Indian Journal of Ecology (2025) 52(6) (SI): 1860-1863
DOI: https://doi.org/10.55362/IJE/2025/4745

Manuscript Number: 4745
NAAS Rating: 5.38

Evaluation of Hermetic Bags for Storage of Sesame seed against *Tribolium castaneum* (Herbst)

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***Abstract*:** Sesame (*Sesamum indicum* L.), commonly referred as the "queen of oil seeds," is valued for its nutritional richness and widely cultivated. Traditional storage in polypropylene and jute bags predisposes sesame seeds to insect infestation particularly by the red flour beetle, *Tribolium castaneum (*Herbst) and often necessitates chemical treatments that pose environmental risks. The present study conducted during 2022-23 and 2023-24, evaluated Purdue Improved Crop Storage (PICS) bags, Super GrainPro bags (SGP) for maintaining seed quality over 90 days in comparison with polypropylene bags, jute bags and jute bags treated with deltamethrin 2.8 EC @ 2ml/L. Results revealed that PICS bag, jute bags treated with deltamethrin and SGP bag recorded the lowest *T. castaneum* populations (3.9, 4.3and 4.4 per 100 grams of seed) compared with polypropylene bag (29.0) and jute bags (32.0) after 90 days of storage. Grain damage was significantly less in PICS (4.1%), deltamethrin treated jute bags (4.38%) and SGP bags (4.52%) than in polypropylene (19.2%) and jute bags (20.3%). Consequently, higher thousand seed weight was recorded in PICS bags (3.08 g) followed by insecticide treated jute bags (3.07g) and SGP bags (3.06 g) in comparison to polypropylene bags(2.41 g) and jute bags (2.38 g). Similarly, seed germination remained highest in PICS bags (88.0%), insecticide treated jute bags (87.0%) and in SGP bags (86.0%) compared to polypropylene bags and jute bags (61% each). The findings confirm that PICS bags and SGP bags effectively maintain pest free conditions and preserve seed quality without reliance on synthetic chemicals. Being eco-friendly and sustainable, hermetic storage solutions need to be promoted among sesame growers for safe and long-term seed storage.

Keywords: Sesame, Postharvest quality, *Tribolium*, Hermetic bags

Sesame (*Sesamum indicum* L.), commonly referred as the "queen of oil seeds", is an ancient oilseed crop belonging to the family Pedaliaceae, with high nutritional and economic value. Sesame seeds are rich in folic acid, oil, protein, unsaturated fatty acids, vitamins, and minerals, making them an important raw material for oil and meal production as well as food, confectionery, and beverage industries. (Kapoor et al., 2014). Globally, sesame ranks eighth among oilseed crops, cultivated in 14.8 million hectares with a production of 6.8 million tons, valued at 3.4 trillion dollars. Consumption is projected to reach 7244.9 million dollars by 2026 (Anonymous 2022). India holds the largest share in sesame area (45%), production (36%) and export (45%) with 1.95 million hectares under cultivation and 0.81 million tonnes of production in 2022–23, recording a productivity of 4.15 q/ha (Anonymous 2023).

Like other oilseeds, sesame is prone to storage pests due to its high protein and fat content. Major insect pests reported in India include sesame seed bug (*Elasmolomus sordidus* Fabricius), red flour beetle (*Tribolium castaneum Herbst*) and rice moth (*Corcyra cephalonica Stainton)* (Rajendran and Devi 2004). *Tribolium castaneum* is particularly destructive, feeding on broken grains, germ portion and milled products causing quality deterioration, foul odor and reduced dough quality. Being a cosmopolitan and polyphagous pest, it significantly reduces seed weight, germination and quality while raising storage temperature and moisture content of the grains (Faroni and Sousa 2006). Management of storage pests traditionally relies on synthetic chemicals, which, apart from posing environmental and health hazards, also threaten export potential due to pesticide residues. Post-harvest losses are substantial, with over 25% of seeds in warehouses deteriorating annually due to insect damage and biochemical degradation (Kumar and Kalita 2017). Although indigenous eco-friendly storage structures exist (Swamy and Wesley 2020), their durability and effectiveness are limited. In this context, hermetic storage technologies have emerged as a sustainable alternative, offering protection against pests without chemical inputs. Hence, the present study was undertaken to assess the performance of different types of storage bags including traditional (polypropylene, jute) and hermetic bags (PICS and Super GrainPro) for storing sesame seed against red flour beetle infestation.

