American Journal of Agricultural and Biological Sciences 7 (1): 56-60, 2012
ISSN 1557-4989

Wheat Resistance to the Adult Insect of Sunn Pest, *Eurigaster Integriceps* Put

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Abstract: Sunn pest is one of the most serious pests of wheat and barley in Asia, North Africa and Eastern Europe. Using of resistant cultivars is an effective strategy for Integrated Pest Management (IPM). In order to identify the resistant wheat to sunn pest, 79 Iranian bread and durum wheat cultivars\lines were evaluated for resistance to natural infestations of sunn pest in field conditions using CRD with four replications in Karaj in two cropping seasons. Analysis of variance revealed significant differences among the genotypes for overwintered density of the adult insect and spike damage. Based on density of overwintered adult insect, cultivar Darab 2 with an average of 12.6 insects per m^2 had the highest density and was the most susceptible cultivar to pest damage and the cultivars Marvdasht, M-82-6 and Bezostaya with densities of one insect/m^2 were the most resistant wheat genotypes. The density of overwintered adult insects in oat (resistant check) was zero. Based on the results for spike damage, line S-83-13 with 80 damaged spikes per m^2 and the two cultivars MV17 and Gaspard both with 10 damaged plants per m^2 were identified as the most susceptible and the most resistant wheat genotypes, respectively. Oat showed no damage based on this index. Based on the results of this study, it can be deduced that adult insects decrease grain yield through a reduction to number of grains per spike and number of spikes/area. It was also determined that at this growth stage of the sunn pest, those cultivars, which produce late heading and early maturing, incur less damage, indicating that the sunn pest prefers those cultivars that produce plants with more height than the shorter varieties.

Key words: Bread, durum, resistance, sunn pest, wheat, Integrated Pest Management (IPM)

INTRODUCTION

Sunn pest (*Eurygaster spp*.) is the most damaging pest to cereals, especially wheat and barley crops in western and central Asia, North Africa and East Europe (Paulian and Popov, 1980; Miller and Morse, 1996). More than two million hectares of the cereal producing areas of Iran were sprayed with chemical insecticides against the sunn pest during the 2011 cropping season Anonymous, 2011. Identification of resistant cultivars is a potentially effective strategy for Integrated Pest Management (IPM) facilitating a reduction to applications of chemical pesticides. Wheat varieties and some wild relative species have already been identified as sources of resistance to this insect (Mirak and Mohammadi, 2004; Mirak *et al*., 2008; Bouhssini *et al*., 2009)

Pre-harvest bug 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) and damaged crops yield grain with a reduced bread making quality (Hariri *et al*., 2000). Infested grain contains a protease that breaks down the gluten structure of dough (Mirak and Mohammadi, 2004; Sivri *et al*., 1999). Previous studies have suggested that bug protease causes dough weakening by degradation of polymeric glutenin, presumably by hydrolysis and possibly other mechanisms that affect the aggregation of the gluten molecules (Sivri *et al*., 2004; Olanca *et al*., 2009).

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

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Some studies have suggested that high quality bread wheat is more resistant to the damaging effects of bug proteinase than low quality wheat (Every *et al*., 1998). While some field studies have demonstrated that hard wheat cultivars are attacked more severely by the bug than cultivars that produce soft grain (Paulian and Popov, 1980). Kinaci *et al*. (1998) and Kinaci and Kinaci (2004) showed that white cultivars were more severely attacked by sunn bugs than red varieties. Small-sized starch grains are more abundant in the endosperm of varieties susceptible to infestation because they are more rapidly hydrolysed by the salivary enzymes of the insect, therefore wheat genotypes with large starch grains are inherently more resistant than those whose endosperm consist of small starch grains (Sazanova, 1973; Rezabeigi *et al*., 2004).

Chemical spraying is the primary method of controlling sunn pest (Miller and Morse, 1996). This method is very costly, hazardous to humans and the environment and also affects other beneficial insects including those that maintain sunn pest populations at lower levels (Moore, 2000). The use of resistant cultivars is an effective and economical strategy for protecting crops against this pest whilst minimizing the use of pesticides (Mirak and Mohammadi, 2004). This study was therefore conducted to identify sources of resistance in bread and durum wheat genotypes of Iran.

