Deterioration of Grain Quality of Wheat by Rice Weevil, *Sitophilus oryzae* (L.) during Storage

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ABSTRACT

**Background:** A number of storage pests viz., *Rhizopertha dominica* (F.), rice weevil, *Sitophilus oryzae* (L.), granary weevil, *Sitophilus granarius* (L.) and Khapra beetle, *Trogoderma granarium* (Evert.) damage stored wheat. However, *S. oryzae* is considered a primary pest of stored wheat and has been reported to prefer soft textured wheat cultivars.

**Methods:** The grains of three bread (soft textured) viz., HD2967, PDW314, PBW658 and three durum wheat (hard textured) cultivars viz., WHD943, PBW621, PDW291 were screened for feeding response by rice weevil, *Sitophilus oryzae* L. in the laboratory. Each cultivar seed was properly cleaned and disinfested before its use. A 100g seed sample of each cultivar was taken into the plastic jars. Of the pure culture, ten 1-2 week young one insects (1:1 sex ratio) were released into the jars each containing different cultivar grains. The jars were covered with white muslin as three separate storage sets, i.e., 30, 60 and 90 days after storage to record data observations.

**Result:** Durum wheat cultivars being low in protein contents were comparatively less preferred for pest feeding and cultivar PDW291 was found highly resistant based on low insect emergence, grain damage and weight loss. The bread wheat cultivars due to high protein contents were highly preferred by the pest and cultivar HD2967 showed maximum preference. The biochemical properties like ash contents and crude fibres showed positive while crude fats and protein a negative correlation with the pest infestation.

**Key words:** Biochemical parameters, Deterioration, Gain quality, Rice weevil, *S. oryzae*, Wheat cultivars.

INTRODUCTION

Among various food grains, wheat is world-wide in its commercial cultivation on every continent except Antarctica. It had global production of 757.2 million tonnes (FAO, 2018) with about 22 per cent of production traded in international market. India is the second-largest wheat grower in the world. It was cultivated over an area of 29.1 and 3.5 million hectares with 102.2 and 17.8 million tons of production, respectively, in India (Anonymous, 2019a) and Punjab (Anonymous, 2019b). Several insect-pests like lesser grain borer, *Rhizopertha dominica* (F.), rice weevil, *Sitophilus oryzae* (L.), granary weevil, *Sitophilus granarius* (L.) and Khapra beetle, *Trogoderma granarium* (Evert.) damage stored wheat in large or small quantities during storage. Of these insect-pests, *S. oryzae* is considered a primary pest of stored wheat (Burges, 2008; Mark et al.2010). *S. oryzae* prefers soft textured wheat cultivars (Zaklanoi and Retanova, 1987). Ahmed (1980) reported 10-15 per cent losses due to various storage pests including *S. oryzae* in stored wheat. All the stored grain pests exhibit varied preference or non-preference for feeding over the grain samples of different wheat cultivars (Sarin and Sharma, 1983; Babolch and Irshad, 1986). Highest grain infestation in stored wheat by *R. dominica* and Khapra beetle, *T. granarium* was found responsible for the reduced crude fats and proteins while there was increase in crude fibres (Jood and Kapoor, 1993; Jood et al.1993; Jha, 2003). Samuels and Modgil (2003) reported the negative correlation of crude fats and proteins with the insect pest infestation in different wheat varieties. However, Chuni and Singh (1996) revealed wheat cultivar HD-2307 as most resistant cultivar based on low population buildup of *S. oryzae*. The levels of different biochemical aspects like total proteins in stored grain samples vary with the incidence of a pest species concerned (Mason et al.1997). The insect pests cause quantitative and qualitative losses to the grain samples during the storage (Fornal et al.2007). Mebarkia et al. (2010) attributed the higher protein contents towards susceptibility of different wheat varieties to the *S. granarius*. Upadhyay and Srivastava (2010) found soft textured wheat cultivar PBW343 as the least preferred for insect infestation based on different biological aspects.

The present studies were carried out to investigate the deterioration of grain samples of different wheat cultivars by *S. oryzae* in the laboratory conditions.

MATERIALS AND METHODS

The present investigations were carried out in the laboratory...
during year 2015 in the Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana. A pure culture of *S. oryzae* was raised on wheat cultivar PBW 2967 in the BOD at 27±1°C and RH 70±5 per cent. The insects were released in the plastic jars (size 12˝ x 6˝), the open tops of which were covered with a piece of white muslin. A two hundred test insects were released into the plastic jars containing wheat grains for egg laying and removed after 24 hours. The new F₁ adults emerged in about 25-30 days were transferred to the new jars containing fresh food grains.

