Journal of Tropical Agriculture 61(1): 8-13, 2023

Seed water status and insect infestation during storage in rice

Harshaprada K.[1], Rose Mary Francies[2]*, Dijee Bastian[1], Berin Pathrose[3] and Amala Thomas[2]

[1] *Department of Seed Science and Technology, College of Agriculture, Kerala Agricultural University, Thrissur 680 656*

[2] *Agricultural Research Station, Kerala Agricultural University, Mannuthy P.O., Thrissur 680 651*

[3] *Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur 680 656*

Received 22 October 2022; received in revision form 15 April 2023; accepted on 19 May 2023

Abstract

In coastal states like Kerala, owing to the hot and humid climate, maintenance of quality of the seed during storage has always been a challenge, mainy because the conditions are highly conducive for the growth and proliferation of storage pests. A study was conducted during 2019-2020 to dissect the relationship between moisture content and pest infestation in seeds of rice variety Jyothi stored under ambient condition. The per cent gain in seed moisture content at the end of storage period of seven months was 25.67. Similarly, an increase in the number of beetles (11.10 folds) and infested seeds (2.29 folds) were also observed as storage period progressed. The weight of damaged seeds increased by 2.90 folds at the end of storage period of seven months. A high significant positive correlation was deduced between seed moisture content and parameters like number of store beetles ($r=0.969^{**}$), number of infested seeds (r=0.967**) and weight of damaged seeds ($r=0.976^{**}$). The results thus pointed out that, as the moisture content in the seed increased, there was a consistent increase in the population of storage pests and the damage inflicted by them, as well. The high relative humidity (varying between 73% and 96%) coupled with a monthly mean maximum temperature ranging from 29.5 °C to 34.1 °C in the storage environment, would have been contributory factors for the increase in seed moisture content and insect population. In addition, jute bags owing to their moisture pervious nature permits moisture imbibition by seeds, paving way for a concomitant increase in insect infestation.

Key words: Seed moisture content, Storage period, Number of beetles, Insect infestation

Introduction

Cereal grains are the major component of the human diet throughout the world. Among the cereals, rice (*Oryza sativa* L.) is the major food crop, which is consumed by over two-third of the population in the world, particularly the Asians. During 2018-19, in India, rice was cropped in an area of 43.90 million hectares, registering a production of 107.80 million tonnes and a productivity of 2455 kg/ha (GOI, 2019). In Kerala, the area under rice during the corresponding period was 0.20 million hectares with a production of 0.57 million tonnes and a productivity of 2850 kg/ha (GOK, 2019).

Seeds need to be stored safely from harvesting to next planting season. Small and marginal farmers in the tropics and subtropics generally use farm-saved seeds for planting in the subsequent season or for use in the next year. The post-harvest losses are reported to be high in developing countries. In India, as much as 50-60 per cent cereal grains is lost during storage owing to inefficient storage conditions alone (Kumar and Kalitha, 2017). The

*Author for Correspondences: Phone: 9447792341, Email: rose.mary@kau.in

major cause for post-harvest losses is the excessive grain moisture content, physical environmental conditions and the biological agents, mainly insect pests and mould (Suleiman et al., 2013). The damage caused by insects may amount to 5-10 per cent in the temperate and 20-30 per cent in the tropical zone (Nakakita, 1998).

Among the several insects attacking rice grain, Rice weevil (*Sitophilus oryzae* Linnaeus), Lesser grain borer (*Rhizopertha domonica* Fabricius), Red flour beetle (*Tribolium castaneum* Herbest), Rice moth (*Corcyra cepholonica* Stainton) and Angoumois grain moth (*Sitotroga cereallela* Oliver), are of economic importance (Padmashri et al*.,* 2017). Owing to the prevalence of tropical to sub-tropical climatic conditions in India, there exists a highly conducive environment for the year-round occurrence of the storage pests in most parts of the country. The spike in relative humidity during the South-west monsoon (June- September) and the North-east monsoon (October - November) in Kerala and the accompanying hot climate, not only adversely affects seed moisture content but also its longevity. Safe storage of rice seeds and maintenance of seed quality over a long period of time thus, have always remained a great challenge in the state. The micro-physical condition coupled with high grain moisture content could enhance insect pests and fungal proliferation in seeds when stored under ambient relative humidity above 70 per cent (Danso et al., 2017). In consideration of the above, an attempt was carried out to assess the relationship between the seed moisture content and the insect infestation during the storage in rice.

