Behavioral Activities of Sitophilus Oryzae with Relation to Quality Deterioration in Basmati Rice

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Abstract: An experiment was carried out in the laboratory at Department of Zoology, Acharya Narendradev Nagar, Nigam Mahila Mahavidyalaya, Kanpur [UP] in 2022 to monitor the behaviour, damage caused and storage losses due to the feeding of rice weevil (Sitophilus oryzae) in basmati rice. The experiment demonstrated that adult weevils are customarily proactive in the relative temperature ranging from 23-35°C and highly humid conditions ranging from 55-65 % RH. Male and female mates quite calmly and can be continued for a long time period more than 3 hours and also show polygamous behaviour. Under the ovipositional activity female drills a tiny hole at the tip of the grains and lays the eggs inside it followed by covering the hole by a gluey secretion. Both larvae and adults feed inside the grain kernel and can reach large numbers in a short time period. Adults pretend to be dead by pulling their legs closest to the body and remain inactive when they are disturbed via any external source. In the developmental behaviour the highest temperature and highest humid conditions presented very high developmental rate of all life stages of S. oryzae and highest rate of damage caused. In the basmati rice Sitophilus oryzae caused a significant damage in its quality and quantity. The damage in the basmati grains was observed at the intervals of 12, 24, 36, 48, and 60 days and the percentage weight loss in grains was 5.34, 10.04, 13.52, 19.68 and 21.36% respectively.

Keywords: Basmati Rice, Grain Moisture, Grain Weight Loss, Oviposition, Sitophilus Oryzae

1. INTRODUCTION

Rice is grown in all the 72 districts of Uttar Pradesh and it is part of the nearly every meal and grown on a majority of the rural farms. Uttar Pradesh is the leading producer of rice, ranks 3rd in the country and its annual rice production is around 12 metric tons [1]. Stored grain pests pose serious threats to the rice by attacking on grains. In common, storages losses in annual grains due to the presence of insect pests is about 15% [2], while the maximum grain loss attributed to a single weevil species reached nearly 57% in rice [3]. *Sitophilus oryzae* L. (Coleoptera: Curculionidae) is a devastating stored grain primary pest attacks on many stored cereals commonly rice, wheat, maize and split peas and has a worldwide distribution [4]. The body length is between 3 and 4.6 mm. with a long snout on head, color appearance is brownish black, but on the wing cover, four orange or red spots are arranged in a cross manner. Mainly adult feeds on endosperm, and larvae feed on germplasm; results reduced germination and nutritional value of the grains. If control is totally absent, the stored cereals can be destroyed even up to 100% by infestation of *S. oryzae* [5]. Climatic factors, such as temperature, relative humidity and air nature movements within the storage home affect the, developmental rate, survival chances, behavior, migrational activities, reproductive rate and population dynamics of insect pests. Because it is a wide spread species in the world particularly in warm and tropical areas [6], so hot and humid climate of Uttar Pradesh is quite suitable for the excellent living of the weevil. As the species name is specifically *oryzae*, it is the major pest of rice. Basmati rice has been received gradually more attention by consumers due to its grain size, flavor, good aroma and potential health benefits like lower GI, less arsenic and more fiber. It is low in fat and gives a little protein boost and brown basmati rice is linked to a lower risk of heart disease because whole grains help to reduce the blood cholesterol levels [7]. But at the same time, it is susceptible to the pests and faces heavy losses in storage so it is a major challenge for it. Due to infestation of *Sitophilus oryzae* as the primary pest of rice, basmati faces a heavy loss in storage more than 30% of its entire [8]. The weevil produces broken grains and grain dust by damaging the whole grain [9]. By producing the broken grains, enhancing the temperature and humidity of the infested grains, *Sitophilus oryzae* also invites the secondary pests like *Tribolium castenium* etc. It induces their accelerated growth and creates most favorable conditions for pathogens and further infestation [9]. Attack of bunches of the pests makes the situation of worse and badly deteriorate the quality and quantity of rice. Most of farmers in rural areas lack the skills or technologies needed to implement admissible long-term storage systems for seed or food grains so global agricultural demand is increasing to postulate further research and
development of more efficient agricultural production, storage, and pest management practices. Thus, the objectives of this study are to monitor behavioral activities and to estimate relative losses caused in basmati rice under no management storage conditions by which we can work on the development of effective management strategies in future.

2. MATERIALS AND METHODS

Experiments were performed in The Department of Zoology, Acharya Narendra Dev Nagar Nigam Mahila Mahavidyalaya, (affiliated to C.S.J.M. UNIVERSITY) Kanpur, Uttar Pradesh [INDIA] during March-May 2022. The experiment was carried out in three replications to avoid chance of errors.

2.1. Insect Collection

The population of *Sitophilus oryzae* L. was collected by random selection of infested grain stock from GALLA MANDI, KANPUR. Just after collection clean and fresh diet was provided immediately to ensure proper survival of the weevils.

2.2. Rice Collection

Fresh WHITE BASMATI RICE was collected from the rice traders as sample for the experiment, of which colour was pure white and shape of the grains was slender.

