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# Screening of some rice germplasm against Angoumois grain moth (*Sitotroga cerealella* (Oliv.)

**Ajay Kumar, RK Pandey, Sandeep Rout, Devendra Singh and Dhaneswar Moharana**

## Abstract
The present investigation was conducted for the screening of rice germplasm against Angoumois grain moth, [*S. cerealella* (Oliv.)] taken up under entomological laboratory of Department of Entomology, N.D.U.A.&T. Kumarganj, Faizabad (Uttar Pradesh) during 2013-2014. There were significant differences observed indifferent rice genotypes against S. cerealella on the basis of grain damage percent. The genotypes under studies were categorized as follows- All 20 tested genotypes were found highly tolerant (<5%) up to 60 days of storage. 120 days, 3 genotypes viz. NDR-80 (3.20%), NDR-97(3.23%), NDR-359 (4.23%) were found to be highly tolerant and 17 genotypes i.e., BPT-5204 (5.23%), Bardan (5.23%), NDR-1 18 (5.26), MTU-7029 (5.28%), Narendra usar-3 (5.50%), Narendra sona (5.60%), Sahbagi (5.65%), Pusa basmati (5.68%), NDR-3 I 12, Narendra usar dhan-2009(6.23%), Narendra usar-2 (6.40%), Narendra usar dhan-2008 (6.42%), Jallahari (6.505), Shusk samrat (6.60%), Srju-52 (6.80%) and Lalmati (7.20%) were tolerant- (6 to 10%). At 180 days, 14 genotypes viz., NDR-80 (6.43%), NDR-97 (7.20%), Narendra song (7.40%), Narendra usar-3 (7.43%), NDR-359 (8.25%), NDR-2064 (8.50%), NDR-118 (8.60%), NDR31 12 (8.80%), Narendra usar dhan-2008 (8.90%), Shusk samrat (9.20%), BPT-5204 (9.00%), Jallahri (9.56%), Pusa basmati (9.65%) and Bardan (9.96%) were found tolerant whereas 6 genotypes viz., Sarju-52 (10.20%), Narendra usar-2 (10.43%), Sahbhagi (10.36%), Narendra usar dhan-2009 (10.43%), MTU-7029 (10.55%) and Lalmati (11.20%) were susceptible (11 to 25%). Grain damage showed significant positive correlation with moisture content, the number of emerged adults and weight loss in grain and significant negative correlation with germination.

**Keywords:** Angoumois grain moth, moisture, Poaceae, rice

## 1. Introduction
Rice (*Oryza sativa* L.) belongs to the family Poaceae (Gramineae). India is one of the world's largest producers of white rice and brown rice, accounting for 20% of all world rice production. Rice is India's pre-eminent crop and is the staple food of the people of the eastern and southern parts of the country. India's rice production reached to a record high of 104.32 million tonnes in the year 2011-2012 [1].

Uttar Pradesh is an important rice growing state in the country. The area and production of rice in this state is about 13.84 million hectare and 14.00 million tonnes, respectively with the productivity of 2358 kg per hectare [2].

Therefore, post-harvest management is an important national issue. In nature, a considerable amount of stored grain is damaged by storage insect in addition to other bio-agent like rodents, mites and microbes. Post-harvest losses of lesser magnitude can be expected in developed countries, whereas losses of grains are frequently high in developing countries [2]. Gorgatti-Netto, (1979) [3] stated that at least 10 percent of total production of grains is lost after harvesting in developing countries. An expert committee, Government of India headed by Panse (1998)[4], assessed the losses of food grains during post-harvest handling at the tune of 9.33 percent, of which 6.6 percent, losses alone are estimated during storage. Out of these 6.6 percent, the insects alone cause the loss as much as 2.55% [5].

A weight loss to the tune of 30 percent during storage has been reported with an average of 8.7% during 3 to 6 months storage period [6]. There are several species of insects associated with stored products directly or indirectly and cause considerable quantitative, qualitative and seed viability losses every year [7]; Khare, (1972) [8] estimated the loss in weight during storage due to insect feeding under different geographic and rainfall conditions varied from 0.70 to 10.63% depending upon the commodity stored, method and duration of storage. Prakash and Rao, (2004) [9] reported 5 to 25% losses in stored paddy by different storage insect every year

in India. The insects not only consume the food grains resulting in weight loss, viability and germination losses and lowering the market value but also contaminate them with fragment, faces, webbings and ill-smelling due to metabolic-end-products rendering them totally unfit for human consumption as well as sowing purpose. Among different stored insects, 18 species reported to infesting stored paddy in India. Out of which only six species viz., Angoumois grain moth, *Sitotroga cerealella* Oliv.; Lesser grain borer, Rhyzopertha dominica Fabr.; Rice weevil, *Sitophilus oryzae* Linn., Wheat weevil, *Sitophilus granarias* Linn., Rice moth, *Corcyra cephalonica* Staint, and saw toothed grain beetle, *Oryzaephilus surinamenasis* Linn. Cause significance losses in stored rice [10] among these six insects, Angoumois grain moth, *Sitotroga cerealella* Oliv. (Gelechiidae: Lepidoptera) is the most destructive pest of stored paddy [11]. *S. cerealella* also is known to damage the grains of other stored cereals than rice such as wheat, maize, sorghum, oat and barley.

