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Research Article

Sealing the Future: Farmers' Perception on Hermetic Technology for Paddy Seed Preservation in Mymensingh District, Bangladesh

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ABSTRACT

In Bangladesh, most farm households store paddy for consumption, emergencies, and seed', but they rely on traditional methods that are vulnerable to insects, rodents, and mold. The study examined farmers' perceptions of hermetic bags for paddy seed storage, their correlations with attributes, and the problems they faced in using hermetic bags. The research was conducted in the Phulpur upazila of Mymensingh district. From a population of 100 hermetic bag users, 80 paddy farmers were selected through simple random sampling following Slovin's formula. Primary data were collected through face-to-face interviews using a structured interview schedule during January–February 2022. Farmers' perception was measured using a 10-item, five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Descriptive statistics and Karl Pearson's Product Moment Correlation were employed for data analysis. Results indicated that 70% of the respondents exhibited a favorable perception toward hermetic bags as an effective method for storing paddy seeds. Significant positive correlations were observed between perception and age, education, farm size, training exposure, and extension media contact. Regarding problems, 83.33% of the farmers experienced a moderate level of problems in using hermetic bags, suggesting the presence of practical and knowledge-related limitations despite overall positive attitudes. Since most farmers showed a favorable perception of hermetic bags despite facing moderate problems, extension agencies should emphasize farmer training, technical support, and awareness programs to enhance effective adoption and reduce practical limitations in paddy seed storage.

Introduction

Global food security depends on seed storage, which keeps seeds alive until the next planting season (Reed et al., 2022). Post-harvest losses account for 20–30% of global grain production, mostly due to insect infestation, mold growth, and moisture-related deterioration (FAO, 2021). Tropical regions are especially difficult since humidity worsens seed destruction (Sharma et al., 2023a). Sacks, timber bins, and earthen pots rarely provide enough seed protection (Patel, 2024). These issues are addressed by hermetic storage technology. Multi-layered plastic hermetic bags restrict oxygen levels, preventing insect and fungus activity (Kavitha et al., 2025). Research in Africa and Latin America shows that hermetic bags can preserve grain quality for a year without chemicals (Baributsa & Concepcion Ignacio, 2020).

Rice, Bangladesh's staple grain, occupies 75% of cultivated land and drives its agrarian economy (Jamal et al. 2023). Seed quality affects production, but storage deterioration limits it. Moisture, bugs, and fungi destroy 10–25% of stored paddy seed annually (Sharma et al., 2023b). Bangladeshi farmers use jute bags, tin containers, or clay pots, although these technologies rarely sustain germination capacity for seasons (Das et al. 2025). Bangladesh Rice Research Institute (BRRI) and Bangladesh Agricultural Research Institute (BARI) recognize the importance of post-harvest management and deploy hermetic storage technologies like SuperGrainbags™ and Purdue Improved Crop Storage-PICS bags. Research shows that hermetic storage reduces losses and keeps germination quality longer than normal approaches (Odjo et al., 2022). A lack of awareness, high initial expenses, and limited access in rural markets limit adoption. The National Agricultural Policy stressed minimizing post-harvest losses, however hermetic technologies are still underutilized (Ahmed et al., 2025).

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Figure 1. GrainPro Bag & PICS Bag (Hossain et al. 2023)

Mymensingh is a significant rice-producing region in Bangladesh, characterized by the prevalence of both Aman and Boro crops (Al Mamun et al., 2024). Farmers mostly use self-saved seed for subsequent seasons; thus, appropriate storage is essential (Nguyen et al., 2025). The humid temperature and heavy rainfall increase mold and insect infestation, reducing seed germination before sowing (Chaudhary et al., 2025). Many farmers must buy seeds at high prices, which hurts their profitability and productivity. Extension and development projects have introduced hermetic bags to the district, but uptake is low (Nakoma Ngoma et al., 2025a). Farmer skepticism about hermetic bags stems from their high cost and lack of demonstrations and peer use. Given local realities, understanding farmers' hermetic storage attitudes and hurdles to its widespread use in Mymensingh is crucial.