The adults from the pure insect culture were used for carrying out the present studies. The grain samples of six wheat cultivars, i.e., 3 bread (soft textured) viz., HD 2967, PBW 621, PBW 658 (soft texture) and 3 durum (hard textured) cultivars, viz., WHD 943, PDW 314, PDW 291 (hard texture) were used for carrying out the experiments. Each cultivar seed was properly cleaned and disinfested before its use. A 100g seed sample of each cultivar was taken into the plastic jars. From the pure culture, ten 1-2 week old young insects (1:1 sex ratio) were released into the jars each containing different cultivar grains. The jars were covered with white muslin as three separate storage sets, i.e., 30, 60 and 90 days after storage (DAS). Three replicates were kept in each treatment. One pre-storage observation was recorded for each storage interval. Observations were recorded based on the insect inflicted losses and biochemical losses.

**A. Insect inflicted losses**

1. **Insect emergence:** The insect population of *S. oryzae* was recorded from the 100g food grain samples in all the six wheat cultivars at 30, 60 and 90 DAS.

**Table 1: Effect of *S. oryzae* activity on grain quality of different wheat cultivars during storage.**

| Varieties  | Insect emergence (adults/100g grains) | Grain damage (%) | Weight loss (%) |
|------------|--------------------------------------|------------------|----------------|
|            | 30DAS      | 60DAS      | 90DAS² | Mean | 30DAS      | 60DAS      | 90DAS² | Mean | 30DAS      | 60DAS      | 90DAS² | Mean |
| HD2967     | 8.67       | (3.10)     | 60.00  | (7.81) | 135.00  | (11.66)   | 67.89  | 2.93  | 12.90  | 26.63  | 14.15  | 0.33  | 1.50  | 9.66  | 3.83  |
| PBW621     | 7.00       | (2.81)     | 45.00  | (6.77) | 115.67  | (10.80)   | 55.89  | 1.73  | 12.67  | 21.37  | 11.92  | 0.09  | 0.65  | 8.25  | 3.00  |
| WHD943     | 5.33       | (2.50)     | 28.00  | (3.53) | 96.33   | (9.86)    | 43.22  | 0.97  | 7.43   | 18.13  | 8.84   | 0.08  | 0.64  | 7.04  | 2.59  |
| PDW314     | 5.00       | (2.44)     | 18.33  | (4.39) | 84.67   | (9.25)    | 36.00  | 1.23  | 5.50   | 13.63  | 6.79   | 0.07  | 0.34  | 4.55  | 1.65  |
| PDW291     | 4.00       | (2.23)     | 17.67  | (4.31) | 48.00   | (7.00)    | 23.22  | 0.93  | 3.07   | 7.57   | 3.86   | 0.06  | 0.18  | 3.80  | 1.35  |
| Mean       | 5.39       | (1.82)     | 30.56  | (3.91) | 85.06   | (5.62)    | 15.78  | 0.67  | 2.20   | 4.27   | 2.38   | 0.03  | 0.10  | 1.97  | 0.70  |

CD (p=0.05)

| CD (p=0.05) | CD (p=0.05) | CD (p=0.05) |
|-------------|-------------|-------------|
| Varieties:  | 0.29        | 0.82        | 0.54        |
| DAS:        | 0.20        | 0.58        | 0.38        |
| Varieties × DAS: | 0.50  | 1.43        | 0.93        |

1Days after storage, ²Means of three replications, ³Based on 100 seed, ⁴Based on 1000 grain count, ⁵Figures in parentheses are the means of \( \sqrt{n+1} \) transformed.
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Table 2: Effect of *S. oryzae* infestation on grain quality of different wheat cultivars during storage.

