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Screening of different rice varieties/genotypes against rice moth, *Corcyra cephalonica* (Stainton) under South Gujarat condition

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Abstract
Rice moth, *Corcyra cephalonica* (Lepidoptera: Pyralidae), is one of the most destructive pests of stored cereals in Asia, Africa, North America and Europe causing severe economic losses. In this study, the variety GNR-4 was recorded the highest adult emergence (F1), susceptibility index, weight loss, total developmental period and overall performance of rice moth, *C. cephalonica*, whereas the variety GNR-2 was found the lowest adult emergence (F1), susceptibility index, weight loss, total developmental period and overall performance of rice moth, *C. cephalonica*. The variety GNR-4 was found to be highly susceptible variety; however, GNR-2 was found tolerant variety against rice moth, *C. cephalonica*.

Keywords: Rice, adult emergence**,** varietal screening, rice moth

Introduction
Rice (*Oryza sativa* L.) is the most important and extensively grown food crop in the world and is the staple food of more than 60 percent of the world's population, of which people of Asian continent occupy the major share of consumption. India has the largest area under rice in the world and ranks second in the production after China. In India, rice grows in 43.66 million hectares area with production of rice was 118.87 million tonnes and average productivity of rice was 2722.63 kg/ha in 2019-20 (Anonymous, 2021a) [2]. In Gujarat, rice is cultivated on an area of 0.904 million hectares with total production of 1.983 million tonnes and productivity 2193 kg/ha (Anonymous, 2021b) [3].

Generally, lepidopterans and coleopterans pests cause maximum damage in storage (Usman, 1957) [16]. Among these, *C. cephalonica* (Lepidoptera: Pyralidae) is one of the most important pests. It is commonly known as "rice moth" (Stainton, 1866) [14], who conditionally named it *Melissoblaptes cephalonica* (Stainton) by giving a concise explanation. Afterwards a new genus, *Corcyra* was erected by (Rogonot, 1885) [13] to put up this insect, the name being imitative from the ancient name of "Corfu", where it was supposed to have been imported into England. *Corcyra* is apparently of eastern origin which has been introduced into Europe and elsewhere by the rice trade (Durant and Beveridge, 1913) [7].

Rice moth, *C. cephalonica* is one of the most destructive pests of stored cereals in Asia, Africa, North America and Europe causing severe economic losses (Atwal and Dhaliwal, 2008) [4]. It is the major pest of rice, wheat, sorghum, corn (maize), peanuts, almonds, dates, groundnut, cotton seeds, coffee, spices, cocoa beans, cashews, raisins and millet. It causes 5 to 10 percent of the stored grains lost (Tooba *et al*., 2005) [15]. It is very serious pest of stored commodities in tropical and subtropical region of the world (Darling, 1952) [5]. *C. cephalonica* create not only sanitation problem in warehouses but also hinders the commodities qualitatively and quantitatively. The damaged grains can be recognized by the presence of webbing. The creamy white larvae start feeding on the grains immediately after hatching. The larvae damage the stored materials by moving, feeding and living silken thread, which are later form dense and tough webbing. The damage also forms frass which make grains unfit for human consumption. When infestation is high, the entire stock of grains may be converted into a webbed mass; ultimately a characteristic bad smell develops and the grains are rendered unfit for human consumption. Moore *et al*. (1966) [12] reported that a single larva consumed an average of 32.9 mg that results to a loss in weight of 10.35 percent.

Materials and Methods

Total twenty-five rice varieties/ genotypes were screened for their susceptibility against rice moth, *C. cephalonica* in the laboratory condition. For study on screening of rice against rice moth, *C. cephalonica* was carried out in Biocontrol Laboratory, Department of Entomology, N. M. College of Agriculture, NAU, Navsari at 27 to 30 °C and 69 to 87 percent relative humidity during the year 2022.

