Journal of Cereal Research
Volume 14 (Spl - 2): 73-80
Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Short Communication

Rhyzopertha dominica (Coleoptera: Bostrychidae): Studies on screening techniques of wheat genotypes/varieties for resistance

Syed Mohamed Ibrahim S[*], Chaudhary F K[1], Prithiv Raj V[2] and Rajasehwaran B[3]

[*1,2,]*Department of Agricultural Entomology, Sardarkrushinagar Dantiwada Agricultural University, Gujarat-385506*
[3]*Department of Agricultural Entomology, Anand Agricultural University, Anand, Gujarat-388110*

Article history: Received: 06 July, 2022 Revised: 1 Aug., 2022 Accepted: 11 Aug., 2022

Citation: Syed Mohamed Ibrahim S, Chaudhary F K, Prithiv Raj V and Rajasehwaran B. 2022. *Rhyzopertha dominica* (Coleoptera: Bostrychidae): Studies on screening techniques of wheat genotypes/varieties for resistance. *Journal of Cereal Research* ***14 (Spl-2):*** *73-80. http://doi.org/10.25174/2582-2675/2022/125475*

****Corresponding author:*** *E-mail: syedali.s1966@gmail.com*

Cereals are cheap to produce, easy to store and transport and do not deteriorate readily if kept dry. Among the cereals, wheat (*Triticum aestivum* L. em Thell.) is the strategic and most important cereal crop for the majority of the world's population about two billion people (36 % of the world population). The annual production and an area of wheat in India was recorded as 109.52 tonnes and 30.55 million hectare with an average productivity of 3464 Kg/ha, respectively (Anonymous, 2021). It was attacked by both field and also storage conditions by many insect pests. Among the pests, it is a very dangerous and harmful primary pest that can able to infest all types of cereals (Perisic *et al.*, 2020). The insect readily infests storage grains and can cause economic losses throughout much of the world due to its high potential viability and adaptability (Scheff *et al.*, 2022). After attaining the adult stage, the large exit holes were bored by mature insect inside the grains, so the control of insect with insecticides and grain protectants is very difficult compared to other pests in stored wheat (Vardeman *et al.*, 2007). Due to its internal feedings, the weight loss caused by adult feeding was varied from 6.5 to 19.4 % during 1st to 4th weeks, respectively after adult emergence (Tiwari and Sharma, 2002). To overcome this problem, farmers are using different synthetic insecticides which have inauspicious effects on the environment and non-target organisms and also create resistance to insects, so the small effective work was done to graded the wheat genotypes/varieties and find out the resistant genotype/variety against *R. dominica* which cause significant damage during storage period (Kumawat and Verma, 2017). Once if the resistant variety was explored, it provides an economically and environmentally safe storage protection at free of cost.

The screening experiment of twenty five wheat genotype/variety for their susceptibility against *R. dominica* carried out under laboratory condition during 2020-2021. The twenty-five genotypes/varieties were procured from Wheat Research Station, Vijapur for screening process. Collected samples were cleaned and examined critically to separate the damaged seeds and avoid contamination. Initially the seeds were dried in sunlight (Solomon, 1951).

The culture of *Rhyzopertha dominica* was collected from Wheat Research Station, Vijapur and the same were multiplied on the regional wheat variety GW 451 for conducting the further study. The culture was kept in the glass jar (1 Kg capacity) containing wheat variety GW 451 and placed inside the rearing cage in department laboratory. The mouth of the jar containing insect culture was covered properly with white muslin cloth and held tightly with rubber band. After a week, parent insects were removed from the jar by sieving and seeds with eggs were kept undisturbed under the laboratory condition at an average temperature of 27 ± 2 °C temperature and 75 ± 5 % relative humidity for rearing. For ensuring the continuous availability of insects, sub culturing was done periodically.

Lesser grain borer, *R. dominica* is almost sedentary in nature but also fly occasionally. The newly emerged adult beetles were collected and transferred from initial culture jar to another jar having wheat seeds by using the forceps and camel hair brush for sub culturing. Those sub cultured insects were used as parent culture for further investigation. Sex differentiation in *R. dominica* on morphological characters are very difficult, so the male and female were distinguished during mating (copulation). During the mating process the female adult remains beneath the male and thus both sexes could easily separated in different Petri plates marked with male and female (Deshwal *et al.*, 2018). Based on size and flying capacity the male and female can also be distinguished. Male is smaller than female and usually more active and better flier than the female adult.