Adults of this pest are nocturnal, good flier, short lived (5-10 days), grey or buff coloured, with wing span 10-15 mm, body length 5-10 mm with greyish /yellowish darker sports on forewings. The apex of hind wings is fringed with hairs, which is sharply pointed towards the tips. Longevity periods of females are more than males. This insect completes its life cycle in 50.6 days within 6 days incubation, 14-20 days larval and 7-10 days pupal period.

It not only infects the grains in storage but also in field which enhances the ability to damage [12]. They are generally able to infest the surface layer of bulk-stored grain, as adults are unable to penetrate deeply. Only larvae able to damage the commodities. Larvae of this pest bored into the grains and feeds about 30-50% contents of the in grain which ultimately gives unpleasant smell and unhealthy appearance [13].

It is essential to evolve the better storage technology to pest ravages. Among the various pest management components under IPM, the use of resistant varieties seem to be one of the most effective, eco-friendly and cheapest methods to prevent the loss due to insect-pest in fields as well as in storage. Inherent characters like narrow angle of spinules on grain husk, thickness of husk, aroma of grain of silica content are very much responsible for greater infestation on the grain. Keeping in view the importance of the study the present work was carried out with objective to screen the important rice cultivars/varieties grown in Eastern Uttar Pradesh against rice grain moth, *Sitotroga cerealella*.

## 2. Materials and Methods

The Present investigation was carried out during 2013-14 in the storage laboratory of the Department of Entomology at Narendra Deva University of Agriculture and Technology, Narandra Nagar, (Kumarganj), Faizabad. The University situated on Faizabad Raibarely road at $26.47^0$N, latitude $82.12^0$E longitudes and an altitude of 113 meter MSL (mean sea level) in the north Indogangetic plain. Four hundred numbers of adults of *S. cerealella* were collected from godowns of seed processing plant of N.D.U.A. &T., Kumarganj, Faizabad and were released in jute gunny bag in which one kg disinfested rice variety Sarju-52 with aluminium phosphide @ 3 tablet/t. The mouth of containers were covered with muslin cloth and tied with the help of rubber band. Jars were kept in B.O.D. incubator a 28±10 C and 75±5% RH. After 7 days, all the released insects were removed from the containers. The newly emerged adults were taken as parental population for the further experimental studies. The adults of *S. cerealella* taken from nucleus culture already maintained in laboratory to sort out male and female on the basis of their size, shape and colour of abdomen. The male was smaller than the female. In male, Abdomen was thinner and pointed, which was blackish from the ventral side, whereas, in females abdomen is bulky and long without any blackish colouration. Twenty rice Cultivars/Genotypes were collected from rice breeder Dr. S.P. Giri of crop Research Station, Masodha, N.D.U.A & T for various ecological conditions after harvesting the crop as maintained in table.1

One kg of all disinfested genotype/cultivars were kept in jute gunny bags in three replications and stored on the rack in the Entomological laboratory of seed Technology section under ambient condition. The germination percent, percent moisture content, percent damaged grain, number of adults, weight loss, and morphological characters such as length and breadth of rice and paddy and husk thickness were recorded. All the collected seeds were kept in container and fumigated with aluminium phosphate (3g tab.)@ 3 tab/t to disinfest before starting the experiment with seven days of exposure periods. Observation of the followings were recorded i.e., moisture content, germination %, grain damage and number of emerged adults of various rice genotype after 60, 120, and 180 days after storage. The experiment was replicated thrice per treatments and designed in completely randomized design (CRD). The data observed were subjected to statistical analysis as for the methods detailed by Gomez and Gomez (1984) [14]. The data were transferred from where ever required before suitability of ANOVA analyzed in statistical package SAS version 7.0.

## 3. Results

### 3.1 Morphological parameters observed on various rice genotypes

The data presented in tatle.2 showed that husk thickness of 20 tested genotypes were ranged from 0.05 mm (Sarju-52) to 0.23 mm NDR-2064 and 0.12 mm (NDR-359, Narendra usar-3, Shusk samrat, Pusa basmati, Sahbhagi, Bardan), whereas L/B ratio ranged from 3.21 (Sarju-52) to 4.97 (Lalmati).

