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Evaluation of resistance to Sunn pest (*Eurygaster integriceps* Put.) in wheat and triticale genotypes

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ABSTRACT

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Sunn pest (*Eurygaster integriceps* Put.) is one of the major pests of wheat in Iran. Identification of resistant cultivars is an effective integrated pest management (IPM) strategy. To identify the genetic response of wheat and triticale to Sunn pest, and determine the relationship between resistance and morpho-physiological traits, eight bread wheat breeding lines/cultivars, four durum wheat lines, three triticale lines and five synthetic wheat lines were evaluated for resistance to Sunn pest. The response of these genotypes to Sunn pest was evaluated in the field under artificial infestation in cages using a randomized complete block design with three replications. At heading, eight adult insects were released into each cage (30×40×120 cm) and 30 nymphs were released at the grain-filling stage. Spike damage (%) and grain damage (%) were recorded. An analysis of variance revealed significant differences among the genotypes for spike injuries caused by adult insects. Cultivar Falat (1.8% spike damage) showed the least damage and is considered the most resistant genotype. Durum line D-81-15 and Triticale-1, each with 2% spike damage, were more resistant than the other genotypes. Based on grain damage caused by nymphs of Sunn pest, Shiraz, with 13% damage, was the most susceptible genotype. In this study, no significant correlation was observed between resistance to Sunn pest and the measured morpho-physiological traits. Nymph feeding on grain reduced grain protein content, Zeleny sedimentation volume, bread volume, flour water absorption rate, gluten index and grain gluten elasticity.

Key words: bread quality, durum wheat, spike damage, grain damage, resistance.

INTRODUCTION

In Iran, Sunn pest (*Eurygaster integriceps* Put.) is a major pest of cereals, especially wheat and barley. More than two million hectares of cereal growing areas in Iran were sprayed with chemical insecticides against Sunn pest during the 2011 cropping cycle (Anon., 2011). Identification of resistant cultivars would be an effective integrated pest management (IPM) strategy and would also reduce chemical applications. A number of wheats and wheat's wild relatives have been identified as being sources of resistance to this insect pest at the vegetative stage (El Bouhssini *et al*., 2007; El Bouhssini *et al.*, 2009).

Pre-harvest damage to wheat caused by *Eurygaster* spp. and *Aelia* spp. occurs in many countries of the Middle East, Eastern Europe and North Africa (Paulian and Popov, 1980; Gul *et al*., 2006), where it reduces wheat grain yield and bread-making quality (Harri *et al*., 2000). Insect infested grains contain a protease that breaks down the gluten structure of dough (Najafi-Mirak and Mohammadi, 2004; Sivri *et al*., 1999). Previous studies have suggested that Sunn pest's protease causes dough weakening by degrading polymeric glutenin, presumably through hydrolysis and possibly other mechanisms that affect the aggregation of gluten molecules (Sivri *et al*., 2004; Olanca *et al.,* 2009).

Dough prepared with flour from bug-damaged grains has an abnormal consistency due to its soft sticky gluten content, and kneading is very difficult. Baking is unsatisfactory and the resulting bread has poor quality because of its crumbly texture, small volume and low porosity (Mastoukas and Morrison, 1990; Every, 1993). Given that the gluten index of damaged grains degrades over time, it has been suggested that it could be used as a parameter for determining insect attack (Aja *et al*., 2004).

Experiments using nylon mesh cages have shown that susceptibility to insect damage is significantly different among wheat cultivars and breeding lines (Every *et al*., 1997; Najafi-Mirak and Mohammadi, 2004). Some studies have suggested that high quality bread wheat cultivars are more resistant to the damaging effects of insect proteinase than low quality cultivars (Every *et al*., 1997). Mikhailova

(1983) reported a relationship between grain damage and certain morphological traits. However, Every *et al.* (1997) reported that there was no relationship between susceptibility to insect damage and grain characteristics such as color, hardness and texture, or head characteristics such as awns and waxiness.

