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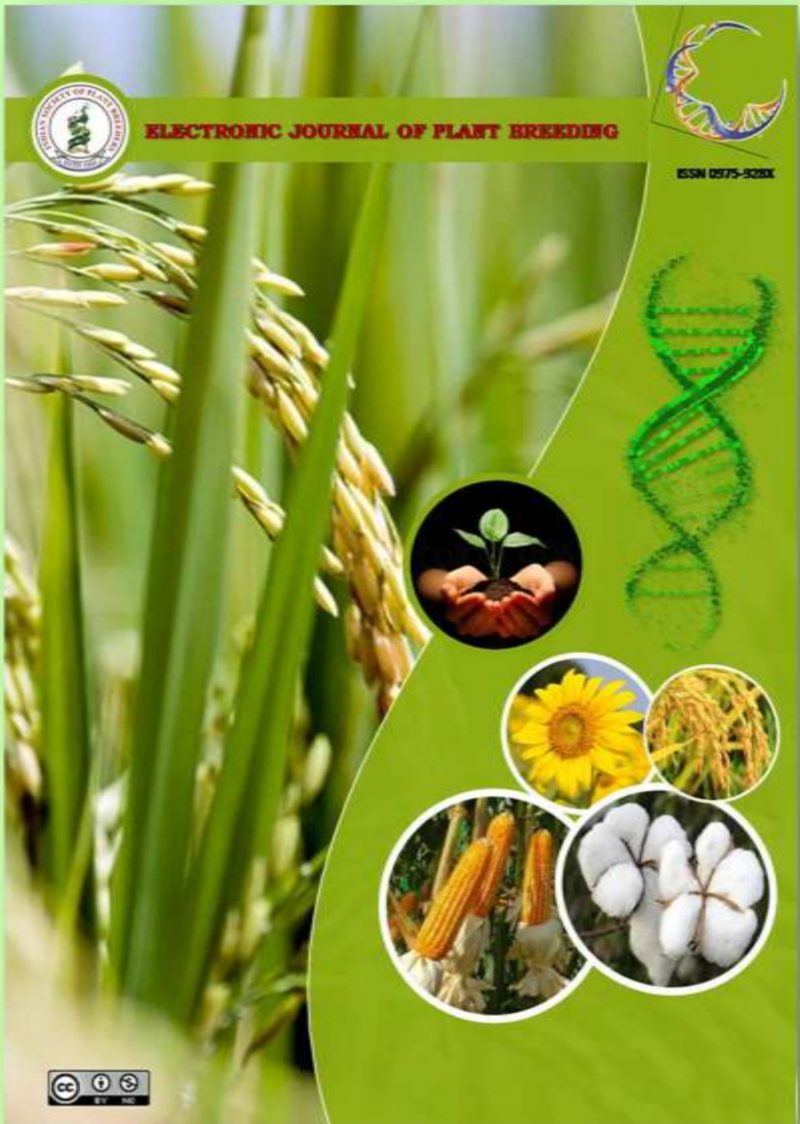

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Research Article

Screening of paddy varieties against angoumois grain moth, *Sitotroga cerealella* Oliv.

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Abstract
Studies were undertaken to identify the resistant genotypes of paddy to Angoumois grain moth, *Sitotroga cerealella* (Oliver.) under laboratory conditions. The parameters *viz.*, moth emergence, loss in the quality and quantity of grains and developmental period were assessed. Among the sixty six genotypes and fourteen varieties screened, none of them was completely immune to insect infestation. The resistant genotypes include RMLT-108, RMLT- 505.Among the genotype the RMLT- 104, which falls under moderately resistant category showed the maximum per cent grain content loss, per cent damage and adult emergence, whereas the least was shown by RMLT- 505. According to the dobie's susceptibility index the resistant genotype was RMLT-108 and the least resistance was for CB-16 116. The mean developmental period was found inversely correlated with the resistance. With the advances in biotechnology, it is possible to transfer the desirable characters to the other varieties to improve their resistance to *Sitotroga cerealella*.

