Pak. J. Bot., 39(2): 397-403, 2007.

GENOTYPIC VARIATIONS IN YIELD AND QUALITY OF WHEAT DAMAGED BY SUNN PEST (*EURYGASTER* SPP.)

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Abstract

Studies were carried out to investigate the effects of sunn pest damage on thousand grain weight, protein content and sedimentation value of bread wheat (*Triticum aestivum*) genotypes grown under natural sunn pest infestation during 1993-94, 1994-95, 1995-1996. Sunn pest damage varied among wheat genotypes. Thousand grain weight, protein content and sedimentation values were decreased significantly as sunn pest damage increased. Decrease in thousand grain weight, protein content and sedimentation value due to sunn pest damage recorded was 17.7, 18.2 and 77.2%, respectively. Wheat genotypes with hard red grains were less affected from sunn pest damage than soft white grains. Results of this research demonstrate the existence of substantial variation among wheat genotypes in the damage due to sunn pest that gives opportunity for selection of less damaged wheats which can be grown directly for production and use in wheat breeding programmes to improve resistance against sunn pest.

Introduction

Sunn pest (*Eurygaster* spp.) attacks and damages the cereals in several countries of Middle East and Europe (Paulian & Popov, 1980; Javahery, 1996; Critchley, 1998; Moore, 2000). Compared to other species, bread wheats posses high sensitivity to sunn pest damage. Sunn pest attack is expressed as the percentage of attacked grains (Popov *et al*., 1996). Investigation on densitiy of bugs and number of damaged grain relation showed that one single new generation nimph feed on 40-55 grains until become adult (Boyacıoğlu, 1998). When grains is attacked during milk stage, most of its contain may suck by bug which results in significant decrease of thousand grain weight and test weight (Rashwani, 1984; Karababa & Ozan, 1998; Waage, 2000; Rosell *et al*., 2002a). If it is damaged during or after dough stage, the bug inject a saliva into grain to soften it to be able to pierce. This salivary secretion contains proteolitic enzymes which breakdown of proteins in grains (Cressey, 1987; Sivri *et al*., 1999; Rosell *et al*., 2002b). Secretion of proteolitic enzymes by saliva into grain greatly lower the baking quality of the dough. If as little as 3% of the grain is in such condition, it is enough for the whole grain lot to be considered unacceptable for any baking purposes (Popov *et al*., 1996).

If the flour of damaged wheat is used for bread making, because of the proteolytic enzymes in it, the dough tend to become runny and sticky which produce a low volume and poor texture (Boyacıoğlu, 1998; Waage, 2000). The extent of hydrolysis of High Molecular Weight (HMW) glutenin subunits due to incubation showed variation among cultivars. This may indicate a better tolerance of certain varieties to the sunn pest damage (Sivri & Köksel, 1996).

The primary method for controlling sunn pest is chemical spraying (Popov *et al*., 1996). Chemical treatments for sunn pest are very costly, hazardous to human and environment and also affects the beneficial insects which maintain sunn pest populations at lower levels (Voegele, 1996; Moore, 2000).

Host plant resistance has received substantial consideration and the level of plant resistance against sunn pest has not been well studied. Study on resistance mechanizm and methods to determine resistance to pest are considered as part of integrated pest management and few attempts were made to determine resistant wheat genotypes (Rassipour *et al*., 1996; Paulian & Popov, 1980; Every *et al*., 1996). As part of IPM system, damage levels on genotypes, effect of damage to quality properties and tolerance of genotypes to damage, in other word, genotypes which suffer less from insect damage and resistant varieties has to be investigated and grown in infested areas. This will be an important input to agricultural economy and benefit to producers, millers and bakers. There is little information on the comparison of insect damage on wheat cultivars grown under field conditions. Javahery (1996) in Iran, Every *et al*., (1996) in New Zealand, Kınacı *et al*., (1998) and Karababa & Ozan (1998) in Turkey have tested wheat cultivars against piercing damage under field conditions and they have reported variation between genotypes for response to Pentatomid insect damage in relation with yield and quality features. This study was, therefore, carried out to:

a) compare winter bread wheats for their response to sunn pest damage under field conditions
b) evaluate the effects of years, cultivars and their interaction on the 1000 grain weight (TGW), protein content (PC) and sedimentation values (SV) under insect damage
c) evaluate the relationship between insect damage and the quality characters.

Materials and Methods

The experiment was conducted under field conditions in Central Anatolian Region of Turkey in crop seasons from 1994 to 1996. Soil properties were: pH 7.8, CaCO3 35%, organic matter 1.5 %, soil texture clayey–loam.

