Scientific Papers. Series A. Agronomy, Vol. LIX, 2016
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ECONOMIC THRESHOLD IN THE MANAGEMENT OF THE SUNN PEST

Ramazan CANHILAL

Erciyes University, Faculty of Agriculture,
Department of Plant Protection, 38039 Kayseri, Turkey

Corresponding author email: r_canhilal@hotmail.com; ramazancanhilal@erciyes.edu.tr

Abstract

Wheat and barley have a significant insect pest, the sunn pest, Eurygaster integriceps Puton (Heteroptera: Scutelleridae) in Turkey. It affects the yield and the quality of flour of which bread is made. In this study; the yield loss due to white spike damage caused by overwintered adults and kernel damage by nymphs and new-generation adults in wheat fields were defined to set up an economic threshold (ET) for the sunn pest. To evaluate the relationship between overwintered adult density and white spike damage, and between percent kernel damage and sedimentation value of the flour, a regression analysis was performed. White spike damage comprised at low levels (0.1 – 1.7%) in the study fields and the relationship between overvintered adult density and white spike damage was not statistically important in bread and durum wheat. Average damaged kernels by E. integriceps were 4.2% in bread wheat and 5.4% in durum wheat. A positive relationship between nymph and new-generation adult density, and kernel damage in bread and durum wheat was found. We determined the sedimentation values of flour that was made of wheat kernels on which the pest fed. It was 7-89 in bread wheat, and 9-28 in durum wheat. There was no effect of sunn pest density on gluten strength up to 2.1% kernel damage in bread wheat or up to 0.9% kernel damage in durum wheat, but kernel damages above these levels restrained dough quality. We assessed these limit values in the regression formula and we found the economic thresholds as 8.1 and 9.2 nymphs/m² in bread and durum wheat, respectively. While the existing ET (10 nymphs/m²) may still be acceptable in durum wheat, it may be reduced to 7-8 nymph/m² for some wheat varieties and regions, especially for low yield levels (~2000 kg/ha) in bread wheat.

Key words: *economic threshold, wheat, sunn pest*.

INTRODUCTION

Wheat, *Triticum aestivum* L. is grown on about 9 million ha area annually with the production of approximately 20 million tons in Turkey (Anonymous 2008). It is important basic food crop consumed mostly as bread in the country. It provides a substantial component of the human diet; cereal (mostly wheat) products provide 53 and 66% of the per capita dietary supply of calories and protein, respectively (Anonymous 1980). It is also consumed as animal feed and used in industry to make various processsed foods. The country exports the about 10% of wheat production. The South Eastern Region of the country represents 13 and 8% of wheat acerage and production, respectively (Anonymous 2008).

The sunn pest, *Eurygaster integriceps* Put. (Hemiptera: Scutelleridae), is a very damaging insect pest of wheat and barley in Turkey (Lodos 1982). Overwintered adults of the sunn pest attack the leaves and stems of young, succulent wheat and barley plants, causing them to wither and die prior to spike formation. They also suck the base of the spike during the early growing period resulting in whitish spikes without kernels, producing white spikes. Yield losses by this pest are estimated at 50-90% in wheat and 20-30% in barley. Apart from the direct yield reduction, the insect injects digestive enzymes during feeding that reduce the baking quality of the dough. If as little as 2-3% of the grain has been fed on, the entire grain lot may be rendered unacceptable for baking purposes because of poor quality flour (Lodos 1982).

The sunn pest is univoltine. Adults rest under bushes and litter at high elevations around cereal fields during the hot and dry months of late summer and autumn. They hibernate during the cold and often severe winter months on hillsides of the mountains. In spring, when soil surface temperature reaches 15°C at overwintering sites, adults migrate to cereal fields. Migration typically continues for 7-10 d. Overwintered adults appear in the fields over a 1-4 week period. After feeding, females lay eggs on leaves, stems, and spikes. After five nymphal instars, a pupal stage occurs and new-generation adults are seen. These new-generation adults feed and return to higher elevations after barley and wheat harvest (Lodos 1982).

