REVIEW ARTICLE Agricultural Science Digest, Volume 46 Issue 2: 191-199 (April 2026)

Pest and Disease Related Post-Harvest Losses in Rice: A Review

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10.18805/ag.D-6397

ABSTRACT

Post-harvest losses (PHL) is a crucial strategy in the global effort to ensure food security for a growing population and achieve sustainable development. With food production needing to increase by 70% by 2050, the staggering reality of up to 40-50% food waste in some regions due to spoilage and infestation presents a significant challenge. Also reducing PHL is not just an option; it is a critical component of an integrated approach to realise the full potential of agriculture. It is very important in combating hunger, increasing income and improving livelihoods. Investing in PHL reduction is seen as relatively modest, yet it yields rapid returns, making it a highly effective pathway to enhancing food availability, reducing poverty and optimizing resource use. Addressing PHL is essential for nourishing a growing global population while minimising the pressure on our planet's precious assets. In global food systems, post-harvest loss is a major problem. Diseases and insect pests are becoming formidable competitors when it involves retaining agricultural products fresh after harvest. Both quantitative depletion and major qualitative degradation result from the significant harm these biological organisms cause to stored grains. Insect infestations and pathogen infections compromise food safety, nutritional value and marketability from the immediate post-harvest period through storage, processing and distribution. This exacerbates food insecurity and causes significant financial hardship for farmers and supply chain participants globally. In India, post-harvest loss (PHL) in rice is a serious problem that affects farmer earnings, food security and overall economic effectiveness.

Key words: Disease, Pest, Post harvest losses, Rice.

In rice, post-harvest losses (PHL) are the quantitative and qualitative decreases in rice grain that occur in between the harvest and human consumption (Qu *et al*., 2021). This encompasses any reduction in the quantity of consumable rice grain that is the result of factors that impede its utilization by humans, such as a decrease in nutritional value, a decrease in its marketability, or a decrease in its edibility (Bendinelli *et al*., 2020 and Mahendran *et al*., 2024). PHL should be distinguished from intentional reductions, such as the removal of bran or husk during milling, which are essential processing stages (Muller *et al*., 2022). Globally, post-harvest losses in rice can range from 10% to 40% of total production, depending on the region and the techniques employed. In developing countries, losses are generally higher due to traditional methods and less advanced infrastructure. The post-harvest losses for grains, including rice, are typically estimated to be between 10% and 20% at the pre-processing stage (Nath *et al*., 2024).

The quantitative harvest and post-harvest losses for cereals, which encompass paddy/rice, were estimated to be between 3.89% and 5.92% in India. According to national estimates, paddy losses total 5.53%, of which 4.67% occur during field activities and 0.86% during storage. A survey of 1,200 farmers in Punjab, Bihar and Madhya Pradesh revealed a paddy loss of 6.37% (including quantity and quality losses). The post-harvest losses are considerably higher during harvesting and threshing operations (Table 1), with traditional methods providing a significant contribution (Gulati *et al*., 2022).

Post-harvest losses in rice due to insect infestation

Insect infestations are major causes of post-harvest losses of rice, which is a staple food and an important agricultural commodity in many developing countries (Kuai *et al.,* 2024; Sun *et al*., 2024a and 2024b; Jayan *et al.,* 2022a, 2022b). The principle insect pests of rice during post-harvest storage are rice weevil *Sitophilus oryzae*, rice moth *Corcyra cephalonica*, khapra beetle *Trogoderma granarium* and grain borers *Prostephanus truncatus*. These insects feed on the stored rice thereby causing quantitative

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How to cite this article: Aruna, G., Nisha, R., Chandraprabha, S., Vanitha, J., Mahendran, R. and Prakash, K. (2026). Pest and Disease Related Post-Harvest Losses in Rice: A Review. *Agricultural Science Digest*. **46(2):** 191-199. doi: 10.18805/ag.D-6397.