Key words
Paddy, *Sitotroga cerealella,* resistance, storage pests, screening, damage

Introduction

Rice (*Oryza sativa* L.) is the most widely consumed staple food in the world. It accounts for about of 60 to 70 per cent of the body calorie intake of the consumers (Das et *al.*, 2018). It is commonly known as 'the Global grain'. About 90 per cent of the world's rice is grown and consumed in Asia. Among Asia, India has the largest area under rice of 43.5 m ha (IRRI STAT, 2018). The production is about 110 million tonnes with productivity of 3.76 t/ha, accounting 40 per cent of the country's total food grain production (ICAR-NRRI Annual Report, 2017-18). The production is expected to climb to a record 111.01 million tonnes during 2017-18, 1.2 per cent higher than last year's output (The Economic times, 2017-18). A huge amount of storage capacity, 354.07 lakh MT is available with FCI, which is very prone to attack storage insect (FCI Annual Report, 2016-17) and expecting heavy losses when proper management was not followed.

The common biological agent for the loss and deterioration of stored paddy are beetles and moths. Among the moths, the Angoumois grain moth, *Sitotroga cerealella* (Olivier) is one of the principal causes of loss in storage (Hall, 1970). It is carried over from field to the storage through infested grains. It is cosmopolitan in distribution. The moths are generally able to infest the surface layer of bulk-stored grain, as adults are unable to penetrate deeply. Only larvae is able to damage the commodities by boring into the grains and feeds about 30-50 content contents of the grain which ultimately gives unpleasant smell and unhealthy appearance (Bushra *et al*., 2013). The emerging adults pushes the flap, which was already made by the final instar larva and forms the typical 'circular hole symptom'. The use of chemical insecticides has toxic effects on the environment and humans. It is very important to find an alternative against the chemical method of control. The innate capacity to resist the attack and damage by this pest on different rice genotypes will provide valuable information in the breeding for developing new varieties. With this view present study was conducted to assess the damage on different rice genotypes against Angoumois grain moth.

Materials and Methods

Screening for assessing the damage level in 80 genotypes was carried out in Bioassay Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India.
Adult moths of *S. cerealella* were collected from Paddy Breeding Station, Tamil Nadu Agricultural

University, Coimbatore. The moths were reared on disinfested paddy grains of popular rice variety CO-52 in 1 L plastic jars. The 20 pairs of *S. cerealella* were released into plastic jar containing 500 g of the medium. The jars were kept horizontally down on their sides to expose a larger surface area of grains for oviposition. The opening of the jars was covered with muslin cloth held in place by rubber bands. The moth culture was maintained by continuously releasing the insects in fresh disinfested grain (Muthukumar *et al*., 2015).

Paddy grains of 66 ART and MLT pre release rice genotypes and 14 varieties maintained at the Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India were used for the screening experiment. All the grains were cleaned of straw, chaff, light grains and other impurities before testing. They were later disinfested (to kill live stages of any insects present) by keeping in the oven at 60 ℃ for 5 hours.

Screening to assess the damage by Angoumois grain moth was carried out under no choice method. Ten gram of de-infested healthy grains of each paddy variety were taken in individual plastic container of 250 ml size and 5 pairs of one-day-old (0-24 hours) healthy adults of *S. cerealella* were released. It was stored under room condition (28 ± 2^0C and 65±5% RH) with three replications. Twenty days after the jars were examined every day for emergence of adults and the data were recorded. The adults that emerged from the jars were counted and removed to avoid double counting and the total was recorded (Muthukumar *et al*., 2015). Moreover F_1 progeny emergence, mean developmental period, insect weight, grain damage, grain weight loss and susceptibility index were assessed as described below to categorize the varieties in to different susceptibility groups.

Twenty days after moth introduction, the jars were checked for the adult emergence and the emerged F_1 progeny was recorded. The insect were counted by immobilizing them using chloroform impregnated cotton plugs (Demissie *et al*., 2015).

The number of days taken from the middle of oviposition period to 50 % of F_1 progeny emergence was worked out for mean development period of the insect in each rice entry (Demissie *et al*., 2015).

The weight of newly emerged moth was taken as and when the emergence of adults. The total weight of five F_1 progeny was calculated as mean adult weight. It was measured using a sensitive weighing balance (Demissie *et al*., 2015).

