russian wheat aphid attack are indicated. Varieties were not statistically different from each other in chlorosis and leaf rolling scores. All the bread- and the durum- wheat varieties rolled their leaves when attacked by RWA. Moreover, 25 days after infestation, the durum variety Arsi Robe and the bread wheat varieties Abola, Dashen, ETBW-4920, HAR-1003, HAR-1868, HAR-934, Kenya leopard, Kubsa and Watera had chlorotic score above 6 and were considered as susceptible. But the remaining wheat varieties had chlorotic score between four and six and fell in the moderately resistant/ susceptible category. However, 30 days after infestation, only the durum wheat variety Quamy and the bread wheat varieties Galama and Pavon-76 had chlorotic score of 6.0 and categorized as moderately susceptible to moderately resistant to RWA, whereas the rest varieties of both wheat types fell in the susceptible category.

Table 1. Response of durum wheat varieties to Russian wheat aphid infestation under glasshouse condition

	Average chlorosis score		
Varieties	25 days after infestation	30 days after infestation	Leaf rolling
Arendato	5.5	8.5	R
Arsi Robe	6.5	8.0	R
Asassa	5.0	6.5	R
Bichena	5.5	7.5	R
Boohai	4.0	7.0	R
Cocorit/71	5.5	8.5	R
Denbl	5.5	7.5	R
Foka	6.0	8.5	R
Gerardo	5.5	8.0	R
Ginchi	6.0	7.5	R
Hitosa	4.0	8.0	R
Kilinto	5.5	8.0	R
LD-357	6.0	8.5	R
Quamy	4.5	5.5	R
Robe	6.5	8.5	R
Ude	4.5	7.0	R
Werer	3.5	6.5	R
Yerer	5.0	9.0	R

Field response

Field responses of the tested varieties in 2012 and 2013 seasons were similar and consequently, only the 2012 season datum was reported. In both seasons the RWA first appeared at three to four leaf stage (Zadok 22), which was equivalent to 15 days after germination. However, chlorotic symptom on leaves was clearly visible two weeks after initial appearance of the aphid. There was no statistically significant difference among the durum wheat varieties in chlorotic score from three leaf stage to the booting stage (Zadok's 45). However, at booting (2 April 2012 score) and ear emergence (Zadok's 51) (11 April 2012 score) stages varieties differed significantly[1] in chlorotic score. At

[1] T_2= 4.58 and T_2= 3.65 for booting and heading stage, respectively, K_1= 2, K_2=34, 0.95 quantile = 3.26)

booting stages varieties Arendeto and Arsi Robe had the highest chlorotic score, whereas varieties such as Robe and Asassa had the lowest (Table 3). Similarly, at the ear emergence stage varieties Arendeto, Arsi-Robe and LD-357 had the highest chlorotic score, whereas Robe, Cocorit 71 and Werer had the lowest chlorotic score. Thus, Arendeto, Arsi Robe, Boohai, Denbi, Foka, Gerardo, Ginchi, LD-357 and Yerer were considered as susceptible to RWA, while Asassa, Bichena, Cocorit 71, Hitosa, Kilinto, Werer, Quamy, Robe and Ude were moderately resistant/ susceptible.

Table.2. Response of bread wheat varieties to Russian wheat aphid infestation under glasshouse condition

Variety	Average chlorosis score (days after infestation)		Leaf rolling	Variety	Average chlorosis score (days after infestation)		Leaf rolling
	25 days	33 days			25 days	33days	
Abola	6.5	8.5	R	HAR-934	6.5	8.0	R
Bobicho	5.5	8.0	R	Hawi	5.0	6.5	R
Dashen	7.0	9.0	R	K6290-BULK	6.0	9.0	R
Dodota	5.5	8.5	R	K6295-4A	4.5	7.5	R
Dure	6.0	9.0	R	Kenya Leopard	6.5	9.0	R
Enkoy	5.5	7.5	R	Ketar	4.0	7.5	R
ET13A2	5.5	6.5	R	Kubsa	6.5	8.5	R
ETBW-462	4.0	7.0	R	Megale	4.5	7.0	R
ETBW-4919	4.0	8.5	R	Millennium	4.5	7.5	R
ETBW-4920	7.5	8.0	R	Mitike	5.0	6.5	R
ETBW-4922	5.5	6.0	R	Pavon-76	5.5	6.0	R
Galama	4.0	5.5	R	Simba	5.5	7.0	R
HAR-1003	7.0	8.5	R	Sirbo	5.0	8.0	R
HAR-1407	5.5	8.5	R	Tura	6.0	7.5	R
HAR-1868	7.0	9.0	R	Watera	7.0	8.5	R