MATERIALS AND METHODS

In order to identify the genetic sources of resistance to sunn pest, *Eurygaster integriceps* Put. 79 bread and durum wheat genotypes were evaluated for their responses to the sunn pest in field conditions. The experiment was performed using a Randomized Complete Block Design (RCBD) with four replications in two cropping seasons. Screening was done under natural insect infestation in Karaj, which is one of the most important cereal-cropping areas of Iran where the sunn pest causes a major loss to wheat and barley crops. Each genotype was planted in 12 rows each 15 m long. The seed rate was 450 seed per m^2. The seeds were treated with Carboxyn tiram fungicide (at a concentration of two-per-thousand) in order to prevent bunt. Insect density and damage were measured at two stages, at the over wintered adult insect stage and the larval stage.

At the heading and flowering stages of wheat, density of insect and damaged spikes were recorded. This was done by construction of four quadrants with metal frames in sizes of $1m^2$ and carefully counting the number of mother bugs and damaged spikes in each quadrant. Also some morphological and physiological characteristics of wheat were recorded as follows: an absence or presence of down and awn, plant colour, days to heading, number of days from January 1st to date of heading, spike density, number of spikelet per spike length (cm) and thousand kernel weight. Correlations between these characters and rates of insect absorption and damage were estimated.

Data were subjected to combined analysis of variance and means of the different traits were compared using Least Significant Difference (LSD) test.

RESULTS

Combined analysis of variance for the two years revealed significant differences among wheat genotypes based on adult insect density and plant damage. Oat hosted an almost negligible quantity of adult insects and was immune to the sunn pest. The average of adult insect numbers in this genotype was less than 0.5 per m^2. Mean comparison of genotypes based on insect densities (Table 1) showed that 13 wheat genotypes had non-significant difference with oat. The cultivars Marvdasht, Bezostaya and Line M-82-6 with pest densities of 1 insect per m^2 were the least preferred wheat by the overwintered sunn pest. Followed by the cultivars; Niknejad, Dn-11, Zarin, Pishtaz, Gaspard, Tous, Shiraz, Shahriar, Mv-17 and M-79-7 with less than 2 insects per m^2, which were considered as the non-preferred wheat varieties for adult insects. Other genotypes had significant differences from oat as an immune check. Nine genotypes with 2-4 insects per m^2 were partly non-preferred by sunn pest. 56 other genotypes were susceptible and of these, the cultivars Arta, Alborz, Atrak, Rye, Tajan and Darab-2 with more than 10 insect per m^2 were the most preferred by the insect. These cultivars were considered as very preferable genotypes to sunn pest.

Oat, which was used as an immune check for sunn pest did not show any plant damage from adult insects. Mean comparison of genotypes based on plant damaged (Table 2) showed that the cultivars MV17 and Gaspard (with 10 damaged plants) incurred the least losses caused by adult insects and could therefore be determined as the most resistant wheat cultivars. Navid, Gascogne and Bezostaya didn’t have any significant difference with resistant genotypes and were considered as resistant wheat cultivars. Other genotypes with more than 19 damaged plants per m^2 were susceptible to sunn pest. Line S-83-18 with 80 damaged plants per m^2 was the most susceptible and followed by S-83-3, Rye, Hiermand and S-80-18 with 71-75 plant damaged per m^2 incurred the most loss from adult insect feeding.