Per cent grain content loss

After the complete emergence of adults, the total weight of grains from each jar or variety was recorded separately. Then the per cent grain content loss was measured in respect of initial weight of grains using the following formula (Muthukumar *et al*., 2015),

$$\text{Per cent grain content loss} = \frac{Weight\ loss}{Initial\ weight\ of\ grains} \times 100$$

Where, weight loss = Initial weight of grains – final weight of grains

Per cent damaged grains

To calculate the per cent damage, 100 grains of each variety of rice was randomly collected from each jar and number of damaged grain was counted by observing the hole of larval entrance under simple microscope and the visible damage of grains. Then damage per cent was calculated by using the following formulae (Muthukumar *et al*., 2015),

$$\text{Per cent damaged grain} = \frac{Number\ of\ damaged\ grains\ found}{Total\ number\ of\ grains\ observed\ (100)} \times 100$$

Dobie's susceptibility index

It was calculated based on the number of moths emerged in each test variety and mean developmental period. The susceptibility index was calculated by the following formula (Dobie, 1978):

$$\text{Susceptibility index (SI)} = \frac{Natural\ \log F1}{D} \times 100$$

Where F_1 is the total number of first generation emerging adults and D is the median developmental period.

(i) Dobie's index of 0 to 4 - resistant
(ii) Dobie's index of 4.1 to 7.0 - moderately resistant
(iii) Dobie's index of 7.1 to 10.0 - susceptible
(iv) Dobie's index of > 10.1- highly susceptible

The resistant and susceptible varieties was sorted out based the Dobie's index.

The above insect parameters adult emergence, mean development period, insect weight, grain content loss, per cent damage grains were subjected to statistical scrutiny in a Completely Randomized Design and the means were compared with ANOVA. Correlation analysis was also carried out with different insect parameters to know the influence of one character over another parameter. Both the analysis was carried out in using the SPSS software.

Results and Discussion

The paddy entries showed a significant difference in the damage level and various parameters which include the number of moths emerged (progeny), per cent grain content loss, per cent damaged grains, adult weight and mean developmental period (Table 1). These above mentioned parameters were used to screen the paddy varieties by several authors, Ayerty (1982); Wahla *et al*. (1984); Khattak and Shafique (1986); Rubbi and Begum (1986); Shazali (1987); Ragumoorthy and Gunathilagaraj (1988); Dhaliwal *et al*.(1989); Mohapatra and Khare (1989); Tirmzy *et al*. (1989); Gillani and Irshad (1990); Riaz *et al*. (1992); Almeida and Murta (1995). Moth emergence was maximum in the genotype RMLT- 104 (63.00 nos.) and the minimum was recorded in genotype RMLT-505 (13.33 nos.). The mean adult weight expressed as mg/5 adult insects was observed more from grains of RMLT- 202 (8.86 mg) and minimum in RMLT-18-105 (2.95 mg). The per cent grain content loss was maximum and minimum in RMLT- 104 (15.67%) and RMLT-505 (1.29%) genotypes respectively. The per cent damage was more in RMLT- 104 (39.67%) and minimum was found for RMLT- 505 (4.33%). Both the per cent grain content loss and the per cent damage were found directly proportional to the adult moth emergence. The mean developmental period found maximum in RMLT-18-204 (27.33 days) and minimum in RMLT- 109 (21.67 days).

The Dobie's susceptibility index was calculated for all the genotypes and varieties and furnished in Table 1. Dobie's susceptibility index was maximum in CB-16 116 (7.19) and it was minimum in RMLT-108 (4.30). On the basis of the per cent grain content loss, per cent damage and the adult emergence the genotype RMLT- 104 was highly susceptible, but according to the dobie's susceptibility index the genotype CB-16 116 was susceptible. In the genotype CB-16 116 there is only slight variation from the RMLT- 104, this variation in the susceptibility may be due to their chemical nature. According to the results reported by Khattak and Shafique (1981) it was found that the protein, fat, carbohydrates contents are also responsible for the susceptibility in addition to the main factors like weight loss, damage.