All the bread wheat varieties were not statistically different in their response to RWA attack in all stages of development. However, at the ear emergence stage only 15.5% of the varieties had chlorotic score between 4 and 7.0, but the remaining varieties had score ≥ 7.0 (Table 4). Thus, varieties Bobicho, Danda'a, Dashen, Enseno, Lackech, Tay and Tosa were moderately resistant/ susceptible to RWA, while the rest bread wheat varieties were susceptible. The color of chlorotic tissue is white or yellow longitudinal band in warm climate; but it is red or pink band in cooler climates (Kazemi et al. 2001). The proposed mechanism of chlorosis development in RWA infested cereals is that the aphid injects toxin capable of damaging chloroplast and cellular membrane of leaves (Botha et al. 2005).Therefore, the high chlorotic score of all the bread wheat and most of the durum wheat varieties both in glasshouse and field test shows that the varieties were susceptible to the RWA. This was true in that the varieties were developed for yield in the absence of the aphid during the rain season or protected with insecticide in the presence of the aphid. For instance, Mohammed (1994) sprayed insecticide (dimethoate) to control aphids in wheat evaluation trials for irrigated production.

Table 3. The response of durum wheat varieties to Russian wheat aphid attack under field condition at DebreZeit (2012)

	Average chlorosis score					
Variety	28/2/12	5/3/12	13/3/12	25/3/12	2/4/12	11/4/12
Arendeto	3.0	4.7	5.7	6.7	8.0	9.0
Arsi Robe	3.7	4.0	5.7	5.3	8.0	8.0
Asassa	1.0	2.3	3.7	3.7	4.0	5.3
Bichena	2.7	2.3	3.0	3.0	4.3	5.3
Boohai	2.3	2.7	3.0	3.3	5.3	7.3
Cocorit 71	0.7	2.0	3.0	2.7	3.7	4.3
Denbi	3.0	4.3	4.7	5.3	7.0	7.0
Foka	2.7	4.0	4.7	5.0	7.3	7.7
Gerardo	3.3	4.0	4.7	5.0	7.0	7.0
Ginchi	3.3	3.3	5.0	5.0	5.7	7.7
Hitosa	3.7	2.3	5.3	5.0	6.0	5.7
Kilinto	2.0	3.3	3.0	3.3	4.7	5.7
LD -357	4.0	3.7	4.3	4.3	7.3	8.0
Werer	2.3	3.0	3.7	3.3	4.3	4.0
Quamy	3.0	3.0	3.0	3.7	5.0	5.3
Robe	1.7	1.0	1.3	1.3	3.3	3.7
Ude	2.0	3.3	4.7	3.7	4.7	5.7
Yerer	3.0	3.0	4.0	5.0	7.0	7.7

Table 4. Reaction of bread wheat varieties to Russian wheat aphid attack under field condition at Debre Zeit (2012)