Submitted: 23-06-2025 **Accepted:** 03-10-2025 **Online:** 12-11-2025

as well as qualitative losses (Kumari *et al.,* 2023). In India, it is estimated that the total post-harvest food grain loss is 12-16 million metric tonnes, which is enough to feed one-third of the country's poor. According to Kumari *et al.* (2023), insects can account for 24.2% of these loses, which totals to around ₹ 1,300 crores in each year. Weight loss, reduced market value due to damage or discoloration of grain, contamination through insect waste and the potential for diseases such as aflatoxin to spread as a result of fungal growth are among the impacts of insect infestations. Several factors such as storage conditions, period of storage, pests control methods, as well as environmental factors such as humidity and temperature, affect the amount of grain lost (Sharma *et al.,* 2024; Wu *et al.,* 2022; Wu *et al.,* 2023).

Key insect pests contributing to post-harvest losses in rice

Rice weevil (*Sitophilus oryzae*)

One of the most important pests of stored rice is the rice weevil. It's a grain eater, chewing and eating the stored grains of rice to the point where up to 57% of rice weight reduction and decline in quality has been recorded for each generation in its laboratory host's larva. Its larvae tunnel through the grain, causing the kernels to hollow out and become contaminated. Research shows that the destruction of grain by the rice weevil can be as high as 12-25% depending on storage situation (Yu *et al.,* 2025).

Rice moth (*Corcyra cephalonica*)

Stored rice is also attacked by the rice moth. It lays its eggs on grains of rice and the larvae feed on the grain causing holes and ruining it. Rice moth infestations commonly cause damage associated with a reduction in quality of up to 18% to 22% in some regions.

Khapra beetle (*Trogoderma granarium*)

The khapra beetle is a serious pest of stored rice, especially in areas with bad storage conditions. Its maggots can inflict heavy damage to the grains by feeding and creating physical damage and contamination. Khapra beetle infestations cause substantial losses (20-25%) and are related to defective rice.

Grain borers (*Prostephanus truncatus*)

A lesser known but equally damaging pest of stored rice is the grain borer. It normally results in weight-loss and deterioration of grain quality. The losses by the grain borers are also not as high as those by the rice weevils and moths but they also give rise to the overall post-harvest loss particularly under poor storage environment.

Angoumois grain moth (*Sitotroga cerealella*)

Larvae of this moth at their late instar stage can infest 69% of stored rice and cause an average weight reduction of 2.11%, varying from 1.09% to 3.10%.

Lesser grain borer (*Rhyzopertha dominica*)

It is one of the 100 insect pests that can cause economic loss to stored grains.

Indianmeal moth (*Plodia interpunctella*)

This moth's caterpillars are known as waxworms in their caterpillar stage. They are a prevalent kind of grain-feeding pest that can be found in the whole world and that feed on cereals, fruit and related commodities. The larvae can chew through plastic or cardboard packaging, allowing infestations of even stored food.

Rust red flour beetle (*Tribolium castaneum*)

A common pest of stored grains, causing contamination and weight loss.

Saw toothed grain beetle (*Oryzaephilus surinamensis*)

Infests stored grains, leading to quality degradation and weight loss.

Almond moth (*Cadra cautella*)

Infests stored grains, leading to contamination and quality degradation.

Table 1: Stages and causes of post-harvest losses in rice.

Stages	Post-harvest losses	Causes
Harvesting	1-5%	Shattering of grains, incomplete harvesting, untimely harvesting (too early or too late) and mechanical damage.
Threshing	1-3%	Traditional beating methods), incomplete separation of grains from the straw and physical damage or breakage of grains.
Drying	2-5%	Uneven drying, rewetting due to unexpected rainfall and exposure to pests.
Cleaning and winnowing	<1%	Grains being discarded along with impurities, or spillage during manual or inefficient cleaning processes.
Storage	2-6%	Insect and pest infestation (weevils, rodents), fungal and microbial contamination moisture reabsorption and inadequate traditional storage structures.
Milling and processing	2-5%	High percentage of broken grains due to outdated or poorly maintained milling machinery, over-milling.
Transportation and handling	0.1-1%	Spillage during loading, unloading, or transit and physical damage.

Table 2: Post-harvest losses in rice caused by insect infestation in global level.

