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Review on Insect Pest *Sitophilus oryzae* (L.) A Threat to Stored Grains

Shashi Bala
Associate Professor
Dept. of Zoology
Raghunath Girls P.G. College, Meerut
Email: shashiverma1580@gmail.com

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Abstract

Storage of grains acts as an integral leg of the post-harvest system, it providing a last stage of food materials when it travels from the field to the consumer (24). grain loss after post harvesting are increasingly and it is becoming a large issue because of several factors such as sanitary, physical, and nutritional losses as grain travels from the point of maturation to the point of use (9). It is reported that post-harvest losses of approximately 9% in developed countries and even up to 50% in developing countries. It can have a large economic implication [7]. In India, post-harvest losses of food grains are estimated at 12-16 million metric tons annually, with pests accounting for nearly 6.5% of the total stored grains [23, 24, 28]. Each year, roughly 25-30% of the crop yield is lost due to insect pests in the fields and during storage [19, 23].

Sitophilus oryzae is a major insect pest that belongs to (Linn 1763) order Coleoptera, Curculionidae. it attacks several stored food grains such as rice, wheat, maize, sorghum, pulses, dried beans and buck wheat, cashew nut and other products. The rice weevil is an economically important and destructive pest all through the world causing damage to grain both qualitatively and quantitatively {7,9,21]. Quality loss often constitutes changes in different aspects of the value of nutrition and aesthetics, and can increase the chance that a grain mass will be rejected or lost capacity to be used commercially. Quantity loss can be evidenced by loss of weight in grain as a result of animal and/or insect feeding activity [10,24]. Quantitative and qualitative loss can arise from different variables of duration of storage such as feeding and waste from insects, mites, rodents and birds, but also because of growth of microorganisms, with all factors possibly altered by storage conditions. Insects, mites, and fungi are capable of causing hydrolysis and oxidation to potential rates of specific nutrients in stored food, and also in some situations producing potentially toxic contaminants like mycotoxins [24].

The rice weevil Di' S. oryzae is a cosmopolitan and very injurious insect pest, where damage can range from 10-65% under moderate storage situations while damage can be 80% with long storage conditions. S. oryzae can have a host preference for a variety of stored products with regard to feeding behavior, development, oviposition, and damage. Also, the behavior and performance of these insects are influenced by the physio/chemical characteristics of the host such as the presence of toxins and inhibitors, volatiles, macronutrients, micronutrients, as well as kernel hardness and textural profile [7,12,29].

The need to protect stored products from spoilage especially through deterioration of quality and weight, continues to be justified [24]. It is difficult to manage this pest because its immature stages will be found developing inside the grain kernel, which complicates accurate identification of infestations and impacts the efficacy of control measures which has ultimately resulted in significant levels of damage within stored cereals [7,29]. In parts of the world where inadequate storage is present, the ability of stored grain to resist or succumb to other forms or combinations of protection may be the only way to restore pest damage [5,22].

Knowledge about Insect Pest *Sitophilus Oryzae*

1. **External morphology**

Rice weevil measures up to 2 to 3 mm in length almost 1/10th of an inch. Its look like the granary weevil but can be differentiated due to its reddish brown to black coloration along with four reddish or pale-yellow spots located on the corner of its hard and protective forewings also known as elytra (9) (Hill, 2002). mouth parts in rice weevil help in chewing but their most identified feature is their elongated snout which is 1mm long (30). The head, along with the snout measures as long as elytra. Their prothorax has irregular pits, while the elytra have longitudinal rows of pits. Larvae of rice weevil do not possess legs and they live inside hollowed grain kernels. The larvae have a cream-colored body with a dark head (9, 18).

The rice weevil is one of the most destructive pests of stored grains all over the world. Beginning in India, this pest has been widely dispersed worldwide by commercial activity, often called a cosmopolitan pest, and is especially common in the Southern United States. Both the adult and larval rice weevil stages will feed on a variety of oats, barley, rye, sorghum, wild bird seeds, dried beans, cereals, cashew nuts and products, it is particularly fond of macaroni [18].