MATERIAL AND METHODS

The experiment was conducted at Agricultural Research Station, Yellamanchili, Andhra Pradesh during 2022–23 and 2023–24 to evaluate different storage bags for storage of field harvested sesame seed over a 90-day period. The experiment was formulated adopting completely randomized block design with five treatments, replicated four times. The five treatments included, Purdue Improved Crop Storage (PICS) bags, Super GrainPro bags (SGP) in comparison to polypropylene (PP) bags, jute bags and jute bags treated with deltamethrin 2.8EC @ 2ml/l (chemical check). The hermetic bags (PICS and SGP) were obtained online from India Mart and the polypropylene (PP) and jute storage bags were procured from local market. The PICS bags contain three layers, while the SGP bags had a single layer of 78 µm polyethylene film.

Sesame seed produced during *Rabi* 2022 and 2023 under recommended practices was homogenized, divided into 40 kg lots and were attributed to every four storage bags; PICS bags, SGP bags, PP bags, and jute bags. PICS and SGP bags act as hermetic storage technologies, while PP and jute bags represent traditional storage materials used by small farmers. The jute bag treated with deltamethrin 2.8 EC @ 2ml/l served as chemical check. Each treatment of the storage bag was filled with 10 kg of sesame seeds, sealed using the twist-tie method after expelling excess air and stored under ambient room conditions. The natural build-up of red flour beetle in the field harvested sesame seed was monitored at 30-day intervals by sampling 100 g seed sample. After 90 days, the bio-physical parameters *viz.* per cent grain damage, seed index (thousand seed weight) and per cent germination were recorded after opening the bags. For seed index, 1000 seeds per replication were weighed. Percentage of seed damage was estimated (Boxall 1998):Germination was tested using the blotter method with 100 seeds per replication placed in filter-paper lined 100 mm petri plates. The plates were incubated at 25°C in a germination chamber with fluorescent lights that cycled on and off for 12 h (Alemayehu et al., 2020). Plates were moistened daily with distilled water and germination percentage was recorded after one week.

Statistical analysis: The data collected regarding various parameters were analysed using AGRES software. The critical differences (CD) were tested at 5 per cent probability level and the percentage values were arc-sin and square root transformed wherever necessary.

RESULTS AND DISCUSSION

The results obtained from the evaluation of different storage bags for sesame revealed significant variation in their effectiveness against red flour beetle (Table 1). The PICS bags, SGP bags, and jute bags treated with deltamethrin 2.8 EC effectively suppressed insect infestation compared to untreated controls. At 90 days after storage (DAS), insect population was lowest in PICS bags (3.9 adults/100 g), followed by insecticide treated jute bags (4.3 adults/100 g) and SGP bags (4.4 adults/100 g) corresponding to 87.8%, 86.56% and 86.25% reduction over the untreated jute control, respectively. In contrast, the traditional packaging materials (polypropylene and untreated jute bags) harbored significantly higher insect populations, reaching 29.0 and 32.0 adults/100 g at 90 DAS, respectively. Accordingly, their protection efficacy was very low, with polypropylene bags achieving only 9.37% reduction, while untreated jute bags with maximum infestation.

Seed quality parameters were also strongly influenced by storage bag. Germination percentage was highest in in PICS bags (90.0%) followed by insecticide treated jute bags (87.0%) and SGP bags (86.0%). In contrast, polypropylene and untreated jute bags recorded significantly reduced germination (61.0%). Similarly, 1000-seed weight was highest in PICS bags (3.20 g), while untreated jute bags recorded the lowest (2.38 g). Seed damage followed a similar trend, with PICS (4.12%), SGP (4.38%) and treated jute bags (4.52%) performing far better compared to polypropylene (19.17%) and untreated jute bags (20.30%), where heavy infestation occurred. Similarly, Germination percentage was highest in PICS bags (90.0%) followed by insecticide treated jute bags (87.0%) and SGP bags (86.0%). In contrast, polypropylene and untreated jute bags recorded significantly reduced germination (61.0%).