Existing research in Bangladesh predominantly emphasizes laboratory trials or controlled experiments that compare hermetic and traditional storage methods (Islam et al., 2024). Although Bangladesh is a major rice-producing country, there is a lack of real-world research focusing on farmers' perspectives, socio-economic impacts, and the practical challenges associated with rice production practices. Hermetic storage methods must be implemented sustainably by studying farmers' perceptions. This research will inform tailored extension methods, policy interventions, and awareness campaigns for Mymensingh farmers and their communities. The study examined farmers' perceptions of hermetic bags for paddy seed storage, their correlations to attributes, and the major problems associated with using hermetic technology in paddy seed preservation.

Methodology

Study site, population, sampleing & instrument of data collection

The study was conducted in Nagua village, Phulpur sub-district, Mymensingh. Mymensingh district is chosen for this study since it is Bangladesh's leading paddy growing region (Al Mamun et al., 2024). Due to the large number of rice farmers, the region represents post-harvest challenges countrywide. High humidity causes storage losses; thus, hermetic bags are essential. The Bangladesh Agricultural University (BAU), a leading agricultural innovation and extension institution, is in Mymensingh, suggesting farmers in this region may have varied exposure to new technologies (Rahman et al. 2025). A map of Mymensingh District showing the study area is presented in Figure 2.

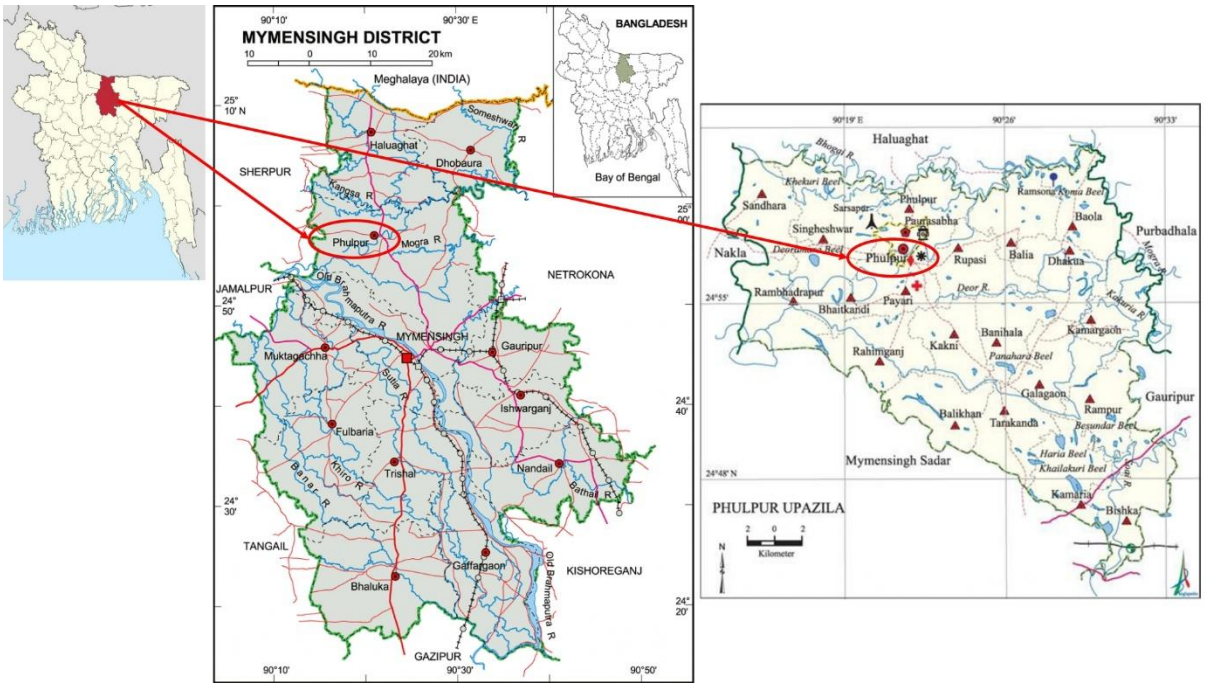

Figure 2. Map of Mymensingh District and Phulpur Sub-district showing the study site