### 3.2 Effect of *S. cerealella* infestation on grain moisture content, germination, grain damage (bored grain) and number of emerged adults in various rice genotypes after 60 days of storage

#### 3.2.1 Moisture content

The observation recorded in table.3 and 6 revealed that the moisture content ranged from 11.40 to 12.83 percent. The highest moisture content percentage was recorded in Narendra usar-3 and Sarju-52 (12.83%) with 44.48 percent increase over its initial followed by Narendra user-3 (12.83%) Sarju-52 (12.83%) with 44.48 and 44.48 percent increase over its initial, respectively. Further, the minimum. Moisture content percentage was recorded in NDR-359 and Narendra usar dhan-2009 (11.40%) with 28.81 and 41.79 percent increase over its initial respectively, followed by Narendra sona (11.45%) with 42.94 percent increase over its initial, respectively.

#### 3.2.2 Grain germination

The table (Susceptible) 3 and 7 showed that germination percent ranged between 78.00 to 84.96 percent. The highest

germination Percentage was recorded in Narendra usar-2 (84.96%) with 4.89 percent reduction over its initial followed by NDR-3112 (84.65%) and Narendra usar dhan- 2009 (84.30%) with 5.23 and 3.46 percent decrease over its initial, respectively. However the minimum germination percentage was recorded in Jallahari (78.00%) and Sarju-52 (78.60%) with 6.39 and 8.24 percent reduction in germination over initial respectively, followed by Lalmati and Shusk samrat (79.50%) with 7.55 and 7.91 percent reduction in germination over its initial, respectively.

**3.2.3 Grain damage**

There was a significant difference for grain damage among the genotypes under studies (Table.3). It was ranged from 0.32 to 4.32 percent. The highest percent damage was found in Lalmati (4.32%) followed by Sarju- 52 (4.10%). The minimum percent damage 0.32 percent was found in NDR-80 followed By Narendra Usar dhan – 2009, 0.65 percent grain damage.

**3.2.4 No. of emerged adults:**

The number of emerged adults of *S. cerealella* ranged from 71.00 to 456.50 (Table.3).The maximum number of emerged adults were found in Lalmati (456.50) followed by Sarju-52 (424.01), Pusa basmati (387.66), Narendra usar dhan-2008 (381.04), Shusk samrat (337.32), Jallahari 46(309.95) and NDR-2064 (292.65). However, the minimum emerged adults were found in NDR-80(71.00) followed by Narendra usar dhan-2009(129.32) and NDR-3112(134.32).

**3.3 Effect of *S. cerealella* infestation on grain moisture content, germination, grain damage (bored grain) and the number of emerged adults in various rice genotype after 120 days of storage**

**3.3.1Moisture content**

The observation recorded in table (Susceptible) 4 and 6 revealed that moisture content ranged from 10.04 to 11.50 percent. The highest moisture content percentage was recorded in Narendra Usar-3 (11.50) with 27.71 percent increase followed by NDR-2064 and Sahbhagi (11.40%) with 37.34 and 41.96 percent increase over initial. Further, the minimum moisture content percentage was found in Narendra sona (10.04%) with 25.34 percent followed by Narendra User dhan-2009 (10.06%) and NDR-97 (10.15%) with 25.12 and 26.71 percent increase over initial, respectively.

**3.3.2 Grain germination**

The table (Susceptible) 4 and 7 showed that germination ranged from 71.66 to 81.16 percent. The highest germination percentage was recorded in NDR-359 (81.16%) with 8.80 percent reduction followed by NDR-118 (80.40%) with 9.31 percent reduction over initial. However, the minimum germination percentage was recorded in Lalmati (71.66%) with 16.67 percent reduction over initial followed by MTU-7029 (72.20%) and Jallahari (72.50%) with 16.36 and 12.99 percent reduction over initial, respectively.

**3.3.3 Grain damage**

There was a significant difference for grain damage (bored grain) among the genotypes was observed under studies (Table.4). Grain damage was ranged from 3.20 to 7.20 percent. The highest percent damage was found in Lalmati (7.20%) followed by Sarju-52 6.80%), Shusk samrat (6.60%) and Jallahari (6.50%) while, the minimum grain damage was found in NDR-80 (3.20%) followed by NDR- 97 (3.23%).

**3.3.4 Number of emerged adults**

The number of emerged adults of *S. cerealella* ranged from 247.00to 751.63 (Table.4).The maximum number of emerged adults were found in Lalmati (751.63) followed by Sarju-52 (674.03) and Shusk samrat (631.66). However, the minimum number of emerged adults was recorded in NDR-80 (247.00) followed by NDR-97 (272.33).

**3.4 Effect of *S. cerealella*, infestation on grain moisture content, germination, grain damage (bored grain) and number of emerged adults in various rice genotypes after 180 days of Storage**

**3.4.1 Moisture Content**

The observation recorded in table.5 and 6 revealed that the moisture content ranged between 10.20 to 12.15 percent. The highest Moisture Content was observed in Lalmati (12.15%) with 51.11 percent increase over its initial. Further, the minimum Moisture Content 10.20 percent was found in Shusk samrat with 22.74 percent increase over its initial followed by Jallahari (10.23%), NDR-97 and Narendra usar dhan-2009 (10.84%) with 27.87, 30.90 and 34.82 percent increase over its initial, respectively.