The study demonstrated the superiority of hermetic storage bags (PICS and SGP) and insecticide-treated jute

Table 1. Effect of storage methods on red flour beetle infestation and seed quality in sesame

Treatment	No. of adults /100 g*			Reduction over control (%)	1000-seed weight (g)	Seed damage (%)$	Germination (%)$
	30 DAS	60 DAS	90 DAS				
Purdue Improved crop storage bags	0.0 (1.0)	2.3 (1.8)	3.9 (2.0)	87.80	3.20	4.12 (11.86)	90.0 (69.13)
Super grain pro bags	0.0 (1.0)	2.5 (1.9)	4.4 (2.2)	86.25	3.07	4.38 (12.07)	86.0 (68.62)
Jute bag treated with deltamethrin 2.8 EC @ 2 ml/l	0.0 (1.0)	2.3 (1.9)	4.3 (2.1)	86.56	3.06	4.52 (12.27)	87.0 (68.71)
Polypropylene bags	12.6 (3.7)	17.0 (6.2)	29.0 (8.4)	9.37	2.41	19.17 (25.96)	61.0 (52.04)
Jute bag	14.6 (4.3)	22.0 (7.3)	32.0 (9.1)	--	2.38	20.30 (26.12)	61.0 (52.04)
CD (p=0.05)	0.4	0.3	0.4		0.10	1.16	3.73

DAS: Days after Storage; Values in the parentheses are *square root and $angular transformed values bags over conventional materials for effective protection of seeds against storage pests. PICS bags consistently outperformed other treatments by maintaining lower insect populations, highest germination percentage, maximum seed weight and minimum insect damage, aligning with earlier reports that hermetic storage suppresses insect multiplication by limiting oxygen availability and increasing CO_2 concentration (Gebregergis et al., 2024). The comparable performance of SGP bags and insecticide-treated jute bags indicates that both hermetic storage and chemical protection can restrict insect infestation. However, chemical treatments may pose environmental and health concerns, making PICS bags a more sustainable alternative. Traditional storage structures like polypropylene and untreated jute bags failed to prevent infestation due to their porous nature and lack of insecticidal protection. The sharp decline in germination percentage and seed weight in these treatments can be attributed to continuous insect feeding and damage, which also resulted in the highest percentage of seed damage.

The findings corroborate earlier studies of Musuya et al., (2022) who reported significantly lower insect proliferation, minimal seed moisture changes, and drastically reduced aflatoxin contamination in sesame stored in PICS and SGP bags over six months compared to polypropylene and conventional bags, in both tropical and semi-arid environments. Similar results were obtained by Sudini et al. (2015) and Baoua et al. (2014) who demonstrated near-complete control of *T. castaneum, Cryptolestes* spp. in hermetically sealed bags. Sharma et al. (2023) confirmed that sesame stored in high-density polyethylene (HDPE) hermetic bags retained more than 88 per cent germination after eight months, while plain jute and PP bags often fell below 60 per cent. Hassan et al. (2023) also observed reduction in insect damage significantly higher 1000-seed weight and viability in PICS bags throughout storage. Chemical control through deltamethrin-treated jute bags offered comparable protection to hermetic bags in the short term. However, previous reports caution that efficacy declines after 2–3 months and pesticide residues raise food safety and seed quality concerns (Rani and Singh 2018; Channaveerayya et al., 2019, Kavitha et al., 2018) making hermetic options preferable for seed material intended for planting.

Storage of sesame in untreated jute and polypropylene bags was consistently inferior. High permeability to air and moisture facilitated rapid insect multiplication, leading to greater seed damage, reduced seed weight, and lower germination. These findings align with earlier reports of 20–25% seed damage and significant viability loss in sesame stored in conventional bags under ambient conditions (Punnuri et al., 2018, Kumar et al., 2020, Bhagirath et al., 2021, ICAR-IIOR 2024).

Across multiple studies, a consistent pattern emerges in which hermetic storage systems such as PICS and SGP bags preserve seed viability, limit insect infestation (<5%), and maintain original seed moisture Musuya et al. (2022) far better than conventional packaging (Ghosh et al., 2023, ICAR-IIOR 2024). Meta-analyses by Nduku et al. (2020) and Sudini et al. (2015) also confirm the superiority of triple-layer hermetic storage bags in maintaining seed quality of sesame and other oilseeds across different environments. Drouin et al. (2021) and Thakur et al. (2022) also confirmed the superiority of PICS bags across multiple parameters including insect population dynamics, seed viability, mass retention, and insect damage.

CONCLUSION

Hermetic storage technologies particularly PICS and SGP bags effectively preserve sesame seed viability and grain quality, outperforming conventional bags. While insecticide-treated jute bags provide similar protection, their environmental and health risks make hermetic bags a more sustainable choice. Hence, adoption of PICS or SGP bags is strongly recommended to minimize post-harvest losses, maintain higher seed germination in sesame and thereby promoting food security.

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Received 19 August, 2025; Accepted 22 October, 2025