Pest name	Location	Per cent loss (%)	Author (s)
Rice yellow stem borer (*Scirpophaga incertulas*)	India (Multiple states)	10-40%	Sanyal *et al.,* 2025
Various insect pests	India (Multiple states)	Not s7pecified	Chintalapati *et al.,* 2023
rice stink bug (*Oebalus pugnax*)	USA (Southern states)	50-80% kernel weight loss	Poston *et al.,* 2024
Lesser grain borer (*Rhyzopertha dominica*)	Bangladesh	4-14%	Kabir *et al.,* 2024
Rice weevil (*Sitophilus oryzae*)	India (West Bengal)	15-25% loss	Firoz *et al.,* 2023
Granary weevil (*Sitophilus granarius*)	Jordan	20-30%	Al-Tamimi *et al.,* 2024
General review	Global	Not specified	Lazzari *et al.,* 2025
Rice borer (*Scirpophaga excerptalis*)	Sri Lanka	10-50%	Abeysekara and Rathnayake, 2024
General review	Global	Not specified	Shahbandeh, 2024
Fall armyworm (*Spodoptera frugiperda*)	Philippines	Not specified	Valdez *et al.,* 2023
Various insect pests	India (Tamil Nadu)	Not specified	Jerlin *et al.,* 2023
Various insect pests	India (Multiple states)	Not specified	Rajendran and Sriranjini, 2024
Rice stemborer (*Scirpophaga excerptalis*)	Nepal	20-35%	Kafle *et al.,* 2023
Rice weevil (*Sitophilus oryzae*)	India (Tamil Nadu)	5-10%	Sumathi and Rajan, 2024
Khapra beetle (*Trogoderma granarium*)	Bangladesh, India	10-40%	Hasan *et al.,* 2025
Granary weevil (*Sitophilus granarius*)	Brazil	12-18%	Lobo *et al.,* 2024
Rice weevil (*Sitophilus oryzae*)	Thailand	10-30%	Muniappan *et al.,* 2023
Rice weevil (*Sitophilus oryzae*)	USA (Southern states)	15-20%	Brummer *et al.,* 2024
Various stored grain pests	Taiwan	10-25%	Kuo *et al.,* 2024
Rice weevil (*Sitophilus oryzae*)	Pakistan	5-15%	Noor *et al.,* 2023
Rice stink bug (*Oebalus pugnax*)	Pakistan	25-35%	Afzal *et al*., 2024
Rice yellow stem borer (*Scirpophaga incertulas*)	India (Andhra Pradesh)	10-30%	Yashoda *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Bangladesh	15-25%	Arif *et al*., 2024
Lesser grain borer (*Rhyzopertha dominica*)	India (Tamil Nadu)	12–20%	Ponnusamy *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Bangladesh	10-20%	Rahman *et al*., 2024
Rice stink bug (*Oebalus pugnax*)	Pakistan	15-30%	Rauf *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Pakistan	5-10%	Baloch *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	India (Haryana)	15-20%	Karan *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	Odisha, India	10-15%	Behera *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	South Korea	8-12%	Lee *et al*., 2024
Rice borer (*Scirpophaga excerptalis*)	India (West Bengal)	20-40%	Ghosh *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Pakistan	12-18%	Ali *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	Egypt	8-15%	Abdel-Rahman *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	India (Bihar)	10-15%	Pandey *et al*., 2024
Rice borer (*Scirpophaga excerptalis*)	India (Uttar Pradesh)	25-35%	Thakur *et al*., 2025
Rice weevil (*Sitophilus oryzae*)	Bangladesh	10-15%	Alam *et al*., 2024
Rice borer (*Scirpophaga excerptalis*)	Bangladesh	20-30%	Islam *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	India (Madhya Pradesh)	15-25%	Gupta *et al*., 2025
Rice weevil (*Sitophilus oryzae*)	India (Uttarakhand)	10-20%	Sakshi *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Pakistan	8-15%	Kiran *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	Pakistan	10-20%	Aslam *et al*., 2024
Rice weevil (*Sitophilus oryzae*)	India (Punjab)	10-12%	Neelam *et al*., 2023
Rice weevil (*Sitophilus oryzae*)	Pakistan	15-20%	Ali *et al*., 2024
Rice stink bug (*Oebalus pugnax*)	India (Bihar)	25-40%	Shamsher *et al*., 2024

Table 3: Post-harvest losses in rice caused by pathogens.

