Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(4): 1954-1961

Received: 12-05-2020
Accepted: 16-06-2020

S Akshay Kiran
M.Sc. Student, Department of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

A Padmasri
Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

B Anil Kumar
Department of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

M Madhavi
Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
S Akshay Kiran
M.Sc. Student, Department of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Varietal preference of different rice genotypes by rice weevil *Sitophilus oryzae* (L.)

S Akshay Kiran, A Padmasri, B Anil Kumar and M Madhavi

Abstract
The present investigation was carried out at Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad during 2019-2020. The laboratory experiment was conducted with 3 replications in CRD design under controlled conditions. Varietal screening studies were carried out with 25 rice genotypes and performance of them were assessed based on various biological parameters, damage and infestation by *Sitophilus oryzae*. Index of susceptibility (IS) was taken as criteria for assessing the resistance or susceptibility of selected genotypes to *S. oryzae*. As per the results obtained, none of the genotypes were found resistant to the weevil attack. However, eight genotypes with less IS *viz*., JGL 3844 (2.53), MTU 1001 (3.16), RNR 2458 (3.21), JGL 1798 (3.26), MTU 1010 (3.29), MTU 7029 (3.37), KNM 118 (4.37) and RDR 7555 (4.64) were categorized as moderately resistant. While JGL 11118 (7.96) with high IS was found susceptible and the rest of genotypes were categorized as moderately susceptible.

Keywords: Index of susceptibility, resistant, rice genotypes, rice weevil, susceptible

1. Introduction
Rice is the second most important cereal crop in the world and is a staple food crop for the majority of the Indians. It occupies a pivotal role in the national food and livelihood security system. India is the leading producer following china as well as a major exporter of rice in the world [1]. The country occupies 43.77 million hectares of cropped area with an annual production of 112.76 million tonnes and productivity of 2576 kg ha^{-1}. While, Telangana state accounts for 0.91 million hectares of area with production and productivity of 3.31 million tonnes and 3624 kg ha^{-1}, respectively [2]. Paddy is grown in almost all districts of Telangana state.

Post-harvest losses during storage are one of the major constraints in the developing countries especially among smallholder farmers who use conventional storage structures [3], where a considerable quantity of food grains are lost every year. Insect pests are considered to be most important among various biotic factors, leading to significant economic losses during storage [4]. It was estimated that insect pests cause 6.5 per cent of grain damage to the total storage amount [5]. Of various stored insect pests, rice weevil (*Sitophilus oryzae* L.) is reported as one of the important pest of paddy. It attack the seeds/grain and feed voraciously leading to both qualitative and quantitative losses during storage. In case of heavy infestation, only pericarp of the kernel is left behind, while the rest of the mass is eaten up [6].

The seed is an important constituent of agricultural production. Most of the small farmers store their seeds (including paddy) for next season for sowing. Nearly thirty per cent of seeds are lost during storage period due to insects, rodents and microorganisms. Insects and mites cause severe damage especially in warm and humid conditions [7]. The stored rice (unhusked) samples which were drawn from six districts of Himachal Pradesh were found infested with *S. oryzae* to an extent of 69%. The weight loss due to *S. oryzae* ranged from 1.09 to 3.10 per cent with an average of 2.11 per cent [8]. So, post-harvest seed management is one of the crucial and vital components to prevent loss of the seed during storage.

Control of this pest is mainly concentrated on the use of insecticides and fumigation. The widespread usage of the same has been evoking global concern due to associated environmental hazards and the presence of residues in the food [9]. Different rice varieties exhibit varying degrees of susceptibility to damage caused by insects [10]. Resistance to attack by insect pests is generally being explored as one of the alternatives to the synthetic insecticides [11].

Resistant genotypes have the potential to provide practical and economical ways to resource poor farmers to minimize losses due to insect pests [12]. So, the varietal screening studies were performed in order to assess the relative resistance or susceptibility of different rice genotypes against *S. oryzae*.

2. Material and Methods

The present investigation was carried out during 2019-20 at Seed Research and Technology Centre (SRTC), PJTSAU, Rajendranagar to assess the performance of 25 rice genotypes for resistance or susceptibility against *S. oryzae*.

2.1 Collection of rice genotypes

Twenty-five rice genotypes were procured from various research stations *viz.*, Regional Agricultural Research Station (RARS), Jagtial, Regional Sugarcane and Rice Research Station (RSRRS), Rudrur, Rice Research Centre, Rajendranagar and Seed Research and Technology Centre (SRTC), Rajendranagar, Hyderabad.