| Cultivar | Total ash (%) | Total fats (%) | Mean | Total ash (%) | Total fats (%) | Mean |
|----------|---------------|----------------|------|---------------|----------------|------|
|          | 30DAS | 60DAS | 90DAS | Mean | 30DAS | 60DAS | 90DAS | Mean |
| Insect free |        |        |        | Mean |        |        |        | Mean |
| Insect Infested |        |        |        | Mean |        |        |        | Mean |
| 30DAS | 60DAS | 90DAS | Mean | 30DAS | 60DAS | 90DAS | Mean |
| HD2967 | 2.40  | 2.49  | 2.40  | 2.65  | 2.40  | 2.58  | 1.65  | 1.54  | 1.64  | 1.52  | 1.65  | 1.35  | 1.65  | 1.47  |
| PBW621 | 2.38  | 2.47  | 2.59  | 2.63  | 2.39  | 2.57  | 1.42  | 1.39  | 1.41  | 1.32  | 1.39  | 1.25  | 1.41  | 1.32  |
| PBW658 | 2.10  | 2.16  | 2.11  | 2.09  | 2.10  | 2.32  | 1.37  | 1.33  | 1.37  | 1.28  | 1.37  | 1.21  | 1.37  | 1.27  |
| WHD943 | 2.00  | 2.15  | 2.30  | 2.02  | 2.01  | 2.28  | 1.34  | 1.32  | 1.34  | 1.26  | 1.34  | 1.17  | 1.34  | 1.25  |
| PDW314 | 1.98  | 2.11  | 2.23  | 2.35  | 1.99  | 2.23  | 0.88  | 0.84  | 0.89  | 0.82  | 0.89  | 0.79  | 0.89  | 0.82  |
| PDW291 | 1.85  | 1.99  | 2.07  | 1.84  | 2.25  | 2.10  | 0.86  | 0.83  | 0.85  | 0.79  | 0.86  | 0.76  | 0.86  | 0.79  |
| Mean    | 2.12  | 2.23  | 2.13  | 2.36  | 2.13  | 2.45  | 1.26  | 1.21  | 1.25  | 1.17  | 1.25  | 1.09  |

CD (p=0.05)

- Varieties: 0.016
- DAS: 0.011
- Varieties x DAS: 0.028
- Infestation: 0.092
- Varieties x Infestation: 0.023
- DAS x Infestation: 0.016
- Varieties x DAS x Infestation: 0.039

CD (p=0.05)

- Varieties: 0.022
- DAS: 0.016
- Varieties x DAS: NS
- Infestation: 0.013
- Varieties x Infestation: 0.032
- DAS x Infestation: 0.023
- Varieties x DAS x Infestation: NS

1Days after storage, 2Means of three replications.
Table 3: Effect of *S. oryzae* infestation on grain quality of different wheat cultivars during storage.

| Cultivar | 30DAS | 60DAS | 90DAS | Mean | 30DAS | 60DAS | 90DAS | Mean |
|----------|-------|-------|-------|------|-------|-------|-------|------|
|          | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested | Insect free | Infested |
| HD2967   | 13.70  | 13.55  | 13.58  | 13.67 | 13.53 | 13.69  | 13.59  | 4.60  | 4.67 | 4.61  | 4.81  | 4.62  | 5.01  | 4.61  | 4.83 |
| PBW621   | 13.11  | 13.13  | 12.94  | 13.12 | 12.89 | 13.12  | 12.95  | 4.50  | 4.63 | 4.51  | 4.75  | 4.52  | 4.95  | 4.51  | 4.78 |
| PBW658   | 12.89  | 12.76  | 12.88  | 12.74 | 12.69 | 12.88  | 12.73  | 4.40  | 4.56 | 4.42  | 4.80  | 4.44  | 4.64  | 4.42  | 4.67 |
| WHD943   | 12.55  | 12.54  | 12.46  | 12.52 | 12.41 | 12.54  | 12.47  | 3.50  | 3.52 | 3.53  | 3.73  | 3.55  | 3.91  | 3.53  | 3.72 |
| PZW314   | 11.54  | 11.49  | 11.53  | 11.45 | 11.63 | 11.53  | 11.52  | 3.10  | 3.14 | 3.12  | 3.52  | 3.16  | 3.71  | 3.13  | 3.46 |
| PZW291   | 10.79  | 10.71  | 10.78  | 10.70 | 10.38 | 10.78  | 10.60  | 2.90  | 3.06 | 2.93  | 3.37  | 2.94  | 3.59  | 2.92  | 3.34 |
| Mean     | 12.42  | 12.36  | 12.43  | 12.31 | 12.41 | 12.26  | 3.83  | 3.93 | 3.85  | 4.16  | 3.87  | 4.30  | |

CD (p=0.05)  
Varieties: 0.025  
DAS: 0.018  
Varieties x DAS: 0.044  
Infestation: 0.015  
Varieties x Infestation: 0.036  
DAS x Infestation: 0.025  
Varieties x DAS x Infestation: NS

1Days after storage, 2Means of three replications.
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At 30 DAS, the food grain samples in infested cultivar HD 2967 registered highest insect emergence (8.67 adults), grain damage (2.93%), weight loss (0.33%), ashes (2.49%) and fibres (4.67%) while decline in total fats (1.54%) and proteins (13.65%) over the insect free samples having declined ashes (2.40%), fibres (4.60%) and increased fats (1.65%) and proteins (13.70%). In contrast, the infested grain samples of wheat variety PDW 291 registered a significant reduction of insect inflicted aspects like insect emergence (2.33 adults), grain damage (0.67%), weight loss (0.03%) and biochemical properties such as crude fats (0.83%) and proteins (10.71%) while increase in ashes (1.99%) and fibres (3.06%) over the uninfested grain samples having reduced ashes (1.85%) and fibres (2.90%) while rise in fats (0.86%) and proteins (10.79%).