Table 1: Rice varieties/genotypes used to study for their susceptibility against rice moth, *C. cephalonica*

T. No.	Varieties/Genotypes	T. No.	Varieties/Genotypes
T_1	NAUR-1	T_{14}	GR -19
T_2	GNR-2	T_{15}	GR -20
T_3	GNR-3	T_{16}	GR -23
T_4	GNR-4	T_{17}	GR -24
T_5	GNR-5	T_{18}	GAR -13
T_6	GNR-6	T_{19}	Jaya
T_7	GNR-7	T_{20}	Mahisagar
T_8	GNR-8	T_{21}	IR -28
T_9	GNR-9	T_{22}	Purna
T_{10}	GR -15	T_{23}	NVSR-335
T_{11}	GR-16	T_{24}	GR-11 (SSC)
T_{12}	GR -17	T_{25}	TN-1 (NSC)
T_{13}	GR -18		

Total 100 grams of apparently sound grains of each varieties/genotypes kept separately in plastic jars. Five pairs of newly emerged male and female moths released for oviposition in each jar for 3 days. The top of the jar covered with muslin cloth which secured and closed firmly with a rubber band. The jars kept under laboratory conditions for the fresh moth emergence (Photo 1). The jar was kept undisturbed till the emergence of adults of new generation. The date of first moth emergence was recorded. Moths emerged from the jar counted daily and removed from the jars to prevent further oviposition. The observations recorded continue until the emergence of adult stopped. The emergence of adults stopped number and weight of healthy and damaged grains in each jar recorded. The experiment replicated thrice with completely randomized design. Later, the data obtained were further analysed statistically. The varieties screened on the basis of susceptibility index, damage caused by insect and overall performance.

Photo 1: Grains of different rice varieties/genotypes in glass jar

Screening on the basis of susceptibility index

The susceptibility index worked out by adopting the formula suggested by Dobie (1974) [6] was as under. On the basis of the index host suitability determined.

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

Where,
F= Number of adults emerged
D=Mean developmental period

Screening on the basis of damage caused by the pest

For the determination of damage, healthy and damaged grains in each jar counted and weighed separately. The percent weight loss calculated by using formula suggested by Adams and Schulten (1978) [1] as below.

$$\text{Weight loss (\%)} = \frac{(U*Nd) - (D*Nu)}{U\,(Nd + Nu)} \times 100$$

Where,
U= Weight of undamaged grains
Nu= Number of undamaged grains
D= Weight of damaged grains
Nd= Number of damaged grains

Screening on the basis of overall performance

To judge the overall performance of the varieties/genotypes on the basis of weight loss percent in each varieties/genotype.

Results and Discussion

The susceptibility index of different varieties/genotypes was computed to draw the inference about their susceptibility or resistance.

The adult emergence (F_1) in different varieties/genotypes was recorded and it was ranged from 7.33 to 24.67 adults. The minimum and maximum number of adult emergence of rice moth, *C. cephalonica* 7.33 and 24.67 adults were recorded in varieties GNR-2 and GNR-4, respectively. The variety GNR-2 was recorded minimum population of *C. cephalonica* (7.33 adults). The number of adult emergence (F_1) was recorded in Purna variety was 7.67 adults and it was followed by Jaya (9.33 adults), GAR-13 (9.33 adults), GR-23 (9.67 adults), GR-19 (10.67 adults), GNR-9 (11 adults), NVSR-335 (11.33 adults), GNR-8 (11.33 adults), GR-20 (11.67 adults), NAUR-1 (12 adults), GNR-5 (13 adults), GR-17 (13 adults), GR-18 (13.33 adults), GR-15 (14 adults), GR-24 (14.67 adults), GNR-3 (16.67 adults), IR-28 (17 adults), GNR-6 (17.67 adults), GR-16 (20 adults), Mahisagar (20 adults) and GNR-7 (23.67 adults). State and national susceptible check varieties GR-11 and TN-1 were recorded 11.33 adults and 24.33 adults, respectively.