To study adult oriental preference, free choice and force choice tests were carried out and the damage potential of lesser grain borer, *R. dominica* was tested. The study was conducted by using circular galvanized tray (35 cm × 11 cm) by fixing white cardboard sheets in a radial manner and twenty five equal compartments were made on the bottom of the cage. 100 seeds of each genotype/variety were weighted and kept in each compartment at equal distance from the centre. Twenty-five pairs of newly emerged adults (male and female) of lesser grain borer were released into the Petri dish (1.5 cm × 9 cm) placed in centre of the circular galvanized cage. After releasing the adults the cage was covered with two fold muslin cloth and tied with the help of thick thread. Orientation of the adults towards each genotype/variety was observed after 12, 24, 36, 48, 60 and 72 hours of release. After completion of the migration of all adults of *R. dominica,* the seeds along with attracted adults were transferred into the separate plastic jar and the number of adult attracted toward each genotype/variety were counted separately and also per cent weight loss and grain damage were calculated after 60 days (Mehta, 2020).

The wheat genotypes/varieties were classified into four category *viz.,* high preference, moderately preference, less preference and no preference by using the arbitrary categorization method on the basis of adult orientation preference (Arya, 2018). The test was conducted providing force choice environment to the adults of *R. dominica* against wheat genotypes/varieties which the samples were restricted for an adults as described by Jha *et al.* (1999). For further confirmation of resistance through force choice test, the low susceptibility index genotype/variety was selected initially. For that purpose, 100 pre-weighted seeds of wheat genotypes/varieties were taken in a plastic sample container (7.0 cm × 5.5 cm) and two pairs of adults (1-2 days old) of lesser grain borer were forcibly released into the each sample containers having separate genotype/variety which make equal preference for all genotypes/varieties. The mouth of the sample container was covered with double folded muslin cloth and held tightly with rubber band. Adults were allowed for oviposition for a period of one week. After a week, the adults were separated from the seed of each genotype/variety. Later, the sample containers were kept undisturbed to document the per cent weight loss, mean development period, and susceptibility index. Based on per cent weight loss, the genotypes/varieties were graded by arbitary categorization as resistant (<6.70) moderately resistant (6.71-10.80), less susceptible (10.81-14.90), moderately susceptible (14.91-19) and highly susceptible (>19). After excluding the frass from the infested seeds, the final weight of sample was taken with single pan electronic balance separately for each treatment. The weight loss (%) was calculated by using the following formula.

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of seed} - \text{Final weight of seed}}{\text{Initial weight of seed}} \times 100$$

The average development time (T) is the time needed for the emergence of 50% of adults and was calculated as (Howe, 1971).

$$\text{Mean development period (day)} = \frac{D1A1 + D2A2 + D3A3 + \ldots\ldots DnAn}{\text{Total number of adults emerged}}$$

Where,

D1 = Day on which adults started emerging

A1 = Number of adults emerged on $D1^{th}$ day

The number of F_1 adults emerged was counted and removed regularly in the each genotype/variety at 25 after days of release. Based on above observation, the susceptibility index was calculated by using the formula suggested by Dobie (1974).

$$\text{Susceptibility index} = \frac{\text{Log F}}{\text{D}} \times 100$$

Where,

F = Total number of adults emerged

D = Mean development period (day)

The data were collected statistically by using the CRD (Completely randomized design) or one way analysis of (ANOVA). Data were analyzed by using the SPSS computer program (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.), the square root and arc sinc transformation were done in required parameters. Significance of difference between the treatments means were compared by Duncan's multiple range test.

The wheat genotypes/varieties *viz*, were screened under free choice and force choice test for their resistance against *R. dominica.* Under free choice test, twenty five wheat genotypes/varieties were screened for their susceptibility and assessed the damage potential of lesser grain borer based on the number of adults migrated at an interval of 12 hours for three days, Per cent weight loss, number of adult emerged and per cent grain damage to the wheat genotypes/varieties which were data recorded and presented in Table 1 & 2.