Among 20 unions of Phulpur sub-district, Nagua village of Phulpur union was purposively scrutinized as there were larger numbers of hermetic bag users for paddy seed storage. The Bangladesh coordination office of the Post-Harvest Loss Reduction Innovation Lab (PHLIL) project, the Department of Farm Power and Machinery, BAU, distributed 100 hermetic bags to interested farmers in 2017. The farmers using hermetic bags in Phulpur Union constituted the population of this study. These 100 hermetic bag users were the population of the study. The list of all farmers was randomly collected from the PHILIL project office of BAU. From this group, 80 farmers were randomly selected as the sample for the study, utilizing Slovin's formula (Solvin, 1960), throughout January and February 2022 via a structured interview schedule.

$$n=\frac{N}{1+Ne^2}$$

Here,

N represent the population size, which is 100.
e represents the error tolerance, which is 0.05 or 5%.
n represents the sample size.

So,

$$n=\frac{10O}{1+10\times(0.05)^2}=80$$

n = 80

Selection and measurement of variables

"Farmers' perception on hermetic technology for paddy seed preservation" was the focus variable of the study. A 5-point Likert scale was used to measure the focus variable. Ten (10) statements were given to the farmers about different aspects of hermetic bag. he positive and negative statements were arranged consecutively. Responding to a statement was possible in five ways: "strongly disagree," "disagree," "no opinion," "agree," and "strongly agree" with a scores of 1, 2, 3, 4, and 5 respectively and scoring was reversed for the negative statements (Rahman et al. 2025a; Podder et al. 2022). Scores for each statement could range from 10 to 50. Based on the score, farmers' attitudes were divided into five (05) different categories: strongly unfavorable (10-20), unfavorable (21-29), no opinion (30), favorable (31-40) and strongly favorable (above 40). The total score of an individual farmer could range from 80 to 400.

Total Score= (N_1×5) + (N_2×4) + (N_3×3) + (N_4×2) + (N_5×1)
Here, N_1= Number of farmers who opined as "strongly agree"; N_2= Number of farmers who opined as "agree"; N_3= Number of farmers who opined as "no opinion"; N_4= Number of farmers who opined as "disagree"; and N_5= Number of farmers who opined as "strongly disagree"

According to the existing literature, eight (08) socio-demographic characteristics of farmers were identified as the explanatory variables in this study.

Problems faced by the farmers in using hermetic bag in paddy seed preservation was measured using a 4-point rating scale (Hira et al., 2025). Farmers were asked about seven (07) hermetic technology issues and given weights ranging from 0 (no problems) to 3 (high problems). The Problem Facing Index (PFI) was calculated to establish the rank order. The computation of the PFI was carried out using the subsequent formula.

$PFI = P_h \times 3 + P_m \times 2 + P_l \times 1 + P_n \times 0$

Where, PFI = Problem Facing Index, P_h = Percent of respondents with high problem; P_m = Percent of respondents with moderate problem, P_l = Percent of respondents with low problem, P_n = Percent of respondents with no problem

Data analysis

The data were analyzed utilizing the Statistical Package for Social Sciences (SPSS) version 25 and Microsoft Excel version 13. Descriptive statistics, including percentage, frequency, standard deviation, mean, and rank order, along with inferential statistics, such as correlation, were calculated to summarize the findings. Solaiman Saad et al. (2026) state that descriptive statistics summarize the characteristics and key performance indicators of research participants. The Pearson Product Moment Correlation coefficient (r) (Pearson, 1920) was employed to evaluate the relationship between socio-economic factors and farmer perception on hermetic technology.