Mehtaet al. (2021) examined the biological characteristics and orientation of S. oryzae towards wheat cultivar HPW-236 and mixed grains from different cultivars (HPW-155, HPW-236, HPW-249, HPW-349, HPW-360, HS-490 and VL-892). The results showed a delay in the incubation, larval, pupal and total life cycle periods of S. oryzae on mixed grains than HPW-236. Weevil orientations were directed more towards HPW-236 and germination of HPW-236 was lower than that of mixed cultivars exposed to S. oryzae. In a qualitative assessment on damage caused by S. oryzae on different wheat cultivars recommended in the northwestern Himalayas under free-choice conditions (unpublished), HPW-236 sustained more damage and ultimately decreased weight more than HPW-360 and HPW-249. On the basis of its cultivation in this area, HPW-236 proved highly susceptible to the weevil promoting growth and delivery as environmentally-favorable for the development of the weevil. Therefore, recommending not storing ÇÑW-236 for a longer period and choosing cultivars like HPW- 249 and HPW- 360 which are not highly susceptible to the weevil is best practice for farmers in the northwestern Himalayas.

*3. **Life cycle of Sitophilus oryzae***

a. Development The adult female rice weevil creates a small cavity within the grain kernel to lay her eggs, then seals it with secretions from her ovipositor. When the egg hatches, it gives rise to a young larva, which then moves to the center of the kernel to feed, grow, and develop into a pupa. The pupa is enclosed within the grain and undergoes significant internal and external modifications that physically transform the pupae into adults. The emerged adults exit through the emergence hole, ready to mate and start the next generation [18,30].

b. Life cycle: Like all holometabolous insects, S. oryzae has complete metamorphosis occurring in four stages: egg, larva, pupa, and adult. [25]

Egg: The rice weevil lays its egg in the cracks of kernels or dust. A female rice weevil lays about 4 eggs a day over its lifetime of 5 months, for a total of about 250 to 400 eggs. The eggs hatch within about 3 days. [30]

Larva: larva feed in grain kernel for 18 days. The main growth period of an insect is the larval phase. s inside of the seed cuticle of the larva become harden and it becomes mature. It feeds several times its growth and increases weight and molts regularly in order to grow and increase in size. [30]

Pupa: The pupal phase complete 6 days without feeding. In some species, the pupa is covered by a cocoon made by the larva. Some internal and external changes occur in this phase. Eventually the adult comes out as a fully developed individual from the pupa. [30]

Adult: The size of an adult is generally between 0.1 and 1.7cm long with three pairs of legs and is segmented at the head, thorax and abdomen allowing them to move and penetrate deep into the mass of grains for effective dissemination. The head has the mouthparts and sensory organs; and the thorax contains the legs and wings and the abdomen contains the reproductive organs [30].

Depending on the time of year and environmental conditions, the full life cycle may take anywhere from 26-30 days in hot summer conditions, to a much longer period if conditions are cooler [18]

Okram and Hath (2019) stated that the laboratory research examining S. oryzae presented substantial differences in its biology and life history based on seasons, specifically the species had the longest times for the various developmental stages and adult longevity during February. These were: incubation period of 5.85±0.31; larval period of 21.33±0.99; pupal period of 10.20±0.5; and adult longevities of male with food mean longevity of 58.72±3.44 and without food 12.98±0.98; and adult longevities of female with food mean longevity were 77.23±3.11 without food 14.47±0.69, and the total lifecycles for both male and female were again longest for February. This period occurred within temperature ranges of 12.39°C to 27.89°C; and relative humidity of 58.33 to 88.81%. Interestingly, regardless of season and food connection, the adult female life expectancy was longer than that of the adult male in all situations.

4. Chemical control

Despite the increased use of new technology for pest management and grain storage, there will always be some producers who continue to store grain using conventional methods, meaning the grains stored in such ways are shrouded in the potential to lose value [9]. Agricultural chemicals have long been portrayed as the “Miracle Weapons” on the frontline of management against stored products pests; however, now there are many shortcomings. There has been a long-standing dependence on the reuse of liquid and gaseous insecticides to manage insect populations in stored products, and excessive dependence on a single chemical or multiple similar products results in challenges such as residual hazards, development of resistance, contamination of the environment, impacting non-target organisms, unacceptable levels of control failure, and possible negative impacts to the natural enemy (biological control) system that creates outbreaks. [17,22].