Pathogen name	Symptoms of seed discolouration	Per cent loss (%)	Author(s)
Pyricularia oryzae	Brown spots and blotches on the grain surface	30-70%	Anonymous, 2024 Patel, 2024 Climate Data 2024 Gupta *et al.,* 2023, Huded *et al.,* 2023a,
Drechslera oryzae	Black or brown spots or blotches on grain	25-75%	Anonymous, 2024 Said *et al* 2025 Huded *et al.,* 2022a, Anju and Pannu *et al.,* 2024, Huded *et al.,* 2023b
Sarocladium oryzae	Light brown discolouration on the seed coat, Endosperm and embryo of discolored seed	20-42%	Usha *et al.,* 2024 Said *et al.,* 2025 Huded *et al*., 2022b Anonymous, 2024 Huded *et al.,* 2023c
Ustilaginoidea virens	Yellow or black in color.	25-48%	Huded *et al.,* 2023a Huded *et al.,* 2022a Huded *et al.,* 2023b Patel, 2024 Sun *et al.,* 2020
Xanthomonas oryzae pv. Oryzae	Yellow-pigmented and grains rotted and darkening.	10-32%	Raghunandana *et al*., 2023(a) Raghunandana *et al*., 2023(b) Huded *et al.,* 2022b, Nayak *et al.,* 2021 Anonymous, 2023b,
Curvularia lunata, Curvularia affinis, Curvularia pallescens, Curvularia geniculata	Brown or black spots on the grain and Base discolouration	20-54%	Said *et al.,* 2025 Patel, 2024. Huded *et al.,* 2022b, Anju and Pannu, 2024, Anonymous, 2024 Huded *et al.,* 2023b Huded *et al.,* 2023a, Yuvarani *et al.,* 2021,
Alternaria padwickii, Alternaria alternate	Ash gray discoloration and Black or brown spots or blotches on grain and	15-47%	Utobo *et al .,* 2011, Anonymous, 2023a Said *et al*., 2025 Anonymous, 2024 Huded *et al.,* 2023a Huded *et al.,* 2022a
Aspergillus niger, Aspergillus flavus	Discolorations can be various colours like ash grey, light brown, or even dark brown, purple or black.	15-36%	Said *et al*., 2025 Utobo *et al .,* 2011 Patel, 2024 Huded *et al.,* 2022b,
Fusarium moniliforme, Fusarium graminaerum, Fusarium sp	Shrivelled, brittle and be lighter in weight than healthy grains.	15-28%	Said *et al.,* 2025 Huded *et al.,* 2022a, Utobo *et al.,* 2011 Singh *et al.,* 2021,
Burkholderia gladeoli, B. glumae,	Discoloured, shrunken spot	10-25%	Kim *et al*., 2021, Said *et al.,* 2025,

Table 3: Continue....

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			Huded *et al.,* 2022b, Huded *et al.,* 2023a Hou *et al.,* 2020;
Pseudomonas oryzhihabitans, P. ananitis, P. agglomerans	Stained with discoloured and rotten	7-22%	Kim *et al.,* 2021, Huded *et al.,* 2022b, Hou *et al.,* 2020
Epicoccum nigrum	Grain discoloration with shrivelling,	5-15%	Singh *et al.,* 2021 Utobo *et al.,* 2011 Shivappa *et al.,* 2022 Huded *et al.,* 2022a
Tilletia horida (Neovossia horida),	*Tilletia barclayana* Dark brown or black discoloration, which can be seen as spots or stripes.	15-37%	Sabin Khanal *et al.,* 2023 Zhou *et al.,* 2021 Way *et al.,* 2020 Wang *et al*., 2021 Wang *et al.,* 2021 Hou *et al.,* 2020
Acidovorax avenae sp. Avenae	Grains can appear partially or completely blackened	7-15%	Huded *et al.,* 2023a
Microdochium oryzae	Grains may show dark brown or black spots, or be discoloured with red, yellow, orange, pink, or black hues.	7-20%	Said *et al.,* 2023, Khamari, 2020
Rhynchosporium oryzae, Penicillium spp	Discoloured with hollow grains Discoloration, with spots or lesions ranging in color from ash grey to black	10-15% 15-25%	Utobo *et al*., 2011 Anju and Pannu, 2024. Utobo *et al.,* 2011

Pulse beetles (*Callosobruchus* species)

While primarily pests of pulses, they can infest stored rice, causing damage and contamination.