Table 1. Adult orientation of *R. dominica* to different wheat genotypes/variety

Genotypes/ Varieties	Number of adults oriented after release				
	12 hrs	24 hrs	36 hrs	48 hrs	Mean
GW 11	1.71^{bcdef} (2.00)	1.62^{def} (1.67)	1.82^{cde} (2.33)	1.82^{bcd} (2.33)	1.75^{de} (2.08)
GW 173	1.91^{bcd} (2.67)	2.06^{bc} (3.33)	2.07^{bc} (3.33)	2.07^{bc} (3.33)	2.04^{c} (3.17)
GW 190	1.52^{defg} (1.33)	1.80^{bcde} (2.33)	1.52^{def} (1.33)	1.52^{defg} (1.33)	1.60^{ef} (1.58)
GW 273	1.71^{bcdef} (2.00)	1.72^{cdef} (2.00)	1.82^{cde} (2.33)	1.82^{bcd} (2.33)	1.78^{de} (2.17)
GW 322	1.80^{bcde} (2.33)	1.82^{bcde} (2.33)	1.73^{cde} (2.00)	1.73^{cdef} (2.00)	1.78^{de} (2.17)
GW 366	1.27^{fg} (0.67)	1.28^{f} (0.67)	1.13^{f} (0.33)	1.13^{g} (0.33)	1.22^{h} (0.50)
GW 451	1.27^{fg} (0.67)	1.52^{ef} (1.33)	1.41^{df} (1.00)	1.52^{defg} (1.33)	1.44^{fgh} (1.08)
GW 496	1.13^{g} (0.33)	1.28^{f} (0.67)	1.13^{f} (0.33)	1.27^{g} (0.67)	1.22^{h} (0.50)
GW 499	3.15^{a} (9.00)	3.10^{a} (8.67)	3.26^{a} (9.67)	3.26^{a} (9.67)	3.20^{a} (9.25)
GW 503	1.33^{defg} (1.52)	1.41^{ef} (1.00)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.38^{fgh} (0.92)
GW 1339	1.62^{cdef} (1.67)	1.52^{ef} (1.33)	1.52^{def} (1.33)	1.52^{defg} (1.33)	1.55^{efg} (1.42)
GDW 1255	1.82^{bcde} (2.33)	1.73^{cdef} (2.00)	1.71^{cde} (2.00)	1.71^{cdef} (2.00)	1.76^{de} (2.08)
VD 18-07	1.62^{cdef} (1.67)	1.82^{bcde} (2.33)	1.24^{f} (0.67)	1.38^{fg} (1.00)	1.54^{ef} (1.42)
VD 18-09	1.80^{bcde} (2.33)	2.08^{bc} (3.33)	2.30^{bc} (4.33)	2.15^{b} (3.67)	2.09^{bc} (3.42)
VD 18-12	1.82^{bcde} (2.33)	1.99^{bcd} (3.00)	1.91^{cd} (2.67)	1.91^{bcd} (2.67)	1.91^{cd} (2.67)
VD 18-13	2.07^{bc} (3.33)	1.80^{bcde} (2.33)	2.06^{f} (3.33)	2.15^{b} (3.67)	2.04^{c} (3.17)
VD 18-14	1.62^{cdef} (1.67)	1.28^{f} (0.67)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.38^{fgh} (0.92)
VD 18-16	2.15^{b} (3.67)	2.16^{b} (3.67)	2.30^{b} (4.33)	2.15^{b} (3.67)	2.20^{b} (3.83)
VD 19-05	1.27^{fg} (0.67)	1.28^{f} (0.67)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.29^{c} (0.67)
VD 19-06	1.27^{fg} (0.67)	1.41^{ef} (1.00)	1.41^{df} (1.00)	1.41^{efg} (1.00)	1.38^{fgh} (0.92)
VD 19-09	1.38^{efg} (1.00)	1.38^{ef} (1.00)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.35^{fgh} (0.83)
HI 8498	1.52^{defg} (1.33)	1.28^{f} (0.67)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.35^{fgh} (0.83)
HI 8737	1.71^{bcdef} (2.00)	1.72^{cdef} (2.00)	1.80^{cde} (2.33)	1.80^{bcde} (2.33)	1.78^{de} (2.17)
HD 2932	1.62^{cdef} (1.67)	1.52^{ef} (1.33)	1.52^{def} (1.33)	1.52^{defg} (1.33)	1.55^{efg} (1.42)
LOK 1	1.52^{defg} (1.33)	1.28^{f} (0.67)	1.27^{f} (0.67)	1.27^{g} (0.67)	1.35^{fgh} (0.83)
S. Em. ±	0.14	0.13	0.13	0.12	0.15
C. D. at 5%	0.40	0.39	0.37	0.36	0.46

Notes : Figures in parentheses are retransformed values of $\sqrt{X+1}$ trransformation; Treatment mean with common superscript letter (s) are not significant by DMRT at 5% level of significance.

Table 2. Reaction of wheat genotypes/varieties to *Rhyzopertha dominica* under free choice test

