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Research Article

Influence of wheat cultivars on digestive enzyme activity and protein content of the Sunn pest, *Eurygaster integriceps* (Hem.: Scutelleridae)

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Abstract: The Sunn pest, *Eurygaster integriceps* (Puton) (Hem.: Scutelleridae), is an economic pest of wheat that reduces the quantitative and qualitative properties of wheat products. We investigated the effect of *E. integriceps* feeding on six different wheat cultivars (Ghermez (Red), Noodle, Antanius, Sabalan, Azar 2 (with two types of cultivation), and Sardari) on the protein content in the adult's gut and fat body and their digestive enzymatic activity. All qualified values of the insect feeding on wheat cultivars differed significantly. The least amount of adult weight and protein content of gut and fat body were observed in the insects fed on Ghermez (Red) cultivar, and the highest amount belonged to the Sardari cultivar. The same results for protein content were obtained from SDS-polyacrylamide gel electrophoresis (SDS-PAGE). Also, the lowest and highest gut α-amylase, pectinase, and protease activities were in Ghermez and Sardari cultivars, respectively. Therefore, it was concluded that the type of wheat cultivar affects the food preference of this insect and, thereby, physiological parameters of the insect gastrointestinal tract. Planting a wheat cultivar like "Ghermez," which may be resistant, can be a suitable and cost-effective method to decrease the chemicals applied against this pest.

Keywords: α-amylase, Pectinase, Protease, SDS-PAGE, Sunn pest

Introduction

Wheat is one of the most important food crops, providing more than 40% of the *per capita* dietary supply of calories and proteins in many developing countries. The Sunn pest, *Eurygaster integriceps* (Puton, 1881) (Hem.: Scutelleridae), is the most economically important insect pest of wheat in Iran, which causes yield loss of up to 30% in barley and 90% in wheat (Davari and Parker, 2018). When the Sunn pest feeds on wheat kernels, it destroys the gluten content and decreases the baking quality of bread (Asgari, 2017).

The most common approach to control the Sunn pest is using chemical pesticides. However, the consistent application of these chemicals has consequences such as harming beneficial insects and causing pesticide resistance (Asgari, 2017). Due to the resistance

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of this insect to a significant number of pesticides, it is necessary to use alternative methods to manage it effectively (Critchley, 1998). One of the best ways to diminish the Sunn pest population in integrated pest management is to use host plant resistance (Mostafavi *et al*., 2005). Plant resistance to insects is a natural phenomenon based on plant self-defense mechanisms, and this phenomenon occurs as a result of plant coexistence with insects. During plant breeding, some important characteristics of plant resistance may be inadvertently lost or, conversely, their sensitivity may increase (Berlinger *et al*., 1997). However, using resistant plants does not have any detrimental effects on the environment, accumulates valuable effects of resistant cultivars over time, and is compatible with other control methods. It is easy to use, reduces production costs, and decreases the use of pesticides (Rezabeigi *et al*., 2000). The plant resistance to the Sunn pest was previously reported from *Aegilops umbellulata* Zhuk (Ali *et al*., 2009) and different wheat cultivars (El Bouhssini *et al*., 2009).

Insect feeding on host plants causes complex physiological reactions in plants (Swingle, 1925). The feeding behavior of this pest is piercing and cutting tissues with their stylet while injecting digestive enzymes through the salivary canal to liquefy the food and make a nutrient-rich slurry (Boyd et al., 2002). The food slurry is ingested through the food canal and passed into the alimentary canal, which is better digested and absorbed (Cohen, 2000). Every digestive enzyme of an insect catalyzes just one reaction in only one composition or a group of structurally related compounds (Laemmli, 1970). Most needed foods by insects are starch, cellulose, hemicellulose, and protein, which are hydrolyzed by digestive enzymes. Amylases can hydrolyze starch (amylose and amylopectin) and glycogen (Lehninger, 1975). α-amylase (endoamylase) (1,4–α–D–glucan glucanohydrolase) hydrolyzes α–1,4 glucosidic bonds in polysaccharides. Pectin is hydrolyzed by pectinase (polygalacturonase), and is a chain of galacturonic acid units linked together by α-1,4 bonds. Proteases are responsible for the full hydrolysis of proteins to amino acids (Bandani, 2013).