Nine winter wheat genotypes were used in the experiment. Five of them were soft white (BDME-10, Kutluk 94, Ak 702, Yayla 305, ES-14), two of them were hard white (Kırkpınar 79, Sertak 52) and two of them were hard red (Partizanka, Kate A-1). Among these cultivars, Yayla 305, Sertak 52, Ak 702 are selections from landrace populations of Central Anatolia. BDME-10, ES –14, Kutluk 94, Kırkpınar 79 are improved by breeding programs for the region. Partizanka is an introduction from former Yugoslavia and Kate A-1 is an introduction from Bulgaria.

Experimental design was randomized complete blocks with 6 replications. Each plot consisted of 6 rows. Grains were harvested from 4 central rows of each plot after maturation to determine level of damage caused by the insects. In each growing season, sunn bug damage (%), thousand grain weight (g), protein content (%), sedimentation value (ml) were determined. To determine the protein content (PC), and sedimantation value (SV), grain samples from plots were milled into flour with Udy mill and sieved for 1.5 minutes. Flour moisture was determined (130^0C for 1 hours).

Estimation of flour protein were done by NIR analysis using a Dickey- John GAC III which was previously calibrated agaist Kjeldahl protein (N x 5.7) determination (American Association of Cereal Chemist Method 46-11) (Anon., 1983). Sedimetation values were determined by Modified Zeleny Sedimentation test (Greenway *et al*., 1965). In this experiment , SV values with 15 ml and less was considered as week while 16-24 ml is medium, 25-36 is strong and over 36 is very strong (Uluöz, 1965).

Using the combined data over three growing seasons, the least significant differences (L.S.D), the analysis of variance and regression analysis were computed (Little & Hills, 1978).

Table 1. Means of the sunn bug damage, thousand kernel weight, protein content and sedimentation value measured for 9 bread wheat genotypes grown over three planting seasons(1994- 1996).

	Sunn Bug Damage (%)			TGW (gr)			PC (%)			SV (ml)		
	94	**95**	**96**	**94**	**95**	**96**	**94**	**95**	**96**	**94**	**95**	**96**
Es 14	7.0	6.2	2.2	28.6	31.4	34.6	9.8	10.5	11.2	6.7	7.0	16.6
BDME-10	7.2	5.3	2.0	28.4	32.4	33.9	9.8	10.7	11.3	5.7	7.7	20.5
Kutluk 94	7.2	5.2	1.8	33.4	35.4	40.6	9.9	11.5	12.1	6.2	9.8	20.8
Ak 702	6.3	4.8	1.8	29.1	31.3	34.5	9.9	11.3	12.0	5.7	8.3	14.2
Yayla 305	6.0	5.0	1.5	30.4	32.2	35.7	10.6	11.6	12.2	6.0	11.0	21.7
Kırkpınar 79	5.3	1.5	1.0	28.7	32.1	34.3	9.6	10.2	10.8	6.7	10.5	21
Sertak 52	4.0	1.7	1.0	32.2	33.6	36.3	10.7	11.4	12.0	13.3	18.0	20.0
Partizanka	2.9	1.0	0.5	29.6	30.6	32.2	10.5	11.6	11.7	13	15.3	25
KateA-1	2.8	1.5	0.7	29.2	31.7	32.1	10.3	10.9	11.5	16.1	21.0	26

Table 2. Reduction in quality values.

	Sunn pest Damage (%)			TGW (%)			PC (%)			SV (%)		
	94	**95**	**96**	**94**	**95**	**96**	**94**	**95**	**96**	**94**	**95**	**96**
Es 14	100	88.6	31.4	17.3	9.2	100	12.5	6.2	100	59.6	57.8	100
BDME-10	100	73.6	27.8	16.2	4.4	100	13.3	5.3	100	77.2	62.4	100
Kutluk 94	100	72.2	25.0	17.7	12.8	100	18.2	5.0	100	70.2	52.9	100
Ak 702	100	76.1	28.6	15.7	9.3	100	17.5	5.8	100	59.9	41.5	100
Yayla 305	100	83.3	25.0	14.8	9.8	100	13.1	4.9	100	72.4	49.3	100
Kırkpınar 79	100	28.3	18.9	16.3	6.4	100	11.1	5.6	100	68.1	50.0	100
Sertak 52	100	42.5	25.0	11.3	7.4	100	10.8	5.0	100	33.5	10	100
Partizanka	100	33.3	16.7	8.1	5.0	100	10.3	1.0	100	48	38.8	100
KateA-1	100	53.6	25.0	9.0	1.2	100	10.4	5.2	100	43.5	19.2	100