According to the Dobie's susceptibility index (Dobie, 1978) the different genotypes and varieties are classified as resistant, moderately resistant, susceptible and highly susceptible (Table. 2). None of the genotype or variety shows as resistant and highly susceptible. The similar results were obtained and reported by Pandey *et al.* (1980); Khattak and Shafique (1981); Quyyum (1982); Khattak and Shafique (1986); Ratnasudhakar (1989); Tirmizy *et al.* (1989); Rizwana *et al*. (2011). All the genotypes/ varieties were either in the moderately resistant or in the susceptible group. Among the entries screened, 67 genotypes/varieties like RMLT- 108, RMLT 505, TN-1, Ptb 33 were moderately resistant to *S. cerealella* and 14 genotypes/varieties like CB-16 116, CO-51, CO-52, RMLT- 102 were susceptible to *S. cerealella*.

The correlation between the parameters like adult emergence, adult weight, per cent grain content loss, per cent damaged grain and mean developmental period was estimated (Table 3). The correlation of adult emergence was positive and highly significant with per cent grain content loss (r=0.961), per cent damage (r = 0.940) and significant with the adult weight (r = 0.386). Relationship between per cent grain content loss and per cent damage was positive and highly significant (r = 0.907). The mean developmental period was negatively correlated and significant with the adult emergence (r = -0.506), per cent grain content loss (r = -0.490) and per cent damage (r = -0.461). It was observed that the mean developmental period was negative and non-significantly correlated with the adult weight (r = -0.064). There was an inverse correlation between the moth emergences, per cent grain content loss, per cent damage and the mean developmental period as the resistant genotype require more developmental period than the susceptible genotypes. Ashamo (2010) reported that Angoumois moth performance was poor in TN-1 variety. The results present study is also line with the same results. The developmental period in TN-1 is 25.33 days in the present study, similarly the same author recorded with the development period of 26.3 days. It is also reported that the poor development in TN-1 might be due to the insufficient endosperm to support the maximum development of the moth.

Among the genotypes and varieties screened, the RMLT-108 was identified as promising resistant genotype to *Sitotroga cerealella* and CB-16 116 as susceptible to *Sitotroga cerealella*. Among the popular varieties, MO-1, Ptb-33, TN-1 and CO- 43 were moderately resistant and the varieties BPT 5204, CO-52, CO-51 and CO-50 were susceptible. The hybrid rice CORH-4 categorized as moderately resistant and it had a moderate grain content loss and per cent damage. It was observed that all the susceptible variety had higher adult emergence, per cent damage and per cent grain content loss compared to the resistant ones. But the developmental period was high for the resistant varieties. Further, the characters associated for the resistance have to be probed to find the mechanisms of resistant. With the advances in biotechnology, it is possible to transfer the desirable characters to the other varieties to improve their resistance to *Sitotroga cerealella*.

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Table 1. Screening of different rice genotypes against Angoumois grain moth