**3.4.2 Grain germination**

The (Table.5 and 7) showed that germination percent ranged 'between 65.33 to 74.66 percent. The highest germination percentage was recorded in NDR-359 (74.66%) with 16.11 percent reduction over initial followed by NDR-3112 (74.40%) and NDR-118 (73.30%) with 16.71 and 17.32 percent reduction over initial, respectively. However the minimum germination percent was found in Jallahari (65.33%) to 21.60 percent reduction in germination over its initial followed by Pusa basmati (67.33%) and Sarju-52 (68.00%) with 21.39 and 20.61 percent reduction over initial, respectively.

**3.4.3 Grain damage**

There was a significant difference for grain damage (bored grain) among the 20 genotypes under studies (Table-6 86 Fig. 3). It was ranged from 6.43 to 11.20 percent. The highest grain damage percent was found in Lalmati (11.20%) followed in MTU-7029 (10.55%) Narendra usar dhan-2009 (10.43%) and Narendra usar-2 (10.40%). Further, the minimum grain damage percent was found in NDR-80 6.43%) followed by NDR-97 (7.20%) and Narendra Sona (7.40%), respectively.

**3.4.4 Number of emerged adults**

The number of emerged adults of *S. cerealella* ranged from 70.53 to 286.00 (Table.5). The maximum number of emerged adults were found in Lalmati (286.00) followed by MTU-7029 (241.66) and Narendra usar dhan-2009 (234.45). However, the minimum emerged adults were found in NDR-80 (70.53) followed by NDR-97 (99.83) and Narendra sona (121.66).

**3.5 Percent weight loss in various rice genotypes after180 days of storage**

The weight loss of grain in various genotypes presented in Table.8 showed that the weight loss ranged from 12.50 to

21.50 percent. Maximum weight loss was observed in Lalmati (21.50%) followed by MTU-7029 and Sahbhagi (21.40%). Further, minimum weight loss was observed in NDR-80 (12.50%) followed by Narendra Sona, (13.50%), Narendra Usar-3 (13.65%) and NDR-97 (15.30%).

**3.6 Varietal reactions of various rice genotype**

The grain damage (bored grain) observations recorded at 60,120 and 180 days after storage revealed that up to 60 days of storage, all 20 genotypes had less than 5 percent grain damage (HT) [Table.9]. At 120 days, 3 genotypes namely; NDR-80 (3.20%), NDR-97 3.23%), NDR-359 (4.23%). Was showed less than 5 percent damage; HT) 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 (T). None of the genotype was showed a susceptible and highly susceptible reaction.

The observation of 180 days after storage revealed that 14 genotypes showed namely; 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 (T) with 6. 10% 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, (HT) above 25 percent (HS) damage at 6 months after storage.

**Table 1:** Rice Cultivars/genotypes used in study of laboratory assessment against *S. Cerealella* (Oliv)

| Treatment | Genotype |
|---|---|
| $T_1$ | NDR-80 |
| $T_2$ | NDR-97 |
| $T_3$ | NDR-359 |
| $T_4$ | NDR-2064 |
| $T_5$ | NDR-118 |
| $T_6$ | NDR-3112 |
| $T_7$ | Narendra user-2 |
| $T_8$ | Narendra user dhan-2008 |
| $T_9$ | Narendra sona |
| $T_{10}$ | Narendra user dhan-2009 |
| $T_{11}$ | Narendra user-3 |
| $T_{12}$ | Shusk samrat |
| $T_{13}$ | Sarju-52 |
| $T_{14}$ | Jallahari |
| $T_{15}$ | Pusa basmati |
| $T_{16}$ | BPT-5204 |
| $T_{17}$ | MTU-7029 |
| $T_{18}$ | Sahbhagi |
| $T_{19}$ | Bardan |
| $T_{20}$ | Lalmati |

