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Short Communication

Differential response of wheat cultivars to grain damage by Rice Weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae)

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In India, post-harvest losses of about 10.0 per cent of total food grains have been reported due to unscientific storage, rodents, insect-pests, micro-organisms etc. In India as much as 25% losses in food grains have been estimated to occur during storage and 4.93% in case of wheat only (Jha *et al.,* 2015). Stored product pests have the capacity to infest both raw and processed agricultural products. More than a dozen stored grain pests attack wheat and other cereals in storage. Among these the weevils *viz.,* rice weevil, *Sitophilus oryzae* (L.), grain weevil, *S. granarius* (L.) and maize weevil, *S. zeamais* (M.) are classified as the most important primary pests of stored wheat (Rees, 2004; Beckett *et al.*, 2007). Among weevils, rice weevil has been identified as most widespread and destructive one. This weevil species has a relatively short developmental period and hence its high populations can build up in a short duration (Aitken, 1975). It is an internal feeder which feeds by boring into the grains. Adults of the weevil feed preferentially on the endosperm and thus reducing the carbohydrate content but larvae feed mainly on the germ portion of the grains and remove proteins and vitamins (Belloa, *et al.*, 2000). This weevil is able to cause losses to the tune of up to 80% under prolonged storage conditions (Park *et al.*, 2004). Grain damage in wheat due to *S. oryzae* was found to be as much as 27.16 ± 10.31 per cent (Mehta *et al.*, 2021). Damage to grains by the larvae makes them prone to infestation by secondary feeders and pathogens, thereby leading to increased damage to the grains.

The prevention of losses in stored grains due to insect-pests is of paramount importance. Among various means and methods of preventing grain damage from insects is developing resistant and tolerant varieties (Kumar *et al.,* 2019). The screening of different varieties of wheat against *S. oryzae* can be a very effective tool in the management of this stored grain pest as the different varieties shows different level of susceptibility (Tiwari and Sharma, 2002). Sarin and Sharma (1983) have revealed that all the stored grain pests exhibit the phenomenon of preference and non-preference for the grains of different varieties. A number of varieties have exhibited resistance to *S. oryzae* in lab experiments (Swamy *et al.*, 2014). There has been little emphasis in breeding for grain resistance to insect pests of stored grain products. This aspect can be achieved by screening the various varieties available for cultivation in different region of the country. As far as the susceptibility of different varieties of wheat to *S. oryzae* is concerned, very scanty literature is available. Keeping the above facts in view, investigations were carried out by screening of different varieties of wheat for ovipositional preference (choice and no choice test), adult emergence and grain damage (number and weight basis). The data collected from present study will help in identifying resistant and susceptible reactions of selected wheat varieties against *S. oryzae*, which can also be useful in further breeding programme.

The present investigations on rice weevil with reference to screening of different varieties of wheat for ovipositional preference (choice and no choice test), adult emergence and grain damage (number and weight basis) were carried out at Department of Entomology, CCSHAU, Hisar during August to October 2017 in laboratory conditions. The minimum and maximum temperature during the period of study ranged from 20.64 to 35.73°C. The morning and evening relative humidity varied from 82 to 58 per cent during the period. The healthy, clean, genetically pure, disease and insect free grains of fifteen varieties of wheat *viz.,* WH1105, WH1124, WH1142, WH283, WH542, WH711, WH1080, WH1025, WH157, DBW17, DPW62150, HD2967, PBW343, C306 and WH147 were procured from the Wheat & Barley Section, Department of Genetics and Plant Breeding, CCSHAU, Hisar. These varieties were further examined to remove foreign material, if any.

The adults of *S. oryzae* were collected from granaries of wheat from local market to initiate stock culture. The collected adults of rice weevil were identified and released in the plastic containers of two litre capacity along with wheat grains. The stock culture was maintained on wheat variety WH1105. For the development of weevils, fresh grains were provided periodically as and when required. Males and females were identified on the basis of form of rostrum. In male weevils, it was comparatively thick, rough and less curved whereas in female, it was thin, shining and slightly curved. In lateral view, the pygidium of the female was found to be straight whereas it was conspicuously curved in male. The details of different methodologies used were furnished as hereunder.