Materials and Methods

The study was carried in the Department of Seed Science and Technology, College of Agriculture, Vellanikkara during 2019-2020. The area is located 40 m above MSL at 10^0 54' North latitude and 76^0 28' East longitude and experiences a warm humid tropical climate with relative humidity remaining above 75 per cent for most part of the year. During the study period, total rainfall received was 3042.9 mm and the relative humidity varied between 73 per cent (December, 2019) and 96 per cent (August, 2019). The monthly mean maximum temperatures ranged from 29.5 °C in August, 2019 to 34.1 °C in January, 2020.

Table 1. Details of seed treatment

Treatment	Common name	Dose/kg of seed
T_1	Neem leaf powder	10 g
T_2	Neem seed kernel powder	10g
T_3	Sweet flag rhizome powder	10g
T_4	Manya Koova rhizome powder	10g
T_5	Panal leaf powder	10g
T_6	Spinosad	10ppm
T_7	Diatomaceous earth	5g
T_8	*Beauveria bassiana*	1×10^8 spores.ml^{-1}
T_9	*Bacillus thuringiensis*	1×10^8spores.ml^{-1}
T_{10}	Untreated (control)	-

Neem: *Azadirachta indica* Sweet flag: *Acorus calamus* Manya Koova: *Curcuma angustifolia* Paanal: *Glycosmis pentaphylla*

The experiment was conducted with the red kernelled rice variety Jyothi following a completely randomized design (CRD) with ten treatments (Table 1) and three replications. Seeds were treated with various seed protectants as detailed in Table 1, while the untreated seeds served as control. Before initiation of storage experiment, the seed lot was observed for its quality. It was having a germination per cent of 95.0 per cent, which is well above the prescribed IMSCS (Indian Minimum Seed Certification Standards) and the moisture content in the seed (11.8 %) was well below the level recommended for safe storage in rice seed (<13.0 %). The insect infestation parameters were negligible and absence of seed microflora was observed. The number of infested seeds and beetle population in 100 g seed sample were found to be 48.0 and 2.0, respectively. The weight of the damaged seeds in 100 g of seed sample was found to be 1.3 g. Hence, the seed lot was considered to be of good quality and suitable for storage studies. The seeds were packed in jute bags and stored under ambient storage conditions. Seed samples were drawn at monthly intervals and observed for moisture content and insect infestation for seven months (June 2019 to January, 2020). With progression in period of storage, germination was found to have decreased imperceptibly and reached 76.0 per cent at the end of seven months of storage *i.e.,* germination fell below the IMSCS of 80.0 per cent for rice seeds, at the end of storage period.

Moisture content (%)

Moisture content (MC) of the seed was measured during the storage period by using the low constant temperature procedure advocated by ISTA (1985). Seeds (5 g) were drawn from each replication of the stored samples and evenly distributed over the surface of the container made of non-corrosive glass of approximately 0.5 mm thickness. Both the container and its cover were weighed before and after filling. They were then placed in a hot-air oven maintained at 103±2 °C and dried for 17±1 h. The drying period was considered to have begun from the time when oven reaches 103 °C. At the completion of the prescribed time, the container and lid were removed from the oven and placed in a desiccator to cool for 30-45 minutes. After cooling, the container along with its cover was weighed and the seed moisture content (%) was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{M_2-M_3}{M_2-M_1} \times 100$$

where, M_1: weight of container with lid

M_2: weight of container with lid + seeds before drying

M_3: weight of container with lid + seeds after drying

Insect infestation

At the end of every month of storage period, 100 g of seed sample was drawn randomly from from each replication of the stored samples and each sample was observed for the number of stored beetles and number of insect infested seeds. They were counted and the average expressed in numbers. The seeds which were damaged by insects (seeds with bored holes) were then weighed and expressed in grams (g).

$$\text{Fold change increase in the weight of damaged seeds} = \frac{\text{Final weight- Initial weight}}{\text{Initial weight}}$$

Data analysis

The monthly data on seed moisture content (%), number of beetles, number of infested seeds and weight of damaged seeds obtained was subjected to completely randomized design (CRD) analysis as per Fisher's method of analysis of variance (Gomez and Gomez, 1976).