	Average chlorosis score in sampling dates							Average chlorosis score in sampling dates					
Variety	28/2	5/3	13/3	25/3	2/4	11/4	Variety	28/2	5/3	13/3	25/3	2/4	11/4
Abola	3.3	4.0	4.3	5.3	8.0	8.0	K6295-4A	2.7	3.3	3.3	5.0	7.0	8.0
Alidoro	4.7	4.3	5.7	5.7	7.7	8.7	Kakaba	4.3	3.3	4.7	5.0	7.0	7.3
Bobicho	2.7	2.7	3.0	3.7	5.7	6.3	KBG-01	4.0	4.7	4.7	5.7	7.7	7.0
Bollo	2.7	3.0	4.0	5.7	7.0	7.7	Katar	3.0	4.7	5.0	5.7	7.3	8.0
Bulk (K6290)	4.0	4.3	4.7	5.0	7.3	8.0	Kubsa	3.0	4.3	5.0	5.0	6.3	8.0
Danda'a	3.7	4.7	4.3	4.7	5.0	6.3	Kulkulu	5.0	5.3	6.0	6.7	9.0	9.0
Dashen	0.7	1.3	2.3	4.0	4.7	5.7	Lakech	2.7	3.7	5.0	4.7	6.7	6.0
Dereselign	2.0	2.3	3.0	5.0	7.0	7.3	Madawalabu	3.3	4.0	5.0	4.7	7.0	7.7
Digelu	1.7	3.0	3.7	5.7	7.3	8.0	Menze	2.0	3.3	3.7	5.7	7.7	7.0
Dinknesh	1.7	3.3	2.7	5.7	7.3	8.0	Meraro	4.7	4.7	6.3	6.0	7.3	9.0
Dodota	1.3	4.3	4.0	5.3	7.0	7.0	Millennium	3.7	4.0	5.0	6.0	7.7	8.3
Dure	0.7	3.7	3.7	5.0	6.3	7.0	Miteke 1709	3.3	4.3	4.0	6.3	6.7	7.3
Enkoy	2.0	3.0	3.7	4.7	5.7	7.3	Pavon 76	3.0	4.7	5.3	5.3	6.0	7.7
Enseno	2.7	4.0	4.3	5.3	5.3	6.0	Senkegn	1.3	2.7	4.3	5.3	6.7	8.3
ET 13A2	2.0	3.7	3.7	5.0	7.7	7.7	Shorima	4.0	4.7	6.0	6.3	8.3	9.0
ETBW 4919	0.7	2.0	4.3	4.0	6.7	7.3	Simba	5.0	6.3	6.3	6.0	7.7	8.7
Galama	2.7	3.0	4.0	5.3	7.3	6.7	Sirbo	4.7	5.0	6.3	6.7	8.3	9.0
Galil	4.0	5.0	5.7	5.3	6.7	7.7	Sofumer	3.3	5.3	5.3	6.0	7.0	8.7
Gambo	1.7	3.0	3.7	4.3	6.7	7.3	Sulla	4.0	4.3	5.7	5.3	7.7	8.0
Gassay	5.7	6.0	6.0	5.0	7.3	9.0	Tay	3.3	2.7	4.0	4.3	7.0	6.3
Hawi	4.3	5.3	5.7	6.3	7.7	7.3	Tosa	2.7	3.0	4.0	3.7	5.0	6.3
Hoggana	5.7	6.0	6.7	7.3	8.0	8.0	Tusie	5.0	5.3	6.7	6.7	8.3	8.3
Huluka	2.0	3.7	3.0	4.7	7.7	7.7							

In terms of leaf rolling, as in the case of glasshouse response, all the tested durum and bread wheat varieties rolled their leaves when attacked by RWA. The flag leaf was also tightly rolled and all varieties exerted deformed head. Moreover, on the bases of grain size only the durum wheat Cocorit 71, Quamy and Robe (DZ-1640) bore plump grain, whereas the rest durum- and all the bread- wheat varieties bore shriveled grain. According to Botha et al. (2005) leaf rolling after RWA feeding is typical response of susceptible varieties, while Burd et al. (2006) indicate that resistant varieties also roll their leaves when infested by RWA. Thus, the tested varieties could not be classified as resistant or tolerant on the bases of leaf rolling. However, leaf rolling protects the RWA from insecticide and natural enemies, traps the subsequent emerging leaf and head, interferes with pollination and grain filling (Botha et al. 2005, Burd et al. 2006), which suggests varieties with flat leaf are preferred.

The response of the susceptible durum varieties to RWA infestation was constant in field and glasshouse conditions. On the other hand, except Werer, the varieties that exhibited moderately resistant/ susceptible reaction under field condition were susceptible under glasshouse condition. Similarly, the reaction of the tested bread wheat varieties to RWA was also variable under glasshouse and field conditions. The difference in reaction to RWA infestation under glasshouse and field conditions is attributed to the variation in environmental factors such as light intensity, humidity, air circulation and temperature in a glasshouse and open field. Under field condition the reaction of varieties was monitored from three leaf to ear emergence stage (between Zadok's 22 and 51, respectively), therefore the present study gives indication of both seedling and adult pant resistance. Infestation by RWA between growth stages of Zadok's 32 and 49 lead to severe damage and up to 90% yield reduction (Du Toit 1990). The RWA is known to develop biotypes (Dolatti et al. 2004, Burd et al. 2006), even though the Ethiopian RWA population did not show genetic variability (Tesfaye and Stauffer 2007). Therefore, from the perspective of RWA

management moderately resistant/ susceptible varieties are preferable because they require few sprays than the susceptible once and reduce the risk of biotype development. Moreover, laboratory study has shown that partial resistance of wheat to cereal aphids has no effect on population of natural enemies of aphids (Contreras and Niemeyer 2000).

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