While some field studies suggest that hard wheat cultivars are attacked more severely by Sunn pest than soft cultivars (Paulian and Popov, 1980), some studies report just the opposite (Kinaci *et al*., 1998; Kinaci and Kinaci, 2007). Kinaci *et al*. (1998) and Kinaci and Kinaci (2004) also showed that white grain cultivars are more severely attacked by the insect than red grain varieties. Small-size starch grains (which are more abundant in the endosperm of susceptible varieties) are rapidly hydrolyzed by the salivary enzymes of the insect (Sazanova, 1973). Shapiro and Nefedova (1985) and Rezabeigi *et al.* (2004) reported that wheat genotypes with large starch grains are more resistant than those with small starch grains in the endosperm.

The use of resistant cultivars is an effective and economical strategy for protecting wheat crops against this insect pest while minimizing the use of pesticides. This study was conducted to identify resistant wheat genotypes and to compare bread and durum wheat and triticale genotypes for resistance to sunn pest.

MATERIALS AND METHODS

Nineteen genotypes, including eight bread wheats, three durum wheats, six synthetic wheats and three triticale lines (Table 1), were evaluated for their response to Sunn pest in a field experiment carried out over two cropping cycles (2005-2006 and 2006-2007). The experiment was performed using artificial insect infestation in the field and a randomized complete block design (RCBD) with three replications. Each genotype was planted in four rows, two meters long, with 20 cm row spacing.

At stem elongation, 50 plants from each plot were placed in three nylon mesh cages (30×40×120 cm). One cage was for evaluating adult insects, another for evaluating nymph damage, and the third cage was the control.

Table 1. Bread wheat, durum wheat and triticale genotypes.

No.	Genotype	Pedigree
1	Azadi	(4820*1-32-15409)*Mexp
2	Falat	Kvz/Buho"s"//Kal/Bb = Seri82
3	Pishtaz	Alvand//AldanIas58
4	Shiraz	Gv/D630//Ald"s"/3/Azd
5	C-79-15	362K2.111/6/NKT/5/TOB/CNO67//TOB/8156/…
6	C-81-4	Ald”s”/Snb”s”/6/T.aest/5/Ti/4/La/3/Fr/Kad/Gb
7	Bahar	BLOYKA ICW84-0008-013AP-300L-3AP-300L-OAP
8	M-81-13	Hahns”s”//Mjl/Lira//Rsh2
9	Dena	Tarro-3
10	Aria	Stork
11	D-81-6	Aghrass-1
12	D-81-15	Coro/Aaz-4/3/Moue/alo//Fdja/4/Carc…
13	Tritcale1	Juanillo 92
14	Triticale2	Mus’s/Beta’s
15	Triticale3	Pesto//2*Tesmo-1/Musx603/ARDI-1…
16	Syn2003-71	CROC-1/AE.SQ.(205)//OPATA CIGM90.393-3Y-5B-2Y-0B
17	Syn2003-74	ALTAR84/AE.SQ.(219)//2*SERI CMSS9201855M-26Y-1M-1Y-0B-0Y-6Y
18	Syn2003-80	BCN//CROC-1/AE.SQ.(879)CASS94Y00256S-4Y-4B-0M
19	Syn2003-89	ALTAR84/AE.SQU(219)//OPATA/3/ALTAR84/AE.SQU(191)//OPATACIGM556-3Y-2B-0PR
20	Syn2003-92	SABUF/3/BCN//CETA/AE.AQU(895)CASS94Y00043S-52PR-1B-0M

At heading, eight adult insects (four males and four females) were released into the first cage (El Bouhssini *et al*., 2009). After three weeks, percent damaged spikes (spikes killed completely or partially) was recorded, and the insects and their eggs were removed from these cages. Biological yield, grain yield, 1000-grain weight (TGW), and number of grains per spike were recorded.

In the second cage, 30 nymphs of age-3 were released on plants at flowering (Zamani *et al*., 2004). Insect larvae feed on spikes for about 20-25 days. After harvest, grain weight per plot, thousand-grain weight, and % damaged grains were recorded. For grains from all cages, grain protein content, gluten (%), bread volume, gluten elasticity, Zeleny sedimentation volume (ml), flour water absorption rate and gluten index were measured based on ICC (International Association for Cereal Science and Technology, 2000) methods.