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Here,

r_{xy} =The value of the Pearson correlation between the two variables x and y,

x_i = Experiment x-values,

$\bar{x}$ = Mean of x-variable values,

y_i = Experiment y-value, - $\bar{y}$ = Mean of y-variable values

Findings and Discussion

Salient features of the farmers

Table 1 presents the profile of farmers' characteristics. A significant portion of the respondents, specifically 78.75%, were identified as middle-aged farmers within the total sample. Young individuals demonstrate a greater openness and readiness to embrace new concepts and gain knowledge (Hasan et al. 2025a). Conversely, 38.75% of farmers lacked formal education, while 30% had attained a primary level of schooling, and 27.5% possessed a secondary degree of education. Education is essential in influencing attitudes and facilitating the utilization of hermetic bags as a solution for paddy storage (Hasan et al. 2025b). It allows individuals to broaden their perspective and expand their information base.

Table 1. Salient features of the farmers (n=80)

Characteristics (Measuring units)	Category	Respondent Percent	Mean	SD
Age (Year)	Young (18-35)	37.5	38	13.49
	Middle-aged (36-55)	41.25		
	Old (above 55)	21.25		
Education (Year of schooling)	Illiterate & can sign only (0-0.5)	38.75	4.09	3.84
	Primary (1-5)	30		
	Secondary (6-10)	27.5		
	Above secondary (>10)	3.75		
Family size (No. of members)	Small (up to 4)	42.5	5.98	1.49
	Medium (5-7)	47.5		
	Large (above 7)	10		
Farm size (Hectare)	Small (up to 0.99 ha)	77.5	0.89	0.55
	Medium (1-3 ha)	21.25		
	Large (>3 ha)	1.25		
Family income ('000' BDT)	Low (up to 150)	17.5	210.97	85.56
	Medium (150.1-300)	57.5		
	High (above 300)	25		
Training exposure (Days)	Short-term (up to 4)	93.75	3.15	1.12
	Mid-term (5-8)	6.25		
	Long-term (above 8)	0		
Extension media contact (Score)	Low (up to 11)	15	19.30	3.22
	Medium (12-22)	65		
	High (>22)	20		
Knowledge on hermetic bag (Score)	Poor (up to 8)	22.5	16.45	1.90
	Moderate (9-18)	65		
	Fair (above 18)	12.5		

Note, SD= standard deviation

A significant portion of the respondents, specifically 47.5%, represented medium-sized households within the total sample. The study region reported an average household size of 5.98, surpassing the national average family size of 4.26 (BBS, 2023). A significant portion of the respondents, specifically 77.5%, operated small-sized farm areas. The average farm size measured at 0.89 hectares, accompanied by a standard deviation of 0.55, suggests that the mean farm size is higher than the national average of 0.60 hectares as reported by BBS in 2023.

Approximately 57.5% of participants are classified within the middle-income category. The farmers in the study demonstrated an average annual income of BDT 210.97 thousand (approximately 1760 USD), which is lower than the average household income of BDT 0.3 million (around 2573 USD) (HIES, 2022). A significant majority of paddy farmers (93.75%) has less training experience. Insufficient training results in a deficiency of information regarding innovative methods, technology, and optimal resource utilization, hence obstructing individuals' agricultural endeavors (Hasan et al. 2025c). A majority of respondents (65%) reported medium extension media contact. The number of extension personnel in rural areas was insufficient (Mansour et al. 2022). Consequently, farmers lost access to numerous facilities. Utilizing diverse extension media increases farmers' opportunities to acquire knowledge regarding agricultural activities and enhanced sustainable practices. Moreover, 65% of respondents demonstrated a moderate level of knowledge regarding hermetic bag technology (Prajapati et al. 2025). The lack of formal education, restricted access to resources, and inadequate exposure to training on hermetic bag technology may account for this phenomenon.