**Table 2:** Morphological parameters of various rice genotype

| Sl. No. | Genotype | Husked Paddy grain(mm) | Unhucked paddy(mm) | | Husk Thickness (mm) | L/B Ratio | Grain type |
|---|---|---|---|---|---|---|---|
| | | Breadth | Length | Breadth | | | |
| 1 | NDR-80 | 1.89 | 7.18 | 1.68 | 0.10 | 4.27 | LS |
| 2 | NDR-97 | 1.85 | 6.89 | 1.63 | 0.11 | 4.22 | LS |
| 3 | NDR-359 | 1.92 | 6.39 | 1.67 | 0.12 | 3.82 | LS |
| 4 | NDR-2064 | 1.87 | 6.90 | 1.40 | 0.23 | 4.92 | LS |
| 5 | NDR-118 | 1.84 | 6.10 | 1.61 | 0.11 | 3.78 | Ls |
| 6 | NDR-3112 | 1.90 | 6.99 | 1.67 | 0.11 | 4.18 | LS |
| 7 | Narendra usar-2 | 1.85 | 6.85 | 1.65 | 0.10 | 4.15 | LS |
| 8 | Narendra usar dhan-2008 | 1.98 | 5.99 | 1.79 | 0.09 | 3.34 | LS |
| 9 | Narendra sona | 1.88 | 6.15 | 1.70 | 0.09 | 3.61 | LS |
| 10 | Narendra usar dhan-2009 | 1.95 | 6.71 | 1.72 | 0.11 | 3.90 | LS |
| 11 | Narendra usar-3 | 2.05 | 7.98 | 1.81 | 0.12 | 4.40 | LS |
| 12 | Shusk samrat | 2.08 | 8.05 | 1.84 | 0.12 | 4.37 | LS |
| 13 | Sarju-52 | 1.67 | 5.05 | 1.57 | 0.05 | 3.21 | MS |
| 14 | Jallahari | 1.93 | 6.99 | 1.71 | 0.11 | 4.08 | LS |
| 15 | Pusa basmati | 1.95 | 7.19 | 1.71 | 0.12 | 4.20 | LS |
| 16 | BPT-5204 | 1.92 | 6.49 | 1.69 | 0.11 | 3.84 | LS |
| 17 | MTU-7029 | 1.96 | 7.10 | 1.76 | 0.10 | 4.05 | LS |
| 18 | Sahbhagi | 1.74 | 5.99 | 1.49 | 0.12 | 4.02 | LS |
| 19 | Bardan | 2.09 | 7.19 | 1.80 | 0.12 | 3.99 | LS |
| 20 | Lalmati | 1.77 | 7.81 | 1.57 | 0.10 | 4.97 | LS |

LS=Long Slender, MS=Medium Slender, Mean of 5 grains

**Table 4:** Effect of *S. Cerealella* infestation on grain moisture content germination, grain damage (bored grain) and number of emerged adults in various rice genotypes after 60 days of storage.

| Sl. No. | Genotype | Moisture Content (%) | Germination (%) | Damage (%) | No. of Emerged adult |
|---|---|---|---|---|---|
| 1 | NDR-80 | 11.88 | 82.32 | 0.32 | 71.00 |
| 2 | NDR-97 | 12.60 | 83.90 | 1.30 | 173.65 |
| 3 | NDR-359 | 11.40 | 81.90 | 1.99 | 186.50 |
| 4 | NDR-2064 | 12.10 | 80.10 | 2.32 | 292.65 |
| 5 | NDR-118 | 12.19 | 84.20 | 2.30 | 287.90 |
| 6 | NDR-3112 | 11.62 | 84.65 | 1.00 | 134.32 |
| 7 | Narendra usar-2 | 12.45 | 84.96 | 1.32 | 178.62 |
| 8 | Narendra usar dhan-2008 | 11.62 | 82.30 | 3.65 | 381.04 |
| 9 | Narendra sona | 11.45 | 80.60 | 2.65 | 290.65 |
| 10 | Narendra usar dhan-2009 | 11.40 | 84.30 | 0.65 | 129.32 |
| 11 | Narendra usar-3 | 12.83 | 80.00 | 1.32 | 177.32 |
| 12 | Shusk samrat | 12.03 | 79.50 | 3.22 | 337.32 |
| 13 | Sarju-52 | 12.83 | 78.60 | 4.10 | 424.01 |
| 14 | Jallahari | 11.88 | 78.00 | 2.95 | 309.95 |
| 15 | Pusa basmati | 11.73 | 80.66 | 3.65 | 387.66 |
| 16 | BPT-5204 | 11.88 | 80.30 | 2.10 | 229.00 |
| 17 | MTU-7029 | 12.67 | 81.30 | 2.32 | 287.22 |
| 18 | Sahbhagi | 11.81 | 81.16 | 2.65 | 289.20 |
| 19 | Bardan | 12.28 | 82.36 | 1.65 | 199.01 |
| 20 | Lalmati | 11.90 | 79.50 | 4.32 | 456.50 |
| | SEm (±) | 0.299 | 1.933 | 0.102 | 10.926 |
| | CD at 5% | NS | 5.533 | NS | 31.282 |

Mean of three replications

**Table 5:** Effect of *S.Cerealella* infestation on grain moisture content germination, grain damage (bored grain) and number of emerged adults in various rice genotypes after 120 days of storage