Correlation analysis

To study the influence of moisture content (%) on storage pest infestation in rice, a correlation analysis was carried out, during the storage period (7 months). The moisture content during each month after storage was correlated to the number of beetles and infested seeds and to the weight of damaged seeds. The analysis was done by SPSS package.

Results and Discussion

Analysis of data indicated a significant increase in mean moisture content of seeds during the storage (Table 2), in spite of the fact that the seeds were dried to less than 12 per cent before the storage. At the end of the first month after storage (1 MAS), the seed moisture was 12.5 per cent. However, it increased significantly over the storage period and reached 14.8 per cent at the end of storage period (7 MAS). The gain in seed moisture content at the end of storage period was 25.67 per cent. This increase in seed moisture may mainly be attributed to the storage of seeds in jute bags, which are moisture pervious in nature. Chatta et al. (2012) reported that the large pore size of jute, cloth and woven polypropylene bags provide free access to the water vapor that were readily absorbed by the seeds and ultimately results in elevated seed moisture contents. Seeds being hygroscopic in nature, they absorb moisture from the atmosphere during the storage period despite being dried initially to less than 12 per cent moisture. Ben et al. (2006) reported that conventional packaging materials are porous in nature and even dried seeds can regain moisture in these packaging materials under high ambient relative humidity.

Table 2. Seed moisture content and insect infestation during storage in rice

Storage period	Seed moisture content (%)	Number of beetles/ 100 g of seed	Number of infested seeds/ 100 g of seed	Weight of damaged seeds (g)/ 100 g of seed
1 MAS (Jul,19)	12.5	1.36	67.10	1.59
2 MAS (Aug.19)	13.3	4.96	96.63	2.45
3 MAS (Sept, 19)	13.8	6.20	122.10	2.62
4 MAS (Oct, 19)	13.9	8.70	135.80	3.08
5 MAS (Nov, 19)	14.3	11.50	165.26	3.45
6 MAS (Dec, 19)	14.6	14.36	200.80	4.13
7 MAS (Jan,2020)	14.8	16.46	220.33	4.49
CD (0.05)	0.22	1.81	13.88	1.09
SE (m)	0.08	0.65	4.97	0.36
SE (d)	0.11	0.92	7.03	0.51
C.V.	3.71	39.02	18.97	63.44

Table 3. Correlation between seed moisture content and insect infestation

	No. of Beetles	No. of infested seeds/ 100 g of seed	Weight of damaged seeds (g)/ 100g of seed
MC (%)	0.969**	0.967**	0..976**

**Correlation is significant at 0.01 level (2-tailed)

The variation in number of beetles and infested seeds with progress in storage period was observed (Table 2). A significant increase in number of beetles and number of infested seeds with the advancement in storage period was evident. By the end of the storage period (7 MAS), a 11.10-fold increase in number of beetles and a 2.28-fold increase in number of infested seeds were observed. The weight of damaged seed was 1.59 g per 100 g seed at the 1 MAS. This was found to have increased with increase in storage duration. At the end of the storage (7 MAS), the weight of damaged seed was 4.49 g implying that there was 2.90-fold increase in the damaged seeds. This directly reflected the increase in pest population over the storage period. The correlation study between moisture content (%) and insect infestation is represented in Table 3. The results showed the existence of significant positive correlation between moisture content and number of beetles ($r=0.969^{**}$). The increase in the seed moisture was accompanied by an increase in beetle population. Manu et al. (2019) reported that the levels of insect damage tended to be positively correlated with seed moisture. During the study period, the climatic conditions of the storage environment was hot and humid (Fig.1 & Fig.2). Such storage environment would have influenced the seed moisture content positively. The high relative humidity of above 80 per cent that prevailed during most part of the storage period, the exceptions being the monsoon-free period (December: 73%; January, 2022: 78%), would have led to the increase in seed moisture content