The specific activity of an insect's digestive enzymes changes when feeding on different host plants. Sivri *et al*. (2002) investigated the effect of several wheat cultivars on Sunn pest proteases. They demonstrated that some cultivars (Lancer, Ankara, and Gün) with similar levels of intrinsic proteolytic activity had different effects. They claimed that high-quality bread wheat (cvs. Bezostaya, Lancer, Kiraç, and Gün) inhibited Sunn pest protease activity. Furthermore, Kinaji and Kinaji (2004) concluded that soft white wheat kernels suffered the most, and soft red wheat kernels suffered the least damage from the Sunn pest. In addition, Saadati and Bandani (2011) reported that different wheat cultivars significantly affected the weight and lifespan of the Sunn pest. Also, Farhoudi *et al*. (2019) studied the proteinaceous seed extracts of different cultivars of wheat (Hamoon, Karkheh, and Arvand) on Sunn pest α-amylase activity. According to their results, the Hamoon cultivar had the highest, and the Karkheh cultivar had the least inhibitory effects.

Fat bodies play a crucial role in storing protein and energy usage. They are located in the hemocoel and simplify the exchange of metabolites in cells in close contact with the insect's hemolymph (Estela *et al*., 2010). Therefore, research on protein content in the alimentary canal, fat body, and digestive enzymes of true bugs is vital for better understanding digestive physiology and finding effective control methods against these pests based on their digestion (Bandani, 2013).

The current study investigated the changes in the protein content, fat bodies, digestive enzyme activity in the Sunn pest's gut, and weight of the insect feeding on different wheat cultivars. This research aimed to find a cultivar that would affect body weight, the protein content of the fat body and gut, and the digestive enzyme activity of the Sunn pest, which would indicate the cultivar would be suitable for planting in areas where there is an outbreak of this pest.

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Materials and Methods

Materials and equipment

Bovine serum albumin (BSA), Azocasein, Ammonium persulfate (APS) were supplied by Sigma® (St Louis, MO, USA), Coomassie brilliant blue G-250, phosphoric acid (H_3PO_4), ethanol (C_2H_5OH), acrylamide, N,N´-methylene diacrylamide, sodium dodecyl sulfate salt (SDS), Tris, N,N,N´,N´-tetramethyl ethylenediamine (TEMED), glycerol ($C_3H_8O_3$), bromophenol blue, methanol (CH_3OH), acetic acid (CH_3COOH), soluble starch, pectin, 2-hydroxy-3,5-dinitrosalicylic acid (DNS), trichloroacetic acid (TCA), sodium hydroxide (NaOH) for buffer were purchased from Merck® (Darmstadt, Germany), β-mercaptoethanol was from Arman Sina® (Tehran, IRI) and glycine ($C_2H_5NO_2$) was from Scharlau® (Barcelona, Spain). Enzyme activity and protein content were measured using a microplate reader, BioTek® ELx800 (Winooski, Vermont, USA).

Insect rearing

A stock population of adult Sunn pests was collected from wheat (cv. Sardari) field in Mehraban, a rural area near Tabriz, East Azarbayjan province, Iran. The colony was bred on wheat seedlings (cv. Sabalan, a susceptible wheat cultivar) at 26 ± 1 °C Temp., 16:8 (light: darkness) h photoperiod, and 50 ± 5% relative humidity in a 12 × 21× 26 cm container. Eggs were collected, placed in other containers with the same dimensions, and maintained under the same conditions until hatching. The emerged nymphs were separated into containers containing leaves of different wheat cultivars. Fresh wheat leaves were added to the containers every two days. These leaves were selected from wheat cultivars that had reached to physiological maturity stage. Finally, adults reared on different wheat cultivar kernels were used in the experiments.

Wheat cultivars

In this research, six commonly cultivated cultivars in East Azarbayjan province, Iran, were used. All leaves and kernels of different cultivars, Ghermez (Red), Noodle, Antanius, Sabalan, Azar 2 (with two different types of cultivation), and Sardari, were collected from villages of Mehraban, East Azarbayjan Province, Iran. The information about the cultivars is presented in Table 1.

Sample preparation

After feeding the insects for five days, adults were randomly selected without gender discrimination. Each adult insect was weighted on a sensitive digital scale, and the average insect weight was calculated. The adult insect body was anesthetized on ice to start dissection. The whole guts and fat bodies of seven adults were dissected under a stereomicroscope and then inserted in 2 ml microtubes containing 150 and 350 µl dH_2O. Subsequently, samples with five replications were homogenized and centrifuged at 10000 rpm for 30 min at 4 °C. The protein liquid phases were stored at -20 °C until subsequent analyses (Ashouri *et al*., 2017).

Table 1 Specifications of wheat cultivars used in the study (Mikhailova, 1983; Haghparast, 2013; Hossieni Migan *et al*., 2019; Cato and Mullan, 2020; Malihipour *et al*., 2021).

