Ricos Biology Journal, December, 2024, Vol. 2 (2) 7-17.
www.ricosbiology.net/Vol.2(2)/December-2024/25

RESEARCH ARTICLE
Open Access

Laboratory Assessment of Wheat Cultivar Susceptibility to Angoumois Grain Moth (*Sitotroga cerealella*) Infestation

[1]Fawad Khan, [1]Farman Ali, [2]Imtiaz Ali Khan, [3]Farhanda Manzoor, , [1]Inam Ullah, [4]Bahar Uddin and [5]H.A. El-Sadawy

[1] Department of Entomology, Abdul Wali Khan University, Marden, Pakistan.

[2] Department of Entomology, The University of Agriculture, Peshawar, Pakistan.

[3] Department of Scientific Research and Development Minhaj University, Lahore, Pakistan.

[4] Department of Zoology, Shaheed Benazir University, Upper Dir, Pakistan.

[5]Department of Parasitology and Animal Diseases, Veterinary Institute, National Research Centre, Dokki, Egypt.

[1]Corresponding author: Fawad Khan *medicalentomologist94@gmail.com*

Received: 27-11-2024, **Accepted:** 3-12-2024, **Published online:** 20-12-2024

Abstract

The 2023 study from the Agricultural University Peshawar's PBG Laboratory explored the effects of three wheat varieties—Abaseen-2021, Zarghoon-21, and Taskeen-2022 - on the biological behavior of the Angoumois grain moth *S. cerealella*. Key metrics included progeny development, adult weight, emergence timing, and longevity under "No-Choice" and "Free-Choice" ovarian selection. Abaseen-2021 showed the highest support for moth development, with maximum progeny, weight, and longevity, especially under No-Choice conditions. Taskeen-2022, however, showed the least support for pest proliferation. The results underscore the importance of wheat variety in pest management strategies.

Keywords: Wheat varieties, *S. cerealella*, Progeny development, Adult longevity, Ovarian selection, Pest management.

Introduction

Triticum aestivum has always been the source of food for centuries. In Western nations, varieties like bread wheat (*Triticum aestivum*) and durum wheat (*Triticum durum*) are grown to provide essential nutrients and energy. Today, China and India are the leading wheat-producing countries; this is primarily because wheat uses less water than other crops (**Igrejas and Branlard, 2020**). It is now one of the most important ingredients in a range of processed foods found in modern predominantly urban environments. As an important commodity traded internationally, wheat serves a key role in food

security and the economy. In Pakistan, wheat is a foundational food item and is grown largely in Punjab, Khyber Pakhtunkhwa, Sindh, and Balochistan provinces. As per the Federal Committee on Agriculture (FCA), the wheat output for the 2022 - 2023 season has been estimated at 26.8 million Tonnes (TNI, March 13th, 2023). The area planted under wheat in the 2021-2022 season was approximately 9.2 million hectares with harvesting of about 27.5 million tonnes (PBS 2021-2022). For instance, an area of 0.76 million hectares was cultivated with wheat in Khyber Pakhtunkhwa yielding 1.4 million tonnes (**Ali *et al.*, 2022**).

In Pakistan, wheat constitutes a leading food item whose areas of cultivation are predominantly in Punjab, Khyber Pakhtunkhwa, Sindh, and Balochistan provinces. As per the Federal Committee on Agriculture (FCA), the total estimated production of wheat for the harvest period between 2022 and 2023 was 26.8 million tonnes (TNI, June 2023). For instance, during the 2021-2022 crop season, about 9.2 million Ha were put aside for growing wheat which yielded approximately 27.5 million tonnes (PBS 2021-2022). For example, in Khyber Pakhtunkhwa, about 0.76 million Ha were used to grow wheat resulting in a yield of about 1.4 million tonnes (**Ali *et al.*, 2022**).

Along with that, food and vegetable produce undergo structural changes over time thus requiring adequate storage to reduce spoilage. Thus, effective storage is meant to ensure that food remains fresh and retains its quality until it gets to the market. It is possible for stored products' quality, different kinds as well as their quantities to deteriorate significantly without proper storage conditions (**Sisman and Albut, 2010**). It is estimated that abiotic factors account for about half of crop yield losses with high temperatures causing 20%, low temperature 7%, salinity 10%, drought 9% while other reasons contribute to 4% **(Kajla, 2015).**

Biotic factors basically insect pests have also a considerable effect on the production and quality of products. Crop yields and qualities can be adversely affected by insect pests such as fungi, viruses, arachnids weed as well as rodents. Globally, pests can account for 20-37% yield loss which counts to about 70 billion dollars per year. Wheat is particularly susceptible to devastation by chewing insect pests whereas sucking ones are more harmful **(Qayyum *et al.*, 2021)**. Understanding the major pests and their biology is crucial to minimizing wheat grain losses **(Qayyum *et al.*, 2021)**. Stored grains are endangered by many insect pests, including the Khapra beetle (*Trogoderma granarium*), Confused flour beetle (*Tribolium confusum*), Angoumois grain moth (*S. cerealella*), Saw-toothed grain beetle (*Oryzaephilus surinamensis*), Wheat weevil (*Sitophilus granarius*), Lesser grain borer (*Rhyzopertha dominica*), Rice weevil (*Sitophilus oryzae*), Red flour beetle (*Tribolium castaneum*), and Maize weevil (*Sitophilus zeamais*). The quality and safety of food grains can be severely degraded by these pests (**Shafique and Ahmad, 2003**; **Ahmed and Raza, 2010**). Of all these pests, the Angoumois grain moth (*S. cerealella*) is considered one of the main threats to wheat and other stored products.