When migration to the fields ends, technical consultants survey fields and overwintered adults are counted in 0.25 m^2 frames to determine field densities. Fields are also monitored for egg parasitism by *Trissolcus* spp. (Hymenoptera, Scelionidae) when 20-30 % of the eggs are 10-12 day-old. Spraying is not conducted if the overwintered adult densities are at or below 0.8, 1.0 and 1.5 adult/m^2 and the parasitism rates are 40%, 50% and 70%, respectively, (Simsek & Sezer 1985). Finally, nymph density is determined in the same manner as for the overwintered adults. The most effective time to spray the sunn pest is during the first two nymphal instars. At the end of the survey, if nymph density reaches 10 nymphs/m^2, fields are sprayed, and this usually coincides with the milky stage of winter wheat (Lodos 1982).

This insect was first reported from the South Anatolia Region of Turkey in 1927 and there have been many outbreaks from the 1950s to the present. Detailed studies on the sunn pest were begun in the 1950s in Turkey (Simsek 1998). The government managed sunn pest control from 1927, until 2001 when an integrated pest management (IPM) approach was adopted. Sunn pest management was changed from aerial application to ground spraying, shifting responsibility to farmers. Currently, ground sprays for sunn pest control are conducted on 1-2 million ha area annually (Anonymous 2004). Government provides technical support and farmers are supposed to apply insecticide with their equipment, as determined by official technical consultants.

One of the key factors affecting the success of IPM programs is economic threshold (ET). The economic threshold used for sunn pest control was established about 50 years ago in the region and Country (Yuksel 1968). There is a need to revise the ET because of changes in climatic conditions, wheat varieties used, agronomical practices, and crop diversity. The purpose of this study was to determine plants (spikes), nymphs and new-generation adults (NGAs) density, and kernel damage caused by nymphs plus NGAs in wheat fields to redefine the ET for the sunn pest in the region.

MATERIALS AND METHODS

The study was conducted in 17 one-ha insecticide-free bread and durum wheat fields in Gaziantep, Kilis and Kahramanmaras provinces in southeastern of Turkey. There were 9 fields of bread wheat and 8 fields of durum wheat. Several varieties of bread and durum wheat were used. Variety was not held constant over all fields.

When the migration of adults from overwintered sites to cereal fields ended, weekly surveys to determine adult and nymph density were begun in each field by using a 0.25 m^2 frame. A total of 25 frames tossed at random in each field were sampled, and overwintered adults, nymphs, and new generation adults were counted in the each frame. The results of these counts were multiplied by 4 and presented.

During the surveys, at the beginning of the milky stage of wheat, all healthy and damaged spikes in each frame were recorded. Before harvest, all plants in each frame were cut and put in a paper bag, and brought to laboratory. In the laboratory, spikes were dried and threshed, and the kernels cleaned. The kernels from each frame were weighed to determine yield per field. The mean yield from 25-0.25 m^2 was used to estimate the yield per ha for each field. Then kernels from all 25 frames were combined and 1-kg kernels taken from this combined kernels for each field. From this sample, 100 kernels, up to 20 times, (total = 2000 kernels) were randomly selected. These sub-samples were checked under the dissecting microscope and damaged and undamaged kernels were separated (Dortbudak 1974), and percent kernel damage was regressed against nymphs and new-generation adult density at the final count in each field.

Sedimentation test: The kernels combined from 25 sampling frames were also used for sedimentation test. All milling was conducted at 23°C and 60% relative humidity. Wheat samples were cleaned and tempered overnight to optimum moisture, as described by Williams et al. (1988). Tempered wheat was milled using

Buhler laboratory mill type MLU-202 (Uzwil, Switzerland), with break roll gaps adjusted to B_2 = 1.2/1000 cm, B_3 = 0.8/1000 cm, C_1 = 1.2/1000 cm and C_3 = 0.8/1000 cm. Medium hard soft-wheat clothing was used. Buhler Bran finisher MLU-302 (Uzwil, Switzerland) was used to extract "bran flour", which was combined with all six flour streams. The Modified Sodium Dodecyl Sulphate (SDS) Sedimentation Test (Cressey & McStay 1987) was used to evaluate wheat-insect damaged in wheat.

Statistical analysis: Regression analysis was used to predict kernel damage (%) based on final nymph and new-generation adult density (P < 0.05). A correlation analysis was applied to determine the relation between overvintered adult density and white spike damage, and between percent kernel damage and sedimentation value (P < 0.05). All statistical analysis was done using SPSS for windows (2003). Data from the two years was combined for regression and correlation analyses.

RESULTS AND DISCUSSIONS

Adult migration was completed during the last week of April and weekly survey studies were started. Sunn pest adults were present in field trials two to four weeks after migration was completed. Nymphs of the sunn pest were seen in the middle of May and reached the new-generation adult stage, which is the most damaging stage, in the first week of June.