Genotypes /Varieties	*Mean No. Of adults attracted	Initial Weight	Final Weight	Weight loss (%)	No. Of adult emergence	% Grain damage
GW-11	1.75^{de} (2.08)	3.62^{l}	3.28^{m}	12.57^{d} (4.77)	1.33^{hi}	7.17^{fgh} (2.33)
GW-173	2.04^{c} (3.17)	4.03^{ij}	3.72^{l}	16.01^{b} (7.62)	3.00^{fg}	17.78^{bcdef} (9.33)
GW-190	1.60^{ef} (1.58)	3.66^{kl}	3.59^{l}	7.72^{hij} (1.82)	9.00^{c}	23.05^{ab} (15.33)
GW-273	1.78^{de} (2.17)	3.77^{kl}	3.66^{l}	9.93^{fg} (3.02)	0.67^{hi}	7.94^{gh} (2.00)
GW-322	1.78^{de} (2.17)	3.69^{kl}	3.62^{l}	8.10^{hi} (1.99)	2.00^{gf}	15.92^{cdefgh} (7.67)
GW-366	1.22^{h} (0.50)	5.49^{c}	5.49^{cd}	5.98^{ijklm} (1.09)	0.33^{i}	4.62^{h} (1.00)
GW-451	1.44^{fgh} (1.08)	4.45^{f}	4.43^{hijk}	4.54^{klm} (0.68)	5.33^{e}	11.01^{efgh} (3.67)
GW-496	1.22^{h} (0.50)	4.57^{f}	4.55^{ghi}	3.43^{m} (0.37)	0.67^{hi}	5.73^{h} (1.00)
GW-499	3.20^{a} (9.25)	4.94^{e}	4.45^{ghijk}	18.23^{a} (9.79)	5.33^{e}	18.01^{bcdef} (9.67)
GW-503	1.38^{fgh} (0.92)	3.70^{kl}	3.67^{l}	5.38^{jklm} (0.90)	0.67^{hi}	5.42^{h} (1.33)
GW-1339	1.55^{efg} (1.42)	4.62^{f}	4.35^{ijk}	14.06^{c} (5.92)	5.00^{e}	20.49^{bcd} (12.33)
GDW1255	1.76^{de} (2.08)	5.20^{d}	4.96^{fg}	12.38^{d} (4.62)	7.00^{d}	20.34^{bcd} (12.33)
VD18-07	1.54^{ef} (1.42)	5.05^{de}	5.00^{f}	5.89^{ijklm} (1.06)	1.67^{hi}	9.97^{efgh} (3.00)
VD18-09	2.09^{bc} (3.42)	4.42^{fg}	4.22^{jk}	12.25^{d} (4.53)	10.67^{b}	26.64a (20.67)
VD18-12	1.91^{cd} (2.67)	4.99^{e}	4.75^{fgh}	12.58^{d} (4.75)	$2.00g^{h}$	18.10^{bcde} (10.33)
VD18-13	2.04^{c} (3.17)	6.12^{ab}	5.91^{ab}	10.42^{efg} (3.38)	1.33^{hi}	12.11^{defgh} (5.00)
VD18-14	1.38^{fgh} (0.92)	5.98^{b}	5.68^{bc}	12.70^{d} (4.85)	3.33^{f}	10.87^{defgh} (5.33)
VD18-16	2.20^{b} (3.83)	5.48^{c}	5.31^{e}	10.13^{efg} (3.10)	8.33^{c}	20.68^{bc} (13.00)
VD19-05	1.29^{c} (0.67)	6.21^{a}	6.06a	8.99^{gh} (2.47)	1.00^{hi}	7.15^{h} (1.67)
VD19-06	1.38^{fgh} (0.92)	4.86^{e}	4.68^{gf}	11.29^{def} (3.85)	1.00^{hi}	7.15^{h} (1.67)
VD19-09	1.35^{fgh} (0.83)	4.17^{hi}	4.17^{k}	11.68^{de} (4.10)	0.67^{hi}	6.22^{gh} (2.00)
HI8498	1.35^{fgh} (0.83)	4.60^{f}	4.52^{ghij}	7.54^{hijk} (1.73)	0.33^{i}	1.91^{h} (0.33)
HI8737	1.78^{de} (2.17)	4.53^{f}	4.15^{k}	16.67^{b} (8.24)	13.00^{a}	23.05^{ab} (16.00)
HD2932	1.55^{efg} (1.42)	4.24^{g}	4.19k	6.89^{hijkl} (1.45)	3.00^{fg}	9.78^{efgh} (4.33)
LOK1	1.35^{fgh} (0.83)	3.87^{jk}	3.85^{l}	3.72^{lm} (0.43)	3.67^{f}	10.20^{efgh} (4.67)
S.Em	0.05	0.15	0.10	0.56	0.4	2.90
C.D at 5%	0.14	0.46	0.29	1.65	1.18	8.53

Notes: *Figures in parentheses are retransformed values of $\sqrt{x+1}$ transformation; Values in parentheses are retransformed values of Arc sin transformation; Treatment mean with common superscript letter (s) are not significant by DNMRT at 5% level of significance.