Susceptibility Index or Dobbie Index

The susceptibility index or dobbie index calculated with the help of total developmental period and adult emergence of rice moth, *C. cephalonica* varied from 4.390 to 7.789 percent in different varieties/genotypes. It revealed an overall picture of the resistance or susceptibility of the varieties/genotypes. Low susceptibility index revealed resistance in the varieties/genotypes, whereas the higher susceptibility index indicated more susceptibility in the varieties/genotypes. The minimum susceptibility index was recorded in Purna (4.390%) whereas it was maximum in variety GNR-4 (7.789%). The susceptibility index in the variety GNR-2 was 4.665 percent and it was followed by GR-23 (5.002%), GAR-13 (5.274%), Jaya (5.374%), GR-19 (5.386%), GR-20

(5.560%), GNR-8 (5.606%), NAUR-1 (5.620%), GNR-9 (5.637%), GR-17 (5.702%), GR-18 (5.755%), NVSR-335(5.816%), GNR-5 (5.965%), GR-24 (6.006%), GR-15 (6.146%), IR-28 (6.520%), GNR-6 (6.685%), GNR-3 (6.812%), GR-16 (7.094%), GNR-7 (7.200%) and Mahisagar (7.327%). State and national susceptible check varieties GR-11 and TN-1 were recorded 5.682 percent and 7.513 percent susceptibility index, respectively (Table 2). The data indicated that none of the varieties was found free from rice moth, *C. cephalonica* infestation, although there existed a considerable difference among the resistance/susceptibility among varieties/genotypes.

Hasan *et al.* (2013) [9] assessed the susceptibility or resistance level in six advanced rice genotypes against red flour beetle, *Tribolium castaneum* (Herbst) at 28 °C, 32 °C and 35 °C and discovered that maximum population of beetle observed in Basmati-2006 (254 beetles) and KSK-133 (223 beetles) at 32 °C and KSK-282 showed minimum beetle population production (69.00 beetles), (97.33 beetles), (83.67 beetles) at 28 °C, 32 °C and 35 °C, respectively. Maximum weight loss was in susceptible genotypes Basmati-385 (36.42%) along with KSK-133 (30.80%) at 28 °C and 32 °C, respectively. KSK-282 was most resistant due to less infestation with minimum weight loss (1.33%).

Table 2: Reaction of different varieties/genotypes on adult emergence and susceptibility index of *C. cephalonica*

T. No.	Varieties/genotypes	Number of adults emerge	Susceptibility index (%)
T_1	NAUR-1	3.53 (12.00)	5.445 (5.620)
T_2	GNR-2	2.80 (7.33)	4.953 (4.665)
T_3	GNR-3	4.14 (16.67)	5.987 (6.812)
T_4	GNR-4	5.02 (24.67)	6.414 (7.789)
T_5	GNR-5	3.67 (13.00)	5.615 (5.965)
T_6	GNR-6	4.26 (17.67)	5.943 (6.685)
T_7	GNR-7	4.91 (23.67)	6.164 (7.200)
T_8	GNR-8	3.44 (11.33)	5.476 (5.606)
T_9	GNR-9	3.39 (11.00)	5.465 (5.637)
T_{10}	GR -15	3.81 (14.00)	5.688 (6.146)
T_{11}	GR-16	4.53 (20.00)	6.123 (7.094)
T_{12}	GR -17	3.67 (13.00)	5.482 (5.702)
T_{13}	GR -18	3.72 (13.33)	5.513 (5.755)
T_{14}	GR -19	3.34 (10.67)	5.334 (5.386)
T_{15}	GR -20	3.49 (11.67)	5.409 (5.560)
T_{16}	GR -23	3.19 (9.67)	5.134 (5.002)
T_{17}	GR -24	3.89 (14.67)	5.634 (6.006)
T_{18}	GAR -13	3.13 (9.33)	5.266 (5.274)
T_{19}	Jaya	3.12 (9.33)	5.324 (5.374)
T_{20}	Mahisagar	4.53 (20.00)	6.223 (7.327)
T_{21}	IR -28	4.18 (17.00)	5.878 (6.520)
T_{22}	Purna	2.85 (7.67)	4.812 (4.390)
T_{23}	NVSR-335	3.44 (11.33)	5.543 (5.816)
T_{24}	GR-11	3.44 (11.33)	5.468 (5.682)
T_{25}	TN-1	4.98 (24.33)	6.288 (7.513)
	SEm±	0.09	0.002
	CD at 5 %	0.25	0.006
	CV (%)	4.06	3.291