Farmers' perception on hermetic bag as a paddy storage technology

The observed range of perception scores among paddy farmers were 29 to 42 out of a possible score from 10 to 50. The mean score was 35.32 with a standard deviation of 2.93. Farmers' perceptions were categorized into five distinct groups according to Rahman et al. (2025b). They were: strongly unfavorable (10 to 20), unfavorable (21-29), no opinion (30), favorable (31-40), and strongly favorable (above 40), as illustrated in Figure 3.

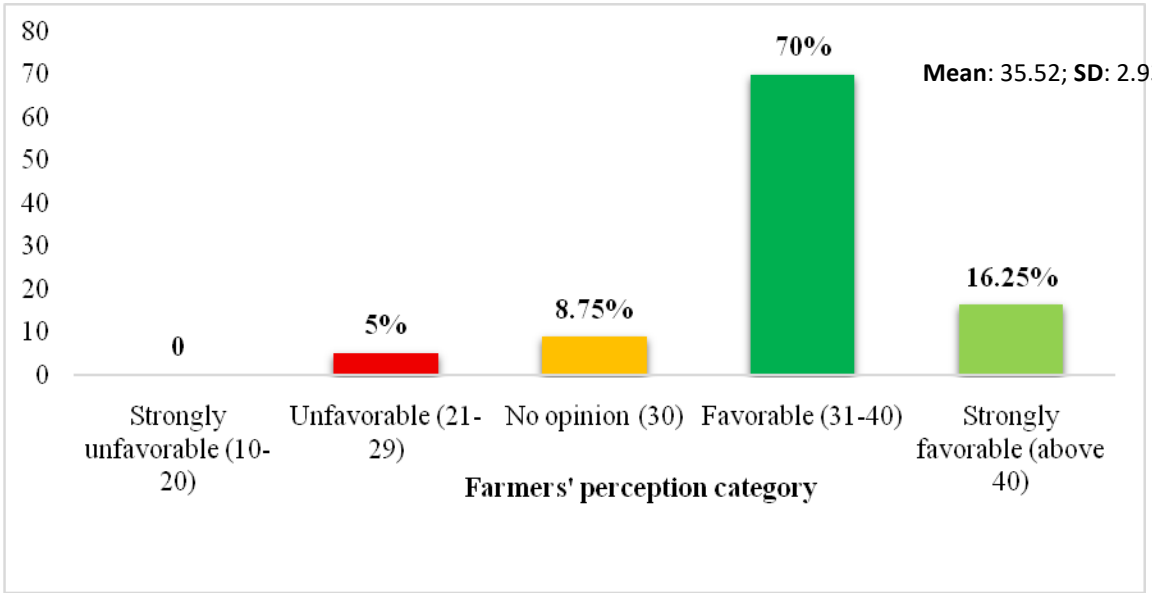

Figure 3. Distribution of farmers based on their perception on hermetic bag as a paddy storage technology

Based on the data shown in Figure 3, the predominant majority (70.0%) of paddy farmers had favorable perception on hermetic bag as a paddy storage technology followed by 16.25% had strongly favorable, 8.75% had neutral opinion and 5.0% had unfavorable perception on hermetic bag as a paddy storage technology. None of the respondent were found with strongly unfavorable perception. This is due to its proven efficacy and tangible economic benefits. After seeing how well the method reduced insect infestation and mold growth without chemicals, farmers undoubtedly liked it. This preserved seed viability and quality for the next season. Rabé et al. (2021) found that Nigerian farmers were satisfied and adopted Purdue Improved Crop Storage Technology for Grain Storage in the South-Central Regions. Table 2 displays the total scores obtained for each statement, providing

insight into the respondents' perception and their extent.