The tabulated result revealed that the wheat genotypes/ varieties differed significantly with respect to the adult oriented toward them at an interval of 12, 24, 36, 48, 60 and 72 hrs after release. The adult orientation among genotypes/varieties varied from 0.33 to 9.00 and 0.67 to 8.67 at 12 and 24 hrs, respectively and 0.33 to 9.67 at 36 and 48 hrs. At 60 and 72 hrs after release, there was no adult orientation observed and same number of adults attracted toward each genotypes/varieties which started feeding the seeds. After 12, 24, 36 and 48 hrs, the orientation of adult *R. dominica* was significantly differed. Mean number of adults orientation to wheat variety ranging between 9.27 and 3.83 adults per 100 grains (Table 1). The variety GW 499 attracted highest adults (9.27 adults), while GW 496 and GW 366 displayed least (0.50 adults) mean number of adults. The rest of the genotypes/ varieties invited the adults ranged between 0.83 and 3.42 adults per 100 grain. The initial weight of 100 grains of each genotypes/varieties were recorded before the adult introduction and after the infestation, as per choice of insect and their emergence, the adults were removed to observed the final weight and per cent weight loss. The least per cent weight loss displayed in the genotype GW 496 (0.37) as par with LOK 1 (0.43) and the genotype GW 499 was displayed as maximum weight loss (9.79) followed by variety HI 8737 (8.24), respectively. The rest of genotypes/varieties were value ranging 0.68 and 7.62 %. Similarly, as per the results the minimum per cent grain damage was noted in the variety HI 8498 (0.33) as par with GW 496 (1.00) and the variety VD 18-09 (20.67) had recorded the maximum per cent grain damage among all (Table 2).

The insects might infest the host of their choice in the free choice test. This method is usually used to measure a cultivar's ability to repel insects (Giga 1995). In past, Sharma *et al.* (2001) found the minimum adult of *R. dominica* oriented in wheat genotypes *viz.,* HD 2705, GW 173 and RAJ 1399 after 48 hrs of release. Korawar (2018) observed the highest number of orientation of adults of *R. dominica* towards genotype NIAW 3581 while lowest toward the genotype MACS 6222 after 24 and 48 hrs of release. Followed by Mehta (2020) revealed highest adult orientation to wheat variety HPW 155 which was followed by HPW 236 and minimum adult orientation was found in HPW 349. They measured grain weight loss and noted fluctuations by using the choice approach. As per results in Table 4, genotype GW 496 and LOK 1 were very less preferred by adult insect on basis of adult movement and grain damage.

Table 3. Classification of wheat genotypes/varieties on basis of adult orientation preference

Category	Number of adults oriented	Genotypes/varieties
Less preference	< 2.69	GW 366, GW 496, VD 19-05, LOK 1, HI 8498, VD 19-09, GW 503, VD 18-14, VD 19-06,GW 451, VD 18-07, GW 11, GW 1339, HD 2932,GW 190, HI 8737, GDW 1255, GW 322,GW 273, VD 18-12
Moderately preference	2.69 – 4.88	VD 18-16, VD 18- 13, VD 18-09, GW 173
High preference	4.89 – 7.06	---
Very High preference	> 7.06	GW 499

The result on evaluation of different wheat genotypes/ varieties against the adults of *Rhyzopertha dominica* on the basis of initial weight (g), final weight (g), weight loss (%), mean developmental period (day), F1 adult emergence (number) and susceptibility index are presented in Table 4. The data of all the parameters of various wheat genotypes/varieties in the test were showed significant difference among various wheat genotypes/varieties, respectively. The wheat variety GW 190 displayed the maximum significant (23.10 %) weight loss followed by GW 503 (20.69 %) but they were statistically at par. Whereas, the LOK 1 displayed least seed weight loss (2.60 %) but it was at par with genotype GW 366 (3.35 %) followed by VD18-14 (3.79 %) which indicated poor preference of *R. dominica* toward wheat varieties. Saad *et al.* (2018) recorded minimum weight loss in wheat variety, Romanian at 10, 15 and 20 unsexed adult infestation level of *R. dominica*, while maximum weight loss was recorded in American variety, Summer Red wheat at same level of adult infestation. We noticed the sustainable variation of mean developmental period of *R. dominica* on various wheat genotypes/varieties (Table 4). The *R. dominica* reared on wheat variety GW 11 demonstrated longest mean developmental period *i.e.* 51.22 days. It was followed by wheat varieties/ genotypes LOK 1(50.63 days), GW 499 (49.73 days) and VD 18-12 (49.58 days), but they were statistically at par. *R. dominica* took shortest mean developmental period on variety GW 366 (35.06 days) followed by wheat variety GW 173 (39.80 days). Based on results, susceptible genotypes showed the rapid and early adult emergence, while the resistant genotypes revealed delayed and slow adult emergence. The results of present study are in similar with the findings of Kumawat and Verma (2017) who reported that the mean duration of life period of *R. dominica* varied from 35.00 to 51.33 days on various wheat variety. Similarly Mehta (2020) reported the maximum and minimum mean developmental period on the wheat varieties HPW 249 and HPW 155, respectively. The number of F_1 adults emergence varied from 10.33-43.33 adults per 100 seeds (Table-4). The highest number of F_1 adult emerged (43.33 adults) in wheat variety GW 190 and genotype VD 18-14 recorded lowest number of F1 adult (10.33 adults). Rest of the genotypes/varieties were recorded the F_1 adult emergence was ranged from12.00 to 41.33 adults. Kakade *et al.* (2014) recorded that the highest and lowest F_1 adult emergence in wheat variety Raj 3765 and Raj 1482, respectively 60 days after release of adults in 100 seeds. The susceptibility index was calculated on the basis of growth parameters in different genotypes/varieties. Despites the weight loss and growth parameters, there were a significant difference among the susceptibility index of 25 wheat genotypes/varieties which values ranging 2.03 to 3.52 (Table-4). The wheat genotype HD 2932 displayed highest susceptibility index