The adults of *S. oryzae* were collected from granaries of wheat from local market to initiate stock culture. The collected adults of rice weevil were identified and released in the plastic containers of two litre capacity along with wheat grains. The stock culture was maintained on wheat variety WH 1105 providing fresh grains as and when required. Males and females were identified on the basis of rostrum structure. For oviposition preference tests, 50 g wheat grains of each variety were taken in ovipositional cage (for choice test) and in separate 250 g capacity containers (for no choice test) with three replications each. The number of pairs of adults released was 100 and 5, respectively for choice test and no choice test. A total of 250 grains of each variety were selected randomly and observations on total number of eggs deposited on grains of each variety were recorded at 15, 30 and 45 days after infestation in both the tests. Similarly, the adult emergence was recorded by releasing newly emerged five pairs of rice weevils in 250 g capacity plastic containers having 50 g wheat grains with three replications separately for each variety. Observations on the number of adult emerged were recorded after 30, 45 and 60 days after release of weevils. The newly emerged adults were counted and these were removed regularly to check further breeding. Adult emergence was recorded to find out the host preference for breeding. Grain damage (%) and weight loss (%) was assessed from 250 grains of each variety after 30, 45 and 60 days of release by using the below formulae:

$$\text{Grain damage (\%)} = \frac{\text{Number of damaged grains}}{\text{Total number of grains used}} \times 100$$

The grain damage on weight loss basis (%) was estimated by the following formula suggested by Adams and Schulten (1978) with the help of single pan electric balance.

$$\text{Weight loss (\%)} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

(Wu-Weight of undamaged grains, Nu-Number of undamaged grains, Nd- Number of damaged grains, Wd-Weight of damaged grains).

Under both choice test and no choice tests, WH 1105 and C 306 exhibited minimum ovipositional preference for *S. oryzae* as well as minimum adult emergence of 66.68 adults and 76.01 adults emerging from 250 grains of C 306 and WH 1105, respectively. The grain damage (%) was also found to be minimum in theses cultivars with damage of 14.12% (C 306) and 15.11% (WH 1105). Similar trend was found in weight loss (%) due to infestation in C 306 (5.65%) and WH 1105 (6.19%).

Varieties WH147 and DPW62150 were found to be preferred by *S. oryzae* with ovipositioning to the tune of 368.78 and 321.89 eggs/250grains. Adult emergence was also maximum in these varieties with adult emergence of 118.33 adults and 112.01 adults emerging from 250 grains of WH147 and DPW62150, respectively. WH147 exhibited maximum grain loss (%) and weight loss (%) with losses 25.53 and 9.84, respectively. According to Gomez *et al.* (1982) the chemical factors may be responsible for the avoidance of the adult female to lay eggs on the wheat grains. The current findings are in support with those of Arve *et al.* (2014) who reported that the number of eggs laid on different varieties varied from 146.00 to 407.83 and 194.33 to 318.50 eggs under free choice and no choice test, respectively. Earlier, Khan *et al.* (2014) and Pradeep *et al.* (2015) observed the similar trend of increase in population of adult with the increase in storage period on wheat and sorghum, respectively. Khan and Halder (2012) also observed that population of adult rice weevil increased gradually as the increase in storage period. The current findings are parallel with those of Khan *et al.* (2014), Pradeep *et al.* (2015) who observed that the per cent grain damage of *S. oryzae* increased with the duration of storage progressed. Adams (1976) revealed that *S. oryzae* caused 18.30 per cent losses to stored grains. Mehta *et al.* (2021) reported the grain damage due to *S. oryzae* in wheat in the tune of 9.92±4.85 to 27.16±10.31 per cent, whereas the weight loss (%) due to infestation was found to be in the range of 2.66±0.53 to 14.82±0.38. The findings of Tiwari *et al.* (1989) and Laskar and Ghosh (2004) on per cent grain damage and weight loss in different varieties of wheat due to *S. oryzae* also support the present findings.

Different varieties exhibit differential response to insect pests and on the basis of studies it can be concluded that the wheat cultivars WH1105, WH1124, WH1142 and C306 are least preferred by *S. oryzae* on the basis of their ovipositional preference, adult emergence and infestation levels on different wheat cultivars under consideration.