Table 2. Farmers' perception on statement specific issues of using hermetic bag

Perception statements	Number of farmers					Total score	Rank order
	SA	A	NO	D	SD		
Hermetic bag helps to retain the original quality and color of seeds	63	17	0	0	0	383	1
The rate of insect infestation is reduced by using hermetic bag	49	31	0	0	0	369	2
In hermetic bag, there is no need to use of chemicals during seed storage time	43	37	0	0	0	363	3
Seed germination percentage is higher when stored with hermetic bags	36	44	0	0	0	356	4
Hermetic bag can be re-used like other seed storage bags	35	40	1	0	4	342	5
Hermetic bag helps in reducing post-harvest loss of seed	33	36	11	0	0	342	5
Humidity and temperature can properly maintain by using hermetic bag	32	25	23	0	0	329	6
Packaging and maintenance of hermetic bag is easier than other storage system	23	7	28	6	16	255	7
Hermetic bag is easily available in local market	20	0	2	38	20	202	8
Hermetic bags are more cost-effective than other seed storage technologies	20	2	2	15	41	185	9

Note: SA= Strongly Agree, A= Agree, NO= No Opinion, D= Disagree, SD= Strongly Disagree

"Hermetic bag helps to retain the original quality and color of seeds" led with 383 out of 400 total score. This high ranking shows that farmers value seed viability and visual integrity, which indicate good health and strong germination potential. By denying pests and molds oxygen, the hermetic bag prevents them from damaging the seed's endosperm and embryo. This preserves physiological quality, preventing fungal or insect excrement-caused discoloration, which farmers know indicates low quality. Baoua et al. (2014a) found that hermetic storage prevented insect damage and conserved cowpea's visual and organoleptic attributes, supporting farmers' opinions.

"The rate of insect infestation is reduced by using hermetic bag" scored 369 out of 400, the second highest. This addresses the most apparent and economically devastating issue farmers confront in traditional paddy storage. Farmers value a non-chemical, effective solution to pests like the rice weevil (*Sitophilus oryzae*), which cause huge losses (de Sousa et al. 2023). Farmers may see the lack of living insects and damaged grains when they open the hermetic bag because it suffocates insects by depleting oxygen. This empirical information supports their principal pest control necessity. De Groote et al. (2013) in Kenya found that hermetic bags consistently suppressed insect proliferation in stored maize, resulting in drastically lower infestation rates than conventional storage methods.

In hermetic bag, there is no need to use of chemicals during seed storage time" scored 363 out of 400, third highest. It addresses major health, economic, and environmental issues about conventional chemical fumigants. The hermetic bag's ability to shield farmers from the health dangers of handling and inhaling harmful pesticides like aluminum phosphide is appreciated. Cost-conscious farmers appreciate this feature since it eliminates the need to buy chemicals. Global research shows that PICS bags are valued for their chemical-free nature. Baoua et al. (2014b) found that hermetic cowpea storage substituted insecticide use, protecting farming families and the environment.

Correlation analysis between farmers' perception on hermetic bag as a paddy storage technology and their selected characteristics

Karl Pearson's Product Moment correlation coefficient (r) was utilized to assess the relationships between the chosen characteristics and their perception. The correlation analysis is summarized in Table 3. Among the eight selected characteristics of the farmers, five—age, education, farm size, training experience, and extension media contact—demonstrated a positive significant relationship with their perception of hermetic bags as a paddy seed storage technology.

Age was positively correlated with hermetic technology perception (r = 0.365), suggesting older farmers liked it more. Due to their significant farming expertise, they certainly recognize the severe post-harvest losses imposed by standard storage practices. Kansanga et al. (2025) discovered that elderly farmers were more inclined to adopt new storage technology because they understood storage losses better. Education correlated positively with perception (r=0.296), indicating that more educated farmers understood and appreciated the hermetic bag's benefits. Formal education improves farmers' cognitive abilities to obtain, understand, and evaluate technical information (Zhang et al. 2024). Farm size (r=0.422) showed the largest positive link with perception, showing that farmers with large farm size liked the technology. This association is mostly economic; larger farms have more seed and grain to safeguard, making post-harvest losses more costly. Manda et al. (2020) also discovered that farm size was a key influence in hermetic storage adoption.

