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Evaluation of traditional pest management practices for storage of pulses in the north bank plain zone of Assam

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The safe storage of pulses in north bank plain zone of Assam is a major challenge due to the warm and humid climate, which promotes rapid infestation of grains by storage insects. Although farmers use several indigenous storage practices, no scientific validation has been done for these practices. Seven traditional storage practices were identified through a survey conducted in the study area, and four out of these practices were selected for evaluation using black gram, green gram and pigeon pea. The pulses were stored in earthen pots from March to August using five treatments: mixing the grains with black pepper powder, mixing the grains with wood ash, covering the pot with kerosene-treated cloth, their combination and untreated control. Bruchids infestation was very high in pigeon pea, while comparatively lower in the case of black gram and green gram. Among the traditional practices, mixing grains with wood ash was found to be the most effective, recording the lowest physical damage to grain of 24.6%, 17.4%, and 53.1% and the least weight loss of 7.9%, 8.8%, and 11.4% in green gram, black gram, and pigeon pea, respectively. Moreover, the highest seed germination (72% in green gram and 78% in black gram) and the lowest rice moth population were recorded under this treatment as compared with the control treatment. Since wood ash is eco-friendly, inexpensive, and locally available, it can be effectively used to reduce post-harvest losses and maintain seed quality of pulses in the warm and humid conditions of this region.

Keywords: Bruchid, Gram, ITK, Mold, Pigeon pea, Rice moth

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Pulses are a vital source of proteins, fibre, vitamins, and minerals such as phosphorus, iron, potassium, and magnesium. They also help improve soil fertility through biological nitrogen fixation. According to the Directorate of Economics and Statistics, Government of Assam, the state produced about 131,777 MT of pulses from an area of 1.65 lakh hectares during 2023-24[1]. One of the major challenges faced by farmers in the state of Assam is storing pulses as food and seed under unfavourable weather conditions. High temperatures accompanied by high humidity adversely affect the storage life of pulses by accelerating biochemical degradation and increasing biotic stress, particularly mould and insects[2]. Grain moisture content above 10% is also not conducive to safe storage of pulses. Similarly, storage conditions with high relative humidity and temperatures above 35°C are detrimental to stored pulses. For safe storage, the ambient temperature should be higher and moisture content of grains should be lower. However, under high-humidity conditions, stored grains absorb moisture from the atmosphere, making it difficult to maintain the grain moisture content at the desired level[2,3]. Under such conditions, storage insect pests, particularly bruchid (*Callosobruchus chinensis*), multiply very rapidly and can cause severe quantitative and qualitative losses within a short period. Other important storage pests of pulses include *Callosobruchus maculatus*, *Trogoderma granarium* (Khapra beetle), *Sitophilus oryzae* (rice weevil), *Corcyra cephalonica* (rice moth), mites, and rodents, all of which contribute significantly to post-harvest losses in stored pulses[4].

The present study was conducted in areas located across the Lakhimpur and Biswanath district of the north bank plain zone of Assam (26.43°N to 27.53°N latitudes and 93.04°N to 94.20°N longitudes). The air temperature of the area begins to increase in March and consistently remains above 30°C from April to August, while the relative humidity varies between

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60% and 90% in this period (Fig. 1 & 2). Under such conditions, the storage of pulses becomes difficult, even for a few weeks. However, farmers in the study area use many traditional practices for storing pulses. Although farmers' ability to observe and interpret their surrounding environment has often been overlooked[5,6], they have long relied on this knowledge to improve farm production and minimize post-harvest losses. Over generations, farmers have developed many technologies through continuous observation and the trial-and-error process in the course of their struggle for sustainable livelihoods[7,8]. Such Indigenous Technical Knowledge (ITK) is eco-friendly, cost-effective, and particularly suitable for marginal and resource-poor farmers in Assam[7,9-13] and other North Eastern states of India[14-17].

Materials and Methods

The study was carried out in two districts of the North Bank Plain Zone of Assam during 2017 (Plate 1). First, a survey was conducted to document the indigenous storage practices of pulses adopted by the farmers of the study area. The survey was conducted in four villages of Lakhimpur district, *viz.*, Changini, Jamuguri, Kenduguri, and Chamua and three villages of Biswanath district, *viz.*, Kamdewal, Adabheti, and Gamiri. In these areas, both black gram and green gram were extensively grown for both grain and seed purposes. Information was also collected from the village markets, namely Badati-Jamuguri, Naraynpur, and Simoluguri in Lakhimpur district and Chengmora, Bedeti, and Biswanath Chariali in Biswanath district. During the survey, the traditional storage practices of pulses were recorded based on farmers' responses. Based on farmers' adoption rates and suggestions from subject matter specialists, four indigenous practices were selected for experimental evaluation regarding the storage of green gram, black gram, and pigeon pea.