Table 1: Mean comparison of wheat genotypes for number of sunn pest per m^2

No.	Lines/cultivars	Insect Density (No./m^2)	No.	Lines/cultivars	Insect density (No./m^2)	No.	Lines/cultivars	Insect density (No.m^2)
1	Oat	0.4	28	D-81-6	4.6	55	C-83-8	7.6
2	Marvdasht	1.0	29	Akbari	4.8	56	Darya	7.6
3	M-82-6	1.0	30	Mughan-1	4.9	57	D-79-15	7.8
4	Bezostaya	1.0	31	D-82-6	5.0	58	C-81-4	7.9
5	Niknejad	1.3	32	D-76-4	5.1	59	Bc. Roshan(S)	8.0
6	Dn-11	1.4	33	Star	5.6	60	Aria	8.0
7	Zarin	1.4	34	C-81-14	6.0	61	Mughan-2	8.1
8	Pishtaz	1.5	35	Mughan-3	6.0	62	Chamran	8.4
9	Gaspard	1.5	36	Falat	6.0	63	S-80-18	8.4
10	Tous	1.5	37	Dez	6.0	64	Karkheh	8.4
11	Shiraz	1.6	38	Bam	6.0	65	Inia	8.6
12	Shahriar	1.6	39	S-78-11	6.1	66	Khazar-1	8.6
13	Mv-17	1.8	40	Juanillo(Triticale)	6.1	67	Chenab	8.6
14	M-79-7	1.9	41	Roshan	6.1	68	S-83-13	8.6
15	Karaj-3	2.1	42	C-81-10	6.3	69	D-81-15	8.6
16	Navid	2.3	43	Vee/nac	6.3	70	Heirmand	8.8
17	Soisson	2.3	44	S-83-3	6.4	71	S-83-4	9.3
18	Sepahan	2.4	45	Sistan	6.6	72	D-82-1	9.4
19	Alamout	2.4	46	Rassoul	6.8	73	N-80-19	9.5
20	Arvand	2.5	47	Bayat	6.8	74	Arta	10.4
21	Gascogne	3.1	48	Maroon	6.8	75	Alborz	11.1
22	Mahdavi	3.5	49	Kavir	6.9	76	Atrak	11.6
23	Kaveh	3.8	50	C-83-9	7.1	77	Danko (Rye)	12.0
24	Line A	4.3	51	Golestan	7.3	78	Tajan	12.4
25	D-79-2	4.3	52	Shiroudi	7.3	79	Darab-2	12.6
26	Alvand	4.5	53	C-83-7	7.4			
27	Yavaros	4.5	54	Hamoon	7.5			

Lsd (5%) = 1.6; Lsd (1%) = 2.1

Table 2: Mean comparison of wheat genotypes for number of plant damaged from sunn pest per m^2

No.	Lines/cultivars	Damaged plant density (No./ m^2)	No.	Lines/cultivars	Damaged plant density (No./m^2)	No.	Lines/Cultivars	Damaged plant density (No./m^2)
1	Oat	0	28	Shiraz	35	55	D-76-4	45
2	Mv-17	10	29	Mughan-2	35	56	Niknejad	46
3	Gaspard	10	30	Khazar-1	35	57	C-83-9	47
4	Navid	13	31	Line A	35	58	Darya	48
5	Gascogne	14	32	D-82-6	36	59	Pishtaz	49
6	Bezostaya	15	33	Shiroudi	37	60	Atrak	49
7	Karaj-3	19	34	Sepahan	37	61	Golestan	50
8	D-81-15	20	35	Vee/nac	38	62	S-78-11	50
9	Dn-11	21	36	C-83-7	38	63	Tajan	50
10	Alamout	23	37	D-79-2	38	64	Falat	50
11	Juanillo (Triticale)	23	38	Hamoon	38	65	Karkheh	51
12	Soisson	23	39	D-82-1	39	66	N-80-19	54
13	Zarin	23	40	Chenab	39	67	Darab-2	56
14	D-79-15	23	41	S-83-4	40	68	Roshan	57
15	Yavaros	24	42	Kavir	40	69	C-81-4	58
16	Arvand	24	43	Bam	40	70	C-83-8	58
17	D-81-6	24	44	Inia	41	71	Sistan	59
18	Aria	28	45	Kaveh	41	72	Bayat	59
19	Tous	28	46	Chamran	43	73	Arta)	59
20	Marvdasht	29	47	C-81-10	43	74	C-81-14	60
21	M-82-6	29	48	Akbari	43	75	S-80-18	71
22	M-79-7	31	49	Alborz	43	76	Heirmand	71
23	Alvand	31	50	Mughan-1	44	77	Danko (Rye)	72
24	Shahriar	32	51	Maroon	44	78	S-83-3	75
25	Mahdavi	33	52	Mughan-3	44	79	S-83-13	80
26	Dez	34	53	Star	44			
27	Rassoul	35	54	Bc. Roshan(s)	45			