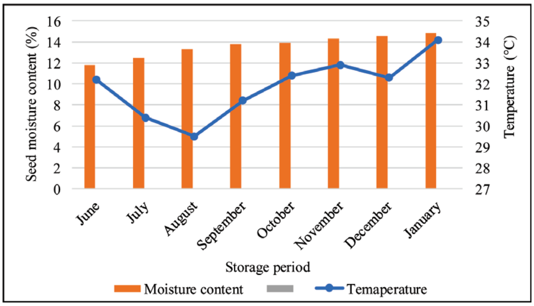

Figure 1. Variation in seed moisture content with temperature during storage (June '19 -Jan '20) in rice

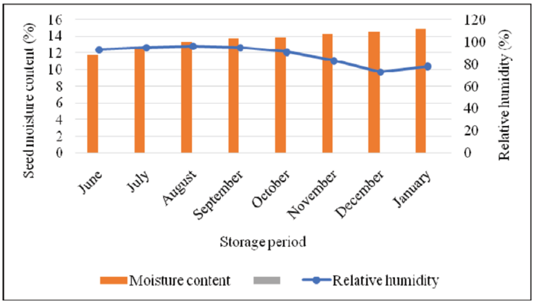

Figure 2. Variation in seed moisture content with relative humidity during storage (June '19 -Jan '20)

(25.67%). Hell, and Mutegi (2011) reported that the micro-physical condition coupled with high grain moisture content could enhanced the insect pests and fungal proliferation in maize cobs when stored under ambient relative humidity above 70 per cent. Hence, the high relative humidity coupled with a temperature above 29^0C during the storage period would have been a contributory factor for high insect infestation in the stored seeds. Similar results were also reported by Danso et al. (2017) in maize.

The significant positive correlation was found to exist between moisture content and number of infested seeds (r=0.967**) and also with the weight of damaged seeds (r=0.976**). It is evident that the increase in the storage pest population was the main reason for the upsurge of insect infestation in seeds. Many agents that cause loss in seed are inter-related and insect activity leads to increased moisture content (Azzam et al., 2011). With the rise in insect population and the subsequent infestation, seed experiences quantitative changes. Kim and Kossou (2003) stated that grain weight loss has positive correlation with increase in insect population. Ahmad et al. (2017) reported that as the storage period increased, there was an increase in kernel damage per cent of wheat grains. The weight loss in grains owing to infestation *Sitophilus oryzae*, *Trogoderma granarium*, *Tribolium castaneum* was 20.0 per cent, 8.0 per cent and 2.5 per cent, respectively.

In the present study, the elevated temperature above 29^0 C and relative humidity above 70 per cent (Fig.1 & Fig.2) might have contributed indirectly for increasing the insect damage over the storage period. A conducive environment was created for insect multiplication and infestation owing to the enhanced rate of moisture imbibition by the seeds above the level stipulated for safe storage (12.0%). Subedi et al. (2009) reported that the per cent grain damage (18.75%) due to weevil infestation was high under room temperature (25 ± 3ºC) in rice compared to controlled condition. It is also known that the low temperature storage can minimize feeding, reproduction, development and survival of insect pests and fungi, because their development, survival and reproduction are largely dependent on temperature. Storage of seeds in the moisture pervious jute bags was also a responsible factor for the moisture fluctuation. The exchange of moisture between the seed and the surrounding atmosphere will continue until the seed reaches the equilibrium moisture content. The porous gunny bags facilitate this exchange unlike moisture impervious storage containers like 400G polyethylene bags, eventually leading to an increase in moisture content of the seed which in turn facilitates higher insect infestation. Maximum insect infestation in paddy seeds was observed when they were stored in traditional storage containers, against the plastic bags and plastic drum (Hossain et al., 2019). They attributed this to the persistence of high moisture content in the seed and the high level of oxygen availability in such porous packing, which had favoured the growth of insects.

The results of the study indicated that storage of seeds under ambient conditions and high relative humidity led to an increase in the seed moisture content. It provided conclusive evidence that there existed a direct correlation between seed moisture content and insect infestation during the storage period. The increased amount of damage caused to the seed was indicative of the surge in the insect population. Therefore, it can be concluded that the traditional storage practice under ambient conditions is unsafe for seed storage under hot and humid tropical climate prevailing in the state of Kerala. Under such situations, storing the seeds under controlled conditions of atmosphere or in moisture impervious containers, could reduce the detrimental effects caused by the storage pests.