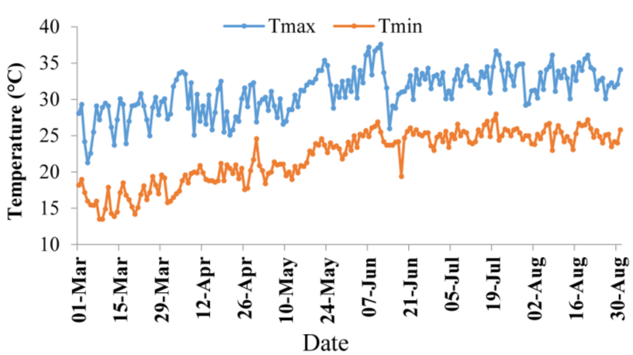

Fig. 1 — Variation of daily maximum (Tmax) and minimum (Tmin) air temperatures at Biswanath Chariali, Assam, from 1st March to 31st August 2017

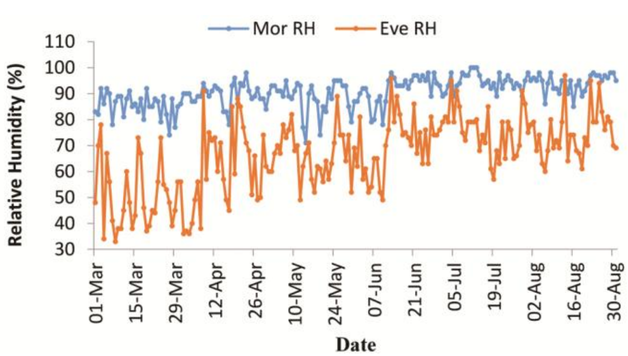

Fig. 2 — Variation of daily morning relative humidity (Mor RH) and evening (Eve RH) relative humidity at Biswanath Chariali, Assam, from 1st March to 31st August 2017

For this purpose, an experiment was conducted at Biswanath College of Agriculture, Biswanath Chariali, Assam, from March to August 2017 under ambient conditions inside a room. To characterise the prevailing weather conditions during the pulse storage period, daily maximum and minimum temperatures, along with morning and evening relative humidity, recorded from 1 March to 31 August 2017, were obtained from the Agro-meteorological observatory of Biswanath College of Agriculture, Biswanath Chariali. The variations of these meteorological parameters are presented in (Fig. 1 & Fig. 2).

Although the daily maximum temperature varied between 22°C and 37°C, it remained mostly within the range of 30°C to 35°C throughout the study period (Fig. 1). The daily minimum temperature ranged from 15°C to 28°C and remained mostly between 24°C and 26°C from June onward. Morning relative humidity remained consistently high (80 - 100%), while evening relative humidity increased from about 35 to 75% during March to April and from 60 to 97% during June to August (Fig. 2). Overall, the pulse storage period was characterised by persistently warm and humid, with relatively stable temperatures and high atmospheric humidity from June onwards.

The experiment was conducted using a Completely Randomised Design (CRD) consisting of five treatments, each replicated twice. As the study on the storage of pulses was conducted under indoor conditions with minimal environmental variation, two replications per treatment were considered adequate for the experiment. The treatments consisted of T_1: mixing two teaspoonful of black pepper (*Piper nigrum* L.) powder with 1 kg of grains; T_2: mixing four teaspoonful of wood-ash with 1 kg of grains; T_3:

covering the storage container with a cotton cloth soaked in kerosene, renewed at 10day intervals; T_4: combination of T_1, T_2 and T_3; and T_5: untreated control. One kilogram of clean, healthy seeds of each pulse crop was stored in an earthen pot, and each earthen pot represented one replication. The pots were kept under identical room-temperature conditions throughout the storage period.

At the end of the storage period, observations on rice moth population (number of live insects per kg of stored seed) as well as mechanical damage, grain weight loss and seed germination were recorded. Bruchid infestation was assessed by counting the infested grains following the standard procedure[17]. Based on the percentage of infested grains, infestation was classified as low (<25%), medium (25 - 50%), high (50 - 75%) and very high (>75%). Mechanical damage of grains caused by insect feeding was estimated by separating damaged grains from healthy ones and expressed as a percentage of total grains in a sample. The weight loss in the stored grains was determined by comparing the weight of the seed samples before and after storage and expressed as the percentage of weight loss. Seed viability was evaluated by doing germination tests of randomly selected fifty seeds from each replication and sowing them in the nursery tray. The germinated seedlings were counted after seven days of sowing and germination percentage was calculated.