2.2 Disinfestation and standardization of moisture

The selected genotypes were disinfested by keeping in an oven at a temperature of 55ºC for four hours to kill the immature stages of insects if any without affecting the viability of the seeds [13]. After disinfestation, the genotypes were kept in a desiccator containing KOH solution (51g of KOH per 100 ml of water) for 21 days so as to bring moisture per cent to near equilibrium [14]. This pre-conditioned seed material was used for screening.

2.3 Mass culturing of test insect under laboratory conditions

The parental cultures of test insect was collected on stored paddy from Rice section, Agricultural Research Institute, Rajendranagar. Hundred pairs of adult weevils were released in the jars containing 2 kg of disinfested paddy (BPT 5204) [15]. They were allowed to oviposit for two weeks and then removed. Freshly emerged seven days old adults obtained from the parental culture were used for screening studies [16].

2.4 Sexing of test insects

Weevils having relatively long rostrum with narrow punctures arranged in regular rows and not touching each other were characterized as females. Whereas, males are characterized by having short rostrum with wide punctures. These are large and irregular, not in a row and often touching each other [17].

2.5 Screening of test genotypes

Three replications were maintained for each treatment under investigation. In each replication, ten grams of seed was taken in small plastic tubes (7.5 cm x 5 cm) with tiny punctures on the lid. Freshly emerged weevils (eight females and four males) were introduced into each tube to infest ten grams seeds of each test genotype [11]. They were incubated at a temperature and relative humidity of 26±2 ºC and 70±5 per cent, respectively. The weevils were allowed to oviposit in the seeds for two weeks and then removed. The performance of various rice genotypes was assessed based on the following parameters.

2.5.1 Adult emergence

The number of adults that emerged from each replication of the treatments were counted and discarded daily from the respective tubes until they cease to emerge from the seeds. The mean adult emergence was worked out by pooling the data.

2.5.2 Mean development period

The mean development period of the weevils that emerged from each replication of the treatment was calculated as suggested by Howe [18].

$$D = \frac{\sum (A \times B)}{C}$$

Where, A = Number of adults emerged on nth day, B = ‘n’ days required for their emergence, C = Total number of adults emerged during experimental period, D = Mean developmental period (days)

2.5.3 Index of susceptibility

The Index of susceptibility was estimated based on the data obtained from adult emergence and mean developmental period using the formula as suggested by Dobie [19].

$$I = \frac{\text{Log } e^F}{D} \times 100$$

Where, F = Total number of adults emerged, D = Mean developmental period, I = Index of susceptibility.

Categorization of test genotypes

Based on Index of susceptibility, test genotypes were categorized into five categories as per scale given by Mensah [20] *viz.*, Resistant (0-2.5), moderately resistant (2.6 - 5.0), moderately susceptible (5.1 - 7.5), susceptible (7.6 - 10.0) and highly susceptible (> 10.0).

2.5.4 Per cent weight loss

The count and weight method was used to determine the seed weight loss using the formula as follows.

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

Where, W = Weight loss (%), Wu= Weight of undamaged seed, Nu = Number of undamaged seeds, Wd= Weight of damaged seeds, Nd = Number of damaged seeds.

2.5.5 Per cent seed damage

The number of damaged seeds by the weevil in each replication of the treatments was counted at the end of the experiment and converted into per cent damaged seeds.

2.6 Statistical analysis

The data obtained was analyzed for ANOVA (5% probability level) following completely randomized design by using INDOSTAT statistical software. Percentage data obtained was subjected to angular transformation.

3 Results and discussion

3.1 Mean adult emergence

The mean number of adults that emerged from various test genotypes ranged from 3.00 to 17.33 (Table 1 and Figure 1). Significantly ($p < 0.05$) less number of adults had emerged from JGL 3844 (3.00) followed by JGL 1798 (4.00), MTU

1001 (4.00), RNR 2458 (4.00) and MTU 1010 (4.00) which were on par with MTU 7029 (4.37). Adult emergence recorded in KNM 118 (6.00) and RDR 7555 (6.67) were on par with each other. Whereas, significantly (p< 0.05) highest number of adults had emerged from JGL 11118 (17.33) followed by RNR 18833 (16.00). The adult emergence recorded in rest of the genotypes varied from 7.00 to 12.67.

From the results obtained, less number of adults were emerged in genotypes *viz.*, JGL 3844 (3.00), JGL 1798 (4.00), MTU 1001 (4.00), RNR 2458 (4.00), MTU 1010 (4.00) and MTU 7029 (4.37). While JGL 11118 (17.33) recorded high adult emergence followed by RNR 18833 (16.00). Present findings are in accordance with Gbaye and Ajiye [11] who reported less number of adult emergence (2.00) in the least susceptible rice variety (WAB 189), while the most susceptible rice variety (Igbimo) recorded highest adult emergence (25.33). Similarly, Thakur [21] screened five rice varieties against *S. oryzae* and recorded the highest number of adults (14.08) in the most preferred rice variety (Jaya), while the least in Anupama (3.88).