2.3. Assessment of Physical Characteristics of Rice

The grains were dried under soft sun light to prevent moldiness and stored in air tight jars. Only complete and intact un-infested grains were selected for the experiment.

2.3.1. Grain moisture content and its removal: - A method of Silva [10] was followed; moisture content of rice grain was assessed by taking 10 gm. of grains and placing in previously weighed crucibles and continuously heat dried in a hot air oven at 105°C until the grains attained constant weight. Moisture content was demonstrated by calculating the difference between initial and dry weight of the sample.

2.3.2. Grain weight: - To demonstrate the loss of rice grain weight after infestation, fresh grain of 150 gm. was taken, weighted and noted out. The process was repeated at interval of 12 days after starting of experiment till 60 days.

2.3.2. Removal of hidden infestation: - The grains were heat sterilized at 70 °C for 15-20 minutes to eliminate hidden infestation of insects, fungi and other microorganisms inside the grains.

2.4. Rearing of the Insect to Monitor Activities

The live specimens of *S. oryzae* culture was obtained from infested rice storage and accurately identified based upon its distinct characteristics. Mass rearing was carried out under laboratory conditions, controlled temperature 30±2 °C and relative humidity in the range of 65±5%. For initiation of the experiment, in a glass container having capacity of 500 ml., 150g of sterilized healthy rice grains of variety basmati were taken into which approximately 50 pairs adults (ratio of male and female was 1:1) were introduced. The mouth of the container was covered with muslin cloth and secured with help of a rubber band for proper aeration and placed in an open shelf to facilitate maximum biological activities. The culture was periodically examined with precautions throughout the whole period of study. As *S. oryzae* is very sensitive to the light hours for mating and proper growth, dark and light hours (in 12:12 ratio) were maintained for the best development of weevil.

2.5. Observation of Damage

After 12 days interval, each container’s rice was weighted and the extent of weight loss was calculated up to 60 days from the release of *S.oryzae* into container. Grains of every three containers were independently weighed by electronic balance machine. Percent of grain weight loss was calculated from the difference of un-infested grain weight and the weight of the grain after the infestation of *S.oryzae*. Percentage of grain damage was assessed using the following formula:

\[
\text{Weight loss} (\%) = \frac{\text{weight loss of grains}}{\text{total weight of grains}} \times 100
\]
2.6. Statistical Analysis

Data collected from the laboratory experiments were statistically analyzed. Statistical design was Complete Randomized Design (CRD). Tabulated data was transformed into percentages (%) and analyzed. Final tables and graph were prepared using Microsoft Office Excel.

3. RESULTS

3.1. Observed behaviour of *Sitophilus oryzae*

3.1.1. Common activities: The results revealed that the longevity of male and female adults of *S. oryzae* was 45-53 and 56-67 days respectively. Both male and females were comparatively more active in day time than night and disguised themselves under the grains at night. As most of the results showed their diurnal activity, the weevils showed continuous crawling on surface and among the grains in the morning up to mid of the day and after the mid-day they sat on the surface of the grains and slowly moved under the grains as they got dark conditions. During the day time their flying activity was also observed as a short flight down to up inside the container.

3.1.2. Sensual activities: Both the male and female continuously moved their antennae during all activities to sense the surroundings and as they were disturbed, at just they became motionless, pulled their legs closest to the abdomen and pretended to be dead. Most of them laid down and raised their ventral surface upside. After 30-50 sec. they moved their antennae first, and then start to move again after sensing the surrounding environment.

3.1.3. Mating behaviour: In their mating behaviour, male mounted and stroke on the back of the female and settled on her dorsal surface, making an angle of 30 degrees. They mated quite calmly and were stay together for a long period which was observed to be more than 3 hours. If female moves during the mating time, male weevil remains settled on her back. Male wouldn’t let go the female and moved with her and continued the mating.

3.1.4. Ovipositional activity: The female drilled a hole in grain by penetrating it and laid the egg in crevices of kernel and then plugged this hole with its own gluey secretion and moved on next grain. Female preferred large grains for the oviposition and also laid more than one egg inside it in comparison to small grains.

3.1.5. Larval activity: As the egg hatched, larva started feeding inside the grain. There was a budging movement observed in the grain when the larva was feeding voraciously inside the grain kernel. As the pupation started larva stopped the feeding before it and came out from the grain as the adult after completing the pupation period.

3.1.6. Feeding behaviour: Both adults and larvae fed on grains, adults fed on the endosperm of the grain with their mandibulate mouthparts and produced lots of grain dust, while larvae fed inside the grain i.e., on germplasm and produced a completely hollow grain inside.

3.2. Identification of heavy infection

When severe infection was caused in the rice and the infestation was at extreme level, cereal was heating up and the temperature of the grains was increased. A large population of weevils was seen and much more damaged grain was found. Continuous feeding of weevils produced too much grain dust and dampness also.

3.3. Grain moisture content

Moisture of the grains is the primary factor for storage conditions; it may vary in different grains and also fluctuate in respect to time and other environmental factors. In this experiment, moisture content has obtained from basmati grains was 13.20% [Table 1]

3.4. Loss of weight in rice grains

In this experiment grain weight loss indicated the quantitative loss due to the infestation of *S.oryzae*. The weight loss in the basmati grains was observed at the intervals of 12, 24, 36, 48, and 60 days and the maximum percentage weight loss in grains was 5.34, 10.04, 13.52, 19.68 and 21.36% respectively [Table 2].