Note: Figures outside the parentheses are $\sqrt{x} + 0.5$ transformed values while figures in parenthesis are retransformed value

Weight loss

The weight loss was recorded in different varieties/genotypes due to incidence of rice moth, *C. cephalonica* was ranged from 28.700 to 48.070 percent. The lowest weight loss 28.700 percent was recorded in the variety Purna whereas it was recorded the highest in the variety GNR-4 (48.070%). The less was recorded in the variety GNR-2 (30.510%) and it was followed by varieties GR-23 (30.905%), Jaya (31.350%), GAR-13 (31.400%), GR-20 (33.205%), GNR-8 (33.480%), NAUR-1 (34.915%), GNR-9 (35.210%), GR-17 (37.805%), GR-18 (39.000%), NVSR-335 (39.125%), GNR-5 (40.280%), GR-24 (41.340%), GR-15 (41.640%), GR-19 (31.880%), IR-28 (42.495%), GNR-3 (43.065%), GNR-6 (44.245%), GR-16 (44.780%), Mahisagar (45.105%) and GNR-7 (45.555%). The State and national susceptible check varieties GR-11 and TN-1 were recorded 35.025 percent and 46.640 percent weight loss, respectively (Table 3).

Khaliq *et al*. (2013) [10] screened out six rice genotypes including two coarse and four fine advanced varieties against coleopterous insect *viz*., *Sitophilus oryzae* under laboratory conditions and discovered that minimum and maximum weight loss was observed in Super Basmati (0.43%) and Basmati-282 (0.59%) at 32 °C and 35 °C and Basmati-385 (12.69%) and KSK-133 (12.46%) at 28 °C and 32 °C, respectively. However, KSK-133 (2.48g) followed by Basmati-515 (0.89g) demonstrated high susceptibility with high frass weight values.

Susceptibility Based on Overall Performance

The weight loss observations recorded in different varieties/genotypes due to incidence of rice moth, *C. cephalonica* after 2 months of infestation. The observations after 2 months of infestation revealed that 3 genotypes *viz*., GNR-2 (30.510%), GR-23 (30.905%) and Purna (28.700%) as tolerant (T) with 15 to 30 percent weight loss and 19 genotypes *viz*., NAUR-1 (34.915%), GNR-3 (43.065%), GNR-5 (40.280%), GNR6 (44.245%), GNR-7 (45.555%), GNR-8 (33.480%), GNR-9 (35.210%), GR-1 (41.640%), GR-16 (44.780%), GR-17 (37.805%), GR-18 (39.000%), GR-19 (31.880%), GR-20 (33.205%), GR-24 (41.340%), GAR-13 (31.400%), Jaya (31.350%), Mahisagar (45.105%), IR-28 (42.495%) and NVSR-335 (39.125%) were categorized under susceptible (31 to 45% weight loss) and only one variety *viz*., GNR-4 was categorized under highly susceptible (>45% weight loss). The State and national susceptible check varieties GR-11 and TN-1 were recorded 35.025 and 46.640 percent weight loss, respectively. None of the genotype was recorded below 15 percent weight loss categorized as highly tolerant (HT) after 2 months of infestation (Table 3).