Data were subjected to simple and combined analyses of variance, and mean comparison was done using Duncan's multiple range test at $P \leq 0.05$.

RESULTS

A combined analysis of variance revealed significant differences among wheat genotypes. Mean comparison of genotypes (Table 2) showed that cultivar Falat had the least spike damage (1.8%)

and was thus considered most resistant to adult Sunn pest at heading (Table 3). Genotype D-81-15 (durum wheat) and Triticale1, with 2% spike damage, were not significantly different from Falat, so they were also recognized as resistant to the adult insect pest. Shiraz, with 13% spike damage, was identified as the most susceptible genotype. Genotypes C-79-15 and Pishtaz (bread wheat), with more than 10% spike damage, were not very different from Shiraz and thus also considered susceptible to adult Sunn pest.

Table 2. Mean comparison of genotypes for grain and spike damages from adult insect and larva of Eurygaster integriceps Put.

Damaged grain (%)			Damaged spike (%)		
Genotype	**Mean**	**Class**	**Genotype**	**Mean**	**Class**
Falat	29.2	a	Shiraz	13.0	a
C-81-4	28.3	ab	C-79-15	11.5	a
Shiraz	27.6	ab	Pishtaz	10.6	ab
Syn2003-74	27.3	ab	Syn2003-74	9.3	abc
Triticale3	24.0	ab	M-79-7	9.1	abc
Syn2003-89	23.9	ab	D-81-6	8.7	abcd
Pishtaz	23.0	ab	C-81-4	7. 9	abcde
C-79-15	22.2	ab	M-81-13	7.9	abcde
Syn2003-92	22.2	ab	Azadi	7.8	abcde
Triticale2	21.9	ab	Tarro-3	6.9	abcde
D-81-15	21.6	ab	Aria	5.7	abcde
D-81-6	21.3	b	Syn2003-80	5.4	abcde
Syn2003-80	19.7	b	Syn2003-92	3. 9	bcde
M-79-7	19.6	b	Tritcale1	3. 9	bcde
M-81-13	17.0	b	Syn2003-89	3.4	cde
Aria	16.8	b	Syn2003-71	2.9	cde
Tarro-3	16.3	b	Triticale3	2.5	de
Syn2003-71	15.5	b	Triticale2	2.0	e
Triticale1	14.2	b	D-81-15	2.0	e
Azadi †		-	Falat	1.8	e

†Impossible to estimate grain damage because of high susceptibility to yellow rust.
Means, in each column, followed by the same letter(s) are not significantly different at the 5% Probability levels using Duncan's multiple range test.

Table 3. **Effect of Sunn pest feeding on three traits associated with grain yield.**

	1000-grain weight (g)		Grain weight per spike (g)		Biological yield (g/50 plants)	
	Adult insect	**Larva**	**Adult insect**	**Larva**	**Adult insect**	**Larva**
Infested samples	47.55	44.98	1.51	1.65	226.50	-
Control (non-infested)	45.05	45.50	1.38	1.38	237.20	-
t-student test	2.80**	0.07ns	2.12*	5.33**	2.91**	-

*** . and ** Significant at the 5% and 1% levels, respectively.**
ns: Not significant

Grain injury caused by Sunn pest nymphs to cultivar Falat (29.2% grain damage) showed that it was the most susceptible to the larvae and new generation of Sunn pest adults, unlike the overwintered adult insects. Genotypes C-81-4, Shiraz and Syn 2003-74, with 28.3%, 27.6% and 27.3% grain damage, respectively, were also more susceptible to Sunn pest nymphs than the other genotypes. Triticale1 (14.2% grain damage) had the least grain damage and was identified as being more resistant than the others to larvae and new-generation adults.