Infestation by *S. cerealella* occurs while wheat is still in the field. Female moths lay eggs on the grain either singly or in clusters. The larvae get inside the grain where they eventually exit as adults through a hole that they create. As primary pests, larvae will lay eggs on top of the grain, into holes or cracks with one female laying between 150-400 eggs at once. Initially white, these eggs turn red before hatching between seven days (**Akter *et al.*, 2013**). The entire developmental period for wheat is about 20 days, with the larvae boring into the grain right after hatching and completing their growth in it (**Mason and McDonough, 2012; Hill, 1990**). The larvae undergo five instars before pupating in a reddish-brown cocoon. At 22.3ºC and 68.8% RH, pupation happens on the 15th day after infestation, lasting for 4-7 days. Adult moths do not live long, only up to 15 days while from egg to adult takes about 35-45 days. They do not feed as adults and their larvae cause most damage to stored grains (**Mason & McDonough, 2012; Hill 1990**).

This study evaluates the influence of

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

different wheat varieties on the development of *S. cerealella* and its resistance level against this pest. By examining how varying wheat cultivars affect *S. cerealella progeny* growth, this research will help make better management strategies as well as improve the immunity of wheat varieties against the pest whose damages are significant.

Material and methods

Research Area

The Plant Breeding and Genetics (PBG) Laboratory at The University of Agriculture Peshawar was the site for this research, which was conducted in 2023. The main objective was to evaluate how variations in wheat food properties influence the biological parameters of the Angoumois grain moth, *S. cerealella* (Olivier) (Lepidoptera: *Gelechiidae*) (**Varela *et al.*, 2015**). This research falls into different fundamental areas of study:

Experimental Conditions

Typical storage conditions for wheat and the environmental needs of *S. cerealella* were simulated in the experimental setup. Photoperiod was maintained as 10 hours light/14 hours dark (10L:14D) with a controlled temperature of 27 ± 2 °C and relative humidity at 50 ± 5 % (**Ma *et al.*, 2014**). The aim was to ensure that these experiments were close to the real natural or common storage environments where we used to store our wheat.

Varieties

This investigation was based on wheat varieties namely Abaseen-2021, Zarghoon-21, and Taskeen-2022. The various samples of wheat were obtained from the Plant Breeding and Genetics Laboratory at The University of Agriculture Peshawar. The slightly breaded grains used for the study were properly examined to ensure that they had no infestation and were healthy; thus, providing a steady source of food for insects throughout the experiment (**Ali *et al.*, 2020**).

Insect Material

Sitotroga cerealella adults that were kept under controlled conditions were used as insect material in this study. The adult moths were reared inside plastic containers with muslin covers for adequate aeration. Temperature was set at 27±2°C, while relative humidity remained at 65±5% which promoted better growth and reproduction of the moths (**Akhtar & Alam, 2021**).

No-Choice Test

The No-Choice Test contained 30g samples of each wheat variety in 275ml glass jars. Hence, two pairs of *S. cerealella* adults aged 1-2 days were introduced into each jar for them to lay their eggs. This experiment lasted a week after which the adults were taken out. Afterward, muslin cloth was tied around the jars with rubber bands so that it could not be contaminated. To make sure that these results would be trustworthy, this procedure was made threefold by a completely randomized design (**Ghosh *et al.*, 2019**).

Free-Choice Test

A muslin cloth chamber of dimensions 30 cm by 30 cm was utilized in the Free-Choice Test. In this chamber, there were 30g samples from each of the wheat varieties placed in separate Petri dishes and arranged randomly. Six pairs of *S. cerealella* adults aged 1-2 days old were released into the chamber so that they could have free access to the different types of wheat. One week later, the adult moths were taken out from it after which all grains from each petri dish were moved into 275ml glass jars which were covered with muslin pieces secured by rubber bands. The experiment was also carried out three times in a completely randomized way (**Hossain *et al.*, 2021**).

Statistical Analysis

Statistical analysis was conducted on the data collected from both No-Choice and Free-Choice experiments to determine significant variations among wheat varieties. An analysis of variance (ANOVA) was done through the statistical software called "Statistic 8.1" to evaluate how different varieties affected growth potential for S. cerealella. For comparing means at a 5% significance level ($\alpha = 0.05$), the least significant difference (LSD) test was used to that warranty about rightness of these statistical conclusions.

Results

The results of our research studies examining

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

how various wheat varieties affect the development of *S. cerealella* reveal distinct trends in progeny development, mass of adults, emergence time for first adults, and life span of adults, when measured under No-Choice and Free-Choice conditions. Under these conditions, most Abaseen-2021 always had the highest progeny with an average of about eighty-two pupae plus or minus four adults. There is a significant difference between the performance of Afaseen-21 (55.2 ± 5.8) and Taskeoon-2022 (45.8 ± 2.1). This indicates that this variety provides a particularly conducive environment that favors larval growth in the absence of other available alternatives. Additionally, it had also supported in terms of bodyweight among adults at 17.3 ± 0.5 grams as against Zarghoon Having about twelve point one ± 0.3 and Taskeon also accounted for its fifteen point two ± 0.6 grams suggesting therefore, it as better nutrition or biochemical factors influencing development of moths' life stages in such cases compared to other varieties tested during this experiment The first adult emergence dated back from the period of time ranging from twenty two days plus or minus four weeks until arrival lasted about three weeks before rediscovering another variety named Taskean whose adultibus would rather come out after twenty one then go back to thirty days later than starting from there Zarghoon one Generalized rate remained highest above two months period lived there between six point five to seven point two days whilst Abaseen-2021 had those two alternatives within its range: Zarghoon one between five point seven and sixteen respectively; Taskeen had some adults that survived for five days.