No.	Genotypes / varieties	Adult emergence (No's)	Adult weight (mg/5moths)	Per cent grain content loss	Per cent damaged grains	Mean developmental period (days)	Dobie's susceptibility index (D.S.I)
1	RMLT-306	22.66	4.93	2.38	12.00	25.33	5.34
2	RMLT- 109	35.00	5.21	5.29	22.33	21.67	7.12
3	RMLT-108	14.67	5.01	0.95	4.00	27.00	4.30
4	RMLT- 202	25.67	8.86	2.81	16.33	25.33	5.56
5	RMLT-311	18.67	6.27	1.95	6.67	26.33	4.82
6	RMLT- 104	63.00	7.94	15.67	39.67	25.00	7.20
7	ART- 1317-1	41.00	6.26	7.43	24.67	24.67	6.54
8	RMLT- 610	33.00	5.96	4.48	22.33	26.00	5.84
9	RMLT- 308	18.00	3.87	1.95	6.33	26.33	4.75
10	ART- 1017-2	23.33	5.19	2.38	12.00	25.67	5.33
11	RMLT- 309	25.67	6.86	3.00	13.67	27.33	5.15
12	ART- 1917-2	42.33	6.74	7.67	26.67	25.33	6.42
13	RMLT-102	56.67	7.56	12.90	32.67	23.33	7.51
14	RMLT- 208	31.33	6.45	5.05	21.67	25.00	5.98
15	RMLT- 505	13.33	5.57	1.29	4.33	25.33	4.43
16	RMLT- 213	26.67	5.56	2.48	16.00	27.00	5.27
17	ART- 1317-6	30.33	5.58	4.67	20.67	23.33	6.34
18	ART- 1317-6	21.33	6.05	2.29	11.67	24.67	5.38
19	RMLT-201	31.33	4.65	4.48	21.67	25.67	5.83
20	RMLT-107	26.33	4.51	2.95	13.00	26.33	5.39
21	RMLT-18-106	25.33	6.01	3.62	12.00	27.00	5.19
22	RMLT-18-303	39.00	5.88	6.95	24.00	25.33	6.28
23	RMLT-18-210	30.67	7.56	4.09	22.00	26.33	5.64
24	RMLT-18-110	26.00	5.67	2.19	14.00	27.00	5.24
25	RMLT-18-509	19.67	5.72	2.14	8.67	25.33	5.10
26	RMLT-18-204	30.00	7.38	4.38	20.00	25.00	5.90
27	RMLT-18-209	18.33	4.53	1.95	8.00	26.33	4.79
28	RMLT-18-307	19.33	7.23	2.19	8.33	26.00	4.93
29	RMLT-18-304	22.00	4.11	2.71	11.33	24.00	5.58
30	RMLT-18-105	15.67	2.95	1.71	6.67	23.67	5.04
31	RMLT-18-305	18.67	5.65	2.24	8.00	25.00	5.08
32	RMLT-18-106	25.33	5.70	2.24	12.33	24.67	5.69
33	RMLT-18-504	17.67	4.63	2.48	7.33	24.67	5.04
34	RMLT-18-510	21.33	6.24	2.48	10.33	25.33	5.24
35	RMLT-18-103	35.00	5.76	5.09	23.33	26.33	5.86
36	RMLT-18-511	20.67	4.38	2.81	7.67	26.67	4.93
37	ART-317-2	23.33	4.86	2.47	11.67	26.33	5.19
38	RMLT-18-508	27.33	5.06	3.24	16.00	24.67	5.82
39	RMLT-18-308	38.33	5.71	6.71	24.00	25.33	6.24
40	RMLT-18-204	19.33	4.08	1.76	8.00	27.33	4.70
41	RMLT-18-205	30.33	4.73	3.81	22.67	24.33	6.09
42	ART-418-3	17.67	3.92	1.48	10.67	26.67	4.67
43	ART-1518-2	39.67	5.50	7.09	24.33	25.67	6.23
44	ART-1918-2	32.67	5.65	4.81	22.33	26.67	5.68
45	ART-1018-3	24.67	4.99	2.53	11.67	24.00	5.80
46	ART-1018-3	40.33	5.88	8.10	23.33	22.33	7.19
47	ART- 1518-1	41.33	5.91	7.53	24.67	25.00	6.46
48	ART-1018-4	18.67	3.71	1.71	9.00	24.00	5.29
49	RMLT-18-211	21.67	4.43	1.86	10.00	24.67	5.41
50	RMLT-18-312	43.33	5.94	8.24	26.67	25.33	6.46
51	RMLT-18-503	38.67	4.64	7.09	23.33	24.67	6.43
52	RMLT-18-101	34.67	5.40	7.00	22.33	24.00	6.37
53	RMLT-18-210	36.33	5.85	6.62	23.67	21.67	7.20
54	RMLT-18-207	74.00	6.27	16.78	44.67	21.67	8.63
55	MLT-CB- 15-144	25.00	5.04	2.57	14.00	25.67	5.44
56	MLT-CB- 15-133	25.00	3.34	2.62	12.33	24.67	5.66
57	MLT-CB-13- 132	34.00	6.53	4.24	22.00	25.67	5.96
58	CB-16 142	20.67	6.18	2.29	10.00	26.00	5.05
59	CB-15 138	22.33	4.62	2.62	10.33	25.67	5.25
60	CB-16 116	58.33	6.00	9.28	34.67	22.33	7.91
61	CB-16 102	46.33	5.10	8.14	25.33	23.33	7.14
62	CB-16 101	20.67	4.56	2.43	9.00	26.33	4.99
63	CB 12 132	35.67	3.67	5.09	22.67	26.33	5.89
64	BPT 5204	54.67	6.57	8.43	30.67	22.00	7.90
65	CB-16 118	22.00	5.56	2.67	10.33	24.67	5.43
66	CB-16 136	20.00	5.66	2.67	8.67	25.33	5.13
67	MO1	23.67	4.87	2.76	11.33	25.00	5.49
68	Ptb 33	24.33	5.62	2.76	11.67	25.33	5.47
69	TN-1	18.33	5.07	1.91	8.00	25.33	4.98
70	CO- 52	43.67	6.61	7.86	26.33	22.67	7.24
71	CO- 51	43.00	6.22	7.67	26.00	22.67	7.77
72	CO- 50	48.33	4.73	8.29	28.33	22.00	7.65
73	CO- 43	36.33	5.19	6.71	22.67	24.00	6.50
74	CORH-4	29.67	6.25	3.50	15.67	25.67	5.73
75	Jeerakashala	27.67	5.70	3.24	18.33	25.33	5.68
76	MRST- 1	25.67	5.62	2.95	13.00	25.00	5.64
77	MRST- 2	25.67	4.89	3.05	12.00	25.33	5.56
78	MRST- 3	26.00	4.50	3.33	14.33	24.67	5.73
79	MRST- 4	28.67	5.92	3.48	15.33	25.00	5.82
80	MRST- 5	30.33	6.07	4.00	21.00	23.67	6.25
	CD (p=0.05)	4.18	0.68	0.75	3.65	1.17	-
	S.Ed	2.12	0.34	0.38	1.85	0.59	-