The data generated for each crop were subjected to the analysis of variance (ANOVA) using the Statistical Package for Agricultural Research (SPAR)[18] and the treatment means were compared using the critical difference (CD) test at the 5% level of significance.

Results

Identification of traditional practices for storage of pulses

The traditional storage practices for pulses used by farmers in the study areas were identified during the survey conducted in selected villages and village-markets, as described below:

1. Matured black gram seeds are initially sun-dried for several hours over successive days, followed by shade drying to reduce the moisture content of the seeds. The dried seeds are stored in a gunny bag, and the mouth of the bag is tightly tied with a rope. The filled bag is now placed inside a larger gunny bag, which is tightly tied at the mouth. The bags are stored on cemented floors, bamboo platforms, wooden planks, or bricks to prevent direct contact with the ground. The bags are usually kept in a corner where family members often walk around, which prevents stored grains from rodents and other pests. During the monsoon season, the stored grains are periodically sun-dried at intervals of 7 to 10 days to avoid fungal growth on the grains.
2. Farmers generally store seeds of pulses mixed with wood-ash; additionally, a layer of wood-ash about 5 cm thick is spread over the stored grains.
3. Some farmers often store pulses by mixing in a few drops of kerosene with the grains before storage.
4. Some farmers cover the storage bags or containers with cotton cloth, which is periodically sprinkled with kerosene at intervals of 10 to 15 days for repelling insects.
5. Bleaching powder is dusted around the storage bags or containers.
6. Pulse grains are also stored after mixing them with black pepper powder
7. Leaves of Neem (*Azadirachta indica*), Posotia (*Vitex negundo*), and Bihlongini (*Polygonum* spp.) are placed over the stored grains as insect repellents.

Evaluation of traditional practices for storage of pulses

Infection of pulses with insects and mold during storage

Treatments formulated based on the farmers' practices were evaluated for storage of black gram, green gram and pigeon pea. The extent of infestation of pulses with bruchid and mold was assessed qualitatively (Table 1), while population of the rice

Table 1 — Infestation level of pulse grains by bruchids and mould during storage under different treatments

Treatments	Bruchids			Mould		
	Green gram	Black gram	Pigeon pea	Green gram	Black gram	Pigeon pea
T_1	L	M	H	M	A	A
T_2	L	L	H	L	A	A
T_3	M	H	VH	H	A	A
T_4	L	M	H	M	A	A
T5	M	H	VH	H	A	A

Infestation Levels: L= light, M= Moderate, H= High and VH= Very high, & A= Absent moth was recorded separately (Table 2) based on visual observations.

Bruchid infestation was observed in all three pulses across the treatments, whereas mould infestation was seen only in green gram (Table 1). Pigeon pea was highly susceptible to bruchid attack and showed high to very high infestation under all the treatments.

The bruchid attack in green gram and black gram was relatively low under certain treatments, indicating the effectiveness of some of the storage practices for these pulses. No mould infestation was observed in black gram and pigeon pea, indicating that prevailing storage condition was not favourable for fungal development in these pulses.

Analysis of results revealed that the storage treatments had a significant impact on the infestation of rice moth in both green gram and black gram; however, no infestation was observed in pigeon pea (Table 2). It was observed that infestation was comparatively higher in black gram (with a mean value of 25 insects kg^{-1}) than in green gram (with a mean value of 5 insects kg^{-1}). In green gram, no insect infestation was observed in T_1, T_2 and T_4, while T_5 recorded the highest insect infestation (16.5 insects kg^{-1}), followed by T_3 (10.5 insects kg^{-1}). In black gram, infestation was statistically at par and the lowest in T_1 (8.0 insects kg^{-1}) and T_4 (8.5 insects kg^{-1}), followed by T_2 (10 insects kg^{-1}); the highest infestation was recorded in T_5 (72.5 insects kg^{-1}). Overall, in can be concluded that rice moth infestation can be effectively controlled by T_1, T_2 and T_4, while in untreated control (T_5) and T_3 the insect cannot be controlled.

Physical damage of stored grains during storage

The physical damage caused by insect feeding on grains of three pulses during storage was assessed as the percentage of damaged grains across different treatments and is presented in Table 3.