Table 3. Relationship between the characteristics of farmers and their perception

Focus Variables	Characteristics	Value of 'r' with 78 df
Farmers' perception of hermetic bag as a paddy seed storage technology	Age	0.365**
	Education	0.296*
	Household size	0.121
	Farm size	0.422**
	Annual income	0.178
	Training experience	0.358**
	Extension media contact	0.401**
	Knowledge on hermetic bag	0.083

Here, * Correlation is significant at the 0.05 level of probability, ** Correlation is significant at the 0.01 level of probability

Farmers' perceptions are strongly influenced by training they received (r=0.358). Hermetic storage demonstrations and workshops gave farmers actual knowledge and proof of its usefulness. This experience eliminated uncertainties, raised confidence, and explained proper usage, proving the technology's benefits. Danso-Abbeam et al. (2018) noted that tailored training programs improve farmers' knowledge and adoption of agricultural technologies. The positive association between extension media contact (r=0.401) and perception emphasize the relevance of extension personnel, television, and mobile phones especially social media for information transmission. Media coverage of hermetic technology reinforces the message, boosts awareness, and keeps farmers' attention on the invention. Anang et al. (2020) observed that access to extension services and media directly boosted awareness and formed positive attitudes of better agricultural technologies, influencing adoption.

Problems faced by the farmers in using hermetic bag

There were seven (07) problem statement about hermetic beg. The problem scores related to using hermetic bag ranged from 8 to 16 against the possible range of 0 to 21 with the mean value of 12.93 and standard deviation of 1.62. Based on the problem scores the farmers were classified into three categories i.e. low, medium and high problem. Figure 4 illustrates the distribution of farmers based on their problem scores.

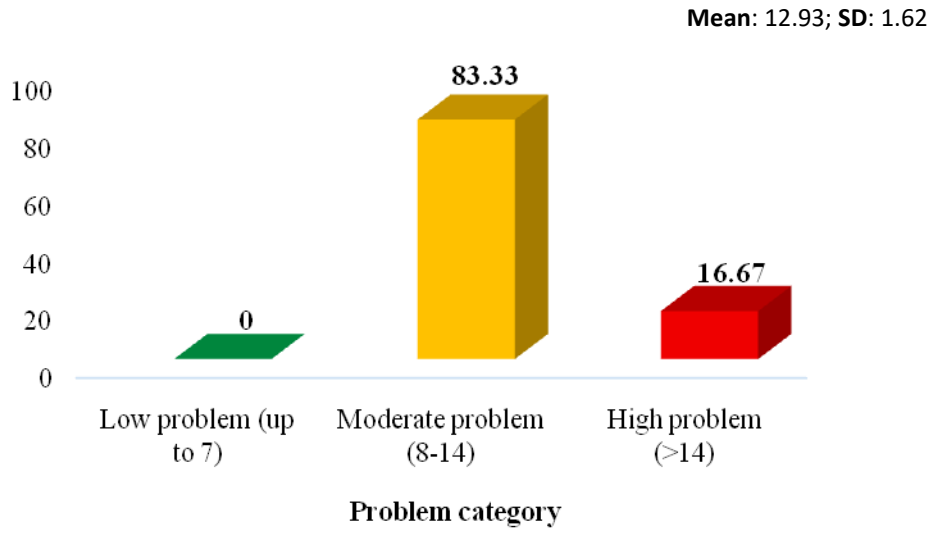

Figure 4. Distribution of farmers based on problems in using hermetic bag

Figure 4 indicates that a significant portion of farmers, specifically 83.33%, encountered moderate problems, whereas 16.67% experienced high constraints. None of the respondents had faced low problems. Farmers in Phulpur sub-district often lacked adequate technical knowledge, training, and hands-on experience with hermetic storage, which resulted in common but manageable difficulties such as improper sealing, occasional bag damage, limited access, or higher purchase cost. Previous studies reported that farmers faced moderate constraints in using hermetic/PICS bags, including limited availability, high purchase cost, inadequate technical knowledge, and poor market access (Nakoma Ngoma et al. 2025b).

To assess the degree of problem associated with specific issues, a rank order was established by

calculating the mean score for each issue outlined in Table 4.