3.2 Mean development period (days)

The mean development period of *S. oryzae* recorded in various treatments ranged from 35.84 to 43.83 days (Table 1 and figure 2). The shortest mean development period was recorded in JGL 11118 (35.84 days) which was on par with RNR 18833 (37.47 days). While, it took maximum time for the adults to emerge in MTU 1001 (43.83 days) which was on par with JGL 3844 (43.48 days), MTU 7029 (43.32 days), RNR 2458 (43.16 days), JGL 1798 (42.56 days) and MTU 1010 (42.10 days). While in the rest of the genotypes, it varied from 37.90 to 41.66 days.

From the results obtained, it was evident that the genotypes *viz.*, MTU 1001, JGL 3844, MTU 7029, RNR 2458, JGL 1798 and MTU 1010 were not suitable for the development of rice weevil that resulted in less progeny emergence and prolonged developmental period (43.83, 43.48, 43.32, 43.16, 42.56 and 42.10 days, respectively). While, the genotypes *viz.*, JGL 11118 and RNR 18833 might have found highly suited for the development of *S. oryzae* as they recorded high adult emergence and took relatively short period to complete its development within 35.84 and 37.47 days, respectively. The results are in conformity with the findings of Ahmed [22] who reported that the resistant variety of rice (Vijaya) with less adult emergence recorded prolonged developmental period (43.60 days), while the susceptible variety (Rajeswari) with high adult emergence recorded comparatively shorter developmental period (39.74 days). Similarly, Yevoor [23] reported a shorter developmental period (39.00 days) of *S. oryzae* on maize hybrid (SAT) with high F1 progeny. While longer developmental period (45.00 days) was recorded on DHM-11 with least F1 progeny.

Table 1: Relative preference of rice genotypes against *Sitophilus oryzae.*

S. No.	Treatment	MAE	MDP	IS	WL (%)	SD (%)
1	JGL 384	09.67	40.68	5.57	4.02 (11.57)	5.11 (13.07)
2	JGL 1798	04.00	42.56	3.26	0.65 (4.62)	1.69 (7.47)
3	JGL 3828	07.00	38.62	5.02	2.28 (8.67)	3.89 (11.37)
4	JGL 11470	08.00	39.11	5.32	2.82 (9.67)	5.73 (13.85)
5	JGL 3855	11.67	40.55	6.06	4.41 (12.12)	5.84 (13.98)
6	JGL 11727	07.00	38.65	5.04	2.18 (8.50)	5.03 (12.97)
7	JGL 11118	17.33	35.84	7.96	7.43 (15.81)	10.82 (19.20)
8	JGL 17004	11.67	40.09	6.13	4.98 (12.90)	7.57 (15.97)
9	JGL 18047	11.00	39.39	6.09	4.65 (12.45)	7.52 (15.91)
10	JGL 24423	08.00	41.16	5.05	3.96 (11.48)	5.91 (14.07)
11	JGL 3844	03.00	43.48	2.53	0.40 (4.05)	1.38 (6.74)
12	KNM 118	06.00	41.66	4.37	1.77 (7.65)	3.84 (11.30)
13	RNR 18833	16.00	37.47	7.42	6.45 (14.71)	8.62 (17.07)
14	RNR 10754	11.67	38.10	6.44	4.34 (12.02)	6.63 (14.92)
15	RNR 15048	08.67	41.17	5.24	3.89 (11.37)	5.49 (13.55)
16	MTU 7029	04.37	43.32	3.37	1.18 (6.23)	2.25 (8.62)
17	MTU 1001	04.00	43.83	3.16	0.71 (4.84)	2.56 (9.21)
18	RDR 7555	06.67	40.80	4.64	1.78 (7.65)	3.81 (11.25)
19	RDR 763	12.67	37.90	6.70	6.32	7.67

					(14.55)	(16.08)
20	RDR 355	08.00	40.59	5.13	3.99 (11.52)	5.91 (14.07)
21	RNR 1446	10.37	39.11	5.97	4.19 (11.81)	6.30 (14.53)
22	RNR 2458	04.00	43.16	3.21	0.63 (4.54)	1.76 (7.62)
23	RNR 2465	07.67	40.59	5.02	2.54 (9.16)	4.03 (11.57)
24	*MTU 1010	04.00	42.10	3.29	0.86 (5.28)	2.56 (9.20)
25	**BPT 5204	09.33	40.26	5.55	4.08 (11.65)	6.90 (15.23)
	SEm±	0.26	0.62	0.11	0.22	0.21
	CD (P= 0.05)	0.73	1.76	0.32	0.63	0.60
	CV (%)	5.28	2.66	3.84	3.91	2.89
	*Resistant check					
	**Susceptible check					