The use of pesticides is one way of reducing losses during storage. The problem with using pesticides to control storage pests is that there are very few pesticides available to use due to the extensive legislation that limits the use of synthetic insecticides in close proximity to food [24]. Regulatory problems surround some of the more common commercial fumigants including methyl bromide, dichlorvos, chloropicrin, and phosphine. Historically, fumigants, especially methyl bromide and phosphine, were among the most effective ways to protect stored food, feedstuff, and agricultural commodities from invading insects. However, EPA regulations in 2001 stated that the use of methyl bromide must be phased out due to its ozone-depleting potential, and dichlorvos is considered a suspected carcinogen. Because of their hazards, and toxicity, use of methyl bromide, dichlorvos and phosphine is restricted to licensed commercial use. In addition, because of the repeated and widespread use of phosphine and methyl bromide, some insect pests associated with stored products have developed resistance to these insecticides [16,17,26]. S. oryzae is of most concern in developing resistance to insecticides and the ability to quickly develop phosphine resistance [25]. The same difficulties arise for methyl bromide and phosphine, and point to the necessity of developing new types of selective insect-control alternative, preferably with fumigant action [8,17].

Park et al. (2004) evaluated the insecticidal fumigation toxicity of both natural and synthetic cyanohydrins on four stored-product pests, the lesser grain borer *Rhizotrypa dominica* (F), the red flour beetle *Tribolium castoreum* Herbst, the saw-toothed grain beetle Oryzaephilus surinamensis L., the corn weevil *Sitophilus zamias* (Motsch), and the housefly Musca domestica L. For houseflies, all but one of the cyanohydrins were found to have more potency compared to 1,3-dichloropropene. All the cyanohydrins had displayed higher insecticidal potency than Di chloropropene and chloropicrin. The acetate of 1-cyano-1-hydroxy-2-propene (CHP-ace) showed antifungal and antibacterial activity in soil, and it also inhibited weed seed germination, suggesting that it could function as a broad-spectrum soil fumigant.

Cao et al. (2024) researched the effects of cereal volatiles on S. oryzae, as well as the electroantennography (EAG) responses and behavioral bioassays for different rice cultivars [red brown rice (RBR). Daohuaxiangmi (DHXM). Baishuigongmi (BSGM). Yashuixinmi (YSXM), and white gelatinous rice (WGR)] across different olfactometer types. The results showed statistically significant variation for S. oryzae preference among rice cultivars and documented this order; RBR>DHXM=YSXMe"BSGM>WGR. Considering volatiles in RBR, the analysis identified 26 compounds in the volatiles, with nonanal (29.37%), hexanal (16.08%) and 1-octen-3-ol (8.83%) the main contributors. The evaluation of the EAG on these three compounds demonstrated that S. oryzae antennae perceived these compounds in a dose-dependent manner (100-1) across the entire range of compounds. The olfactory preferences for S. oryzae among these three compounds at their optimal concentration; and similarly used to evaluate host preferences, were nonanal>1-octen-3-ol=hexanal. The findings of this study demonstrated the capacity of the peripheral olfactory system of S. oryzae to detect volatiles that could originate from the preferred rice cultivar (RBR) which elicited positive chemotaxis that may provide many valuable implications to understand the mechanisms involved in influencing host preferences of stored grain pests. Among these compounds, nonanal showed potential viability as a new mark and attack control tool for this storage beetle pest.

5. Biological control

During the last two decades addressing the wasted stored food due to insect damage has primarily involved the use of synthetic insecticides. Infestation lessens economic value, along with a loss of quality and weight (Padin et al., 2002). Heavy reliance on specific chemicals has led to concerns over toxic residues, resistance, environmental contamination, and control failures. Novel limitations, in combination with increased environmental issues, have influenced researchers to explore alternatives to chemical pesticides. Plant-based products are among some of the alternatives being explored as they are biodegradable, environmentally friendly, safe for humans, and are a rich source of bioactive compounds. Though many bioactive compounds may be effective against specific targeted pests they may also degrade into non-toxic byproducts and their suitability for integrated pest management systems is being contemplated. Some plant extracts used as grain protectants seem to have potential efficacy against S. oryzae [7,17].