The storage treatments significantly influenced the mechanical damage of the stored grains in all three pulse crops. Among the pulses, the most serious mechanical damage was observed in pigeon pea (with an average damage of 71.1 %), while the damage was substantially lower in green gram (48.9%) and black gram (40.1%). In green gram, the lowest mechanical damage was recorded in T_2 (24.6%), whereas the highest was observed in T_5 (76.8%). The second lowest mechanical damage was observed in T_1 (33.5%), followed by T_4 (38.5%) and T_3 (71.2%). A similar trend was observed in black gram, where the lowest damage was recorded in T_2 (17.5%), while the maximum damage was recorded in T_5 (60.6%) and T_3 (60.8%). Like the other two pulses, the lowest and the highest mechanical damage of grains of pigeon pea was observed in T_2 (54.1%) and T_5 (83.3%), respectively. Analysis of results revealed that the wood-ash treatment (T_2) was the most effective in minimising mechanical damage during storage, while the untreated grains suffered the maximum deterioration.

Weight loss of grains during storage

The weight loss of stored pulse grains was assessed by measuring the difference in grain weight before and after the storage period. Significant differences in grain weight loss were observed among the storage treatments (Table 4).

Table 2 — Population count of rice moth in stored grain of pulses under different storage treatments

Treatments	Rice moth (No of insects kg^{-1} stored grains)		
	Green Gram	Black gram	Pigeon pea
T_1	0.0	8.0	0
T_2	0.0	10.0	0
T_3	10.5	25.5	0
T_4	0.0	8.5	0
T5	16.5	72.5	0
SE (±)	1.96	6.48	-
CD (0.05)	5.04	16.66	-
CV (%)	51.28	36.64	-

Table 3 — Physical damage (%) of stored grains of pulses under different storage treatments

Treatments	Green gram	Black gram	Pigeon pea
T_1	33.5	29.4	57.7
T_2	24.6	17.5	54.1
T_3	71.2	60.8	97.0
T_4	38.5	32.2	58.7
T_5	76.8	60.6	83.3
Mean	48.8	40.1	71.1
SEm (±)	2.66	3.98	6.12
CD (0.05)	8.19	12.25	18.84
CV (%)	7.70	14.03	12.16

Table 4 — Weight loss of stored grains of pulses under different storage treatments

Treatments	Loss of weight of grains (%)		
	Green gram	Black gram	Pigeon pea
T_1	10.8	13.1	13.9
T_2	7.4	9.8	13.0
T_3	25.8	39.6	35.1
T_4	15.1	18.9	20.7
T_5	20.6	43.1	29.9
SEm (±)	1.29	3.22	2.12
CD (0.05)	3.98	9.93	6.53
CV (%)	12.76	16.85	14.89

Weight loss of stored grains of green gram, black gram and pigeon pea during storage varied significantly under different treatments. Irrespective of treatments, the highest average weight loss was recorded in the case of pigeon pea (22.5%), and the lowest average weight loss was observed in green gram (15.9%). In green gram, the lowest weight loss was recorded in T_2 (7.4%), followed by T_1 (10.8%) and T_4 (15.1%). On the other hand, the highest weight loss was recorded in T_3 (25.8%). In black gram, the lowest weight loss was recorded in T_2 (9.8%), while the highest was recorded in T_5 (43.1%). Like other pulses, weight loss in pigeon pea was lowest in T_2 (13.0%), followed by T_1 (13.9%), T_4 (20.7%), T_5 (29.9%), and T_3 (35.1%). No treatment difference was observed between T_1 and T_2 in the case of both black gram and pigeon pea. Thus, in all pulses, the lowest weight loss was recorded in the T_2 (wood-ash treatment), indicating its superior efficacy in protecting the grains during storage.

Germination of stored seeds of pulses

To assess the viability of the stored grains of green gram and black gram, fifty seeds were randomly selected from each replication of every treatment and were sown in the nursery trays outside room under uniform condition. The germination percentage of the seeds of pulses was calculated and is presented in Table 5.

The storage treatments significantly influenced the seed germination of both black gram and green gram. The highest germination of seeds was recorded in T_2 (72.0% in green gram and 78.0% in black gram), which was significantly superior treatment as compared to other treatments. In both the pulses, the germination was comparatively higher (>60%) in T_1 and T_4, while reduced significantly in T_3 and T_5, indicating a marked reduction in seed viability under these treatments. In pigeon pea, stored seeds were not found suitable for sowing due to severe deterioration of quality of seeds during storage. Therefore, no germination test was done in the case of pigeon pea.