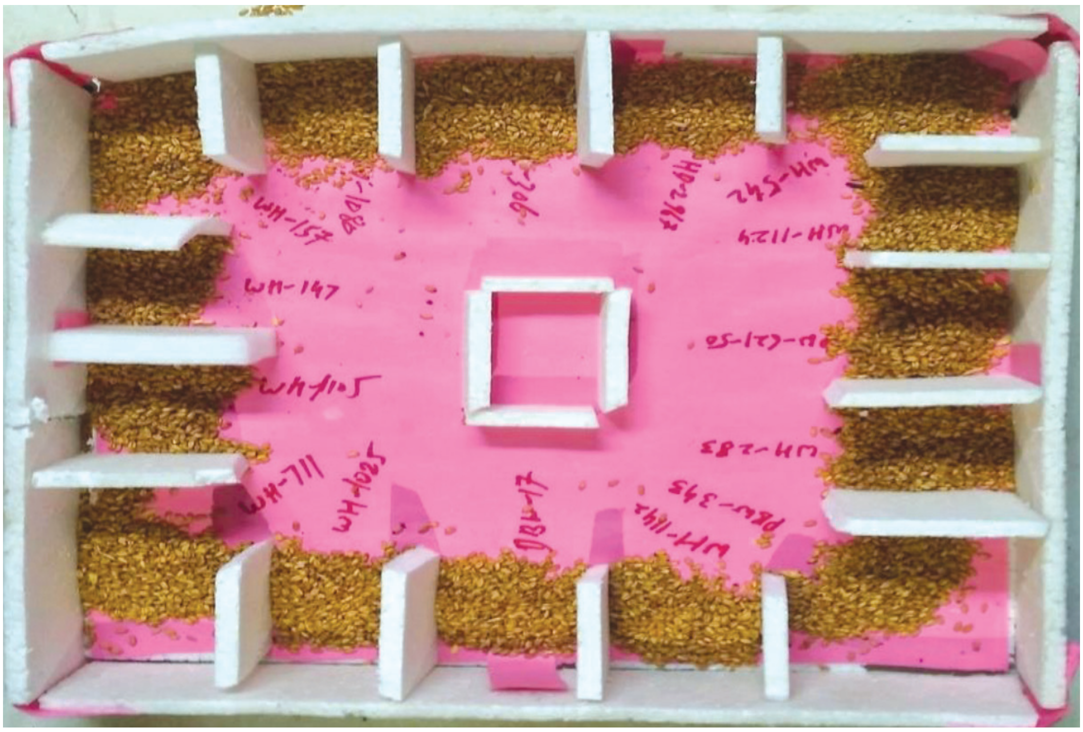

Fig 1. Ovipositional cage for performing choice test

Table 1. Ovipositional preference of rice weevil, *S. oryzae* on different varieties of wheat under choice and no choice conditions