Average overwintered adult density was 1.1 per m^2 in bread wheat (Table 1), and 1.4 per m^2 in durum wheat (Table 2). Adult populations in some study fields decreased or increased in consecutive sampling dates. This was likely because of sunn pest movement in or out of the fields.

The nymph population averaged 7.2/m² in bread wheat, and 15.5/m² in durum wheat, respectively. While bread wheat yield averaged 4798 kg/ha (Table 1), yields for durum wheat were 3820 kg/ha (Tables 2).

No leaf or stem damage was observed because when the sunn pest completed migration to the fields, wheat plants reached 10-15 cm in height, and it was late for the sunn pest to damage leaves and stems, as observed by Lodos (1961).

White spike damage (overwintered adult damage): White spike damage occurred at low levels. It averaged 0.3% in bread wheat (Table 1), and 0.6% in durum wheat (Table 2). Correlation analysis indicated that there was no significant relationship between overwintered adult density and white spike damage caused by overwintered adults in bread ($r = 0.288$, $r^2 = 0.083$, $P = 0.226$) or durum wheat ($r = 0.568$, $r^2 = 0.322$, $P = 0.071$).

Canhilal et al. (2005) also found that the low level of white spike damage (<0.1-0.9%) occurred at various overwintered sunn pest adult densities (1, 2, 3, 5, 10 overwintered adults/m²) in large field cages (2 by 2 by 1.7 m) and was not statistically significant in bread or durum wheat.

On the other hand, Kılıç et al. (1973) found that 0.4, 1.0-1.5, 1.6-2.0, and 2.1-2.3 overwintered sunn pest adults/m^2 caused 1.1%, 3.6%, 4.2% and 6.6% white spike damage in wheat fields, respectively.

Şimşek et al. (1997) stated that when overwintered adult density was one adult/m^2, 7% stem damage and 1.9% spike damage occurred.

These high levels of white spike damage differ from our results, perhaps because of high levels of overwintered adult parasitism that might have occurred in the fields, reducing adult feeding and damage.

Kernel damage (nymph and new-generation adult damage) in bread wheat: Average kernel damage caused by nymphs and new-generation adults was 4.2% in bread wheat (Table 1).

There was a positive relation between nymph and new-generation adult density, and percent kernel damage in regression analysis ($r = 0.947$, $r^2 = 0.898$, $P = 0.000$).

The regression equation used to predict percent kernel damage, based on nymph and new-generation adult density per m^2, was $Y = -0.899+0.364X$, (SE a=1.041, SE b=0.046, $P = 0.000$).

Table 1. Overwintered adult and nymph + new generation adult densities of the sunn pest, % kernel damage, sedimentation values, % white spike damage, varieties, and yield in bread wheat field trials in Gaziantep and Kahramanmaras provinces

Place	Variety	Yield kg/ha	No. OW adults[a]/m²	% White spikes	No. nymphs + NGA[b]/m²	% Kernel Damage	Sedimen-tation
T. Tigem	Golye	5210	0.5±0.1	0.1±0.1	1.9±0.2	0.6±0.2	77
I. Hanagzi	Golye	5210	0.5±0.1	0.1±0.1	2.9±0.2	0.4±0.1	64
I. Zincirli	Golye	6260	1.1±0.1	0.2±0.1	4.0±0.3	1.6±0.3	82
N. Ciftlik	Golye	6130	0.6±0.1	0.1±0.1	10.4±0.5	2.1±0.3	52
I. Sakcagozu	Özdemir Bey	4210	4.1±0.2	0.3±0.1	34.1±1.1	6.2±0.6	18
T. Tigem	Golye	4860	0.3±0.1	0.2±0.1	1.0±0.1	0.5±0.1	89
N. Ciftlik	Basribey	4200	0.3±0.1	0.9±0.2	6.2±0.4	1.2±0.2	69
I. Kozdere	Golye	3710	0.5±0.1	0.1±0.1	8.5±0.4	2.2±0.4	63
S. Degirmenonu	Golye	3392	2.4±0.1	0.9±0.2	55.8±1.2	22.7±1.2	7
Mean		4798	1.1	0.3	13.9	4.2	

[a]Over wintered adults, [b]New generation adults

Sedimentation values ranged from 7 to 89. The relation between sedimentation values and percent damaged kernels was strongly negative ($r = -0.821$, $r^2 = 0.674$, $P = 0.003$). The sedimentation value dropped to 52 when percent kernel damage was 2.1 in sedimentation tests (Table 1). No effect of sunn pest density on gluten strength up to kernel damage of 2.1% was detected. Sedimentation value around 50 is generally accepted as the value at which dough quality is ruined (Fouad et al. 2005). When this value is entered in our equation, the nymph density that causes the kernel damage that ruins dough quality (the economic threshold) is 8.1nymphs/m².