Wheat cultivar	Type of cultivation	Grain color	Grain performance	Positive characteristics
Ghermez	Dryland	Red	High	High gluten
Noodle	Wetland	White	High	Resistant to stem rust, lodging, and drowning
Antanius	Wetland	White	High	Resistant to lodging, high protein
Sardari	Dryland	White	Medium	Resistant to cold climate, grain shedding, lodging, and disease
Azar 2	Wetland	Light	Highest of all cultivars	Resistant to cold and drought stresses
Azar 2	Dryland	Light	Highest of all cultivars	Resistant to cold and drought stresses
Sabalan	Wetland	Yellow	High, especially in cold climates	Resistant to lodging and grain shedding

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Protein content estimation

Protein concentration was estimated according to Bradford (1976) method using bovine serum albumin (BSA) as standard at five concentrations (0.032, 0.063, 0.125, 0.25 and 0.5 mg/ml). Thirty-five adult insects were used in this experiment. The protein sample (10 µl) was mixed with 190 µl Bradford dye and poured into the microplates. The optical density of the samples was recorded at 590 nm using a microplate reader. Based on preliminary results, all samples were diluted 30 times with dH_2O (to reach the desired protein scale according to the standard curve). After that, the protein content of the samples was estimated according to the standard protein curve equation.

SDS-PAGE

Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was established using Laemmli's (1970) method to visualize the protein content and pattern. For this purpose, 12% separating gel and 4% stacking gel were prepared. Before loading the samples on the gel, the protein samples were denatured at 95 °C for 5 min, and β-mercaptoethanol was used in the sample buffer. The electrophoresis was run at 140 volts and 4 °C. The gels were stained using Coomassie brilliant blue R-250 (0.05% w: v in methanol, water, and acetic acid 50:40:10) for 24 h on a shaker and then destained (methanol, water, and acetic acid 40:50:10) for about 24 h again until obtaining blue bands on transparent gel background. Finally, gels were imaged on a scanner. The molecular weight of protein bands was estimated using standard protein ladder SL7011 (11-180 kD, Sinaclon®).

α-amylase and pectinase assays

α-amylase and pectinase relative activities were assayed using 3,5-dinitrosalicylic acid (DNS) (Bernfeld, 1955), 1% soluble starch, and 1% pectin as substrates, respectively. Thirty-five adult insects were used for this experiment. The reaction consisted of 10 µl enzyme, 65 µl universal buffer 0.02 M (Glycine, MES, and Succinate, adjusted by 1 N NaOH to pH 6.5), and 25 µl substrate, which was incubated at 37 °C in a water bath for 30 min. Then 100 µl DNS was added to the microtubes and placed in boiling water for 10 min. After cooling the microtubes, 190 µl samples were poured into the microplates, and the absorbance was read at 540 nm. All the assays were done in five replicates. The activity of enzymes obtained from Sardari fed insects was considered 100 % for finding relative activity, and other enzymatic activities were calculated based on it.

General protease assay

General protease relative activity was assessed using Elpidina *et al*. (2001) and Gatehouse *et al*. (1999) method. Thirty-five adult insects were used during this experiment. The enzyme (10 µl), 40 µl universal buffer 0.02 M (Glycine, MES, and Succinate, adjusted by 1 N NaOH to pH 6.5), and 50 µl azocasein 2% (as substrate) were mixed and incubated at 37 °C in a water bath for 90 min. Then, the reaction was stopped by adding 100 µl of 30% trichloroacetic acid (TCA), and the mixture was kept at 4 °C for 30 min to sediment the non-hydrolyzed substrate. Finally, centrifugation was done at 13000 rpm for 20 min at 4 °C, and 100 µl of 1 N NaOH was added to the 100 µl liquid phase in a microplate, and the absorbance was read at 405 nm. Assays were repeated five times. For finding relative activity, the total protease activity of enzymes obtained from Sardari-fed insects was considered 100%, and the protease activity of the other samples was calculated based on it.

Statistical analysis

The experiment was done in a completely randomized design (CRD), and the data were analyzed by one-way analysis of variance (ANOVA) using SPSS statistics 22 software. Instat 3 software was used for testing the normality of data distribution. Means of the five replicates were compared by the Tukey HSD test for detection of significant differences.

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Results

Total protein content in the gut and fat body

The amount of gut protein in Sunn pest adults fed on wheat cultivars had significant differences ($F_{6,34} = 30.522$, $p < 0.01$) (Fig. 1). The least and highest amount of protein belonged to Ghermez (1.60 mg/ml) and Sardari (12.46 mg/ml) cultivars, respectively. Also, there was no significant difference between Sardari and Sabalan (10.29 mg/ml) cultivars. Subsequently, the highest amount of protein was recorded on Azar 2 dryland (8.55 mg/ml), Antanius (7.78 mg/ml), Noodle (6.85 mg/ml), and Azar 2 wetland (4.83 mg/ml), respectively.