Variety	Ovipositional preference (No. of eggs laid/250 grains)							
	Choice conditions				No choice conditions			
	15 DAI*	30 DAI	45 DAI	Mean	15 DAI	30 DAI	45 DAI	Mean
WH 1105	185.00 (13.64)**	184.33 (13.61)	207.33 (14.43)	**192.22 (13.89)**	184.33 (13.60)	176.00 (13.30)	191.00 (13.84)	**183.78 (13.58)**
WH 1124	249.33 (15.79)	238.00 (15.44)	246.67 (15.73)	**244.67 (15.65)**	206.00 (14.39)	204.00 (14.31)	215.67 (14.72)	**208.56 (14.47)**
WH 1142	199.33 (14.15)	193.67 (13.95)	204.00 (14.31)	**199.00 (14.39)**	202.33 (14.25)	206.00 (14.38)	210.33 (14.51)	**206.22 (14.38)**
WH 283	285.00 (16.88)	275.00 (16.60)	279.33 (16.74)	**279.78 (16.74)**	251.67 (15.88)	249.67 (15.83)	259.33 (16.14)	**253.56 (15.95)**
WH 542	252.33 (15.90)	277.33 (16.67)	282.33 (16.80)	**270.66 (16.46)**	222.33 (14.92)	234.67 (15.34)	247.67 (15.76)	**234.89 (15.34)**
WH 711	274.00 (16.58)	262.00 (16.21)	265.67 (16.30)	**267.22 (16.36)**	270.00 (16.44)	264.67 (16.29)	267.00 (16.36)	**267.22 (16.36)**
WH 1080	288.67 (17.02)	277.33 (16.68)	286.67 (16.95)	**284.22 (16.88)**	243.00 (15.61)	248.67 (15.80)	264.67 (16.30)	**252.11 (15.90)**
WH 1025	207.33 (14.40)	206.33 (14.36)	214.00 (14.65)	**209.22 (14.47)**	250.67 (15.85)	261.33 (16.18)	277.33 (16.67)	**263.11 (16.23)**
WH 157	292.00 (17.11)	285.33 (16.91)	289.33 (17.02)	**288.89 (17.01)**	233.67 (15.31)	222.33 (14.90)	234.67 (15.34)	**230.22 (15.18)**
DBW 17	258.33 (16.10)	264.67 (16.30)	285.33 (16.91)	**269.44 (16.44)**	262.67 (16.22)	256.67 (16.04)	264.33 (16.25)	**261.22 (16.17)**
DPW 62150	330.33 (18.20)	318.67 (17.87)	316.67 (17.82)	**321.89 (17.96)**	302.33 (17.41)	288.00 (16.99)	300.67 (17.34)	**297.00 (17.25)**
HD 2967	203.67 (14.30)	211.33 (14.54)	213.67 (14.65)	**209.56 (14.50)**	254.33 (15.97)	254.33 (15.98)	256.33 (16.03)	**255.00 (15.99)**
PBW 343	288.67 (17.01)	275.33 (16.61)	291.33 (17.09)	**285.11 (16.90)**	315.33 (17.78)	311.33 (17.67)	318.67 (17.88)	**315.11 (17.78)**
C 306	161.67 (12.72)	160.00 (12.69)	178.33 (13.39)	**166.67 (12.93)**	187.67 (13.73)	190.33 (13.83)	208.00 (14.42)	**195.33 (13.99)**
WH 147	378.67 (19.47)	359.00 (18.97)	368.67 (19.23)	**368.78 (19.22)**	311.67 (17.68)	300.67 (17.34)	312.67 (17.68)	**308.34 (17.57)**
Mean	**256.95 (15.95)**	**252.55 (15.83)**	**261.95 (16.13)**	**257.16 (15.99)**	**246.53 (15.67)**	**244.58 (15.61)**	**255.27 (15.95)**	**248.78 (15.74)**
C.D. (P=0.01)	**(1.43)**	**(1.26)**	**(1.21)**	**(0.97)**	**(1.27)**	**(1.19)**	**(1.42)**	(0.52)

* DAI – days after infestation **Figures in the parentheses are square root transformed values

Table 2. Adult emergence of rice weevil, *S. oryzae* on different varieties of wheat

Variety	Adult emergence (adults/50 g wheat grains)			
	30 DAI*	45 DAI	60 DAI	Mean
WH 1105	0.00	47.67 (6.98)	104.33 (10.26)	**76.01 (7.69)**
WH 1124	0.00	57.67 (7.68)	111.67 (10.60)	**84.68 (9.14)**
WH 1142	0.00	57.33 (7.64)	110.33 (10.53)	**83.84 (9.09)**
WH 283	0.00	62.67 (7.98)	132.00 (11.53)	**97.33 (9.75)**
WH 542	0.00	63.67 (8.03)	115.67 (10.80)	**89.67 (9.42)**
WH 711	0.00	63.33 (8.02)	132.33 (11.54)	**97.83 (9.78)**
WH 1080	0.00	64.67 (8.10)	135.67 (11.68)	**100.17 (9.88)**
WH 1025	0.00	59.00 (7.74)	139.67 (11.84)	**99.33 (9.79)**
WH 157	0.00	65.33 (8.14)	142.33 (11.97)	**103.83 (10.05)**
DBW 17	0.00	59.00 (7.74)	151.67 (12.35)	**105.33 (10.05)**
DPW 62150	0.00	64.00 (8.06)	160.00 (12.67)	**112.01 (10.36)**
HD 2967	0.00	54.67 (7.45)	127.33 (11.17)	**91.01 (9.31)**
PBW 343	0.00	66.00 (8.18)	156.33 (12.54)	**111.17 (10.36)**
C 306	0.00	43.67 (6.68)	89.67 (9.52)	**66.68 (8.10)**
WH 147	0.00	71.00 (8.48)	165.67 (12.91)	**118.33 (10.69)**
Mean	**0.00**	**59.98 (7.78)**	**131.64 (11.46)**	**95.82 (9.56)**
C.D. (P=0.01)	--	**(0.44)**	**(0.76)**	**(0.47)**

*DAI – days after infestation ; **Figures in the parentheses are square root transformed values.

