J. Agric. Res. Technol., 47 (3) : 338-343 (2022) https://doi.org/10.56228/JART.2022.47314

Appraisal of Quantitative Losses in Different Wheat Varieties Due to *Sitotroga cerealella*

Ruby Garg[1], Bishan Singh[2*], Sunita Yadav[1], Sangeeta Tiwari[1], Dalip Kumar[1], Bajrang Lal Sharma[1]
Department of Entomology,
Chaudhary Charan Singh Haryana Agricultural University, Hisar - 125 004 (India)
Corresponding author Email : bishanhau@gmail.com

Abstract

An experiment was conducted using five different wheat genotypes to determine their resistance to *Sitotroga cerealella* (L.) at Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2018-2020. The experiment was carried out in Completely Randomized Design (CRD) with three replications in a control temperature of 29±2˚C with 65±5% relative humidity. The cultures were maintained in glass jars of 1 kg capacity containing the wheat grains and 25 adults of *S. cerealella* were released in these jars, separately. The results were evaluated by calculation of susceptibility index, percent grains damaged and percent weight loss of wheat grains against the infestation of *S. cerealella*. Among all the genotypes percent grains damaged (52.91%), percent weight loss (21.75%) and was found to be 'highly susceptible' genotype, while the lowest percent damaged grains (25.25%) and weight loss (8.64%) were recorded in genotype HPBW 1 and was found the 'susceptible' genotype against the infestation of pest, while all the remaining genotypes were intermediary to the pest attack.

Key words :

According to the Food and Agriculture Organization (FAO) "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Still, food security remains major goal to accomplish in the developing countries. In spite of lots of improvement and numerous government policies, the problem of food security pose a major challenge around the world and deterioration of grains in storage conditions due to the activity of pests, contributes the issue. Stored grain insects can cause post-harvest losses, estimated from 9 percent in developed countries to 20 percent or more in developing countries (Phillips and Thorne, 2009). The quantitative and qualitative losses vary among different zones of the world ranging from 5 to 30 percent; highest in tropical zone (20-30%) and lowest in temperate zone (5-10%) (Jadhav, 2006).

1. Dept. of Entomology and 2. Dept. of Agronomy.

Wheat (*Triticum aestivum* L.) plays a major role for hunger mitigation of the World. India is the second largest producer of wheat in the world with production of 99.70 million tons which constitutes 13.58 percent of total wheat grain production of the world (FAO, 2018). Wheat contributes about 31.32 percent of total food grain production of country (FAO, 2018).

Wheat crop is less vulnerable to insect-pest in field but suffer relatively higher losses during storage. Abnormal grain moisture, temperature and storage conditions create conducive conditions for the attack of various agents such as insects, mites and rodents resulting in quantitative and qualitative loss. Besides rendering the grain unfit for human consumption, infestation may even downgrade the physical and nutritional value of grains. Infestation enhances the cost and efforts to transport, grow, harvest and store food grains. Stored grain pest encourages the incidence of different type of moulds, hence increases the chances of toxic residues accumulation in the grains. In postharvest conditions, wheat grains are prone to attacked by many insect pests. Among these, lesser grain borer Rhyzopertha dominica (Fabricius), grain weevils complex Sitophlilus spp., Angoumois grain moth Sitotroga cerealella (Olivier), Khapra beetle Trogoderma granarium Everts and red flour beetle Tribolium castaneum (Herbst) are the important insect pests (Ebeling, 1971).

In storage, cereal grains are also infested by Angoumois grain moth, *S. cerealella* (Olivier). This pest was first reported in Angoumois Province of France in 1736, but now it is cosmopolitan pest (Cotton 1960). This moth cause serious damage in many cereals like rice, wheat, maize, barley, and sorghum (Ghosh and Durbey, 2003). It developed as serious pest due to its ability to feed inside grains at larval stage. Therefore, it is difficult to control at larval stage by the application of contact insecticides (Boshra, 2007). However, S. cerealella can be controlled by changing the physical properties and nutrition contents of cereal grains (Gomez and Santos 1992) like ferulic, amylose content, coumaric acids, kernel hardness, phenolic contents and texture (Arnason *et al*., 1994). Changes in protein and carbohydrate content can also alter the body weight, developmental time, fecundity and viability of the pest (Slansky, 1985).