The amount of protein in fat bodies of adults fed on wheat cultivars had significant differences ($F_{6,34} = 12.884$, $p < 0.001$) (Fig. 2). The least and highest amount of protein belonged to Ghermez (0.51 mg/ml) and Sardari (6.33 mg/ml) cultivars, respectively. Also, there were no significant differences between Sardari, Sabalan (5.27 mg/ml), Azar 2 dryland (4.27 mg/ml), and Antanius (3.72 mg/ml) cultivars as well as between Noodle (1.83 mg/ml), Azar 2 wetland (1.24 mg) and Ghermez.

SDS-PAGE

Protein patterns of samples prepared from the gut and fat body of Sunn pest adults fed on wheat cultivars were compared using SDS-PAGE (Fig. 3, A and B). Both gels showed that gut and fat bodies protein bands of adults fed on Ghermez wheat cultivar had the least intensity (column 5). On the other hand, protein bands of adults fed on Sardari cultivar showed the highest intensity (column 1) compared to others. Moreover, the intensity of protein bands related to gut and fat bodies of adults fed on Azar 2 dryland cultivar (column 6) was higher than wetland (column 7). Generally, the information obtained from the Bradford protein content estimation method was verified by the SDS-PAGE.

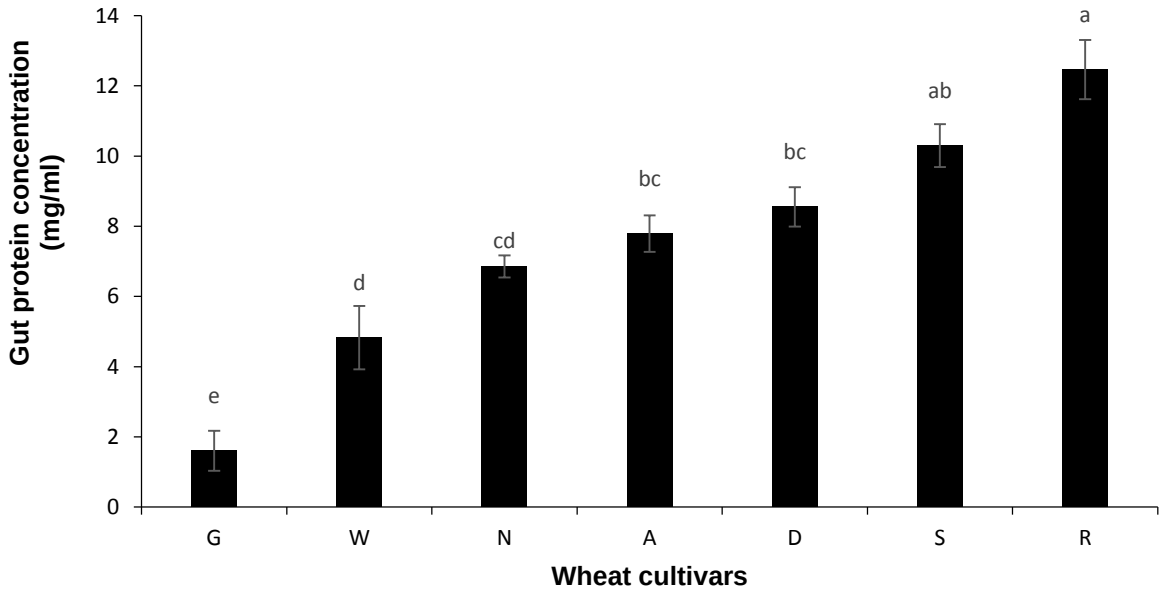

Figure 1 Gut protein content of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.