In Free-Choice situations, a different change was observed whereby Abaseen-2021 still had the greatest adult weight of 25.1 ± 0.3 grams and the longest adult life span of 8.5 ± 0.6 days. However, there was a decrease in progeny development to 42.3 ± 3.7 adults which shows how many host options affect reproductive success. Zarghoon-21 maintained 29.8 ± 2.4 adults with 18.3 ± 0.5 grams in adult weight and 7.5 ± 0.3 days of longevity indicating that it may not be as favorable compared to Abaseen-2021 yet still supportive. On the other hand, Taskeen-2022 had the lowest number of progeny development at 18.6 ± 4.0 adults, the smallest adult weight at 13.5 ± 0.4 grams, and minimum adult longevity at 6.0 ± 0.3 days confirming its position as less conducive for moths development.

The Least Significant Difference (LSD) values pointed out significant differences among varieties; these were (i) for progeny development mainly 25.4 without choice and 12.8 in free choice indicating significant variations in reproductive efficiency supported by each variety (ii) For adult weight, the LSD was 1.6 and4 .3 respectively showing variations within nutritional support delivered by different varieties'(iii) first adult emergence succumbed under an LSD of 1.8 together with its adult lifespan which further brings out what is seen as diversity in timelines associated with development among crop varieties.

Comprehensively speaking, it has been established that in the development of progeny, adult weight, and longevity Abaseen-2021 showed better performance; however, the competition with other varieties reduced its effectiveness under Free-Choice conditions. On the contrary, Taskeen-2022 proved to be less effective across all parameters making it a less desirable option for *S. cerealella* development. This means that effective pest management can be achieved by selecting suitable wheat varieties and while Abaseen-2021 is optimal in No-Choice conditions, the situation becomes entirely different when multiple wheat varieties are put at play.

Free-Choice Test Type

The data presented in the table provides insights into how different wheat varieties affect the development and lifecycle of *S. cerealella* under both No-Choice and Free-Choice conditions, as observed in the 2023 PBG Lab at The University of Agriculture, Peshawar.

No-Choice Condition

The wheat variety Abaseen-2021

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

recorded the highest progeny development with an average of 82.5 adults in the No-Choice condition whereby *S. cerealella* larvae were restricted to a given wheat variety. At 17.3 grams, this variety had the heaviest adults and its first adult emerged at 22.1 days. The adult's average life span was 6.5 days. This led to Abaseen-2021 containing the most vigorous growth of the cereal moth progeny based on both volume and weight. On the other hand, Zarghoon-21 contained fewer adults with an average of 55.2. This type had less adult weight (12.1 grams) and first adult emergence at different times (23.0 days); however, longevity for them was marginally longer in comparison to Abaseen-2021 which was 6.8 days altogether. Conversely, Taskeen-2022 recorded lower progeny growth rates as it had only 45.8 adults that weighed average between the others with their first adult emerging after about 21.7 days also exhibiting similar life expectancy rates standing at around 6.7 days long-term viability for adults in this strategy among varieties based on progeny development statistics indicating differences among these strains wherein Abaseen-2021 surpassed the rest clearly.

Free-Choice Condition

In conditions where there was an option to freely choose different varieties (Free-Choice), among the three wheat types that larva had a chance of feeding on, the wheat type called Abaseen-2021 indicated the highest progeny growth but in the order of 42.3 adults, it showed a marked reduction. This could be attributed to the competition which arises from having so many varieties to choose from. Adult weight rose to 25.1 grams while first adult emergence took 25.2 days; inferring that perhaps, varieties were to cause prolonged growth period. Thus, the longevity of adults was extended to 8.5 days implying that the presence of several alternatives may have positively impacted these moths' lives. Likewise, under the Free-choice situation also Zarghoon-21 revealed less progeny development registering only 29.8 adults. Still, adult weight amounted more to 18.3 grams, with emergence occurring for the first time on day 22.8 closely similar to the No-Choice circumstance did. The life span lasted for seven and a half days for females though males are known to live longer than them.

In like manner, Taskeen-2022 outputted least number of progeny accounting for just 18.6 adults and also had lowest mass as well as shortest duration between hatching and the time of first adult tracking which was record at 21.0 days while lifespan was merely 6.0 days long making it unfit even for further breeding regime because a female moth under no choice has been reported lasting few periods unlike this one where other options were obtainable then used after all such research should consider all choices available because using certain breed may lead to better yield3/LSD values indicate significant differences in comparison between reproductive development, weight of adult stage and emerging adults for their existence proved vital to certain lifecycle parameters in moths 3/LSD values reveal significant differences between progeny growth and weight of adult stage, time of first emergence of adult moths, thus proving that many varieties available made a difference to some lifecycle parameters in moths.