Results and Discussion

Damaged wheat plant by sunn pest was recorded as 0.5% to 7.2% in three years (Table 1). Under same infestation levels of sunn pest, the damage estimated on genotypes were quite different. Five soft white and two hard white wheat genotypes were damaged considerably higher than two hard reds in first two years of the experiment. This may mean that some genotypes less preferred or have higher resistance to piercing. In the first year, under high infestation Partizanka and Kate A-1 were damaged by 2.9 and 2.8% respectively . These are lower than generally accepted treshold for deletorious effects on grains (Tsen, 1965). In the second year, infestation was somewhat lower than first year, however damage rate on varieties increased to 6.2%. The varieties damaged less than 3% were Partizanka, Kate A-1, Kırkpınar 79 and Sertak 52. In the third year under very low infestation, the damages on grains were less than 3% in all varieties. Flour obtained from the varieties which are damaged less than 3% can be used for baking without flour improvers as stated by Tsen (1965). A combined analysis of variance (ANOVA) over years indicated that the differences between years, genotypes and "years x genotypes" interactions were significant for the sunn pest damage (Table 3). This means that varieties responded differently to the bug damage.

Thousand grain weight (TGW), one of the physical quality indicator of wheat increased from first year to third (Table 2) related with reduction of the damage rate due to lower infestation in second and third year are compared with the first year. TGW loss

was highest in Kutluk 94 with 17.7% which means 177.3 kg/ton production loss. TGW loss in Partizanka was 8.1% and Kate A-1 9% which are equal to 80.5 kg/ton and 90.3 kg/ton production loss respectively. According to Rashwani & Cardona (1984), grain yield was reduced by up to 40% in two wheat varieties by sunn pest damage. TGW loss were higher in the varieties damaged more than 3%. Chritchley (1998), reported that TGW can be reduced by sunn pest damage up to 78-92% of that undamaged grain. Hariri *et al*., (2000) found 24% reduction in TGW due to damage by Pentatomid insects. According to the ANOVA for TGW the years, genotypes and "years x genotypes" interactions were significant which are indications of variation for TGW between wheat genotypes (Table 3).

In protein content, one of the most commonly used criterion of quality in wheat (Williams *et al*., 1998), similar tendency were obtained in the wheat genotypes. It increased from first year to third due to decrease in damage rate (Table 2). Protein content loss in first year were higher than third in Kutluk 94 with 2.2% and Ak 702 with 2.1%. Lowest protein content loss were in Kate A-1, Partizanka and Kırkpınar 79 with 1.2%. The difference between these varieties and Kutluk 94 is only 1% but this difference should not evaluate as small where wheat is the staple food for the people and also grain protein content is frequently considered as grading factor in wheat market because it could in many cases be the determinant factor in the use of a wheat crop (Hoseney & Péna, 1997). Although, the variation exist between the wheat genotypes for PC was not as high as for the TGW and SV but it was still significant. Variations in grain protein content may significantly influence the dough strenght properties of a wheat variety (Hoseney & Péna, 1997).

The sedimentation value (SV) is one of the most considered determinant of protein quality (Williams *et al*., 1988). It was the most affected quality feature from damage caused by sunn pest in all varieties in the experiment. More than 50% SV loss was estimated in all soft white varieties and hard white Kırkpınar 79. Sertak 52 and Kate A-1 had the lowest SV loss with 33.5% and 43.5% respectively followed by Partizanka with 48%. Loss in sedimentation value dropped the gluten strenght from strong to medium in Kate A-1 while the gluten strenght of Partizanka dropped from strong to week and Sertak 52 from medium to week like rest of the other genotypes (Table 1). Lower than medium level of SV spoils the baking quality as reducing the dough mixing tolerance (Dewey, 1963). ANOVA of the SV data showed similar results that obtained for TGW and PC. There was significant differences between genotypes, years and "years x genotypes" interactions for the sedimentation value (Table 3).

The linear regression analysis were done to determine of insect damage and the TGW, PC and SV relationship. These traits were negatively correlated with insect damage in all genotypes (Table 4). All regression coefficients (b values) were significant, indicating that the relationships between sunn bug damage and TGW, PC and SV were strong. The rate of reduction in TGW due to each percent of sunn pest damage varied from 0.78 g in Partizanka to 1.19 g in Kutluk 94. Variation in reduction of TGW because of the bug damage was determined as 36-94%. Lowest correlation between insect damage and TGW was in Partizanka, Kate A-1 and Kırkpınar 79, respectively.

Reduction in PC was highest in Kate A-1 with 0.43% and lowest in Kırkpınar 79 with 0.20%. From 71% to 87% variation in reduction of PC accounted for sunn pest damage in wheat genotypes.

Table 3. Combined analyses of variance of four characters data obtained from 9 bread wheat genotypes grown with over three seasons(1994-1996) in Konya.