The practical tolerance for damaged kernels in industry, regardless of wheat type (bread or durum) or variety, is 2-3%. We found that the expected ET was 9.4 nymphs/m² when the 2.5 value, which is the average of 2-3% of tolerance for damaged kernels, is used in our equation.

The expected ET of 8.1 nymphs/m² obtained from the sedimentation value is different from the ET of 9.4 nymphs/m² calculated from the tolerance level for damaged kernels used in industry and ET (10 nymph/m²) regardless of wheat variety and region in Turkey. Thus, the ET (10 nymph/m²) may be lowered to 7-8 nymph/m² for wheat varieties and regions where there are complaints and practical observations, and especially for low-yield levels (~ 2000 kg/ha) until more detailed research is conducted.

Durum wheat: Average kernel damage was 5.4% in durum wheat (Table 2). A strong, positive relation was determined between nymph and new-generation adult density, and percent kernel damage in regression analysis ($r = 0.859$, $r^2 = 0.738$, $P = 0.003$). The regression equation obtained to predict percent kernel damage, based on nymph and new-generation adult density per m^2, was $Y = - 3.206+0.443X$, (SE a = 2.368, SE b = 0.108, $P = 0.006$).

Sedimentation values varied from 9 to 22. Most fields yielded low sedimentation values and were of poor quality. There was a strong negative relation between sedimentation values and percent damaged kernels ($r = -0.699$, $r^2 = 0.489$, $P = 0.027$). The sedimentation value was 28, which is around the limit that weakens gluten strength (Fouad et al. 2005), when the kernel damage was 0.9% (Table 6). When this level of kernel damage (0.9%) is placed in the equation, the nymph density that causes the kernel damage that spoils dough quality is 9.2 nymphs/m².

As in bread wheat, the expected ET is calculated as 12.9 nymphs/m² when 2.5, which is the average of 2-3% of tolerance for kernel damage, is used in our equation. This is much over the ET that is used (10 nymphs/m²) now in Turkey.

Table 2. Overwintered adult and nymph+new generation adult densities of the sunn pest, % kernel damage, sedimentation values, % white spike damage, varieties, and yield in durum wheat field trials in Gaziantep and Kilis provinces

Place	Variety	Yield kg/ha	No. OW adults[a]/m²	% White spikes	No. nymphs + NGA[b]/m²	% Kernel Damage	Sedimen-tation
O.Kutlar	Ege 88	4015	1.6±0.1	1.7±0.3	29.6±1.0	6.7±1.0	10
O. Havaalanı	Akcakale 2000	4680	2.4±0.1	1.0±0.2	38.7±0.8	19.0±1.6	9
O. Sanko	Ege 88	4660	2.6±0.2	0.6±0.2	14.9±0.5	3.5±0.7	22
E. Yavuzlu	Ege 88	5240	1.1±0.1	0.4±0.1	12.6±0.5	2.7±0.3	13
O. Kutlar	Ege 88	1692	0.2±0.1	0.1±0.1	5.3±0.2	0.9±0.2	28
O. Havaalanı	Akcakale 2000	3000	0.5±0.1	0.3±0.2	14.2±0.4	4.0±0.6	10
Y. Arpaci	Zenit	4776	1.9±0.1	0.4±0.2	26.9±1.0	4.2±0.5	9
E. Yavuzlu	Ege 88	2496	0.6±0.1	0.1±0.1	13.0±0.4	2.3±0.3	17
Mean		3820	1.4	0.6	19.4	5.4	

[a]Overwintered adults, [b]New generation adults

Although the level of kernel damage (0.9%) that weakens the gluten in our study differed from practical tolerance for kernel damage in industry (2-3%), the ET of 9.2 nymphs/m² calculated from the equation and the ET that is currently used (10 nymphs/m²) are similar. Hence, in durum wheat, the tolerance for kernel damage in industry should be lowered about 1%, but the ET which is 10 nymphs/m² appears to be still valid. However, almost no low-level kernel damage was recorded in the study plots; sedimentation was low and damage was high for all measured points. Thus the regression operated close to the lower limit of its valid range when it was used for gluten strength and ET calculations, or for 2.5% damage and ET. This should be considered when the results are used.