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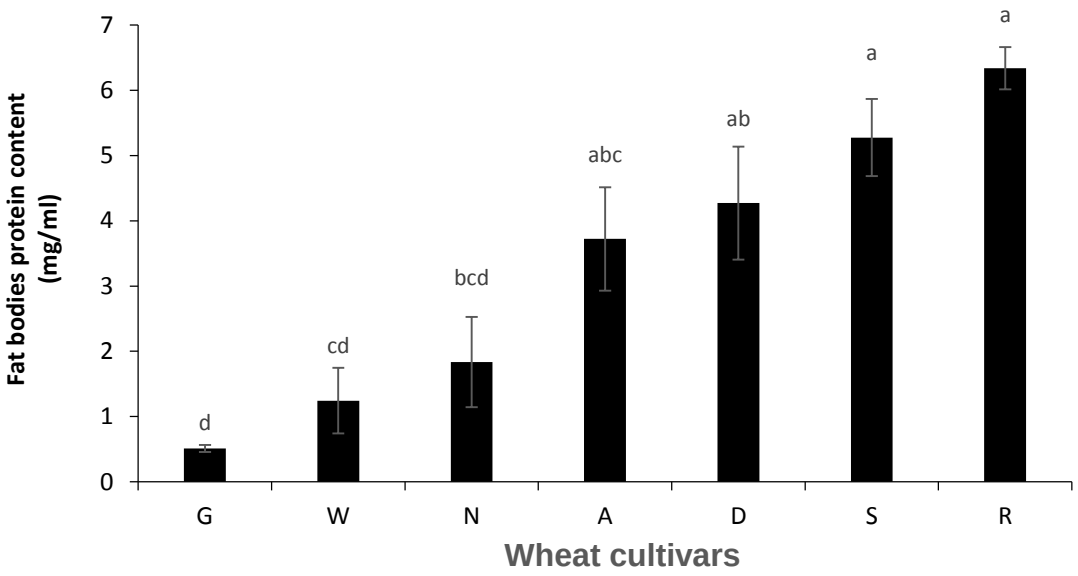
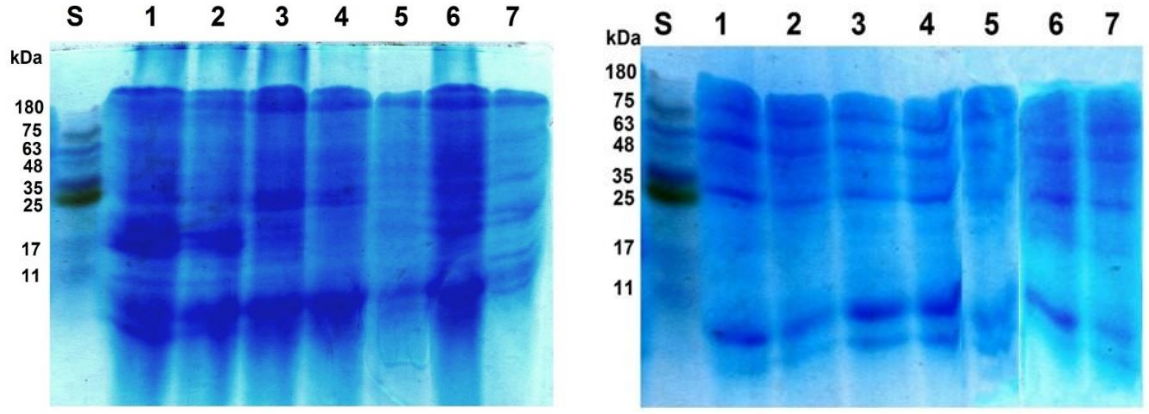


Figure 2 Fat bodies protein concentration of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan, and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.



A **B**

Figure 3 SDS-PAGE gut (A) and fat bodies (B) proteins of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The numbers 1-7 represent Sardari, Sabalan, Antanius, Noodle, Ghermez, Azar 2 dryland, and Azar 2 wetland cultivars, respectively. The letter "S" indicates standard protein (11-180 kDa). Coomassie brilliant blue was used for staining the proteins.

The digestive enzyme activities

The gut α-amylase activities in Sunn pest adults feeding on different wheat cultivars showed significant differences ($F_{6,34} = 4.496$, $p < 0.003$) (Fig. 4). According to the relative gut α-amylase activities of insects fed on Sardari cultivar, which was considered 100%, the least relative α-amylase activity was in the gut of adults fed on Ghermez (59.20%). In addition, non-significant differences were observed between Sardari (100%), Sabalan (100%), Noodle (91.73%), Azar 2 dryland (90.86%), Antanius (81.85%), and Azar 2 wetland

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(69.12%), as well as between data obtained from Azar 2 wetland, Antanius, and Ghermez.

The gut pectinase relative activity of adults was significantly different when fed on different wheat cultivars ($F_{6,34} = 43.817$, $p < 0.001$) (Fig. 5). The lowest relative pectinase activity was on Ghermez (44.91%). Also, results provide information about the non-significant differences in relative digestive pectinase activity between insects that fed on Sardari (100%) and Sabalan (93.20%) cultivars, and also between Noodle (68.53%), Azar 2 wetland (67.48%), Azar 2 dryland (64.31%) and Antanius (78.16%).