An increasingly promising method with great potential to limit the negative effects caused by insecticides is the use of entomopathogenic fungi, and other types of microbial control agents. The use of fungal pathogens to manage insects has been studied for a number of years, but not as much attention has been given to using fungi as agents of control for storage pests. Presently, essential oils are one of the most widely studied options [1,6,24]

Parisot et al. (2021) used a combination of short and long reads to sequence the S. oryzae genome, producing the richest assembly for a Curculionidae species yet. Their analysis further indicated that S. oryzae had undergone repeated bursts of transposable element (TE) amplification comprising 72 % of its genome. Additionally, they showed that multiple TE families displayed transcriptional activity and changes in their expression were associated with the insect's endosymbiotic state. In addition, numerous beetles, S. oryzae have also been considerably increased their gene content. S. pier Antonius required its host for diverse amino acids and nucleotides for basic survival and vitamin and essential amino acids for insect development and cuticle biosynthesis.

Asawa et al. (2012) reported that the powders derived from four indigenous plants in Nigeria: Dennettiatripetala Baker F. fruits, Curcuma longa L. rhizomes, Piper quineense, Schum and Thonn, seeds, and Zingiber officinale Rose. rhizomes were assessed for their insecticidal activity as a laboratory evaluation against the rice weevil, S. oryzae (L.). The results showed that the botanical powders contributed toward increasing adult mortality and inhibiting adult emergence of the rice weevil. P. guineense and D. tripetala had the highest rate of mortality at 18.8% and 16.5%, respectively, when assessed 35 days post-treatment when compared to the other treatments. P. guineense seed powder resulted in a lower adult emergence of rice-treated (3.25%) seeds, and consequently demonstrated the greatest (% weight loss) in comparison to the control group also. Overall, these studies demonstrated the potential use of these botanicals in the protection of stored rice against damage by storage insects.

Mehta and Kumar (2020) investigated environmentally sound alternatives to chemical fumigants and synthetic insecticides for the control of weevils in stored grains. Among all the treatments, Ageratum conyzoides leaf powder exhibited the best activity against the weevils, with the highest mean cumulative mortality (96.67%); the lowest mean monthly population increase (18.33%) and the least amount of grain damage (12.61%) and weight loss of grain (17.5%). after 6 months of storage. Ageratum conyzoides was followed by drupe powder of Melia azedarach, then Vitex negundo and Ocimum sanctum. Ageratum conyzoides, Melia azedarach and Ocimum sanctum were still effective 3 months post-preparation. Murrayakoenigii displayed the lowest mean cumulative adult mortality (14.23%), the highest mean monthly population increase (132.78%) and the greatest amount of grain damage (47.50%) and weight loss (11.07%), attesting to the ineffectiveness of this treatment.

Benziet al. (2009) investigated the Brazilian pepper tree. (Schinus molle L. var. areira (L.) DC.) Several biological activities are described, including insecticidal activity, and they evaluated the repellent, fumigant activity, nutritional indices, and feeding deterrent action of the Brazilian pepper tree oil on S. oryzae adults. They reported leaf essential oils displayed repellent activity at both the concentrations (0.04 and 0.4% w/w), while fruit essential oils did not. Fruit essential oils also showed strong feeding deterrent activities (62%) while leaves were less effective (40.6%) and neither essential oil showed any significant toxicity with respect to fumigant activity

Conclusion

The range of pesticide options for the control of stored pests is limited by stringent safety standards for the use of synthetic insecticides in proximity to food. When it comes to protection of stored food and agricultural products from insect infestations, fumigants e.g. methyl bromide and phosphine, have historically been the most effective means of treatment. Heavy reliance on these chemicals has led to issues e.g. toxic residues, resistance, environmental pollution and control failure. The task of confronting these challenges alongside growing environmental issues has prompted researchers to evaluate alternatives to chemical insecticides. From these alternatives, plant-based products have generated interest due to their biodegradability, environmental safety, and human safety. Another promising alternative with great potential to counteract the adverse effects of insecticides is the use of entomopathogenic fungi and other microbial control agents. At present, essential oils are also another alternative to chemical pesticides.

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