Discussion

The results revealed that pigeon pea was more susceptible to bruchid infestation than green gram and black gram. This might be attributed to the larger seed size, thinner seed coat, and favourable nutritional composition of pigeon pea, which make it suitable for egg laying, larval development and adult emergence for bruchids[19]. Among the traditional storage practices, mixing wood-ash with grains (T_2) was the most effective for preserving grain quality during storage. The effectiveness of this treatment can be attributed to the fine ash particles forming a protective layer on the grain surface, which irritate the insects physically and restrict their movement and oviposition, thereby suppressing their population build-up during storage. Furthermore, mixing ash with grains might have increased insect mortality by removing the protective waxy layer from the insect cuticle and blocking the spiracles, leading to significant water loss from their bodies[20]. A decrease in insect population build-up might be the reason for the significant reduction in mechanical damage and grain weight loss under T_2 across all three pulses. Besides its insecticidal effects, wood-ash contributed to maintaining low grain moisture content through its hygroscopic properties, thereby creating an environment unfavourable for insect multiplication and fungal growth[21]. This also resulted in the lowest mechanical damage and weight loss of stored pulses under this treatment. The highest seed germination was recorded in wood ash-treated (T_2) black gram and green gram, likely due to the improved maintenance of seed viability due to reduced insect infestation, lower mechanical damage, and grain weight loss during storage. Similar to the wood-ash, black pepper powder also exhibited insecticidal properties,

Table 5 — Germination of stored seeds of green gram and black gram under different storage treatments

Treatment	No of seed sown	Green gram		Black gram	
		No of seed germinated	Germination (%)	No of seed germinated	Germination (%)
T_1	50	31	62	33	66
T_2	50	36	72	39	78
T_3	50	9.5	19	10.5	21
T_4	50	30.5	61	33.5	67
T_5	50	11	22	13.5	27
SEm (±)			1.63		1.83
CD (0.05)			3.63		4.08
CV (%)			6.00		6.27

resulting in higher mortality of pulse beetles, reduced grain damage and weight loss, and a higher percentage of seed germination in black gram[22] and green gram. This explains why the treatments involving black pepper powder, either alone (T_1) or in combination with wood-ash and kerosene (T_4), were more effective in maintaining the quality of stored pulses than the control (T_5). The present results are also supported by earlier studies, which reported that effective control of bruchid infestation during pulse storage minimized insect populations and seed deterioration, thereby preserving seed quality, vigour, and germination[23]. The use of wood-ash as a traditional storage material for pulse seeds has also been documented in Uttarakhand[24]. The use of charcoal and ash to maintain quality has been reported for vegetable seeds[25]. Various plant powders and oils were found to be effective against *Callosobruchus chinensis* in the storage of soybeans, demonstrating their potential as eco-friendly alternatives for storage of pulses[26].

Conclusions

The study showed that traditional storage practices differed in their ability to protect pulse grains from storage pests and maintain grain quality. Among the treatments, mixing grains with wood-ash (T_2) was the most effective, resulting in the lowest insect infestation, least grain damage and weight loss, and the highest seed germination in green gram and black gram. Mixing grains with black pepper powder (T_1) and the combined treatment (T_4) also reduced insect damage compared with the untreated control (T_5), which recorded the maximum grain deterioration and the lowest seed germination after storage. Pigeon pea was highly susceptible to bruchid infestation, while rice moth infestation was observed only in green gram and black gram. No mould infestation was recorded in black gram and pigeon pea during the storage period. Overall, the results confirmed that in a warm and humid climate like in the study area, the use of wood-ash is a simple, low-cost, eco-friendly, and effective method for storage of green gram and black gram. Promotion of such indigenous practices can help in effective storage, maintain seed quality, reduce dependence on synthetic pesticides and support sustainable pulse storage for small and marginal farmers.

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Author Contribution

All authors planned the work. SN, AD & KN collected, compiled & analysed data; AKS & PN assist in analysing data and prepared the draft MS. All authors finalize the MS.

Conflict of Interest

There is no conflict of interest among the authors.

Ethics Approval

Not applicable.

Prior Informed Consent

Prior informed consent was taken from all knowledge holders.

Use of artificial intelligence (AI)

Use of artificial intelligence (AI): No AI was used for preparing the MS.

Data Availability

All the data generated during the study have been included in this article.

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