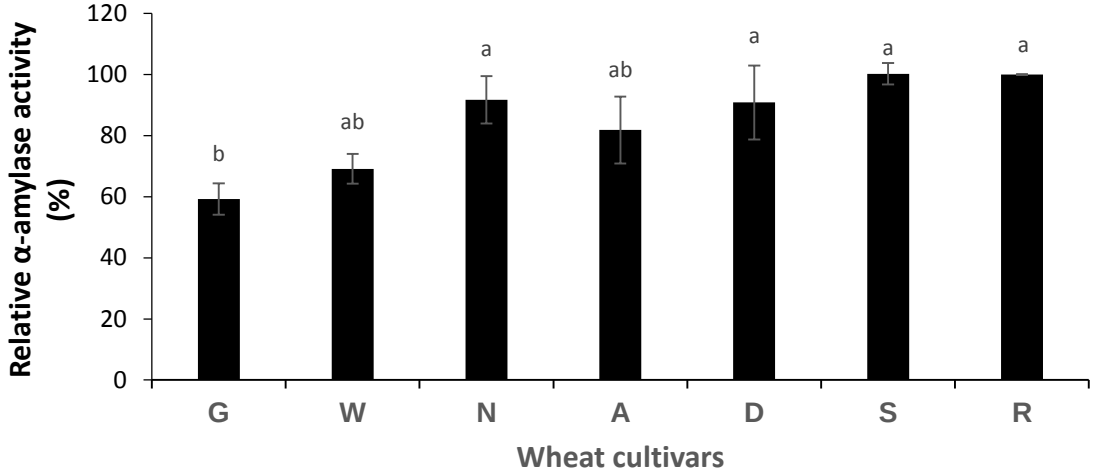

Figure 4 Relative gut α-amylase activity of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan, and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.

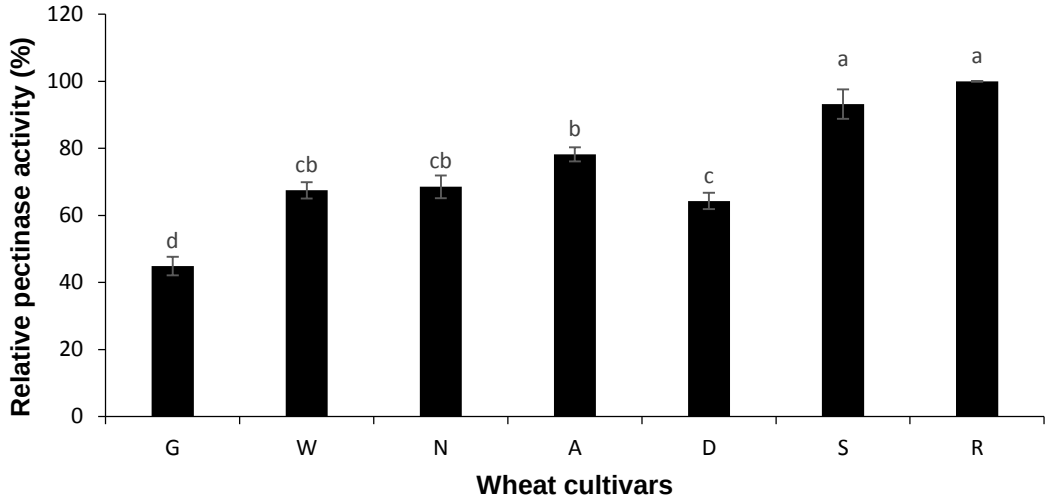

Figure 5 Relative gut pectinase activity of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan, and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.

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Total digestive protease activity of Sunn pest adults fed on different wheat cultivars showed significant differences ($F_{6,34} = 40.573$, $p < 0.001$) (Fig. 6). There were no significant differences in protease activity of the adults fed on Sardari (100%), Sabalan (83.07%), Azar 2 dryland (86.75%), and Antanius (87.42%), and also between Ghermez, Azar 2 wetland (38.65%) and Noodle (50.42%). The least relative protease activity was obtained on Ghermez (33.46%).

Effect of wheat cultivars on the body weight

The weight of adults reared on different wheat cultivars was significantly different ($F_{6,34} = 54.402$, $p < 0.001$) (Fig. 7). The highest and lowest weight of adults belonged to Sardari (104.22 mg) and Ghermez (58.06 mg) treatments, respectively. There were non-significant differences between the weight of adults fed on Ghermez, Noodle (61.23 mg), and Antanius (63.38 mg), nor between Sabalan (80.35 mg), dryland (73.67 mg) and wetland (72.16 mg) Azar 2 cultivars.