References

Ahmad, A., Ali, Q. M., Baloch, P. A., Udiin, R., and Quadri, S. 2017. Effect of preliminary infestation of three stored grain pests *Tribolium castaneum* (H), *Sitophilus oryzae* (L.), *Trogoderma granarium* (E.), their population build up and loss in wheat seeds. *J.*

Basic Appl. Sci. 13: 79-84.

Azzam, M. R. H., Sorour, M. A., and Elmahrouky, A. S. 2011. Improvement of jute packages to resist insects during storage of bean. *Seeds. J. Textile Sci. Eng.* 1:101-105.

Ben, D. C., Liem, P. V., Dao, N. T., Gummert, M., and J. F. Rickman. 2006. Effect of hermetic storage in the super bag on seed quality and milled rice quality of different varieties in Bac Lieu. *Vietnam Agric. Eng.* 31(2): 55-56.

Chatta, S. H. E., Has-Dalna, C. M., Mirani, B. N., Mahdi, M. R., and Lee, T. S. 2012. Food grain losses associated with indigenous storage methods and development of storage facilities for food security. *Int. Food Res. J.* 23: 57 -63.

Danso, J. K., Osekre, E. A., Manu, N., Opit, G. P., Armstrong, P., Arthur, F. H., Campbell, J. F. and Mbata, G. 2017. Moisture content, insect pests and mycotoxin levels of maize at harvest and post-harvest in the Middle Belt of Ghana. *J. Stored Prod. Res.* 74: 46-55.

GOI [Government of India]. 2019. *Agricultural Statistics at a Glance*. Ministry of Agriculture and Farmers' Welfare, Department of Agriculture, Cooperation and Farmers' Welfare, 314p.

GOK [Government of Kerala]. 2019. *Agricultural Statistics*. Department of Economics and Statistics, Thiruvananthapuram, 72p.

Gomez, K. A. and Gomez, A. A. 1976. *Statistical Procedures in Agricultural Research.* International Rice Research Institute, Los BanÞos, Philippines, 680p.

Hell, K. and Mutegi, C. 2011. Aflatoxin control and prevention strategies in key crops of Sub-Saharan Africa. *Afr. J. Microbiol. Res*. 5(5): 459-466.

Hossain, M. A., Awal, M. A., Ali, M. R., and Alam, M. M. 2019. Efficacy of diversified rice storage technologies in Bangladesh. *Prog. Agric*. 30(1): 51-56.

ISTA [International Seed Testing Association]. 1985. International rules for seed testing. *Seed Sci. Technol.* 13(2): 307-355.

Kim, S. K. and Kossou, D. K. 2003. Responses and genetics of maize germplasm resistant maize weevil *Sitophilus zeamais* Motschulsky in West Africa. *J. Stored Prod. Res.* 39: 489-505.

Kumar, D. and Kalita, P. 2017. Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods* 6(1): 8.

Manu, N., Osekre, E., Opit, G., Campbell, J., Arthur, F., Mbata, G., Armstrong, P., and Danso, J. 2019. Population dynamics of stored maize insect pests in warehouses in two districts of Ghana. *J. Stored Prod. Res*. 76: 102-110.

Nakakita, H. 1998. *Stored Rice and Stored Product Insects*. A.C.E Corporation, Tokyo, pp. 49-65.

Padmashri, A., Cherupally, S., Lakshmi, K., Tekale, P., Rameash, K., Anuradha, C., and Anil, B. 2017. Management of rice weevil (*Sitophilus oryzae* L.) in maize by botanical seed treatments. *Int. J. Curr. Microbiol. Appl. Sci*. 6(12): 3543-3555.

Subedi, S., Gc, Y. D., Thapa, Resham, Rijal, and Jhalendra. 2009. Rice weevil (*Sitophilus oryzae* L.) host preference of selected stored grains in Chitwan Nepal. *J. Inst. Agric. Anim. Sci.* 30(1): 151-158.

Suleiman, R., Rosentrater, K., and Bern, C. J. 2013. Effects of deterioration parameters on storage of maize. *J. Nat. Sci. Res.* 3: 147.