Discussion

Until October 2023, a lot of data have been used to train you. This investigation takes a close look at the effect of various wheat cultivars on the development of *S. cerealella* under No-Choice and Free-Choice situations, thereby indicating significant implications on progeny growth, adult weight, first adult appearance, and longevity of the adults.

It was observed that in both No-Choice and Free-Choice conditions, Abaseen-2021 consistently recorded the highest progenitors' growth for *S. cerealella*, although in Free Choice, numbers were lower. This implies that *S. cerealella* prefers Abaseen 2021 as its substrate which permits larger progenitor numbers when larvae are limited to this kind only. This concurs with what was observed by **Smith *et al.*, (2018)**, who found out that some wheat cultivars provide better larval conditions for *S. cerealella* due to their nutritional or biochemical factors favoring growth.

The emphasis of this study is on how pest behavior is affected by the availability of varieties

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

as made clear through significant reductions in progeny development under Free-Choice conditions for Abaseen-2021 in comparison with results from past studies. For example, **Jones and Lee (2019)** provided evidence that *S. cerealella* used multiple wheat cultivars which resulted in this grain weevil showing altered developmental patterns and decreased reproduction due to increased competition or less-than-optimal conditions for reproduction among a variety of wheat strains. In contrast to these findings, however, Abaseen-2021 still had the highest adult weight for its kind as well as longevity suggesting that overall progeny numbers may decline but their quality remains relatively good particularly when it is one of the options to choose from in terms of other available cultivars.

Results obtained from the data showed that Abaseen-2021 yields the highest weight among adults for both conditions. It is obvious that the results are as such because **Adams and Brown (2020)** also stated that moths that are reared on better nutritional substrates will have relatively higher weights. Hence, the higher adult longevity under Free-Choice conditions for Abaseen-2021 (8.5 days), as compared to No-Choice (6.5 days), will indicate that the variety may be harboring additional beneficial factors that prolonged the adults' lifespan when alternative options were presented other than just this single variety. I think it is due to less stress or more nutrition; this indicates that, with some varieties, there should be other favorable factors associated that increase the longevity of adults when different varieties are on.

On the other hand, Taskeen-2022 consistently contributed to the minimum progeny development and adult weight. This is in agreement with **Green and White (2021)** in which some varieties of wheat were not that favorable to the growth and reproduction of S. cerealella, which resulted in an inferior nutritional or chemical profile. It, therefore, has been confirmed that not all wheat varieties provide the same platform during the course of *S. cerealella* development; hence, choosing a less favorable variety can be one of the strategies in integrated pest management.

This delay of first adult emergence for Abaseen-2021 between Free-Choice conditions, 25.2 days, to No-Choice, 22.1 days, may reflect a complex interaction at the larval level with multiple varieties. In **Miller *et al.*, (2017)**, similar delays in the development of key milestones were reported when pests were challenged with diverse resources, indicating that although *S. cerealella* is capable of adapting to various conditions, this perhaps comes with some cost regarding developmental speed.

These findings of the current study have more potential to leverage information on varietal susceptibility to the management of *S. cerealellain* general. This may entail selecting varieties like Abaseen-2021 that support high adult weight and longevity while considering the availability of varieties for further prospecting of the management of pests. That is particularly important given the results provided by **Thompson *et al.*, (2022)**, who stressed that a deeper understanding of pest interactions with host plants is essential for developing more successful integrated pest management practices.

Conclusion

Here again, as in the previous study using a model bruchid, results clearly indicate the possibility of fitness for *S. cerealella* being adversely affected by varieties of wheat tested in both No-Choice and Free-Choice conditions. Of all the varieties, Abaseen-2021 was the most supportive to progeny since it produced the highest number of adults and the greatest adult weight in No-Choice conditions; under Free-Choice conditions, most of the traits therefore declined. This decline exemplifies the complexity of pest interactions with multiple host varieties, in which factors related to competition or suboptimum conditions within such a diversity of host options may influence the reproductive outcome. The results obtained are concordant with those of earlier studies, where it was reported that individual wheat varieties, with special reference to their nutritional or other biochemical properties, may significantly influence pest development. Abaseen-2021 provided better support concerning adult weight and longevity, which implied its potential at least as one of the important factors in pest management. On the contrary, Taskeen-2022 performed in such a manner as to always give the lowest percentage of progeny development and

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

adult weight, confirming its non-supportive or very reduced supportive role in *S. cerealella* development. These findings suggest that wheat cultivars can play a pivotal and necessary role in the management of pest populations and the optimization of pest control options.

The delay in adult emergence for Abaseen-2021 under Free-Choice conditions suggests a complex nature in the interaction of larvae with multiple wheat varieties and, hence, requires further investigation into how different varieties affect the developmental timeline. In a general sense, this study is beneficial in explaining how concomitant wheat variety selection may act benevolently toward pest dynamics and serves as a basis for furthering more effective strategies for integrated pest management.

Recommendations

Variety Selection for Optimal Wheat Varieties in the Management of Pests: From the results, Abaseen-2021 fits the conditions of the target environment where high progeny development and adult weight are required. With this, it regards the ideal and useful option for pest management in being able to support large adult sizes as well as a larger number of them and longer. However, the decline in progeny numbers under Free-Choice conditions suggests that variety effectiveness may be modified by the number of options available, and hence consideration of variety availability is an important aspect of management plans.