Table 2. Classification of genotypes and varieties according to Dobie's susceptibility index]

Susceptibility index (s.i)	Genotypes/Varieties
Resistant	_
Moderately resistant	RMLT-306, RMLT-108, RMLT- 202, RMLT-311, ART- 1317-1, RMLT- 610, RMLT- 308, ART- 1017-2, RMLT- 309, ART- 1917-2, RMLT- 208, RMLT- 505, RMLT- 213, ART- 1317-6, ART- 1317-6, RMLT-201,RMLT-107, RMLT-18-106, RMLT-18-303, RMLT-18-210, RMLT- 18- 110, RMLT- 18-509, RMLT- 18- 204, RMLT- 18-209, RMLT- 18- 307, RMLT-18-304, RMLT-18-105, RMLT-18-305, RMLT-18-106, RMLT-18-504, RMLT-18-510, RMLT-18-103, RMLT-18-511, ART-317-2, RMLT-18-508, RMLT-18-204, RMLT-18-205, ART-418-3, ART-1518-2, ART-1918-2, ART-1018-3, ART-1018-3, ART-1018-4, RMLT-18-211, RMLT-18-312, RMLT-18-503, RMLT-18-101, RMLT-18-210, MLT-CB- 15-133, MLT-CB- 13- 132, CB-16 154, CB-16 142, CB-15 138, CB-16 101, CB 12 132, CB-16 118 CB-16 136, MO1, Ptb 33, TN-1, CO- 43 CORH-1, Jeerakashala , MRST- 1, MRST- 2, MRST- 3, MRST- 4, MRST- 5
Susceptible	RMLT- 109, RMLT- 104, RMLT-102, ART- 1518-1, RMLT-18-207, MLT-CB- 15-144, CB-16 116, CB-16 102, BPT 5204, CO- 52, CO- 51, CO- 50
Highly susceptible	_

Table 3. Correlation analysis between different growth and damage parameters

Parameters	Adult emergence	Weight of adult insects	Per cent grain content loss	Per cent damaged grain	Mean developmental period
Adult emergence	1.000				
Weight of adult insects	0.386*	1.000			
Per cent grain content loss	0.961**	0.391*	1.000		
Per cent damaged grain	0.940**	0.408*	0.907**	1.000	
Mean developmental period	-0.506*	-0.064	-0.490*	-0.461*	1.000

**Correlation is significant at p= 0.01 level
*Correlation is significant at p= 0.05 level

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