(3.52). Rest of the genotypes/varieties were values ranging between 2.58 and 3.47.The wheat variety LOK 1 recorded lowest susceptibility index (2.03) followed by genotypes VD 18-12 (2.15). Similarly, Bhanderi *et al.* (2015) reported that higher susceptibility index in wheat variety samurai 2 and were lower in wheat variety Suri 3. These results are in conformity with the findings of present study. As per tabulated results in Table 6, GW 503 and GW 190 were severely damaged and cause heavy weight loss by adult insects.

Table 4. Evaluation of wheat genotypes/varieties against lesser grain borer under force choice test

Genotypes/ varieties	Parameters					
	Initial Weight (g)	Final Weight (g)	Weight loss (%)	Mean developmental period (day)	F_1 adult emerged (Number)	S I
GW 11	3.67^{op}	3.27^{j}	19.19^{f} (10.81)	51.22^{a}	21.00^{gh}	2.58^{m}
GW 173	4.00^{mno}	3.81^{ghi}	11.32^{ij} (3.87)	39.80^{j}	12.67^{ijk}	2.77^{kl}
GW 190	3.59^{p}	2.76^{k}	28.72^{a} (23.10)	47.18^{hi}	43.33^{a}	3.47^{a}
GW 273	3.59^{p}	2.93^{jk}	25.46^{c} (18.49)	48.87^{def}	31.33^{de}	3.06^{fgh}
GW 322	4.07^{lmn}	3.75^{ghi}	18.74^{f} (10.32)	48.32^{bcde}	24.33^{f}	2.87^{ijk}
GW 366	5.62^{cde}	5.45^{b}	10.52^{jk} (3.35)	35.06^{k}	12.00^{jk}	3.08e^{fgh}
GW 451	4.39^{kl}	3.67^{hi}	25.71^{c} (18.84)	48.82^{efgh}	41.33^{ab}	3.31^{bc}
GW 496	4.95^{hij}	4.43^{ef}	18.81^{f} (10.40)	46.31^{hi}	29.67^{e}	3.18^{cdef}
GW 499	4.63^{jk}	3.98^{ghi}	25.30^{c} (18.28)	49.73^{def}	36.00^{c}	3.13^{defg}
GW 503	3.85^{nop}	3.04^{jk}	27.05^{b} (20.69)	47.29^{fgHI}	34.00^{cd}	3.24^{cde}
GW 1339	4.45^{k}	3.83^{gHI}	21.18^{de} (13.06)	46.83^{ghI}	39.33^{b}	3.41^{ab}
GDW 1255	5.10^{fgh}	4.56^{de}	18.48^{f} (10.05)	47.11^{cde}	26.00^{f}	3.00^{ghI}
VD 18-07	5.93^{bc}	5.42^{b}	16.95^{g} (8.50)	44.80^{cde}	29.00^{e}	3.26^{bcd}
VD 18-09	4.55^{k}	3.91^{ghI}	21.54^{d} (13.49)	48.74^{efgh}	30.67^{e}	3.05^{fgh}
VD 18-12	5.03^{ghi}	4.91^{cd}	12.36^{ij} (4.60)	49.58^{abcd}	11.67^{jk}	2.15^{o}
VD 18-13	6.34^{a}	6.11^{a}	11.93^{ij} (4.29)	43.46^{cde}	14.00^{ij}	2.64^{lm}
VD 18-14	5.77^{bcd}	5.55^{b}	11.22^{ij} (3.79)	42.34^{cde}	10.33^{k}	2.40^{n}
VD 18-16	5.46^{def}	5.19^{bc}	12.74^{hI} (4.87)	45.98^{abc}	23.00^{fg}	2.96^{hij}
VD 19-05	6.08^{ab}	5.43^{b}	18.08^{f} (9.63)	49.44^{cde}	24.67^{f}	2.81^{jk}
VD 19-06	4.94^{hij}	4.44^{ef}	14.12^{h} (5.96)	47.30^{cde}	19.00^{h}	2.70^{klm}
VD 19-09	4.04^{lmno}	3.64^{i}	18.62^{f} (10.20)	46.40^{efg}	18.33^{h}	2.72^{klm}
HI 8498	4.70^{ijk}	4.06^{gh}	20.37^{ij} (12.13)	41.75^{ij}	15.33^{i}	2.84^{jk}
HI 8737	5.35^{efg}	4.56^{de}	21.98^{d} (14.01)	47.64^{cde}	34.67^{c}	3.23^{cde}
HD 2932	4.33^{klm}	4.11^{fg}	11.98^{ij} (4.30)	45.31^{bcde}	39.33^{b}	3.52^{a}
LOK 1	3.75^{nop}	3.65^{i}	9.26^{k} (2.60)	50.63^{ab}	10.67^{k}	2.03^{o}
S. Em. ±	0.12	0.12	0.39	0.84	0.97	0.05
C. D. at 5%	0.35	0.35	1.06	2.47	2.87	0.15
C. V. %	4.39	4.80	3.58	3.14	6.69	3.08