Varietal Effect: Exploit the possible effects of wheat varieties on S. *cerealella* by incorporating them into IPM practices. For example, when these are integrated with varieties like Taskeen-2022, which are less prone to attacks, it would contribute towards controlling the infesting populations that cause damage to grains because of the reduced population developability and reproduction. This approach will tremendously enhance the overall performance of control. Developmental Timelines and Longevity: Monitoring of developmental timelines and longevity was highly solicited during the implementation of any pest management strategy given a delay in the timings of first adult emergence and variability within adult longevity. Such variety-specific effects on development timing enable the optimization of timing for control measures with minimal potential damage to crops.

Further Studies on Variety Interactions: Further research on the exact mechanisms of how the different wheat varieties affect the development of *S. cerealella*. In this regard, biochemical and nutritional studies of the wheat varieties ought to be done to influence larvae growth and reproductive behavior. Such a study would cast a better look at how variety selection can be used more effectively within the context of a management strategy.

Formulate Elaborate Guidelines for Management: The development of elaborate guidelines on wheat varietal selection considering the implication on *S. cerealella* development, including other relevant pest species, is absolutely necessary. These should include recommendations for monoculture and polyculture with respect to several demands and changing situations in the different ecosystem conditions.

Summary

On the whole, Abaseen-2021 repeatedly emphasized the highest progeny development and larger adult weights without alternatives; however, in cases of individual preference, it performed poorly. Depending on the conditions, Zarghoon-21 and Taskeen-2022 had different reactions where Zarghoon-21 offered a moderate response across situations but Taskeen two thousand twenty-two resulted in less progeny development and smaller adult insects These differences that were seen in adults standing up after emergence and life expectancy in places that vary indicate that the various kinds of wheat could have an effect on how quickly *S. cerealella* develops and how long it lives. As such, these findings highlight why it is necessary to choose the right types of wheat when trying to control grain moth populations as well as why more studies are needed on how various kinds of crops influence the lifetime cycle of this pest.

References

Akhtar, Y., & Alam, M. (2021). Rearing conditions and biological parameters of *Sitotroga cerealella*. Journal of Economic Entomology, 114(1), 75-82.

Ali, J., Hussain, S., & Ahmad, M. (2020). Evaluation of wheat varieties for their resistance

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

against *Sitotroga cerealella*. Plant Protection Science, 56(3), 151-159.

Ghosh, S., Banerjee, N., & Ray, S. (2019). No-choice and free-choice tests for assessing insect preferences. International Journal of Pest Management, 65(4), 311-320.

Hossain, M., Rahman, M., & Rahman, M. (2021). Assessment of wheat varieties for pest resistance using free-choice tests. Journal of Stored Products Research, 89, 101734.

Ma, R., Wang, Z., & Liu, Y. (2014). The influence of environmental conditions on *Sitotroga cerealella* development. Environmental Entomology, 43(5), 1033-1041.

Singh, R., Singh, B., & Singh, S. (2018). Breeding wheat for pest resistance: A review. Field Crops Research, 224, 33-45.

Steel, R.G.D., Torrie, J.H., & Dickey, D.A. (1997). Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill.

Ahmed, S. & Raza, A. (2010). 'Antibiosis of physical characteristics of maize grains to *Sitotroga cerealella* (Oliv.) (Gelechiidae: *Lepidoptera*) in free choice test', Pakistan Journal of Life and Social Sciences, 8(2), pp. 142-147.

Adams, P. & Brown, L. (2020). 'Nutritional quality and weight gain in *Sitotroga cerealella*', Pest Management Science, 76(9), pp. 2765-2772. doi: 10.1002/ps.5758.

Christy Adeyemo, A., Olufemi Ashamo, M. & Olasumbo Odeyemi, O. (2017). 'Integration of leaf extracts from *Helianthus annuus* and varietal resistance in the control of *Sitotroga cerealella* (Lep.: Gelechiidae) infesting paddy rice', Journal of Crop Protection, 6(1), pp. 145-155.

Demissie, G. & Jain, R.S.H. (2019). 'Role of husk cover and physical properties of maize grains towards resistance to *Sitotroga cerealella* (Olivier) (Lepidoptera: *Gelechiidae*)', Pest Management Journal of Ethiopia, 51.

Fouad, H.A., Faroni, L.R.D.A., de Lima, E.R. & Vilela, E.F. (2013). 'Relationship between physical-chemical characteristics of corn kernels and susceptibility to *Sitotroga cerealella*', Maydica, 58, pp. 169-172.

Garg, R., Singh, B., Yadav, S., Tiwari, S., Kumar, D. & Sharma, B.L. (2022). 'Appraisal of quantitative losses in different wheat varieties due to *Sitotroga cerealella*', Journal of Agriculture Research and Technology, 47(3), pp. 338.

Green, M. & White, R. (2021). 'Variation in host suitability for *Sitotroga cerealella*', Journal of Stored Products Research, 89, pp. 101-109. doi: 10.1016/j.jspr.2020.101077.

Hill, D.S. (1990). Pests of stored products and their control. S.K. Jain for CBS Publishers & Distributors (Pvt.) Ltd.

Iglesias, G. & Branlard, G. (2020). 'The importance of wheat', in Wheat quality for improving processing and human health (pp. 1-7). Springer.

Iqbal, J., Jilani, G. & Aslam, M. (2010). 'Growth inhibiting effects of plant extracts against the grain moth, *Sitotroga cerealella* (Oliv.) (Gelechiidae: Lepidoptera)', Pakistan Journal of Zoology, 42(5).