Table 3. Grain damage and weight loss (%) by rice weevil, *S. oryzae* (L.) on different varieties of wheat

Variety	Grain damage (%)				Weight loss (%)			
	30 DAI*	**45 DAI**	**60 DAI**	**Mean**	**30 DAI**	**45 DAI**	**60 DAI**	**Mean**
WH 1105	6.27 (14.47)**	13.47 (21.51)	25.60 (30.38)	**15.11 (22.12)**	2.89(9.79)	5.47 (13.49)	10.21 (18.85)	**6.19 (14.04)**
WH 1124	7.40 (15.70)	17.07 (24.39)	30.80 (33.69)	**18.42 (24.59)**	3.19 (10.31)	5.99 (14.16)	11.86 (20.13)	**7.01 (14.87)**
WH 1142	7.52 (15.80)	13.87 (21.85)	26.93 (31.24)	**16.10 (22.96)**	3.22 (10.35)	6.31 (14.54)	11.39 (19.71)	**6.97 (14.86)**
WH 283	7.87 (16.28)	20.67 (27.02)	36.53 (37.17)	**21.69 (26.82)**	3.91 (11.40)	7.07 (15.42)	14.17 (22.10)	**8.38 (16.30)**
WH 542	7.87 (16.28)	22.53 (28.33)	32.27 (34.60)	**20.89 (26.40)**	3.75 (11.11)	6.93 (15.25)	13.27 (21.33)	**7.98 (15.90)**
WH 711	7.73 (16.13)	22.00 (27.94)	34.40 (35.89)	**21.38 (26.65)**	3.60 (10.93)	6.60 (14.88)	13.59 (21.61)	**7.93 (15.81)**
WH 1080	7.43 (15.72)	21.07 (27.31)	33.86 (36.14)	**20.79 (26.39)**	3.73 (11.05)	6.42 (14.66)	12.36 (20.57)	**7.50 (15.43)**
WH 1025	7.81 (16.20)	20.80 (27.12)	37.20 (37.57)	**21.94 (26.96)**	3.95 (11.46)	6.10 (14.29)	12.14 (20.38)	**7.40 (15.38)**
WH 157	7.60 (15.95)	21.20 (27.39)	35.60 (36.61)	**21.47 (26.65)**	4.05 (11.61)	7.76 (15.41)	14.56 (22.43)	**8.79 (16.48)**
DBW 17	7.47 (15.84)	19.73 (26.35)	32.93 (35.01)	**20.04 (25.73)**	4.03 (11.57)	7.25 (15.61)	14.19 (22.12)	**8.49 (16.43)**
DPW 62150	8.67 (17.10)	22.27 (28.13)	36.00 (36.86)	**22.31 (27.36)**	4.86 (12.72)	8.12 (16.55)	15.47 (23.14)	**9.48 (17.47)**
HD 2967	6.93 (15.25)	19.60 (26.26)	32.13 (34.52)	**19.55 (25.34)**	3.24 (10.36)	6.68 (14.97)	11.53 (19.84)	**7.15 (15.06)**
PBW 343	8.40 (16.83)	23.73 (29.14)	37.86 (37.96)	**23.34 (27.98)**	4.24 (11.87)	8.01 (16.43)	15.51 (23.17)	**9.25 (17.16)**
C 306	5.87 (13.98)	11.70 (19.90)	24.80 (29.85)	**14.12 (21.25)**	2.64 (9.34)	5.22 (13.20)	9.10 (17.54)	**5.65 (13.36)**
WH 147	9.64 (18.05)	25.47 (30.29)	41.47 (40.07)	**25.53 (29.47)**	5.02 (12.94)	8.53 (16.97)	15.96 (23.99)	**9.84 (17.96)**
Mean	7.63 (15.97)	19.68 (26.19)	33.23 (35.17)	20.18 (25.78)	**3.75 (11.12)**	**6.83 (15.05)**	**13.02 (21.06)**	**7.87 (15.77)**
C.D. (P=0.01)	(1.71)	(1.63)	(1.33)	(1.75)	(0.92)	(0.94)	(1.37)	(0.62)

*DAI – days after infestation; **Figures in the parentheses are square root transformed values.

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Compliance with ethical standards

NA

Conflict of Interest

The authors declare that they have no conflict of interest.

Author contributions

RK, SSY, SY & VS designed the experiments; VS helped in procuring the grains of wheat varieties, RK & PR collected & analysed the data and prepared the manuscript: SSY & HK helped in preparing the final version of the manuscript.

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