Materials and methods

Procurement of wheat seed : The experimental material consisted of 5 genotypes, namely HD 2967, WB 2, HD 3086, HPBW 1 and WHD 948 (Table 1). The clean, disease and insect free seeds were procured from godown of wheat section, Department of Genetics and Plant Breeding, CCS HAU, Hisar to initiate stock culture. The seeds of various genotypes were stored separately in individual plastic container (6.5 x 6.5 x 10 cm^3) at Storage Laboratory, Department of Entomology.

Maintenance of stock culture : In case of *S. cerealella*, freshly emerged adults were collected from stock culture and caged in inverted glass funnel covered with mosquito net. They mated in the net and laid eggs. Then the eggs were kept in glass beaker and newly hatched 1^{st}, 3^{rd} and 5^{th} instar larvae were used for conducting the experiments. The stock culture was maintained under laboratory conditions throughout the experimental period. The adults were emerged from the stock culture were used for further experiments.

Plastic jars of about 250 g capacity were filled with 50 g wheat seeds of each genotype i.e. (HD 2967, WB 2, HD 3086, HPBW 1 and WHD 948) and tightly covered with rubber band and muslin cloth. Ten pairs of test insects male and female of *S. cerealella* were released separately in each container for oviposition. After thirty days adults were removed and wheat grains were retained in the containers. The wheat genotypes were compared by the observations taken on number of adult produced and mean development period. The data was used to calculate the index of susceptibility:

Index of susceptibility (S.I.) : It is a ratio of the log of F1 progeny completing development x 100 divided by the mean of the development period. The higher ratio indicates greater resistance relative to other cultivars or varieties under evaluation (Dobie, 1974). The resistance was classified according to the susceptibility index rating (Table 1).

Table 1. Classification of susceptibility index (rating 0-11)

Susceptibility index rating	Classification
0-3	Resistant
4-7	Moderately resistant
8-10	Susceptible
11	Highly susceptible

$$I = (\ln F/M.D) \times 100$$

Where, I= Index of susceptibility, ln= Natural log, F= Total number of F1 adult and M.D = Mean development period

Quantitative losses : 50 g wheat grains of each genotype was kept separately in plastic containers and newly emerged 10 pairs of test insects of S. cerealella was released. The number based damage estimation was done by randomly selecting 100 grains from infested sample of each genotype. On the basis of damage symptoms the healthy and infested grains were separated from randomly selected 100 grains at intervals of 30, 60 and 90 days after infestation. These containers were kept at standard laboratory temperature conditions. The healthy and damaged grains were counted from each container at 30, 60 and 90 days after storage, then percent grain damage and weight loses was worked out from following formula.

$$\text{Percent grain damage} = \frac{\text{No. of damaged grains}}{\text{Total no. of grains used}} \times 100$$

$$\text{Percent loss in weight} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu\,(Nd + Nu)} \times 100$$

Where, Wu = Weight of undamaged grains, Wd = Weight of damaged grains, Nu = Number of undamaged grains and Nd = Number of damaged grains.

Results and Discussion

Appraisal of Susceptibility Index (S.I.) of different insect-pest on various wheat genotypes : The data presented in Table 2 revealed that maximum F1 emergence (65.33) of angoumois grain moth was found in HD 2967 followed by WHD 948 (59.00) and HD 3086 (52.33) whereas minimum F1 emergence (41.00) was recorded for genotype HPBW 1. The susceptibility index of various genotypes varied from 9.36 to 13.93. The minimum (9.36) susceptibility index was recorded in HPBW 1 and it was followed by WB 2 (10.00) whereas maximum (13.93) susceptibility index was recorded for HD 2967 and WHD 948 (12.36) during 2019.