Notes: Figures in parentheses are retransformed values of Arc sin transformation; Treatment mean with common superscript letter (s) are not significant by DNMRT at 5% level of significance.

The results of correlation analysis of different growth parameters of *R. dominica* on wheat genotypes/varieties are presented in Table-5. It revealed that initial weight had highly significant positive correlation with final weight (r = 0.97**), but it was significant negative correlation with per cent weight loss (r = -0.45*). Mean developmental period (r = -0.37), F1 adult emerged (r = -0.29) and susceptibility index (r = -0.22) were negatively correlated with the initial weight. Similarly, the final weight had highly significant negative correlation with per cent weight loss (r = -0.65**), but it was negatively correlated with mean developmental period (r = -0.42) and had significant negative correlation with F_1 adult emergence (r = -0.46*) and susceptibility index (r = -0.39*). Weight loss (%)

exhibited highly significant positive correlation with F_1 adult emergence (0.76**) and susceptibility index (0.69**), while established significant positive correlation with mean developmental period (0.41*). Mean developmental period formed significant positive correlation with F_1 adult emergence (0.39*), while it showed positive correlation with susceptibility index (0.01). F_1 adult emergence established highly significant positive correlation with susceptibility index (0.88**). From ongoing discussion, indicated that increase in developmental period, F_1 adult emergence and susceptibility index increased the weight loss in all the wheat genotypes/varieties. The more number of F1 adult emerged also indicated the susceptibility of wheat genotypes/varieties against *R. dominica*. Earlier, Syed *et al.* (2006), observed positive significant correlation between weight loss (%) and progeny development and moisture (%) of seed. Similarly, the positive correlation between per cent weight loss and mean developmental period, susceptibility index and F_1 adult emergence were reported by Arya (2018) which were close conformity to present study.

Table 5. Classification of wheat genotypes/varieties on basis of force choice weight loss (%)

Category	% weight loss	Wheat genotypes/varieties
Resistant	< 6.70	GW 366, LOK 1,VD 18-14, GW 173, VD 18-13, HD 2932, VD 18-12, VD 18-16,VD 19-06
Moderately resistant	6.70 – 10.80	VD 18-07, VD 19-05, GDW 1255, VD 19-09, GW 322, GW 496
Less susceptible	10.81 – 14.90	GW 11, HI 8498, GW 1339, VD 18-09, HI 8737
Moderately susceptible	14.91 – 19.0	GW 499, GW 273,GW 451
Susceptible	> 19.0	GW 503, GW 190

Table 6. Correlation between the growth parameters of *R. dominica* on various wheat genotypes/varieties

Parameters	Initial weight	Final weight	Weight loss	Mean developmental period	F_1 adult emergence	SI
Initial weight	1.00	0.97**	-0.45*	-0.37	-0.29	-0.22
Final weight		1.00	-0.65**	-0.42	-0.46*	-0.39*
Weight loss			1.00	0.41*	0.76**	0.69**
Mean developmental period				1.00	0.39*	0.01
F1 adult emergence					1.00	0.88**
Susceptibility index						1.00

* Significant at 5 per cent level of significance (r = 0.396); **Significant at 1 per cent level of significance (r = 0.505)

Twenty five wheat genotypes/varieties were screened, since the cultivar LOK 1 had least per cent weight loss, F1 adult emergence and susceptibility index which have an immune potential and ability to resist against *R. dominica*. These germplasm can be used as resistance lines donor in future breeding programmes. Although the biochemical parameters of the varieties used in this study were not examined, the reasons for differences in susceptibility/preference to *R. dominica* can be discovered by examining biochemical parameters of different varieties and determining their relationship to the borer's biological parameters.