Figures in parentheses are angular transformed values
MAE- Mean adult emergence, MDP-Mean development period, IS- Index of susceptibility, WL- Weight loss, SD- Seed damage

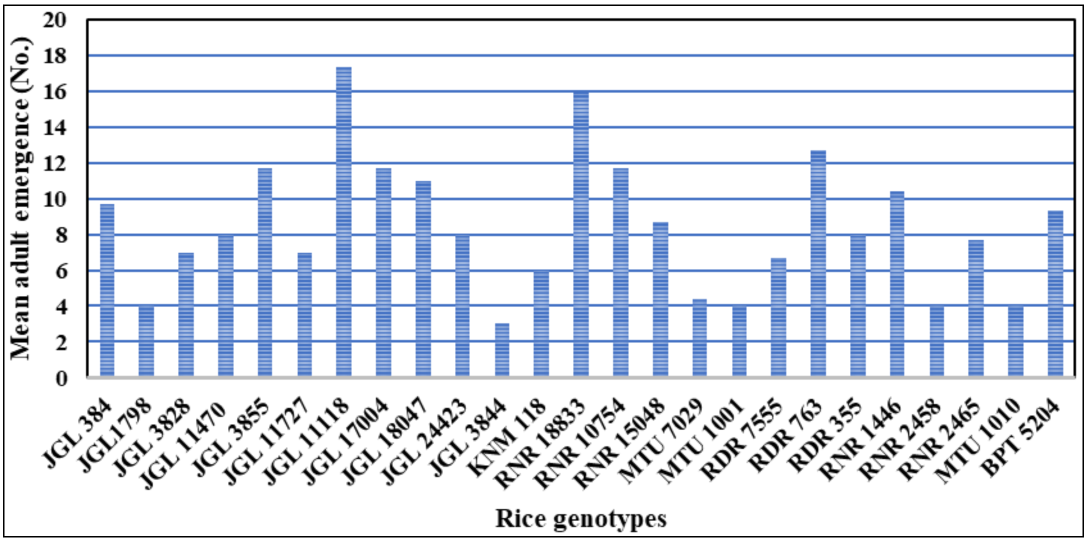

Fig 1: Mean adult emergence of *S. oryzae* in various treatments

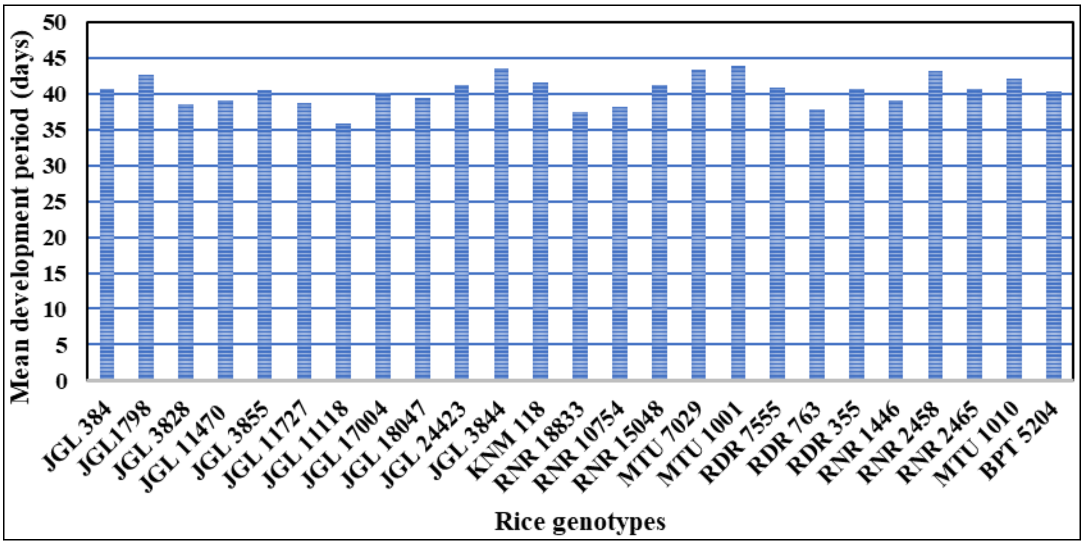

Fig 2: Mean development of *S. oryzae* in various treatments

3.3 Index of susceptibility

The index of susceptibility of various rice genotypes ranged from 2.53 to 7.96. (Table 1 and figure 3). Susceptibility index was found significantly lowest (p< 0.05) in JGL 3844 (2.53) followed by MTU 1001 (3.16) which was on par with RNR 2458 (3.21), JGL 1798 (3.26), MTU 1010 (3.29) and MTU 7029 (3.37). Susceptibility index recorded in KNM 118 (4.37) and RDR 7555 (4.64) were on par with each other. While index of susceptibility was found significantly highest ($p < 0.05$) in JGL 11118 (7.96) followed by RNR 18833 (7.42). While in rest of the genotypes, it varied from 5.02 to 6.70.