Table 2. Appraisal of the susceptibility index of different varieties of wheat against Sitotroga cerealella

Genotypes	Susceptibility Index									Category
	2019			2020			Pooled Mean			
	F1 adult emergence (no.)	M.D	S. I.	F1 adult emergence (no.)	M.D	S. I.	F1 adult emergence (no.)	M.D	S. I.	
HD 2967	65.33 (08.08)	30.00	13.93	67.00 (08.18)	31.33	13.42	66.17 (08.13)	30.67	13.67	Highly Susceptible
WHD 948	59.00 (07.68)	33.00	12.36	65.00 (08.06)	35.00	10.16	62.00 (07.87)	34.00	11.26	Highly Susceptible
HD 3086	52.33 (07.23)	32.67	12.11	47.00 (06.85)	37.37	10.30	49.67 (07.05)	35.17	11.20	Highly Susceptible
WB 2	46.33 (06.81)	38.33	10.00	44.00 (06.63)	43.67	8.67	45.17 (06.72)	41.00	9.33	Susceptible
HPBW 1	41.00 (06.40)	39.67	9.36	38.00 (06.16)	47.00	07.74	39.50 (06.28)	43.33	8.55	Susceptible
C.D. (0.05%)	(03.30)	(02.97)	-	(03.59)	(03.08)	-	(07.50)	N.S	-	-
S.E (m)	01.03	00.93	-	01.12	00.33	-	02.02	02.38	-	-

Figure in parentheses are square root transformed values. M.D. = Mean development period in days, S.I. = Susceptibility index

The genotypes having minimum susceptibility index (HPBW 1 and WB 2) showed maximum median development period (M.D.) of 39.67 and 38.33 days, respectively during 2018-19. In 2019-2020 similar observations were recorded with maximum (67.00) F1 emergence for HD 2967 followed by WHD 948 (65.00) whereas minimum F1 emergence (38.00) was recorded for HPBW 1. Similarly, maximum susceptibility index was recorded in HD 2967 (13.42) and minimum in HPBW 1 (7.74).

On the basis of pooled susceptibility index data of both years the various genotypes were categorized as resistant, moderately resistant, susceptible and highly susceptible. HD 2967, WHD 948 and HD 3086 were found to be 'highly susceptible' whereas all other genotypes were found 'susceptible'.

Extent of grain damage (%) of major insect-pest on various wheat genotypes : During 2018-19, maximum grain damage (36.33%) was observed in HD 2967 followed by WHD 948 (28.67%) at 30 DAR against angoumois grain moth (Table 3). Minimum grain damage was observed in HPBW 1 (10.33%) followed by HD 3086 (18.00%). At 60 DAR, maximum (48.00%) grain damage was recorded in HD 2967 followed by WHD 948 (36.00%) whereas minimum (19.00%) grain damage was recorded in HPBW 1 followed by HD 3086 (25.00%). At 90 DAR, the maximum (54.67%) grain damage was recorded in genotype HD 2967 followed by WHD 948 (43.33%), WB 2 (36.67%) and HD 3086 (31.00%) whereas minimum (25.33%) grain damage was recorded for HPBW 1. All the genotypes varied significantly from each other at 90 DAR. Similar trend was followed at 120 DAR in case of grain damage. The mean percent grain damage for 2018-19 showed that HPBW 1 has minimum (21.58%) grain damage followed by HD 3086 (27.67 %) and WB 2 (33.58%). The mean grain damage during 2018-19 was highest in HD 2967 (49.58%) followed by WHD 948 (39.92%) which were at par with each other.