In this study, no significant correlation was found between resistance to Sunn pest and any morpho-physiological traits. This finding is in agreement with results reported by Every *et al.* (1997). The effect of insect feeding on some traits that influence crop yield indicated that adult insects caused significant reduction in biological yield, but did not affect TGW and grain number per spike. Larval feeding on developing grain caused an increase in grain weight (Table 3). Najafi-Mirak *et al.* (1999) also reported that grain weight increased following Sunn pest larval feeding on developing wheat grain.

Comparing the bread-making quality of grains from infested and non-infested plants showed that protein content was reduced from 11.79% in grains of non-infested plants to 11.17% in grains of infested plants. Nymphs' feeding on grains also led to reductions in other bread-making quality traits such as Zeleny sedimentation volume, water absorption rate, gluten index and gluten elasticity (Tables 4 and 5).

The number of adult insects and larvae in each cage (which contained 50 wheat plants) was too high for evaluating wheat's resistance to Sunn pest. This is reflected in the damage caused by adult insects and larvae, which was greater than expected

Table 4. Effect of insect feeding on bread quality traits of genotypes.

	Gluten elasticity	Gluten index	Flour water absorption rate	Bread volume	Zeleny sed. volu
Infested samples	Normal	13.50	63.21	440.80	28.30
Control (non-infested)	Soft	39.20	64.93	480.80	31.58
t-student test	-	**11.89	10.52**	4.38**	7.03**

Table 5. Some of quality traits and bread value of genotypes under insect infested and non-infested c

Genotypes	† Gluten elasticity		Gluten Index		Flour water absorption rate (%)		Zeleny Sed. Volum	
	non-infested	infested	non-infested	infested	non-infested	infested	non-infested	in
1	N	S	42.0	13.2	64.3	50.1	29.8	
2	N	S	48.0	10.0	64.7	62.8	30.8	
3	N	S	50.7	12.8	65.8	62.8	31.0	
4	N	S	31.3	19.5	65.2	63.1	32.0	
5	N	S	39.7	4.5	65.7	63.0	33.4	
6	N	S	50.2	8.4	64.0	62.5	30.0	
7	N	S	35.5	29.3	65.8	62.6	31.6	
8	N	S	37.5	18.8	65.9	62.5	33.0	
9	N	S	39.5	13.3	65.6	62.8	31.4	
10	N	S	45.3	16.8	65.4	63.3	32.4	
11	N	S	51.0	11.5	65.0	63.4	30.6	
12	N	S	34.0	11.8	64.5	63.4	31.2	
13	S	S	32.3	7.2	63.8	62.6	28.8	
14	S	S	15.6	7.0	62.9	62.4	28.4	
15	S	S	36.0	14.8	63.2	62.5	29.2	
16	N	S	44.8	13.8	63.9	62.9	31.2	
17	N	S	32.8	12.0	65.1	62.7	33.8	
18	N	S	39.3	17.0	66.0	64.2	35.2	
19	N	S	35.0	17.8	65.6	63.4	32.2	
20	N	S	33.2	6.2	65.3	63.5	32.6	

† N: Normal; S: Soft.

for example, 14% grain damage in resistant genotypes. Hence, it is suggested that smaller numbers of insects and larvae be used for infestation in similar studies. For example, 4-5 adults and 8-12 larva per meter have been proposed for evaluating Sunn pest resistance in two wheat growth stages: heading and grain-filling. Cultivar Falat had the least spike damage and was regarded as the most resistant cultivar to *E. integriceps* adults under field conditions. Under natural conditions, cultivars resistant to adult insects can help decrease the number of larvae and the density of new adult populations, and may reduce larva damage during grain development. Therefore, using cultivars resistant to adult insects can be useful for lessening the damage caused by Sunn pest larvae.

Cultivar Falat has been reported as resistant to Sunn pest by Rezabeigi *et al.* (2002) and Najafimirak *et al.* (1999). In addition to cv. Falat, one durum wheat (D-81-15) and one triticale (Juanillo 92) line showed some level of resistance to Sunn pest at different growth stages (heading and grain-filling). It could be postulated that the resistance genes in these genotypes may have come from related species of wheat, such as rye (triticale is a cross between wheat and rye). Falat (KVZ/BUHO//KAL/BB) has the short arm of chromosome 1BL/1RS through KVZ (Villareal *et al*., 1995). Resistance in adult plants makes it difficult for insects to attack and feed on wheat spikes. In the field and under natural conditions, adult plant resistance also decreases the population of Sunn pest larvae, thereby reducing the damage they cause to the grain.