Kumar *et al.* (2018) [11] recorded the grain damage (bored grain) at 60, 120 and 180 days after storage against *Sitotroga cerealella* and revealed that up to 60 days of storage, all 20 genotypes had less than 5 percent grain damage. After 120 days, 3 genotypes *viz*., NDR-80 (3.20%), NDR-97 (3.23%), NDR-359 (4.23%) was showed less than 5 percent damage and 17 genotypes *i.e*., BPT-5204 (5.23%), Bardan (5.23%), NDR-118 (5.26%), MTU-7029 (5.28%), Narendra usar dhan-3 (5.50%), Narendra sona (5.60%). Sahbhagi (5.65%), Pusa basmati (5.68%), NDR-3112 (6.20%), Narendra usar dhan-2009 (6.23%), NDR-2064 (6.26%), Narendra usar-2 (6.40%), Narendra usar dhan-2008 (6.42%), Jallahari (6.50%), Shusk samrat (6.60%), Sarju-52 (6.80%), Lalmati (7.20%) were showed 6 to 10 percent damage. After180 days of storage, 14 genotypes showed viz., NDR-80 (6.43%) NDR-97 (7.20%), Narendra sona (7.40%), Narendra usar-3 (7.43%), NDR-359 (8.25%), NDR-2064 (8.50%), NDR-118 (8.60%), NDR.3112 (8.80%) Narendra usar dhan-2008 (8.90%), Shusk Samrat (9.20%), BPT-5204 (9.00%) Jallahari (9.56%), Pusa Basmati (9.65%), Bardan (9.96%) as tolerant with 6 to 10 percent grain damage and 6 genotypes namely: Sarju-52 (10.20%), Narendra Usar-2 (10.40%), Sahbhagi (10.36%), Narendra usar dhan-2009 (10.43%) MTU-7029 (10.55%), Lalmati (11.20%) were categorized under susceptible (11 to 25%). None of the genotypes were showed below 5 percent (highly tolerant) and above 25 percent (highly susceptible) damage at 6 months after storage.

Table 3: Overall performance of different varieties/genotypes of rice against rice moth, *C. cephalonica*

Sr. No.	Varieties/Genotypes	Weight loss (%)
T_1	NAUR-1	13.686 (34.915)
T_2	GNR-2	12.772 (30.510)
T_3	GNR-3	15.225 (43.065)
T_4	GNR-4	16.059 (48.070)
T_5	GNR-5	14.705 (40.280)
T_6	GNR-6	15.430 (44.245)
T_7	GNR-7	15.647 (45.555)
T_8	GNR-8	13.326 (33.480)
T_9	GNR-9	13.762 (35.210)
T_{10}	GR -15	15.997 (41.640)
T_{11}	GR-16	15.477 (44.780)
T_{12}	GR -17	14.215 (37.805)

T_{13}	GR -18	14.463 (39.000)
T_{14}	GR -19	15.049 (31.880)
T_{15}	GR -20	13.294 (33.205)
T_{16}	GR -23	12.802 (30.905)
T_{17}	GR -24	14.908 (41.340)
T_{18}	GAR -13	13.010 (31.400)
T_{19}	Jaya	12.971 (31.350)
T_{20}	Mahisagar	15.570 (45.105)
T_{21}	IR -28	15.136 (42.495)
T_{22}	Purna	12.363 (28.700)
T_{23}	NVSR-335	14.514 (39.125)
T_{24}	GR-11	13.779 (35.025)
T_{25}	TN-1	13.648 (46.640)
	SEm±	0.004
	CD at 5 %	0.012
	CV (%)	3.096

Note: Figures outside the parentheses are arcsine transformed values while figures in parenthesis are re-transformed value

Conclusion

On the basis of above all observations of varieties/genotypes, GNR-4 was found highly susceptible variety and GNR-2, GR-23 and Purna were found tolerant variety against rice moth, *C. cephalonica*.

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