During 2019-20 the maximum grain damage was observed in HD 2967 (43.33%) followed by HD 3086 (25.67%) at 30 DAR. Minimum grain damage was observed in HPBW 1 (16.33%) and that was at par with WB 2

Table 3. Extent of grain damage (%) by Sitotroga cerealella in different varieties of wheat

Genotypes	Grain damage (%)										Pooled mean
	2019					2020					
	30 DAR	60 DAR	90 DAR	120 DAR	Mean	30 DAR	60 DAR	90 DAR	120 DAR	Mean	
HD 2967	36.33 (37.05)	48.00 (43.84)	54.67 (47.66)	59.33 (50.36)	49.58 (44.73)	43.33 (41.15)	52.67 (46.51)	61.33 (51.53)	67.67 (55.32)	56.25 (48.63)	52.91 (46.67)
WHD 948	28.67 (32.36)	36.00 (36.85)	43.33 (41.15)	51.67 (45.94)	39.92 (39.08)	22.00 (27.96)	31.00 (33.81)	40.00 (39.21)	47.33 (43.45)	35.08 (36.11)	37.50 (37.61)
HD 3086	18.00 (25.07)	25.00 (29.97)	31.00 (33.81)	36.67 (37.25)	27.67 (31.54)	25.67 (30.42)	30.33 (33.40)	37.67 (37.84)	43.00 (40.96)	34.17 (35.66)	30.91 (33.63)
WB 2	23.67 (29.08)	31.67 (34.21)	36.67 (37.25)	42.33 (40.57)	33.58 (35.29)	15.67 (23.28)	24.00 (29.31)	29.33 (32.78)	37.00 (37.45)	26.50 (30.71)	30.04 (33.05)
HPBW 1	10.33 (18.71)	19.00 (25.80)	25.33 (30.18)	31.67 (34.23)	21.58 (27.25)	16.33 (23.81)	25.33 (30.20)	33.67 (35.45)	40.33 (39.41)	28.92 (32.33)	25.25 (29.81)
C.D. (0.05%)	(03.43)	(04.83)	(04.46)	(01.06)	(13.72)	(02.89)	(02.97)	(01.51)	(01.43)	(14.91)	(14.29)
SE(m)	01.07	01.51	01.4	00.33	04.51	00.91	00.93	00.47	00.45	04.90	04.70

Figure in parentheses are angular transformed values. DAR= days after release of insects

(15.67%). All other genotypes varied significantly from each other. At 60 DAR, maximum grain damage was observed in HD 2967 (52.67%) followed by WHD 948 (31.00%) and it was significantly at par with HD 3086 (30.33%) in percent grain damage. Minimum grain damage was observed in WB 2 followed by HPBW 1 (25.33%) which was at par with each other. At 90 DAR, minimum grain damage was observed in WB 2 (29.33%) followed by HPBW 1 (33.67%). Maximum grain damage was observed in HD 2967 (61.33%) followed by WHD 948 (40.00%). All the genotypes varied significantly from each other. Similar trend was followed at 120 DAR. The mean grain damage recorded at different stages was highest in case of HD 2967 (56.25%) followed by WHD 948 (35.08%). The genotype HD 2967 varied significantly from all other genotypes. Minimum mean percent grain damage was observed in WB 2 (26.50%) followed by HPBW 1 (28.92%), HD 3086 (34.17%) and WHD 948 (35.08%) which were at par with each other.

The pooled mean grain damage was highest in case of HD 2967 (52.91%) followed by WHD 948 (37.50%). Minimum mean grain damage was observed in HPBW 1 (25.25%) followed by WB 2 (30.04%), HD 3086 (30.91%) and WHD 948 (37.50%) which were at par with each other. These results were in line with Upadhyaya *et al*. (1979) and Arve *et al*. (2014). Uttam *et al*. (2002) found a significant positive correlation with percentage of damaged grains and loss in grain weight, from the incidence of *R. dominica* and *S. cerealella* on different rice varieties. Similarly Meghwal and Bajpai (2010), also reported that varieties with minimum percent weight loss were found resistant and the varieties having maximum percent weight loss were susceptible.