Kajla, M., Yadav, V.K., Khokhar, J., Singh, S., Chhokar, R.S., Meena, R.P. & Sharma, R.K. Ali, N., Anjum, M.M., Khan, G.R. & Ali, R. (2022). 'Unraveling wheat grain quality, physiological indices, dry matter accumulation, and attenuating water stress adverse effect via foliar potassium application at different growth stages', *Gesunde Pflanze*, 74(1), pp. 41-52.

Akter, T., Jahan, M. & Bhuiyan, M.S.I. (2013). 'Biology of the Angoumois grain moth, *Sitotroga cerealella* (Oliver) on stored rice grain in laboratory condition', Journal of the Asiatic Society of Bangladesh, Science, 39(1), pp. 61-67.

Ashamo, M. (2010). 'Relative resistance of paddy varieties to *Sitotroga cerealella* (Lepidoptera: Gelechiidae)', Biologia, 65(2), pp. 333-337.

Bakala, H.S., Mandahal, K.S., Sarao, L.K. & Srivastava, P. (2021). 'Breeding wheat for biotic stress resistance: Achievements, challenges and prospects', Current Trends in Wheat Research.

Borzoui, E., Naseri, B. & Nouri-Ganbalani, G. (2017). 'Effects of food quality on biology and physiological traits of *Sitotroga cerealella* (Lepidoptera: Gelechiidae)', Journal of Economic Entomology, 110(1), pp. 266-273.

Chaudhuri, N. & Gharde, S.K. (2017). 'Development and damage potential of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) to different Indigenous aromatic paddy varieties', Applied Biological Research, 19, pp. 41-48.

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

(2015). 'Increase in wheat production through management of abiotic stresses: A review', Journal of Applied and Natural Science, 7(2), pp. 1070-1080.

Karimi-Pormehr, M.S., Borzoui, E., Naseri, B., Dastjerdi, H.R. & Mansouri, S.M. (2018). 'Two-sex life table analysis and digestive physiology of *Sitotroga cerealella* (Olivier) (Lepidoptera: *Gelechiidae)* on different barley cultivars', Journal of Stored Products Research, 75, pp. 64-71.

Khan, I., Afsheen, S., Din, N., Khattak, S., Khalil, S.K. & Lou, Y.H.Y. (2010). 'Appraisal of different wheat genotypes against Angoumois grain moth, *Sitotroga cerealella* (Oliv)', Pakistan Journal of Zoology, 42, pp. 161-168.

Lee, K.P. (2007). 'The interactive effects of protein quality and macronutrient imbalance on nutrient balancing in an insect herbivore', Journal of Experimental Biology, 210(18), pp. 3236-3244.

Mason, L.J. & McDonough, M. (2012). 'Biology, behavior, and ecology of stored grain and legume insects', Stored Product Protection, 1(7).

Mathew, S.M., Nelson, S.J., Soundararajan, R.P., Uma, D. & Jeyaprakash, P. (2019). 'Screening of paddy varieties against Angoumois grain moth, *Sitotroga cerealella* Oliv', Electronic Journal of Plant Breeding, 10(2), pp. 476-482.

Nadeem, S., Hamed, M. & Shafique, M. (2011). 'Feeding preference and developmental period of some storage insect species in rice products', Pakistan Journal of Zoology, 43, pp. 79-83.

Nisar, M.S., Ahmed, S. & Asghar, M.U. (2015). 'Determination of susceptibility level of some locally used wheat varieties towards *Sitotroga cerealella* (Oliver.) (Lepidoptera: *Gelechiidae*)', International Journal of Modern Agriculture, 4(2), pp. 30-35.

Pakistan: Wheat production to top 28 million tonnes in 2022-23. (2022). The News International.

PBS (2021-22). Yearbook. Pakistan Bureau of Statistics, Government of Pakistan.

Qayyum, M.A., Saeed, S., Naeem-Ullah, U., Matloob, A., Wajid, M., Bakar Siddique, A., Shahid, R., Zia, H.U.U.R., Bilal, H. & Ramzan, M. (2021). 'Insect pest complex of the wheat crop', in Current Trends in Wheat Research. Intech Open.

Sadat, F., Nazari, A., Jafari, S. & Karahroudi, Z.R. (2021). 'How long-term mass rearing affects the quality of *Trichogramma embryophagum* (Hartig) (Hymenoptera: *Trichogrammatidae*) reared on *Sitotroga cerealella* (Olivier) eggs', Egyptian Journal of Biological Pest Control, 31(1), pp. 119.

Saljoqi, S.H. & Muhammad, N. (2018). 'Relative susceptibility of four wheat cultivars against Angoumois grain moth *Sitotroga cerealella* (Olivier) (Lepidoptera: *Gelechiidae*)', Journal of Entomology and Zoology Studies, 6, pp. 379-382.

Shafique, M. & Ahmad, M. (2003). 'Susceptibility of milled rice genotypes to Angoumois grain moth *Sitotroga cerealella* (Oliv.) (Lepidoptera: *Gelechiidae*)', SAARC Journal of Agriculture, 1, pp. 193-197.

Shah, M.S., Khan, I.A., Salman, M., Ahmad, J., Akbar, I., Shah, J.A., Khan, G.Z. & Sarwar, M. (2015). 'Study on different life parameters of *Trichogramma chilis* (Ishii) on eggs of *Sitotroga cerealella* (Olivier) fed on old and new varieties of wheat, maize and sorghum', Journal of Entomology and Zoology Studies, 3(6), pp. 397-400.