Author contributions

All the authors contributed to the article and approved the submitted version.

Compliance with ethical standards

Yes

Conflict of interests

No commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Perisic V, F Vukajlovic, D Predojevic, V Rajicic, G Andric and P. Kljajic. 2020. Effects of abamectin on lesser grain borer, *Rhyzopertha dominica* F. (Coleoptera: Bostrichidae), infestation on some stored grains. *Egyptian Journal of Biological Pest Control* **30**(1):1-7.
2. Arya PS. 2018. Comparative damage potential of *Sitophilus oryzae* (L.) and *Rhyzopertha dominica* (F.) on wheat cultivars. M. Sc. (Ag) Thesis, Indian Agricultural Research Institute, New Delhi, 78p.
3. Bhanderi GR, GG Radadia and DR Patel. 2015. Eco friendly management of rice weevil, *Sitophilus oryzae* (Linnaeus) in sorghum. *Indian Journal of Entomology* **77**(3): 210-213
4. Deshwal R, PK Gupta, V Vaibhav and A Kumar. 2018. Biology of lesser grain borer (*Rhyzopertha dominica* Fab.), under different temperature and humidity at laboratory condition. *Journal of Entomology and Zoology Studies* **6**(4): 364-368
5. Giga DP. 1995. Selection of oviposition sites by the cowpea weevils *Callosobruchus rhodesianus* (Pic.) and *Callosobruchus maculatus* (F.). *International Journal of Troprical Insect Science* **16**(2): 145-149.
6. Howe RW. 1971. A parameter for expressing the suitable environment for insect development. *Journal of Stored Product Research* **7**(1): 63-65.
7. ICAR-IIWBR. 2021. Director's Report of AICRP on Wheat and Barley 2020-21, Ed: GP Singh. ICAR Indian Institute of Wheat and Barley Research, Karnal, Haryana, India. p 76.
8. Jha AN, SC Khanna and S Singh. 1999. Olfactory response of insect pests to stored grains to wheat cultivars. *Indian Journal of Entomology.* **61**(3): 288-290.
9. Kakade SP, SV Dhonde , AL Sarda, PW Khillare and HL Deshwal. 2014. Screening of wheat varieties and eco-friendly management of *Rhyzopertha dominica* (F.) on wheat. *Plant archives* **14**(1): 431-437.
10. Korawar LM. 2018. Varietal screening and management of *Rhyzopertha dominica* (Fabricius) in stored wheat. M.Sc. Thesis Submitted at Mahatma Phule Krishi Vidhyapeeth, Rahuri.
11. Kumawat KC and BS Verma. 2017. Screening of wheat varieties for their resistance against *Rhizopertha dominica* (Fab.). *Indian Journal of Appied Entomology* **31**(1): 18–22.
12. Mebarkia A, Y Rahbe, A Guechi, A Bouras and M Makhlouf. 2010. Susceptibility of twelve soft wheat varieties (*Triticum aestivum*) to *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). *Agriculture and Biology Journal of North America* **1**(4): 571-578.
13. Mehta V. 2020. Impact of different wheat cultivars on lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) under storage conditions. *Journal of Entomology and Zoology Studies* **8**(3): 1063-1066.
14. Saad ASA, EHM Tayeb, MME Shazli and SA Baheeg. 2018. Susceptibility of certain Egyptian and imported wheat cultivars to infestation by *Sitophilus oryzae* and *Rhyzopertha dominica*. *Archives of phytopathology and Plant Protection* **51**(2): 14-29.
15. Scheff DS, JF Campbell and FH Arthur. 2022. Seasonal, landscape, and attractant effects on lesser grain borer, *Rhyzopertha dominica* (F.), captures in Northeast Kansas. *Agronomy* **12**: 99
16. Sharma V, SS Bhadauria and V Sharma. 2001. Reaction of some wheat varieties to lesser grain borer, *Rhyzopertha dominica*. *Indian Journal of Entomology* **63**(2): 163-165.
17. Solomon ME. 1951. Control of humidity with potassium hydroxide, sulphuric acid, or other solutions. *Bulletin of Entomological Research* **42**(3): 543-554.
18. Syed TS, FY Hirad and GH Abro. 2006. Resistance of different wheat varieties to Khapra beetle, *Trogoderma granarium* (Everts) and lesser grain borer, *Rhizopertha dominica* (Fabricius). *Pakistan Journal of Bioscience* **18**(1):1-4.
19. Tiwari R and VK Sharma. 2002. Susceptibility of wheat germplasm to stored grain pests. *Indian Journal of Entomology* **64**(1):1-11.
20. Vardeman EA, JF Campbell and FH Arthur. 2007. Behavior of female *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in a mono-layer of wheat treated with diatomaceous earth. *Journal of Stored Product Research* **43**(3): 297-301.