Lsd (5%) = 4.34; Lsd (1%) = 5.7

Table 3: Correlation between sunn pest damage and some traits of wheat genotypes

	Days to heading	1000 kernel weight	Spike Density	Plant height	Damaged plant density
Day to heading	1.000				
1000 kernel weight	-0.287*	1.000			
Spike density	0.246*	0.040	1.000		
Plant height	0.329**	0.017	-0.268*	1.000	
Damaged plant density	-0.299**	0.086	-0.279*	-0.179	1.000
Insect density	-0.437**	0.256*	-0.042	-0.463**	0.576**

Correlation analysis among some traits of wheat genotypes and sunn pest damage (Table 3) showed that there are a negative and high significant correlations between insect density per m^2 and number of days to heading and plant height. Insect density also had a significant positive correlation with 1000 kernel weight of wheat. Number of plants damaged per m^2 had a significant negative correlation with number of days to heading and spike density. Correlation between Number of damaged plants and number of insects per m^2 was positive and had high significance.

DISCUSSION

In this study oat, which had been used as a resistant small grain cereal genotype, did not host any insects and showed no plant damage from adult insects of the sunn pest. Three genotypes of bread wheat the cultivars; Bezostaya, Gaspard and MV17 were not only the most preferred by the insect but also showed no significant plant damaged. Moreover the cultivars Navid and Gascogne were much less preferred by the insect and sustained loss due to damage from feeding by the adult insects, so these cultivars can be considered as resistant wheat genotypes to the sunn pest. Bezostaya and Navid have already been identified as resistant to overwintered sun pest in Iran. The genotypes S-83-13, S-83-3, Heirmand and S-80-18, which had the highest plant damaged from adult insects and were highly preferable by sunn pest were identified as susceptible wheat genotypes to the adult insects. In this study the resistant cultivars are the winter wheat varieties, except for Navid, which is facultative but tolerant to cold (Najafian *et al*., 2008). Susceptible genotypes were mostly those spring wheat varieties. Therefore, it can be inferred that probably there are relationships between tolerance to cold and resistance to sunn pest.

Both adult insect density and plant damage from the pest had a negative and highly significant correlation with days to heading, therefore it was demonstrated that those genotypes that started heading later, incurred less insect damage and those that start heading sooner incurred more insect damage. For example of two crops in similar climatic conditions, the winter sown crop will usually head later than the spring grown crop confirming the presence of a positive correlation between resistance to sunn pest and days to heading in wheat. Unlike days to heading days to maturity of wheat has a positive correlation with sunn pest damage (Geits and Pavlov, 1977; Susidko and Felko, 1997). Also there was a negative and significant correlation between plant damage and spike density, meaning that the cultivars with more spike density are more tolerant to sunn pest. A negative correlation between insect density per m^2 and plant height demonstrated that overwintered sunn pest prefer the short stemmed wheat for feeding. No significant correlation was found between sunn damage and some other morphological characteristics of wheat such as the presence of wax on leaf and stem, presence of awn and pubescence on wheat. There are different reports with regards to this: reported a positive correlation between grain damage and awn length in wheat but in the researches by Mirak *et al*. (1999) and Mirak and Mohammadi (2004), no significant correlation was found between grain and spike damage and the above mentioned traits.

CONCLUSION

From the results of this study five wheat cultivars can be introduced as resistant to sunn pest in overwintered adult stage, they are; Bezostaya, Gaspard, MV17, Navid and Gascogne. It can also be deduced that adult insects decrease grain yield through a reduction in the number of grains in spike and number of spikes per area. At this growth stage damage by sunn pest showed that those cultivars that produce heading late and early maturing incur less damage and those cultivars with more height were more preferable to sunn pest less than the cultivars that produced shorter plants.

ACKNOWLEDGMENT

We thank the Cereal Research Department of Seed and Plant Improvement Institute (SPII) for their financial supports.

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