Results showed that adult insects caused a significant reduction in biological yield without affecting TGW and grain number per spike; however, the larvae that fed on the developing grain caused increases in grain weight. Therefore, it can be concluded that adult insects decreased grain yield by reducing the number of grains per spike and the number of spikes m^{-2}. This also suggests that the damage caused by larvae feeding on some grains is compensated for by other grains in the same spike, as a larger sink for assimilates translocated from the source.

No significant correlation was found between Sunn pest damage and wheat morphological characteristics such as the presence of wax on leaf and stem, presence of awns, pubescence, spike density, plant height, grain hardness and TGW. A study by Kinaci and Kinaci (2004) supports this finding. One thousand-grain weight, protein content and sedimentation values decreased in response to insect damage by 9%, 17.4% and 71.5%, respectively. Rezabeigi *et al.* (2004) reported a negative correlation between grain damage and grain hardness and a positive correlation between grain damage and awn length in wheat. Najafi-Mirak *et al.* (1999) and Najafi-Mirak and Mohammadi (2004), however, found no significant correlation between grain and spike damage and other morphological traits.

No significant correlations were found between quality characteristics and grain damage. Therefore, it should be possible to find genotypes that show severe grain damage (%), but maintain their bread-making quality. Using quality indices has been suggested for more precise evaluation of bread wheat quality under Sunn pest infestation.

Every *et al.* (1997) also found no correlation between grain damage and morphological traits. It has been suggested that biochemical substances such as silica content in plant tissue, and the amount and activity of plant enzymes that may have inhibiting effects on insect feeding, should be considered in future studies.

REFERENCES

Aja, S., G. Perez, and C. M. Rosell. 2004. Wheat damage by *Aelia* spp. and *Eurygaster* spp.: effects on gluten and water-soluble compounds released by gluten hydrolysis. J. Cereal Sci. 39: 187-193.

Anonymous. 2011. Organization of Plant Protection. Ministry of Agriculture of Iran. http://www.ppo.ir/portal/Home. Accessed 25 September 2011.

El Bouhssini, M., M. Nachit, J. Valkoun, M. Mousa, H. Ketata, O. Abdallah, M. Abdoulhai, B. L. Parker, F. Rihawi, A. Joubi, and F. J. El Haramein. 2007. Evaluation of wheat and its wild relatives for resistance to Sunn pest under artificial infestation. Pp. 363-368. In: B. L. Parker, M. Skinner, M. El Bouhssini, and S. G. Kumari (eds.). Sunn pest management: a decade of progress 1994-2004. Arab Society for Plant Protection. Beirut.

El Bouhssini, M., K. Street, A. Joubi, Z. Ibrahim, and F. Rihawi. 2009. Sources of wheat resistance to sunn pest, *Eurygaster integriceps* Puton, in Syria. Genet. Resour. Crop 56: 1065-1069.

Every, D. 1993. Purification and characterization of a glutenin hydrolyzing proteinase from wheat damaged by the New Zealand wheat bug, *Nysius huttoni*. J. Cereal Sci. 18: 239-250

Every, D., J. A. Farrell, M. W. Stufkens, and A. R. Wallace. 1997. Wheat cultivar susceptibility to grain damage by the New Zealand wheat bug, *Nysius huttoni*, and cultivar susceptibility to the effect of bug proteinase on baking quality. J. Cereal Sci. 27: 37-46.

Gul, A., C. Akbay, and M. Direk. 2006. Sunn pest control policies and effect of sunn pest damage on wheat quality and price in Turkey. Quality and Quantity 40: 469-480.

Kinaci, E., and G. Kinaci. 2007. Genotypic variations in yield and quality of wheat damaged by sunn pest (*Eurygaster* spp.). Pak. J. Bot. 39: 397-403.