| Sl. No. | Genotype | Moisture Content (%) | Germination (%) | Damage (%) | No. of Emerged |
|---|---|---|---|---|---|
| 1 | NDR-80 | 10.50 | 78.65 | 3.20 | 247.00 |
| 2 | NDR-97 | 10.15 | 79.56 | 3.23 | 272.33 |
| 3 | NDR-359 | 10.40 | 81.16 | 4.23 | 328.33 |
| 4 | NDR-2064 | 11.40 | 74.80 | 6.26 | 596.66 |
| 5 | NDR-118 | 10.40 | 80.40 | 5.26 | 509.33 |
| 6 | NDR-3112 | 10.86 | 79.00 | 6.20 | 568.33 |
| 7 | Narendra usar-2 | 10.60 | 75.01 | 6.40 | 607.66 |
| 8 | Narendra usar dhan-2008 | 11.25 | 78.10 | 6.42 | 617.00 |
| 9 | Narendra sona | 10.04 | 76.23 | 5.60 | 541.66 |
| 10 | Narendra usar dhan-2009 | 10.06 | 76.43 | 6.23 | 579.00 |
| 11 | Narendra usar-3 | 11.50 | 75.30 | 5.50 | 533.66 |
| 12 | Shusk samrat | 10.85 | 74.60 | 6.60 | 631.66 |
| 13 | Sarju-52 | 10.98 | 74.30 | 6.80 | 674.03 |
| 14 | Jallahari | 10.86 | 72.50 | 6.50 | 627.66 |
| 15 | Pusa basmati | 10.60 | 75.60 | 5.68 | 549.33 |
| 16 | BPT-5204 | 10.65 | 76.10 | 5.23 | 500.00 |
| 17 | MTU-7029 | 10.80 | 72.20 | 5.28 | 516.33 |
| 18 | Sahbhagi | 11.40 | 76.60 | 5.65 | 543.33 |
| 19 | Bardan | 10.60 | 78.30 | 5.23 | 499.03 |
| 20 | Lalmati | 10.99 | 71.66 | 7.20 | 751.63 |
| | SEm (±) | 0.418 | 3.147 | 0.244 | 30.235 |
| | CD at 5% | NS | 9.009 | NS | 86.559 |

Mean of three replications

**Table 6:** Effect of *S. Cerealella* infestation on grain moisture content germination, grain damage (bored grain) and number of emerged adults in various rice genotypes after 180 days of storage

| Sl. No. | Genotype | Moisture Content (%) | Germination (%) | Damage (%) | No. of Emerged adult |
|---|---|---|---|---|---|
| 1 | NDR-80 | 11.10 | 73.23 | 6.43 | 70.53 |
| 2 | NDR-97 | 10.84 | 72.65 | 7.20 | 99.83 |
| 3 | NDR-359 | 10.90 | 74.66 | 8.25 | 129.04 |
| 4 | NDR-2064 | 11.70 | 70.65 | 8.50 | 155.33 |
| 5 | NDR-118 | 11.55 | 73.30 | 8.60 | 167.66 |
| 6 | NDR-3112 | 11.65 | 74.40 | 8.80 | 189.03 |
| 7 | Narendra usar-2 | 11.54 | 71.50 | 10.40 | 228.00 |
| 8 | Narendra usar dhan-2008 | 11.56 | 71.66 | 8.90 | 198.97 |
| 9 | Narendra sona | 11..54 | 72.33 | 7.40 | 121.66 |
| 10 | Narendra usar dhan-2009 | 10.84 | 72.00 | 10.43 | 234.45 |
| 11 | Narendra usar-3 | 11.73 | 70.66 | 7.43 | 129.33 |
| 12 | Shusk samrat | 10.20 | 71.20 | 9.20 | 213.66 |
| 13 | Sarju-52 | 11.03 | 68.00 | 10.20 | 221.33 |
| 14 | Jallahari | 10.23 | 65.33 | 9.56 | 216.66 |
| 15 | Pusa basmati | 11.05 | 67.33 | 9.65 | 219.00 |
| 16 | BPT-5204 | 11.30 | 69.66 | 9.00 | 203.00 |
| 17 | MTU-7029 | 10.99 | 68.32 | 10.55 | 241.66 |
| 18 | Sahbhagi | 11.08 | 68.10 | 10.36 | 224.03 |
| 19 | Bardan | 11.25 | 72.66 | 9.96 | 220.66 |
| 20 | Lalmati | 12.15 | 68.33 | 11.20 | 286.00 |
| | SEm (±) | 0.272 | 2.779 | 0.396 | 8.012 |
| | CD at 5% | NS | 7.957 | NS | 22.938 |