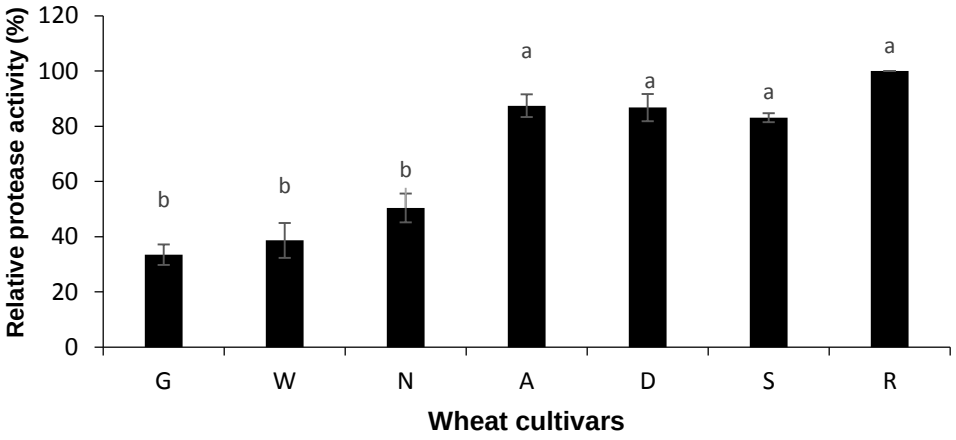

Figure 6 Relative gut total protease activity of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan, and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.

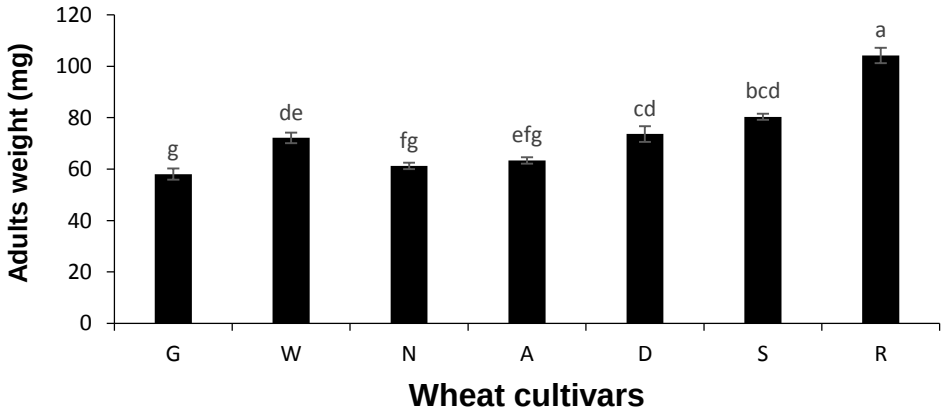

Figure 7 Average weight of *Eurygaster integriceps* adults (35 insects on each cultivar) fed on different wheat cultivars. The letters represent different wheat cultivars: G: Ghermez, W: Azar 2 wetland, N: Noodle, A: Antanius, D: Azar 2 dryland, S: Sabalan, and R: Sardari. Different letters indicate a significant difference ($p < 0.05$) based on Tukey's test.

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Discussion

Investigation of protein content in the insect's gut and fat bodies is essential to emphasize the effect of dietary changes on the amount of protein in main organs, and consequently, disruption of insect digestion and other physiological processes will be achieved in resistant cultivars (Lazarević and Janković-Tomanić, 2015; Canavoso, 2001). To effectively manage pest control using resistant cultivars, it is crucial to study the activity of insect digestive enzymes on different cultivars. If the plant is resistant, the specific activity of insect digestive α-amylase is reduced (Yazdani *et al*., 2010). This study observed that the type of diet affects the enzyme activity of adults, and the insects fed on the Ghermez cultivar had minor enzyme activity. Similar results were observed in the experiments of other researchers. Abdolahadi *et al*. (2016a) showed that proteinaceous seed extract of wheat cultivars (Arvand and Behrang) inhibited the α-amylase activity of *E. integriceps*. Also, Abdolahadi *et al*. (2016b) claimed Sunn pest α-amylase activity inhibition by seed proteinaceous extracts of different wheat cultivars (Bezostaya, Gaspard, and Darab) were 73%, 63%, and 33%, respectively. Wool *et al*. (1986) reported that α-amylase activity of *Tribolium confusum* Jacquelin du Val (Col.: Tenebrionidae) adults highly depended on the type of diet. Feeding corn starch with brewer's yeast, casein, or glutamine significantly increased the enzyme activity compared to insects feeding on pure starch. Nejat *et al.* (2020) illustrated the digestive α-amylase and pectinase activity of *Helicoverpa armigera* (Hübner) (Lep.: Noctuidae) in fifth instars significantly differed when fed on diverse nutrients. They reported the corn-based artificial diet as the unsuitable diet for the insect. In another study on the Mediterranean flour moth, *Ephestia kuehniella* (Lep.: Pyralidae)**,** Mohammadzadeh *et al.* (2020) showed that digestive α-amylase activity of last instar larvae was significantly affected by the decrease in protein content of the gut when fed on different diets. Sivri *et al*. (2002) claimed that between the flour of wheat cultivars, high-quality flours were generally more resistant to proteases of the Sunn pest.