According to the painter [24], susceptibility index is a direct measure of relative resistance or susceptibility of the host to pest. It was calculated on the basis of adult emergence and mean development period and different genotypes were categorized as per the scale given by Mensah [20] (Table 2). As per the results obtained, none of the varieties were found resistant to *S. oryzae*. Among the test genotypes, JGL 3844 (2.53), MTU 1001 (3.16), RNR 2458 (3.21), JGL 1798 (3.26), MTU 1010 (3.29), MTU 7029 (3.37), KNM 118 (4.37) and RDR 7555 (4.64) were found to be moderately resistant (2.6-5.0). Whereas JGL 11118 (7.96) was found susceptible (7.6-10.0) and the rest of the genotypes were categorized as moderately susceptible (5.1-7.5). From the results, it was clear that the genotype which favoured high adult emergence with shorter developmental period recorded a high index of susceptibility as seen in JGL 11118. While, lower index of susceptibility was recorded in the genotypes (JGL 3844, MTU 1001, RNR 2458, JGL 1798, MTU 1010 and MTU 7029) with the least adult emergence coupled with a prolonged developmental period. The present findings are in accordance with Anuradha [25] who reported the highest index of susceptibility (5.1) in most preferred rice variety, while lowest susceptibility index (1.72) was recorded in rice variety resistant to *S. oryzae*. Similarly, Demissie *et al.* [26] reported the lowest susceptibility index (2.88) in resistant maize variety (Pratap Makka-5) with lowest progeny emergence (*Sitotroga cerealella*). While susceptible variety (HQPM-1) with greater progeny emergence recorded a high index of susceptibility (10.80).

Table 2: Grouping of test genotypes based on index of susceptibility to rice weevil

S. No.	Name of the genotype	Scale	Index of susceptibility	Category
T1	JGL 384	5.1-7.5	5.57	Moderately susceptible
T2	JGL 1798	2.6-5.0	3.26	Moderately resistant
T3	JGL 3828	5.1-7.5	5.02	Moderately susceptible
T4	JGL 11470	5.1-7.5	5.32	Moderately susceptible
T5	JGL 3855	5.1-7.5	6.06	Moderately susceptible
T6	JGL 11727	5.1-7.5	5.04	Moderately susceptible
T7	JGL 11118	7.5-10.0	7.96	Susceptible
T8	JGL 17004	5.1-7.5	6.13	Moderately susceptible
T9	JGL 18047	5.1-7.5	6.09	Moderately susceptible
T10	JGL 24423	5.1-7.5	5.05	Moderately susceptible
T11	JGL 3844	2.6-5.0	2.53	Moderately resistant
T12	KNM 118	2.6-5.0	4.37	Moderately resistant
T13	RNR 18833	5.1-7.5	7.42	Moderately susceptible
T14	RNR 10754	5.1-7.5	6.44	Moderately susceptible
T15	RNR 15048	5.1-7.5	5.24	Moderately susceptible
T16	MTU 7029	2.6-5.0	3.37	Moderately resistant
T17	MTU 1001	2.6-5.0	3.16	Moderately resistant
T18	RDR 7555	2.6-5.0	4.64	Moderately resistant
T19	RDR 763	5.1-7.5	6.70	Moderately susceptible
T20	RDR 355	5.1-7.5	5.13	Moderately susceptible
T21	RNR 1446	5.1-7.5	5.97	Moderately susceptible
T22	RNR 2458	2.6-5.0	3.21	Moderately resistant
T23	RNR 2465	5.1-7.5	5.02	Moderately susceptible
T24	*MTU 1010	2.6-5.0	3.29	Moderately resistant
T25	**BPT 5204	5.1-7.5	5.55	Moderately susceptible
	* Resistant check			
	** Susceptible check			

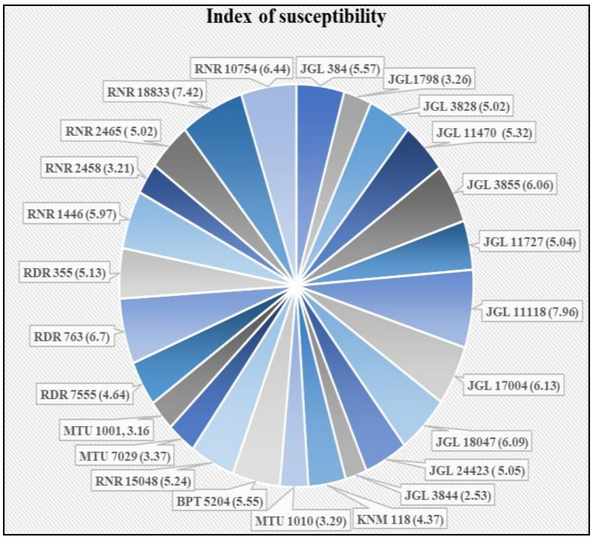

Fig 3: Index of susceptibility of *S. oryzae* in various rice genotypes.