Mean of three replications

**Table 7:** Percent increase in moisture in different rice genotypes at 60,120 and 180 days after storage

| Sl. No. | Genotype | Initial Moisture (%) | Percent reduction in moisture over | | |
|---|---|---|---|---|---|
| | | | 60 DAS | 120 DAS | 180 DAS |
| 1 | NDR-80 | 8.80 | 35.00 | 19.31 | 26.13 |
| 2 | NDR-97 | 8.01 | 57.30 | 26.71 | 35.33 |
| 3 | NDR-359 | 8.85 | 28.81 | 17.51 | 23.16 |
| 4 | NDR-2064 | 8.30 | 45.78 | 37.34 | 40.96 |
| 5 | NDR-118 | 8.01 | 52.18 | 29.83 | 44.19 |
| 6 | NDR-3112 | 8.60 | 35.11 | 26.27 | 35.46 |
| 7 | Narendra usar-2 | 8.30 | 50.00 | 27.71 | 39.03 |
| 8 | Narendra usar dhan-2008 | 8.31 | 39.83 | 35.37 | 39.10 |
| 9 | Narendra sona | 8.01 | 42.94 | 25.34 | 44.06 |
| 10 | Narendra usar dhan-2009 | 8.04 | 41.79 | 25.12 | 34.82 |
| 11 | Narendra usar-3 | 8.88 | 44.48 | 29.50 | 32.09 |
| 12 | Shusk samrat | 8.31 | 44.76 | 30.56 | 22.74 |
| 13 | Sarju-52 | 8.88 | 44.48 | 23.64 | 24.21 |
| 14 | Jallahari | 8.00 | 48.5 | 35.75 | 27.87 |
| 15 | Pusa basmati | 8.02 | 46.25 | 32.16 | 37.78 |
| 16 | BPT-5204 | 8.05 | 47.57 | 32.29 | 40.37 |
| 17 | MTU-7029 | 8.69 | 45.79 | 24.28 | 26.46 |
| 18 | Sahbhagi | 8.03 | 47.07 | 41.96 | 37.98 |
| 19 | Bardan | 8.35 | 47.06 | 26.94 | 34.73 |
| 20 | Lalmati | 8.04 | 48.00 | 36.69 | 51.11 |

**Table 8:** Percent increase in germination in different rice genotypes at 60,120 and 180 days after storage

| Sl. No. | Genotype | Initial germination (%) | Percent reduction in germination over initial | | |
|---|---|---|---|---|---|
| | | | 60 DAS | 120 DAS | 180 DAS |
| 1 | NDR-80 | 84.66 | 2.76 | 7.09 | 13.47 |
| 2 | NDR-97 | 86.33 | 2.81 | 7.84 | 15.84 |
| 3 | NDR-359 | 89.00 | 7.97 | 8.80 | 16.11 |
| 4 | NDR-2064 | 86.00 | 6.86 | 13.02 | 17.84 |
| 5 | NDR-118 | 88.66 | 5.03 | 9.31 | 17.32 |
| 6 | NDR-3112 | 89.33 | 5.23 | 11.56 | 16.71 |
| 7 | Narendra usar-2 | 89.33 | 4.89 | 16.03 | 19.95 |
| 8 | Narendra usar dhan-2008 | 89.00 | 7.52 | 12.24 | 19.48 |
| 9 | Narendra sona | 85.66 | 5.90 | 11.00 | 15.56 |
| 10 | Narendra usar dhan-2009 | 87.33 | 3.46 | 12.48 | 17.55 |
| 11 | Narendra usar-3 | 84.00 | 4.76 | 10.35 | 15.88 |
| 12 | Shusk samrat | 86.33 | 7.91 | 13.58 | 17.52 |
| 13 | Sarju-52 | 85.66 | 8.24 | 13.26 | 20.61 |
| 14 | Jallahari | 83.33 | 6.39 | 12.99 | 21.60 |
| 15 | Pusa basmati | 85.66 | 5.83 | 11.74 | 21.39 |
| 16 | BPT-5204 | 85.00 | 5.52 | 10.47 | 18.04 |
| 17 | MTU-7029 | 86.33 | 5.82 | 16.36 | 20.86 |
| 18 | Sahbhagi | 86.00 | 5.62 | 10.93 | 20.81 |
| 19 | Bardan | 88.00 | 6.40 | 11.02 | 17.50 |
| 20 | Lalmati | 86.00 | 7.55 | 16.67 | 20.54 |

**Table 9:** Percent weight loss in various rice genotypes after 180 days of storage against *S.cerealella*

| Sl. No. | Genotype | Weight loss (%) |
|---|---|---|
| 1 | NDR-80 | 12.50 |
| 2 | NDR-97 | 15.30 |
| 3 | NDR-359 | 15.60 |
| 4 | NDR-2064 | 16.50 |
| 5 | NDR-118 | 16.30 |
| 6 | NDR-3112 | 16.80 |
| 7 | Narendra usar-2 | 19.80 |
| 8 | Narendra usar dhan-2008 | 17.25 |
| 9 | Narendra sona | 13.50 |
| 10 | Narendra usar dhan-2009 | 19.60 |
| 11 | Narendra usar-3 | 13.65 |
| 12 | Shusk samrat | 18.50 |
| 13 | Sarju-52 | 19.50 |
| 14 | Jallahari | 19.30 |
| 15 | Pusa basmati | 19.35 |
| 16 | BPT-5204 | 17.30 |
| 17 | MTU-7029 | 21.40 |
| 18 | Sahbhagi | 21.30 |
| 19 | Bardan | 19.20 |
| 20 | Lalmati | 21.50 |
| | SEm (±) | 0.410 |
| | CD at 5% | NS |