At 60 DAS, food grain samples of infested cultivar HD 2967 revealed increased insect emergence (60.00 adults), grain damage (12.90%), weight loss (1.50%), ashes (2.61%), fibres (4.81%) and declined total fats (1.52%) and proteins (13.58%) as against insect free samples with ashes (2.40%), fibres (4.61%), fats (1.64%) and proteins (13.71%). However, infested cultivar PDW 291 showed a declined insect emergence (14.33 adults), grain damage (2.20%), weight loss (0.10%), fats (0.79%) and proteins (10.70%) while increased ashes (2.07%) and fibres (3.37%) over the insect free cultivar with declined ashes (1.86%), fibres (2.93%) and increased fats (0.85%) and proteins (12.43%). Similarly, at 90 DAS, food grain samples in infested cultivar HD 2967 showed increased insect emergence (135.00 adults), grain damage (26.63%), weight loss (9.66%), ashes (2.65%), fibres (5.01%) and declined fats (1.35%) and proteins (13.53%) as compared to insect free samples with ashes (2.41%) and fibres (4.62%), fats (1.65%) and proteins (13.67%). In contrast, the infested cultivar PDW 291 showed declined insect emergence (30.67 adults), grain damage (4.27%), weight loss (1.97%), fats (0.76%), proteins (10.38%) and increased ashes (2.25%) and fibres (3.59%) as against insect free cultivars with declined ashes (1.84%) and fibres (2.94%) and increased fats (0.86%) and proteins (10.77%).

A highest and lowest grain damage (14.15 and 2.38%) and weight loss (3.83 and 0.70%) due to *S. oryzae* in cultivars HD 2967 and PDW 291, respectively, was as per Dwivedi and Shukla (2019) who also recorded lesser grain weight loss and grain damage in wheat varieties HD-2733 and K-307. A direct correlation in total ashes with pest infestation was supported by Hameed et al. (2013) for acarid mite, *Rhizoglyphus triticii*. The increased fibres and ashes in insect free and infested food grain samples in their findings also supported the present research work. A highest insect emergence, grain damage and weight loss in *R. dominica* infested grain samples in cultivar HD2967 in current findings was fully supported by Kakde et al. (2014) for wheat cultivar HD2329. A highest susceptibility based on insect activity and biochemical aspects in bread wheat cultivar HD2967 due to pest infestation in present findings was supported by Arve et al. (2014) for bread wheat cultivar HD2189. A negative correlation of *S. oryzae* infestation with total fats and proteins while positive with ashes and fibres in present studies was partially supported by Keskin and Ozkaya (2015) who reported a negative correlation of *S. granarius* infestation with total fats but positive correlation with proteins and ashes.

**CONCLUSION**

The grain samples infested cultivar HD 2967 encountered an increase in insect emergence, grain damage, weight loss, total ashes, crude fibres while decrease in total fats and proteins over the insect free cultivars. In contrast, infested grain samples of cultivar PDW 291 showed decline in insect emergence, grain damage, weight loss, fats, proteins but rise in total ashes and fibres over the insect free food grain samples.

**REFERENCES**

Adams, J.M. (1976). Weight loss caused by development of *S. oryzae*. Journal of Stored Products Research. 12: 269-72.

Ahmed, E. U. (1980). Insect pests and their control in stored wheat. Pakistan Agriculture. 3: 9-10.

AOAC (2000). Official Method of Analysis. 17th Edition. Association of Official Analytical Chemists, Washington, D C.

Anonymous (2019a). Agricultural Statistics at a Glance 2019. Directorate of Economics and Statistics, Government of India. https://eands.dacnet.nic.in/PDF/A%c3%a1t%202019%20 %20Glance%202019%20Eng.pdf

Anonymous (2019b). Package of Practices for Crops of Punjab. Rabi. Punjab Agricultural University, Ludhiana, India. 35: 1-18.

Arve, S.S., Chavan, S.M. and Patel, M.B. (2014). Effect of rice weevil (*Sitophilus oryzae* L.) infestation on the biochemical properties of six wheat varieties. Trends in Bioscience. 7: 925-34.

Baloch, U.K. and Irshad, M. (1986). Post-harvest Research on Food Grains. Review of Crop Science, Division, Pakistan Agricultural Research Count, Islamabad, 45pp.