Kinaci, E., and G. Kinaci. 2004. Quality and yield losses due to sunn pest (*Hemiptera*: Scutelleridae) in different wheat types in Turkey. Field Crops Res. 89: 187-195.

Kinaci, E., G. Kinaci, A.F. Yildirim, and A. Atli. 1998. Sunn pest problems in Central Anatolia and the role of wheat varieties in integrated control. Euphytica 100: 63–67.

Mastoukas, N. P., and W. R. Morrison. 1990. Bread making quality of ten Greek bread wheats baking and storage tests on bread made by long fermentation and activated (chemical) dough development process and the effects of bug-damaged wheat. J. Sci. Food Agric. 53: 363-367.

Mikhailova, N. A. 1983. Model of a wheat variety resistance to sucking pests. Vse. Inc. Zash. Ras. Ramon. USSR Biol. 2: 32-35.

Najafimirak, T., A. H. Hoseinzadeh, and M. R. Gannadha. 1999. Genetic study of resistance to sunn pest, *Eurigaster integriceps* (Mordvilko), in wheat. Iranian J. Agric. Sci. 3: 495-504.

Najafi-Mirak, T., and V. Mohammadi. 2004. Resistance to Sunn pest (*E. integriceps*) in Advanced lines of Durum and Bread Wheat. 2nd International Conference on Sunn Pest. ICARDA, Aleppo, Syria.

Olanca, B., D. Sivri Ozay, and H. Koksel. 2009. Effects of suni-bug (*Eurygaster* spp.) damage on size distribution of durum wheat (*Triticum durum* L.) proteins. European Food Res. Technol. 229: 813-820.

Paulian, F., and C. Popov. 1980. Sunn pest or cereal bug. Pp. 69-74. In: Hafliger, E. (ed.). Wheat. Basle, Ciba-Geigy.

Rezabeigi, M., G. Radjabi, and G. Nouri Ghanbalani. 2004. The effect of starch size of grain endosperm on the resistance of wheat cultivars to Sunn Pest (*Eurygaster integriceps* Puton). Proceedings of the 2nd International Conference on Sunn Pest, ICARDA, Aleppo, Syria.

Rezabeigi, M., G. Radjabi, G. Nouri Ghanbalani, and G. A. Abdolahi. 2002. Mechanisms of resistance to Sunn Pest (*Eurygaster integriceps* Put.) in wheat cultivars. Proceedings of the 15th Iranian Plant Protection Congress.

Sazanova, V. P. 1973. The anatomy of the grain of wheat varieties with different degrees of resistance to the noxious pentatomid. Tru. Tssi. Sk. Ins. Zash. Ras. USSR. 37: 76-81.

Shapiro, I. D., and L. I. Nefedova. 1985. Endosperm structure as a criterion of resistance to wheat shield bug (*E. integriceps*) in wheat. Ust. Sel. Sk. Ras. Kvre. Opro. Zash. Ras. USSR. 28-34.

Sivri, D., H. D. Sapirstein, H. Köksel, and W. Bushuk. 1999. Effects of wheat bug (*Eurygaster maura*) protease on glutenin proteins. Cereal Chem. 76: 816-820.

Sivri, D., L. I. Batey, D. J. Skylas, L. Daqiq, and C. W. Wrigley. 2004. Changes in the composition and size distribution of endosperm proteins from bug-damaged wheats. Aust. J. Agric. Res. 55: 477-483.

Villareal, R.L., E. Del Toro, A. Mujeeb-Kazi, and S. Rajaram. 1995. The 1BL/1RS chromosome translocation effect on yield characteristic in a *Triticum aestivum* L. cross. Plant Breed. 14: 497-500.

Zamani, P., M. Rezabeigi, M. R. Gannadha, and R. Bozorgipour. 2004. A study of the relationship between resistance to sunn pest (*Eurygaster integriceps* Put.) of different wheat genotypes and starch granules in their grain endosperm. Iranian J. Agric. Sci. 35: 107-114.