Similarly, the current study recorded the highest protease activity in Sardari, a cultivar with low grain yield. However, the least protease activity was in Ghermez cultivar, known for its high gluten and sound quality (Mikhailova, 1983). Kinaji and Kinaji (2004) investigated the qualitative and functional damage caused by the Sunn pest in different wheat cultivars performed in four groups; soft white, hard white, soft red, and hard red. They concluded that soft white grains had the highest loss, and soft red grains found the least damage. This experiment can be extended to the current study results because Sardari is a white seed while Ghermez is a red seed, which could explain the insect's great desire to feed on Sardari cultivars. On the other hand, following our data, Nasrollahi *et al*. (2019) stated that *E. integriceps* adult males had the highest weight on the Sardari cultivar among 25 wheat cultivars. Therefore, this cultivar was known as a non-resistant wheat cultivar.

Conclusion

It is concluded that planting resistant cultivars of wheat can be a suitable and cost-effective method to reduce the proportion of chemical control usage against the Sunn pest. Sardari and Ghermez are desirable and undesirable cultivars for this insect, respectively. Moreover, in most current experiments, the data obtained from adults fed on Sardari and Sabalan showed non-significant differences. Besides the Sardari cultivar, Sabalan can be considered desirable for this pest. Also, data obtained from adults fed on dryland Azar 2 cultivar was mainly higher than those fed on wetland cultivar, proving the effect of wheat cultivation type on the nutritional value of grains for this pest.

Statement of conflicting interests

The authors state that there is no conflict of interest.

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Author's contributions
Solmaz Ghanbari: Conceptualization, Investigation and Writing Original Draft.

Reza Farshbaf Pour Abad: Supervision and Methodology. Shabnam Ashouri: Writing-Review & Editing, Consultation, Methodology and Data Analysis.

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تأثیر رقم گندم بر فعالیت آنزیم‌های گوارشی و محتوای پروتئینی روده و اجسام چربی سن گندم، *Eurygaster integriceps* (Hemiptera: Scutelleridae)

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چکیده: سن گندم *Eurygaster integriceps* (Puton) (Hem.: Scutelleridae)، آفت اقتصادی گندم است و سبب خسارت کمّی و کیفی روی محصول گندم می‌شود. در این پژوهش، تأثیر تغذیه از شش رقم مختلف گندم (قرمز، نودل، آنتانیوس، سبلان، آذر ۲ (با دو نوع کشت) و سرداری) بر میزان پروتئین موجود در روده و اجسام چربی و نیز فعالیت آنزیم‌های گوارشی حشرات کامل بررسی شد. همه مقادیر به‌دست آمده از حشرات تغذیه کرده از رقم‌های مختلف گندم تفاوت معنی‌داری داشتند. کم‌ترین وزن حشرات کامل و محتوای پروتئینی روده و اجسام چربی در حشرات تغذیه کرده از رقم قرمز و بیش‌ترین مقادیر در اثر تغذیه از رقم سرداری مشاهده شدند. نتایج مشابه برای محتوای پروتئینی از الکتروفورز ژل پلی‌آکریل‌آمید (SDS-PAGE) به‌دست آمد. هم‌چنین، فعالیت آنزیم‌های آلفا- آمیلاز، پکتیناز و پروتئاز در روده حشرات کامل تغذیه کرده از ارقام قرمز و سرداری به‌ترتیب به‌طور معنی‌داری کم‌ترین و بیش‌ترین میزان را دارا بود. بنابراین، می‌توان نتیجه گرفت که نوع رقم گندم بر ترجیح غذایی و در نتیجه مؤلفه‌های فیزیولوژیک دستگاه گوارش سن گندم تأثیر می‌گذارد. کاشت ارقامی از گندم مانند قرمز که می‌توانند به‌عنوان ارقام مقاوم به سن گندم شناخته شوند، روشی مناسب و مقرون به‌صرفه برای کاهش میزان استفاده از سموم شیمیایی برای کنترل این آفت می‌باشد.

واژگان کلیدی: آلفا-آمیلاز، الکتروفورز ژل پلی‌آکریل‌آمید، پروتئاز، پکتیناز، سن گندم

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