CONCLUSIONS

Differences between our results on the tolerance for kernel damage and ET, and the ones that are used in the country might have occurred because our studies and the previous studies were not conducted on the same varieties or in the same region, and there were some changes in climatic conditions, agronomical practices, and crop diversity over time. Therefore, future research should be done based on region, irrigated and rain-fed farming condition, wheat type and variety, and various yield levels.

REFERENCES

Anonymous, 1980. Buğdaydan Ekmeğe. T.M.M.O.B. Yayınları No 26/3. 336 page.

Anonymous, 2004. Technical Instructions for Plant Protection. General Directorate of Protection and Control, the Ministry of Agriculture and Rural Affairs, Ankara, 291p.

Anonymous, 2008. TÜİK Tarımsal Yapı, Üretim, Fiyat, Değer 2006. Türkiye İstatistik Matbaası, Ankara, Nisan 2008.

Canhilal R., Kutuk H., Islamogul M., Kanat A.D., Gul A., 2005. Damage loss assessment of sunn pest, *Eurygaster integriceps* Puton (Hemiptera; Scutelleridae) on wheat in Turkey. Arab J. Plant Protect. In press.

Cressey P.J., McStay C.L., 1987. Wheat-bug damage in New Zealand wheat. Development of a simple SDS-sedimentation test for bug damage. J. Sci. Food Agric., 38: 357-366.

Dortbudak Y., 1974. Investigation on *Eurygaster* species, identification, distribution and population densities in the Southeast Anatolia. General Directorate of Plant Protection and Agricultural Quarantine Research Trace Series, Ministry of Food-Agriculture and Livestock Farm, Ankara, 40 p.

Fouad J.H., El-Bouhssini M., Mafi M.A., Canhilal R., Kutuk H., 2005. The impact of sunn pest density in wheat fields on grain and flour quality. Arab J. Plant Protect. In press

Kılıç A.U., Çatalpınar A., Adıgüzel N., Dörtbudak Y., Çavdaroğlu S., 1973. Investigation on distribution, biology, epidemiology and chemical control of sunn pest (*Eurygaster integriceps* Put.) in the Southeast Anatolia region of Turkey. Annual Report of the Plant Protection Research Institute, Diyarbakır (in Turkish), 121 p.

Lodos N., 1961. Observation on problems of the sunn pest (*Eurygaster integriceps* Put.) in Turkey, Iran and

Iraq. Eagean University, Faculty of Agriculture Publications. Izmir, 15pp.
Lodos N., 1982. Turkey Entomology 2. General, Practical and Faunistic. E.U. Ziraat Fakultesi Yay. No. 429, E. U. Mat. Bornova-Izmir, 591 pp (in Turkish).
Simsek N., Sezer A.C., 1985. Hatay ilinde buğdayda Süne (*Eurygaster integriceps* Put.)'nin yumurta ve nimf popülasyonu ile zararı üzerinde ön çalışmalar. Bitki Koruma Bülteni 25 (1-2): 30-48.
Simsek Z., Simsek N., Ozkan M., Melan K., Derin A., 1997. Sunn Pest. Ministry of Agriculture and Rural Affairs, General Directory of Agricultural Research Publications, Ankara, 39 p.
Simsek Z., 1998. Past and current status of sunn pest (*Eurygaster* spp.) in Turkey. FAO PPCRI Integrated Sunn Pest Control Meeting, Ankara, 6-9 January 1998.
SPSS, 2003. A simple Guide and Reference, 11.0 Update. Pearson Education Inc., Boston, 386 pp.
Williams P.C., El-Haramein F.J., Nakkoul H., Rihawi S., 1988. Crop Quality Evaluation Methods and Guidelines. Technical Manual No. 14. ICARDA, Aleppo, Syria. 145 p.
Yuksel M., 1968. Investigation on distribution, biology, epidemiology and damage of Sunn pest (*Eurygaster integriceps* Put.) in the South and Southeast Anatolia region of Turkey. Publications of General Directorate of Plant Protection and Agricultural Quarantine, the Ministry of Agriculture, No. 46, 255 pp (in Turkish).