Table 4. The rank order of the problems faced by the farmers in using hermetic bag

Problem statements	No of response				PFI	Rank
	H	M	L	NP		
Leakage by mice or ant	77	3	0	0	237	1
High cost of hermetic bag	75	5	0	0	235	2
Unavailability of hermetic bag in market	68	11	1	0	227	3
Low awareness of rural farmers	14	37	25	4	141	4
Lack of training facilities	13	20	30	17	109	5
Lack of operational knowledge of using hermetic bag	1	32	34	13	101	6
Infestation of insects and pest	0	10	16	54	36	7

Here, H=High, M=Medium, L=Low, N=Not at all

Table 4 demonstrated that "Leakage by mice or ant" got the highest PFI score of 237 out of total score of 240. That's why it was ranked 1st. This is because rodent and insect attacks significantly damage the bags, reducing their airtight condition and ultimately affecting the effectiveness of seed or grain storage. These pests not only consume significant quantities of seeds but also contaminate the remaining stock, leading to substantial post-harvest losses that directly impact farmers' economic security and future planting capacity. This finding is consistent with research by Islam et al. (2019), who similarly identified rodents and insects as the primary agents of loss in conventional storage systems.

"High cost of hermetic bag" got the second highest PFI score of 235. The high upfront investment deters small-scale farmers with limited capital, making this the second-ranked problem. While the bags reduce seed losses over time, their initial cost is much higher (around 200 BDT equivalent to 1.62 USD) than jute sacks (around 40 to 80 BDT equivalent to 0.32 to 0.65 USD) or earthen pots (less than 0.5 USD), making them unaffordable for many. A similar finding was reported in a study by Mutungi et al. (2019) on the adoption of hermetic storage bags in Kenya, which also identified the high initial cost as a primary constraint for smallholder farmers.

"Unavailability of hermetic bag in market" got the third highest PFI score of 227. This is because farmers cannot use the technology even when they are confident in its benefits and willing to pay for it if a reliable local supply chain is not available. The fact that these specialized bags aren't sold in nearby rural markets or agro-shops is a big problem because it forces farmers to go to faraway cities, which takes longer and costs more. This market infrastructure gap hinders technology scalability and implementation. A similar finding was reported by Adetunji & Ojo, (2020) in their research on hermetic storage adoption in Nigeria, which also identified poor market availability and distribution networks as a critical constraint for smallholder farmers.

Conclusions

The majority of farmers in Mymensingh exhibited a favorable perception of hermetic bag technology due to its proven effectiveness in practice. Farmers directly observed its key benefits: superior preservation of seed quality and color, drastic reduction in insect infestation without relying on chemical pesticides, and overall economic advantages from reduced post-harvest losses. Age, education, farm size, training experience and extension media contact were noticed as the significant influential variables in Karl Pearson's Product Moment Correlation test. The largest share of the farmers faced moderate level of problem in using hermetic bag as a paddy storage technology. Leakage by mice or ant, high cost of hermetic bag, and unavailability of hermetic bag in market were identified as the major problems that farmers faced.

Given the favorable reception of hermetic bag technology among paddy farmers, it is advisable for government agencies, NGOs, and agricultural extension services to focus on and enhance its distribution in Mymensingh and comparable agro-ecological regions. Promotion strategies must be tailored to effectively engage farmers across various age groups and educational levels, emphasizing the importance of hands-on training and utilizing mass media to showcase the economic and protective advantages of the technology. It is essential to advance policies aimed at enhancing affordability and accessibility, which will promote broader adoption and strengthen paddy seed security in the region, ultimately alleviating existing challenges.

Author's Contribution

H.O.R.: Data collection, initial draft preparation, Identification of research problem, formal data analysis; M.A.R.: Methodology development, formal data analysis, initial draft preparation, review and preparation of final version; H.R.: Supervision of the research, conceptualization, review of manuscript.; M.N.U.: Supervision of the research, reviewing of draft, methodology development.

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