Sourcers	Mean squares				
	df	Sunn bug damage	TGW	PC	SV
Rep (Year)	15	0.23	0.76	0.01	0.52
Year (Y)	2	219.4**	330.29**	32.3**	2017.5 **
Cultivars (C)	9	38.0**	59.08**	3.28**	277.08**
Yx C	18	4.48**	5.06**	0.34**	25.06**
Error	135	0.43	0.91	0.007	0.54

*p< 0.05. **p<0.01.

Table 4. Relationships between sunn bug damage and TGW, PC, SV in wheats.

Cultivars	TGW			PC			SV		
	Regression equation Y=a + bx	R^2	r	Regression equation Y=a + bx	R^2	r	Regression equation Y=a + bx	R^2	r
Es-14	36.6 – x	0.79	0.89	11.7 – 0.23x	0.81	0.90	20.3 – 2x	0.90	0.95
BDME-10	35.5 –0.81x	0.63	0.79	11.7 – 0.23x	0.77	0.88	23.2 – 2.47x	0.76	0.87
Kutluk 94	42.0 – 1.19x	0.76	0.87	12.7 – 0.33x	0.69	0.83	23.3 – 2.33x	0.81	0.90
Ak 702	36.2 – 1.07x	0.88	0.94	12.8 – 0.40x	0.80	0.89	16.8 – 1.72x	0.90	0.95
Yayla 305	37.3 – 1.10x	0.94	0.97	12.7 – 0.31x	0.77	0.88	26.7 – 3.31x	0.97	0.99
Kırkpınar 79	34.2 – 0.96x	0.60	0.78	10.7 – 0.20x	0.71	0.84	17.6 –1.88x	0.46	0.68
Sertak 52	36.5 – 1.12x	0.74	0.86	12.2 – 0.37x	0.87	0.93	21.7 – 2.07x	0.90	0.95
Partizanka	32.0 – 0.78x	0.36	0.60	11.9 – 0.39x	0.73	0.85	22.5 – 3.15x	0.50	0.71
KateA-1	33.0 – 1.18x	0.58	0.76	11.6 – 0.43x	0.79	0.89	26.9 – 3.50x	0.75	0.86

Regression and correlation coefficient are significantly different at p< 0.01.
Correlation coefficient are negative.

The SV was also correlated negatively with sunn pest damage. The rates of reduction changed from 1.72 ml in Ak 702 to 3.5 ml in Kate A-1. Variation in reduction due to the insect damage was determined as 46% to 99%. According to regression analysis, the relationship between sunn pest damage and SV was lower in Kırkpınar 79, Partizanka and Kate A-1 which means they suffered less than others.

During outbreaks, infestations may result in 100% crop loss (Moore, 2000). Sunn pest has mainly been controlled by chemical pesticides which is costly, hazardous to human and environment safety. The development of new, sustainable and environmentally acceptible alternatives is an important priority. Breeding of resistant or tolerant wheat varieties can serve to be very effective component in integrated control for sunn pest. Sunn pest attack causes yield loss by reducing test weight and TGW and quality loss by reducing PC and SV. Only 2-3% damaged grains can deteriorate baking quality of wheat and it can only be used for animal feeding. Identifiying the varieties whose yield and quality traits are less affected by sunn pest damage is important to reducing production loss. In this research, variations were determined among wheat genotypes to sunn pest damage and the effects of piercing on economic value of grains. Paulian & Popov (1980), Critchley (1988), and Every *et al.*, (1996) reported variations to piercing insects damage in wheats. As a result of this research, when the combination of low insect damage and better quality is considered, Partizanka and Kate A-1 were the best choice.

Yield and quality are important for farmers growing wheat as a subsistence crop and large and small-scale producers growing wheat as a cash crop. Sunn pest is a serious pest of wheat accomplish economic loss in yield and quality. Wheat genotypes investigated in this research were affected differently from sunn pest damage and showed variable loss in yield and quality. Variation in wheats to sunn pest damage gives opportunity to make choice of variety to grow in infested areas. Thus, yield and quality loss can be reduced and chemical control needs will be less. These may reflect as economic gains for producers and even consumers. Lowering the use of chemicals is also an important addition to environmental protection, including beneficial insects. In particular, Kırkpınar 79, Partizanka, Sertak 52 and Kate A-1 were less damaged than other genotypes. Partizanka, Kate A-1 and Sertak 52 suffered less than others for TGW. Partizanka, Kate A-1 Sertak 52 and Kırkpınar 79 were less afected than other wheats for PC and SV. These differential reactions of wheat genotypes can also be used to select potential gene sources for wheat breeding programmes to utilize for resistance against sunn pest.

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(Received for publication 9 September 2005)