A majority of small scale farmers depend on conventional rice storage and processing methods which are rudimentary and are not efficient in preventing losses (Hariharan *et al*., 2025a and 2026). Antiquated machinery and methods of pest control have led to high wastage (Ponsiva *et al*., 2025). Lack of post-harvest storage facilities, especially in rural regions, also contributes to post-harvest losses. Rice is more easily damaged by pests and spoilage if it does not have adequate temperature and humidity control. Warmer temperatures and altering weather patterns can exacerbate existing post-harvest storage conditions and make crops more susceptible to pests and diseases. A lot of the farmers and actors are not adequately trained and/or knowledgeable on best practices for PHH, pest control and storage capacity which results in avoidable loss (Gulati *et al*., 2024).

Insects infestations are responsible for large amount of postharvest losses particularly in countries such as India which has a significant focus on food security and their main crop rice FAO (2022). Among the most important implications are economic loses, food scarcity and quality deterioration. The farmer and market handlers suffers the losses due to damage of rice caused by insects during storage. As a result, less rice is left for sale and hence lower income for farmers. In areas where rice is the staple diet, any decrease in yield caused by insect attack can result in serious food shortages, particularly if it occurs during the lean season. The post-harvest rice that are infested with insects have a lower market value that is not worth for farmers and retailers to keep as stock or sale it. In addition, low-quality rice can lead to health problems for consumers through insect eggs, excrements, or it is toxicologicaly undevaluable for moulds (Table 2). Better storage, insecticides and fumigation, farmers training, improved milling procedures, research into pest resistant varieties, research and innovation and government policies and support are the mitigation strategies for insect-related post-harvest losses (Pradhan Mantri Fasal Bima Yojana, 2025).

Post-harvest losses in rice due to disease and microbial discoloration

Although infections caused by bacteria or viruses may result in discoloration in rice kernels, fungi are more frequently related to this particular condition. *Sarocladium oryzae, Fusarium spp.* and *Pyricularia oryzae* are the fungi causing grain discoloration in the field. During storage, *Aspergillus* and *Penicillium* are frequently related to discolouration. The moisture content, temperature, length

of storage, insect activity and condition of the grain at the time of storage significantly affect the development of fungus in stored grains (Table 3).

Symptoms of seed discoloration

The microorganism and infection severity may cause different symptoms. Rice seed discoloration can cause brown to black stripes or patches on the grains and hollowed-out panicles with empty grains, depending on the fungus. Grain discoloration affects size, color and shape. Wind pressure during pollination, a lack of food, a low plant population, improper fertilization or pollination, immature grain filling and maturity-stage rainfall can cause black blotches (Hariharan *et al*., 2025b). Discoloration was greatest during flowering, milking and soft dough.

Diseases that cause discoloration in seeds. 99 different species and 59 different genera of fungi were found to infect rice seeds. There are two categories for these fungi: Field fungi are parasitic fungi that contaminate grains before harvest, whereas storage fungi are saprophytes that grow after harvest.

Pyricularia oryzae, Drechslera oryzae, Sarocladium oryzae, Ustilaginoidea virens, Curvularia spp., Fusarium spp., Phoma spp., Alternaria spp., Aspergillus spp. and *Xanthomonas oryzae pv. oryzae* are some of the primary pathogens that lead to color changes in seeds. Additionally, there are several minor pathogens, including *Penicillium spp., Pseudomonas spp., Burkholderia glumae, Tilletia spp.* and *Cladosporium spp.*

Conclusion

Rice post-harvest losses are a serious issue of concern, particularly in countries where rice is a staple food and also serves as the major source of livelihood for millions of people. The losses decrease food availability, disrupt the economy and affect human health. But with targeted interventions, such as technological solutions, better storage, education and policy support, these losses can be reduced and we can move toward making the rice supply chain more sustainable, secure and resilient. Minimizing post-harvest losses not only contributes to food security, but also provides a platform for poverty reduction and environmental degradation. Since seed discoloration in rice causes losses and is linked to infectious agents, the management approaches should be centered on ways to improve how farmers grow their crops. To cut down on the damage caused by seed discoloration, we should leverage rice's genetic resources, such as resistant types and treat the pathogens using new-generation formulations, bio-fungicides and bio-intensive approaches.

Conflict of interest

We wish to confrim that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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