Extent of weight damage (%) of major insect–pest on various wheat genotypes : The percent weight loss by angoumois grain moth was presented in Table 4 for years 2018-19 and 2019-20. During 2018-19, the minimum 4.24 percent weight loss was recorded for HPBW 1 which was followed by WB 2 (6.07%) and HD 3086 (7.63%) while maximum 17.46 percent weight loss was recorded in HD 2967 followed by WHD 948 (10.21%) at 30 DAR. All the genotypes varied

Table 4. Extent of percent weight loss by Sitotroga cerealella in different varieties of wheat

Genotypes	Weight damage (%)										Pooled mean
	2019					2020					
	30 DAR	60 DAR	90 DAR	120 DAR	Mean	30 DAR	60 DAR	90 DAR	120 DAR	Mean	
HD 2967	17.46 (24.69)	19.73 (26.36)	22.07 (28.00)	25.70 (30.45)	21.24 (27.28)	18.77 (25.66)	19.51 (26.20)	23.16 (28.76)	27.59 (31.67)	22.26 (28.07)	21.75 (27.73)
WHD 948	10.21 (18.63)	11.78 (20.06)	14.49 (22.36)	17.44 (24.67)	13.48 (21.43)	06.43 (14.68)	10.55 (18.95)	12.98 (21.11)	16.19 (23.72)	11.5 (19.61)	12.51 (20.56)
HD 3086	07.63 (16.03)	08.69 (17.14)	12.41 (20.62)	13.75 (21.75)	10.62 (18.89)	07.69 (16.10)	09.37 (17.82)	12.21 (20.44)	14.94 (22.73)	11.05 (19.27)	10.84 (19.08)
WB 2	06.07 (14.26)	10.49 (18.89)	11.82 (20.10)	18.92 (25.77)	11.82 (19.75)	05.14 (13.09)	08.17 (16.60)	10.57 (18.97)	12.25 (20.48)	09.03 (17.28)	10.43 (18.56)
HPBW 1	04.24 (11.87)	05.43 (13.47)	10.83 (19.21)	12.80 (20.95)	08.32 (16.68)	05.54 (13.61)	06.23 (14.44)	11.33 (19.67)	12.77 (20.93)	08.97 (17.16)	08.64 (16.78)
C.D. (0.05%)	(00.46)	(00.61)	(00.38)	(00.29)	(05.95)	(00.47)	(00.59)	(00.25)	(00.25)	(05.53)	(05.64)
SE(m)	00.15	00.19	00.12	00.09	01.96	00.15	00.18	00.08	00.08	01.83	01.85

significantly from each other. Minimum 5.43 percent weight loss was recorded in HPBW 1 , followed by HD 3086 (8.69%) whereas maximum 19.73 percent weight loss was recorded in HD 2967 which was followed by WHD 948 (11.78%). All the genotypes varied significantly from each other. Similar trend was followed at 90 and 120 DAR. The mean percent weight loss for 2018-19 showed that maximum (21.24%) weight loss was recorded in HD 2967 whereas minimum (8.32%) in HPBW 1. No significant difference was found among the genotypes.

During 2019-20, the maximum (18.77%) weight loss was recorded for HD 2967 and it was followed by HD 3086 (7.69%) and WHD 948 (6.43%) but minimum 5.14 percent weight loss was recorded for WB 2 which was followed by HPBW 1 (5.54%) at 30 DAR. At 60 DAR, maximum (19.51%) weight loss was recorded in HD 2967 which was followed by WHD 948 (10.55%) while minimum 6.23 percent weight loss was recorded for HPBW 1 followed by WB 2 (8.17%). Similar trend was followed at 90 and 120 DAR. The mean percent weight loss during the year 2019-20 was maximum (22.26%) in HD 2967 and minimum (8.97%) in HPBW 1.

The pooled mean percent weight loss data of both years (2018-19, 2019-20) showed that maximum (21.75%) of weight loss was in HD 2967 followed by WHD 948 (12.51%) whereas minimum (8.64%) in HPBW 1 followed by WB 2 (10.43%). The results were in confirmation of Shafique *et al*., (2006) who observed that twelve wheat varieties were resistant to angoumois grain moth, *S. cerealella* and observed that the resistance in different genotypes was based on the progeny of moths emerged and weight loss of grains.

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