Burges, H.D. (2008). Development of the khapra beetle, *Trogoderma granarium*, in the lower part of its temperature range. Journal of Stored Products Research. 44: 32-35.

Cheema, H.S. and Singh, B. (1990). A User’s Manual to CPCS 1. Punjab Agricultural University, Ludhiana. Pp.46.

Chuni, R. and Singh, V.S. (1996). Resistance to *Sitophilus oryzae* L. in wheat and associated grain characteristics. Indian Journal of Entomology. 58: 79-90.

Dwivedi, R.K. and Shukla, A. (2020). Screening of different wheat varieties against rice weevil (*Sitophilus oryzae* Linn.) and
their Management. International Journal of Current Microbiology and Applied Science. 8: 2405-16.
FAO (2018). Food Outlook Biannual Food and Agricultural Organization of United States of America, Report on Global Food Markets. 169 pp.
Fornal, J., Jelinski, T., Sadowska, J., Grunda, S., Nawrot, J., Niewiady, A., Waechalenski, J.R. and Braszczok, W. (2007). Detection of granary weevil Sitophilus granarias L., eggs and internal stage analysis. Journal of Stored Products Research. 43: 142-48.
Hameed, A., Qayyum, H.A. and Ali, A. (1984). Biochemical factors affecting susceptibility of flour wheat varieties to Trogoderma granarium (Evert.). Pakistan Entomologist. 6: 57-64.
Jha, A.N. (2003). Feeding propensity of Ephestia cautella and Trogoderma granarium to eighteen cultivars of wheat. Indian Journal of Entomology. 65: 228-32.
Jood, S. and Kapoor, A.C. (1993). Protein and uric acid contents of cereal grains as affected by insect infestation. Food Chemistry. 46: 143-46.
Jood, S., Kapoor, A.C. and Singh, R. (1993). Biological evaluation of protein quality of sorghum as affected by insect infestation. Journal Plant Food Human Nutrition. 43: 105-14.
Kakde, S.P., Dhanote, S.V., Sarda, A.L., Khillare, P.W. and Deshwal, H.L. (2014). Screening of wheat varieties and eco-friendly management of Rhizopertha dominica (F.) on wheat. Plant Archives. 14: 431-37.
Keskin, S. and Ozkaya, H. (2015). Effect of storage and insect infestation on the technological properties of wheat. CyTA- Journal of Food. 13: 134-39.
Mahmood, S.U., Muhammad, H.B., Abrar, M., Sabri, M.A. and Khan, M.A. (2013). Appraising the changes in the nutritional value of stored wheat, Triticum aestivum (L.) infested with acarid mite, Rhizoglyphus tritici (Acari: Acaridae). Pakistan Journal of Zoology. 45: 1257-61.
Mark, A.C., Severtson, D.L., Brumley, C.J., Szito, A., Foottit, R.G., Grimm, M., Munyard, K. and Groth, D. M. (2010). A rapid non-destructive DNA extraction method for insects and other arthropods. Journal of Asia-Pacific Entomology. 13: 243-48.
Mason, L.J., Rulon, R.A. and Maier, D.E. (1997). Chilled versus ambient aeration and fumigation of stored popcorn. Part 2: Pest management. Journal of Stored Products Research. 33: 51-58.
Mebarkia, A., Rahbe, Y., Guechi, A., Bouras, A. and Makhlouf, M. (2010). Susceptibility of twelve soft wheat varieties (Triticum aestivum) to Sitophilus granarius (L.) (Coleoptera: Curculionidae). Agricultural Biology Journal of North America. 1: 571-78.
Paudel, L.R., Sharma, R.K. and Sharma, K. (2003). Evaluation for resistance against Khapra beetle, Trogoderma granarium Evert. in stored maize. Annals of Plant Protection Sciences. 11: 23-42.
Samuels, R. and Modgil, R. (2003). Physico-chemical changes in insect infested wheat stored in different storage structures. Indian Journal of Agricultural Sciences. 73: 562-63.
Sarin, K. and Sharma, K. (1983). Study of antibiosis in wheat varieties. Part I. Correlation of diapause and growth index. Bulletin Grains Technology. 21: 24-30.
Upadhay, M. and Srivastava, A.K. (2010). Response of wheat varieties to lesser grain borer, Rhizopertha dominica (F.). Annals of Plant Protection Science. 18: 144-47.
Zaklanoi, G.A. and Ratanova, V.F. (1987). Stored Pest and their Control. Oxonian Press Pvt., Ltd., New Delhi. 268pp.