3.4 Weight loss (per cent)

The weight loss in test genotypes ranged from 0.40 to 7.43 per cent (Table 1 and figure 4). Less weight loss (%) was recorded in JGL 3844 (0.40%) which was on par with RNR 2458 (0.63%), JGL 1798 (0.65%), MTU 1001 (0.71%) and MTU 1010 (0.86%). Weight loss in MTU 7029 (1.18%) was on par with KNM 118 (1.77%) and RDR 7555 (1.78%). Significantly highest ($p < 0.05$) per cent weight loss was recorded in JGL 11118 (7.43%) followed by RNR 18833 (6.45%) which was on par with RDR 763 (6.32%). While it varied from 2.18 to 4.98 per cent in rest of the genotypes

In the present investigation, treatments *viz.*, JGL 3844, RNR 2458, JGL 1798, MTU 1001, MTU 1010 and MTU 7029 which were least preferred for adult emergence recorded relatively less per cent loss in weight (0.40%, 0.63%, 0.65%, 0.71%, 0.86% and 1.18%, respectively). While, the genotypes *viz.*, JGL 11118 and RNR 18833 with greater weevil emergence recorded more per cent loss in weight (7.43% and 6.45%, respectively).

The present results are in conformity with the findings of Saljoki *et al*. [27] who reported that resistant cultivars of wheat with low weevil emergence recorded less per cent loss in weight *viz.*, Tatara-96 (3.90%) and Bakhtawar (3.92%). While most preferred cultivar for weevil emergence recorded more percent loss in weight *i.e* Khyber (7.99%). Similarly, Jalbani *et al*. [28] the reported highest percentage weight loss due to *S. oryzae* in most preferred rice variety *i.e* Super basmati (3.74%), while least in Sela 86 Tarazo (0.03%).

3.5 Seed damage (per cent)

Seed damage in rice genotypes ranged from 1.38 to 10.82 per cent (Table 1 and figure 5). Lowest seed damage was recorded in JGL 3844 (1.38%) which was on par with JGL 1798 (1.69%) and RNR 2458 (1.76%). Per cent seed damage in MTU 7029 (2.25%) was on par with MTU 1010 (2.56%) and MTU 1001 (2.56%). While seed damage was significantly highest ($p < 0.05$) in JGL 11118 (10.82%) followed by RNR 18833 (8.62%). Seed damage in the rest of the genotypes varied from 3.81 to 7.67 per cent.

It was evident from results that, highest seed damage was recorded in genotypes with greater progeny emergence *i.e* JGL 11118 (10.82%) and RNR 18833 (8.62%) (Plate 1). Whereas, seed damage was lowest in genotypes with less progeny emergence *i.e* JGL 3844 (1.38%), JGL 1798 (1.69%), RNR 2458 (1.76%), MTU 7029 (2.25%), MTU 1010 (2.56%) and MTU 1001 (2.56%). The present findings are in agreement with Ajao *et al*. [29] who reported that seed damage due to *S. oryzae* was very less (1.13%) in resistant rice genotype (G4) with least adult emergence, while the susceptible genotype (G8) with greater adult emergence recorded more seed damage (8.4%). Similarly, Antunes *et al*. [30] also reported that the least preferred paddy genotype (Thaibonnet) recorded less seed damage (1.4%). While the most preferred one (Eurosis) recorded more seed damage (7.4%) due to *S. oryzae* infestation.