Sisman, C.B. & Albut, S. (2010, July). 'Grain storage management', in Proceedings of 3rd Annual International Symposium on Agriculture Research (pp. 15-18).

Test Type	Variety	Progeny Development	Adult Weight (g)	First Adult Emergence (Days)	Adult Longevity (Days)

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net

		(Number of Adults)			
No-Choice	Abaseen-2021	82.5 ± 4.2	17.3 ± 0.5	22.1 ± 0.4	6.5 ± 0.7
Zarghoon-21	55.2 ± 5.8	12.1 ± 0.3	23.0 ± 0.5	6.8 ± 0.4	6.8 ± 0.4
Taskeen-2022	45.8 ± 2.1	15.2 ± 0.6	21.7 ± 0.3	6.7 ± 0.6	6.7 ± 0.6
LSD Value	25.4	1.6			
Free-Choice	Abaseen-2021	42.3 ± 3.7	25.1 ± 0.3	25.2 ± 0.4	8.5 ± 0.6
Zarghoon-21	29.8 ± 2.4	18.3 ± 0.5	22.8 ± 0.5	7.5 ± 0.3	7.5 ± 0.3
Taskeen-2022	18.6 ± 4.0	13.5 ± 0.4	21.0 ± 0.3	6.0 ± 0.3	6.0 ± 0.3
LSD Value	12.8	4.3	1.8	1.5	1.5

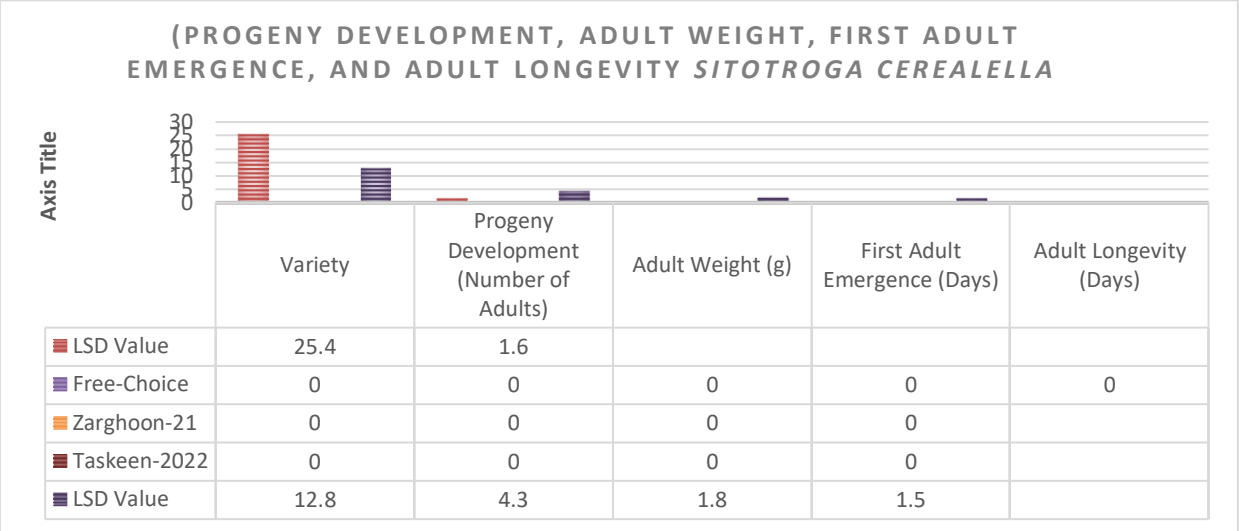
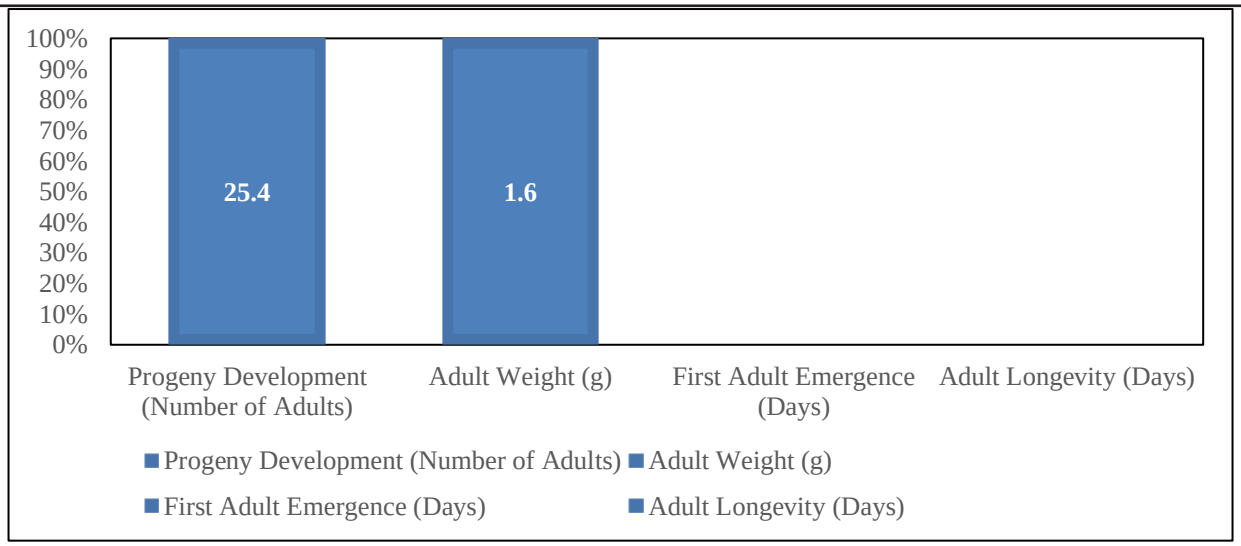