3.5. Quality damage caused by *Sitophilus oryzae*
The adults of *S. oryzae* fed mainly on the grain endosperm thus reduced the content and quality of carbohydrate, while its larvae fed preferentially on the germplasm of the grain, made the grain hollow inside and produced lots of broken grains thus removed a large percentage of the proteins and vitamin’s part from the grain. The grain’s quality was severely deteriorated and condition of the grains was extremely inferior.

4. TABLES AND GRAPHS

Table 1: Moisture content demonstrated in basmati rice (per 10 gm.)

<table>
<thead>
<tr>
<th>Grain Type</th>
<th>Weight of Grain</th>
<th>Weight of Petridish Total Weight before Incubation</th>
<th>Total Weight after Incubation</th>
<th>Weight Loss after Incubation</th>
<th>% Age Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basmati Rice</td>
<td>10 gm.</td>
<td>22.12 gm.</td>
<td>22.12+10=32.12 gm.</td>
<td>22.12+8.68=30.80 gm.</td>
<td>1.32 gm</td>
</tr>
</tbody>
</table>

Table 2: Percentage weight loss demonstrated in basmati rice (per 150 gm.)

<table>
<thead>
<tr>
<th>Days Of The Observation</th>
<th>No. of Replication</th>
<th>Weight of Grains before Infestation [in gm.]</th>
<th>Weight of Grains after Infestation</th>
<th>Loss of Weight in Grains [in gm.]</th>
<th>% Age Loss of Weight in Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 DAYS</td>
<td>R1 150</td>
<td>141.99</td>
<td>8.01</td>
<td>5.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2 150</td>
<td>142.01</td>
<td>7.99</td>
<td>5.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R3 150</td>
<td>142.02</td>
<td>7.98</td>
<td>5.32</td>
<td></td>
</tr>
<tr>
<td>24 DAYS</td>
<td>R1 150</td>
<td>134.95</td>
<td>15.05</td>
<td>10.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2 150</td>
<td>134.94</td>
<td>15.06</td>
<td>10.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R3 150</td>
<td>134.99</td>
<td>15.01</td>
<td>10.00</td>
<td></td>
</tr>
<tr>
<td>36 DAYS</td>
<td>R1 150</td>
<td>129.75</td>
<td>20.25</td>
<td>13.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2 150</td>
<td>129.80</td>
<td>20.20</td>
<td>13.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R3 150</td>
<td>129.52</td>
<td>20.28</td>
<td>13.52</td>
<td></td>
</tr>
<tr>
<td>48 DAYS</td>
<td>R1 150</td>
<td>120.48</td>
<td>29.52</td>
<td>19.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2 150</td>
<td>120.54</td>
<td>29.46</td>
<td>19.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R3 150</td>
<td>120.49</td>
<td>29.51</td>
<td>19.67</td>
<td></td>
</tr>
<tr>
<td>60 DAYS</td>
<td>R1 150</td>
<td>117.99</td>
<td>32.01</td>
<td>21.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2 150</td>
<td>118.03</td>
<td>31.97</td>
<td>21.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R3 150</td>
<td>117.96</td>
<td>32.04</td>
<td>21.36</td>
<td></td>
</tr>
</tbody>
</table>

Graph 1: Percentage weight loss demonstrated in basmati rice (per 150 gms.)
5. DISCUSSION AND CONCLUSION

*S. oryzae* L. is regarded as one of the most destructive universal primary pests of stored cereals such as rice, barley, maize, and wheat [11]. It is the grain’s internal feeder and damages whole grains in storage [12]. It has been reported that *Sitophilus oryzae* can consume 0.49 mg. of grain daily and produce 11-12 mg. of waste products throughout their lives [13]. The behaviour of the weevil is voracious feeding, calm mating, active in day light, well organized oviposition and fast development completed within a month. The grains with smooth surface are more preferred by weevil [14], and also the hardness of grain is very important factor which affects the rate of oviposition [15]. Weevil is highly sensitive to its surroundings and sometimes shows some short flights. Annual grain loss in storage due to infestations approaches 15% [2]. In one study, the maximum grain loss attributable to a single weevil was measured at 57% in rice [3]. The carbohydrate content mainly stored in the form of starch in the rice grains would be the possibility of the insect incidence. In the current study a rice cultivar- BASMATI was examined against the infestation of *S. oryzae* and maximum grain damage was 21.16% after 60 days following release of *S. oryzae*. Conclusion of the study reveals that the basmati faces a heavy loss during storage and it require better management strategies to be saved from this devastating pest.

6. REFERENCES


Author’s Contribution: SS collected all the samples, performed monitoring of experiment, find values, noted out and tabulate the data. SA sat the laboratory experiment, monitored and fulfilled the required lab conditions, carried out statistical analysis and provided data for tables and graphs. Both authors wrote the manuscript of the study and reviewed it finally.

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