**Table 10:** Varietal reactions of different rice genotype on the basis of grain damage due to *S. Cerealella*

| Category | Grain damage (%) | Days after storage | | |
|---|---|---|---|---|
| | | 60 | 120 | 180 |
| Highly Tolerant (HT) | <5% | All Varieties | NDR-80,NDR-97,NDR-359 | NDR-80,NDR-97 Narendra sona,Narendra Usar-3,NDR-359 NDR-2064,NDR-118 NDR.3112 Narendra usar dhan -2008, Shusk samrat, BPT-5204,Jallahari Pusa Basmati and Bardan |
| Tolerant | 6-10% | ---------- | BPT-5204,Bardan NDR-118,MTU-7029, Narendra usar dhan-3, Narendra sona .Sahbhagi, Pusa basmati,NDR-3112, Narendra usar dhan-2009, Ndr-2064,Narendra usar-2, Narendra usar dhan-2008, Jallahari, Shusk samrat Sarju-52, and Lalmati | Sarju-52, Narendra Usar-2, Sahbhagi, Narendra usar dhan-2009, MTU-7029 and Lalmati |
| Susceptible (S) | 11-25% | ---------- | ---------- | Sarju -52, Narendra Usar-2, Sahbhagi, Narendra usar dhan-2009, MTU-7029 and Lalmati |
| Highly Susceptible (HS) | Above 25% | ---------- | ---------- | ---------- |

## 4. Discussion

In the present study, the husk thickness ratio was unable to draw any clear opinion in relation to grain damage due to an appearance of non-significant both negative and positive correlation at different intervals of storage. These results are similar to previous studies, in which some were reported negative correlation with grain damage at significant and non-significant level [12] whereas other reported positive significant correlation with grain damage.

Length and Breadth (L/B) ratio was able to present positive correlation with the non-significant level which is also similar to the findings of Prakash and Rao, (1993) [7].

### 4.1 Moisture content (%)

Moisture content at different intervals of storage in different genotypes showed a vital factor due to the positive correlation with grain damage, number of emerged adults along with storage period. These findings are in conformity with the findings of Chatterjee *et al*. (1977) [15].

### 4.2 Loss of germination (%)

Grain damage in stored seed has showed significant impact on the germination of various rice genotypes at different storage period. The germination percent decreased simultaneously with an increase in the damage of grain due to *S. cerealella*.

Similar results were also obtained by Prakash *et al.* (1987) [16] and Prakash and Kauraw, (1982) [17].

### 4.3 Grain damage and loss of weight

In the present study, it was cleared that the considerable grain damage increased progressively with storage period along with the combined effects of moisture content and grain type.

During storage, insect mainly caused a loss in weight of grain (quantitative loss) by directly feeding of the kernel. Further, it was observed that the maximum weight loss was observed in those varieties which had maximum grain damage. The least grain weight loss was obtained in varieties which had less infestation. These findings are in conformity with the results of Singh *et al.* (2007) [18].

### 4.4 Varietal reaction of different rice genotypes against *S. cerealella*

Reaction of different genotypes against *S. cerealella*, at different storage period, indicated that all the 20 genotypes have less than 5 percent grain damage up to 60 days of storage.

At 120 days of storage, 3 genotypes showed below 5 percent grain damage and 17 genotypes had 6 to 10 percent grain damage which could be classified as highly tolerant (HT) and tolerant (T), respectively. None of the varieties could be categorized under susceptible (S) and highly susceptible (HS). None of the varieties were found highly susceptible up to 180 days to storage. Fourteen genotypes were categorized under highly tolerant (<5%), and six genotypes were categorized under tolerant (6 to 10%), whereas six varieties were grouped under susceptible (S) category with 11-25% grain damage.

More or less similar information was also reported by Singh *et al*. (2007)[18], after testing 32 aromatic slender grain of rice against *S. cerealella* that Dubraj, Heerakani, Khosakani and Jeeraphool as tolerant and R-1462-243-100-7-1-1, Kalanamak, IGSR-2-1-4-6 and Nanu as susceptible to Angoumois grain moth under storage. Rao *et al.* (2005) [19] reported Ketkijoha in aromatic and Kalakeri, Blackgora and Ananda under upland non-aromatic rice showed highly tolerant, whereas Heera, Dhaula, Heera, Vandana, LN-41 and Neela showed susceptible reaction to such. Singh *et al*. (2007)[18] screened 10 rice varieties against this pest up to 3, 6 and 9 months of storage and reported that Kalanamak appeared with 23.5 percent grain damage (greater susceptibility) followed by Pankaj, Sona and Basmati during 9 month of storage. However, IR-8 and Jaya showed the least infestation with 7.9 and 9.8 percent grain damage, respectively.

## 5. Conclusion

It was concluded that grain moisture increased with the increase in grain damage, number of emerged adults along with storage period. Germination of rice genotypes deceased with an increase in grain damage. Weight loss of grain increased with increasing the grain damage on the basis of varietal reactions.

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