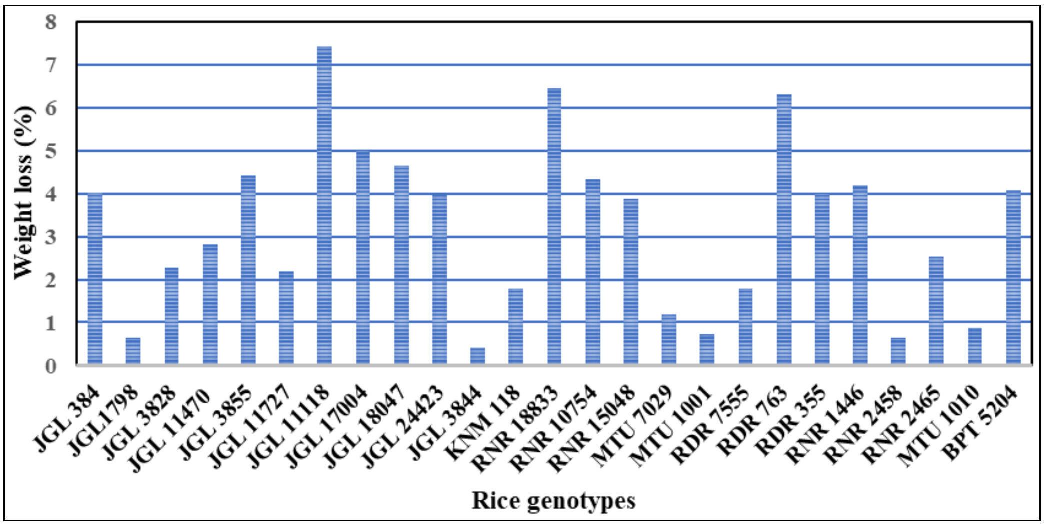

Fig 4: Per cent weight loss due to *S. oryzae* in rice genotypes

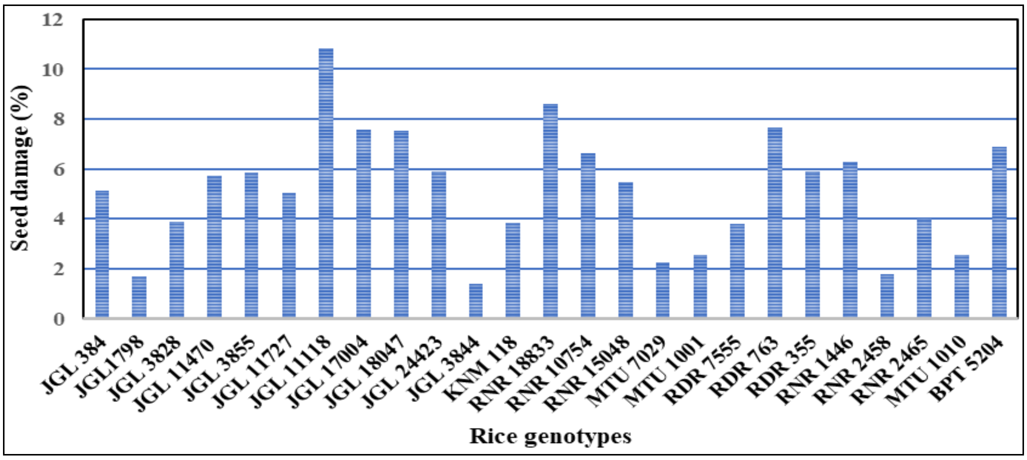

Fig 5: Per cent seed damage due to *S. oryzae* in various rice genotypes

JGL 11118

RNR 18833

Plate 1: Most infested revealed in screening studies

4. Conclusion

Among the genotypes screened, JGL 3844, MTU 1001, RNR 2458, JGL 1798, MTU 1010, MTU 7029, KNM 118 and RDR 7555 were found moderately resistant and acts as good sources to minimize post-harvest losses. While JGL 11118 (7.96) was found susceptible to weevil infestation.

5. Acknowledgements

We are thankful to Head, Dept. of Entomology, College of Agriculture, Rajendranagar for providing necessary facilities for conducting research and also extend our thanks to the authorities of Regional Agricultural Research Station (RARS), Jagtial, Regional Sugarcane and Rice Research Station (RSRRS), Rudrur, Rice Research Centre, Rajendranagar and Seed Research and Technology Centre (SRTC), Rajendranagar for the provision of seed material.