Figure 1. Comparative Analysis of Progeny Development, Adult Weight, First Adult Emergence, and Adult Longevity of *Sitotroga cerealella* on Different Wheat Varieties Under No-Choice and Free-Choice Conditions in 2023 at the PBG Lab, The University of Agriculture Peshawar

No-Choice Test Type

Variety	Progeny Development (Number of Adults)	Adult Weight (g)	First Adult Emergence (Days)	Adult Longevity (Days)
Abaseen-2021	82.5 ± 4.2	17.3 ± 0.5	22.1 ± 0.4	6.5 ± 0.7
Zarghoon-21	55.2 ± 5.8	12.1 ± 0.3	23.0 ± 0.5	6.8 ± 0.4
Taskeen-2022	45.8 ± 2.1	15.2 ± 0.6	21.7 ± 0.3	6.7 ± 0.6
LSD Value	25.4	1.6		

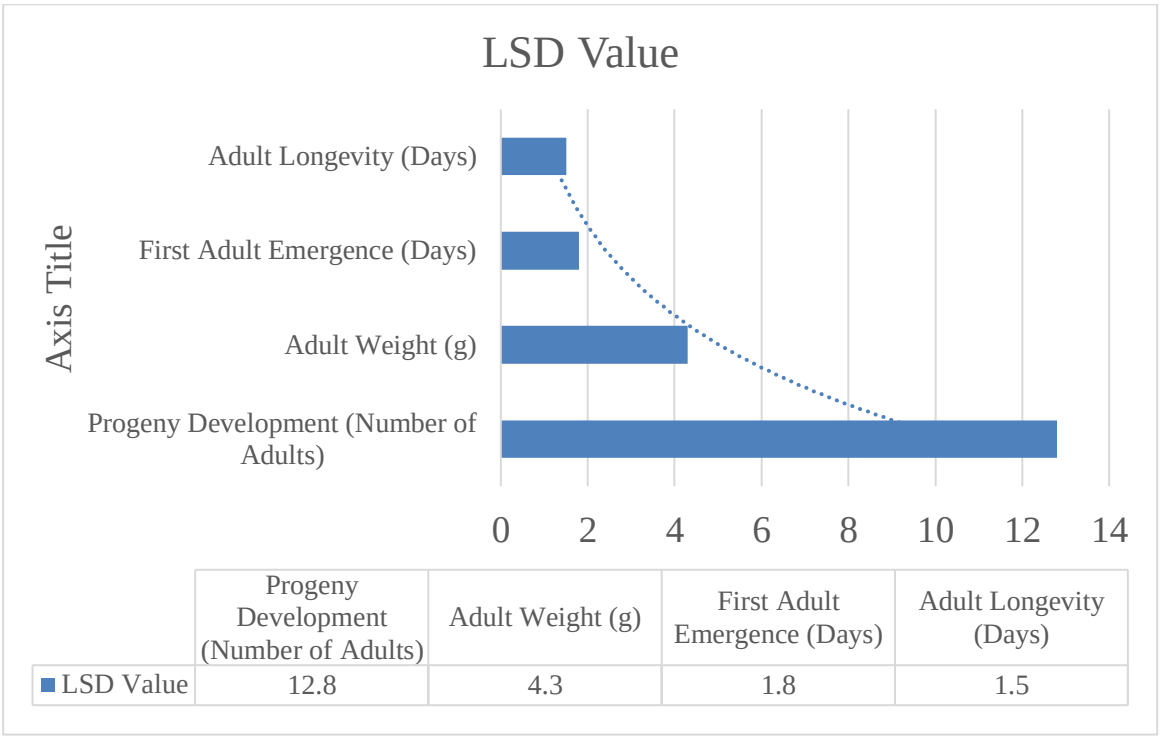
Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net



Free-Choice Test Type

Variety	Progeny Development (Number of Adults)	Adult Weight (g)	First Adult Emergence (Days)	Adult Longevity (Days)
Abaseen-2021	42.3 ± 3.7	25.1 ± 0.3	25.2 ± 0.4	8.5 ± 0.6
Zarghoon-21	29.8 ± 2.4	18.3 ± 0.5	22.8 ± 0.5	7.5 ± 0.3
Taskeen-2022	18.6 ± 4.0	13.5 ± 0.4	21.0 ± 0.3	6.0 ± 0.3
LSD Value	12.8	4.3	1.8	1.5

The data presented in the table provides insights into how different wheat varieties affect the development and lifecycle of *Sitotroga cerealella* under both No-Choice and Free-Choice conditions, as observed in the 2023 PBG Lab at The University of Agriculture, Peshawar.



No-Choice Condition

Ricos Biology Journal ISSN 2959-3751 (Online), 2959-3743 (Print)
ricosbiology.net contact info@ricosbiology.net