6. References

1. Viraktamath BC, Bentur JS, Rao KV, Mangal S. Vision 2030. Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, 2011, 1-2.
2. Area, production and productivity of paddy 2017-18. https://www.indiastat.com. 15 may 2020.
3. Manandhar A, Milindi P, Shah A. An overview of the post-harvest grain storage practices of smallholder farmers in developing countries. Agriculture. 2018; 8(4):57.
4. Boxall RA. Post-harvest losses to insects - A world overview. International Biodeterioration & Biodegradation. 2001; 48(1):137-152.
5. Raju P. The staggering storage losses-causes and extent. Pesticides. 1984; 18(1):35-37.
6. Sinha JP, Sunil J, Atwal SS, Sinha SN. Post-harvest management of paddy seed. Indian Agricultural Research Institute Regional Station, Karnal - 132 001, 2010, 35-36.
7. Parimala K, Subramanian K, Mahalinga KS, Vijayalakshmi K. Seed storage techniques - A Primer. Centre for Indian Knowledge Systems (CIKS). PM Digital Products, Chennai- 600 014, 2013, 1-3.
8. Thakur AK and Sharma JK. Assessment of storage losses in rice in Himachal Pradesh. Pest management and Economic Zoology. 1996; 4:97-100.
9. Nwosu LC, Nwosu UI. Assessment of maize cob powder for the control of weevils in stored maize grain in Nigeria. Journal of Entomological Research. 2012; 36(3):21-24.
10. Ashamo MO. Relative susceptibility of some local and elite rice varieties to the rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Journal of Food, Agriculture and Environment. 2006; 1:249-252.
11. Gbaye OA, Ajiye OB. Susceptibility of some Nigerian hybrid and local rice varieties to *Sitophilus oryzae* L. (Coleoptera: Curcilionidae). International Journal of Entomology Research. 2016; 1(2):10-13.
12. Abebe F, Tefera T, Mugo S, Beyene Y, Vidal S. Resistance of maize varieties to the maize weevil *Sitophilus zeamais* (Motsch.) (Coleoptera: Curculionidae). African Journal of Biotechnology. 2009; 8:5937-5943.
13. Singh RK. Effect of different rice varieties on the growth and development of *S. oryzae* Linn. Ph. D (Zoology) Thesis, Kanpur University, Kanpur, 1989.
14. Solomon ME. Control of humidity with potassium hydroxide, sulphuric acid, or other solutions. Bulletin of Entomological Research. 195; 42:543-54.
15. Bhusal K, Khanal D. Role of maize weevil, *Sitophilus zeamais* Motsch. on spread of *Aspergillus section flavi* in different Nepalese maize varieties. Advances in agriculture. 2019; 1-5.
16. Padmasri A. Survey and management of rice weevil [*Sitophilus oryzae* (Linnaeus)] in maize. Ph.D (Ag.) Thesis, Professor Jayashankar Telangana State Agricultural University, Hyderabad. 2018.
17. Halstead DGH. External sex differences in stored products Coleoptera. Bulletin of Entomological Research. 1963; 54:119-134.
18. Howe RW. A parameter for expressing the suitability of an environment for insect development. Journal of Stored Products Research. 1971; 7:63-65.
19. Dobie P. The contribution of the tropical stored products center to the study of insect resistance in stored maize. Tropical Stored Product Information. 1977; 34:7-22.
20. Mensah GWK. Infestation Potential of *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) on cowpea

cultivars stored under subtropical conditions. International Journal of Tropical Insect Science. 1986; 7:781-784.

21. Thakur AS. Biological studies on rice weevil *Sitophilus oryzae* (L.) as a pest of stored rice. M.Sc. (Ag.) Thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, 1978.
22. Ahmed, T. Relative resistance or susceptibility of some rice varieties to rice weevil *Sitophilus oryzae* L. M.Sc. (Ag.) Thesis, Orissa University of Agriculture and Technology, Bhubaneswar, 1973.
23. Yevoor M. Biology and management of rice weevil *Sitophilus oryzae* (Linn.) in maize grains. M. Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, 2003.
24. Painter RH. Insect resistance in crop plants. The Mac. Million Co., New York, 1951, 520.
25. Anuradha K. Studies on the relative reaction of rice cultivars to insect pests in storage. M.Sc. (Ag.) Thesis, Andhra Pradesh Agricultural University, Hyderabad, 1987.
26. Demissie G, Swaminathan R, Ameta OP, Jain HK, Saharan V. Biochemical basis of resistance in different varieties of maize for their relative susceptibility to *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae). Journal of Stored Products and Postharvest Research. 2015; 6(1):1-12.
27. Saljoki A, Afridi MK, Sajjad A, Raqi, A. Relative resistance of some wheat cultivars to *Sitophilus oryzae* L. in stored wheat grains. Sarhad Journal of Agriculture. 2002; 18(2):237-240.
28. Jalbani FH, Bashir L, Khanzada KK, Arshi AA, Talpur, MNR, Jamali A *et al*. Assessment of different rice varieties for resistance to granary weevil *Sitophilus granarium* L. under laboratory conditions. Journal of Entomology and Zoology Studies. 2017; 5(6):2424-2427.
29. Ajao SK, Poopola KO, Mande S, Togola A. Resistance levels of selected rice genotypes to *Sitophilus oryzae* L. and *Rhyzopertha dominica* F. infestations. The Zoologist. 2019; 17:39-46.
30. Antunes C, Mendes R, Lim A, Barros G, Fields P, Costa LBD *et al*. Resistance of rice varieties to the stored-product insect, *Sitophilus zeamais* (Coleoptera: Curculionidae). Journal of Economic Entomology. 2015; 109(1):445-453.