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Assessment of triple-layer hermetic bags for safe storage of cowpea seeds in tropical conditions

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Abstract

Cowpea seeds in traditional containers in the tropics can lose more than half their germination within ten months. This research compared triple-layer hermetic bags, single-layer polypropylene bags, and jute sacks for cowpea seed storage over ten months at a tropical simulation facility at ETH Zurich (2022-2023). After ten months, seeds in hermetic bags retained 87.6% germination versus 58.4% in polypropylene and 41.7% in jute. Moisture stayed below 12.5% in hermetic bags versus 16.1% and 18.4% in the others. Insect damage was 3.2% in hermetic bags versus 31.6% and 42.3%. Triple-layer hermetic bags maintained seed quality within planting standards throughout.

Keywords: Hermetic storage, cowpea seeds, triple-layer bags, seed germination, moisture content, insect damage, tropical storage, post-harvest technology, seed quality

Introduction

Cowpea (*Vigna unguiculata*) ranks among the most important grain legumes in tropical Africa and South Asia, but post-harvest losses destroy 20-50% of the harvest ^[1, 2]. The bruchid *Callosobruchus maculatus* is the chief storage pest, and high humidity accelerates fungal degradation of seed viability ^[3]. Traditional containers offer almost no barrier to insect entry or moisture exchange ^[4]. Triple-layer hermetic bags create a modified atmosphere by allowing respiration to deplete oxygen and raise CO₂, killing insects without chemicals ^[5]. Most published trials focused on consumption grain ^[6, 7]; seed quality has received less attention. This research assessed hermetic bags against conventional containers over ten months, tracking germination, moisture, insect damage, and vigour ^[8].

Materials and Methods

Materials

Cowpea seeds (cv. 'IT97K-499-35', germination 96.4%, moisture 11.2%) were used. Triple-layer PICS bags (two 80 µm HDPE liners inside woven PP, 50 kg capacity), single-layer PP bags, and jute sacks were tested with four replications of 10 kg lots ^[5].

Methods

Storage ran from September 2022 to July 2023 in a climate chamber at ETH Zurich (30 ± 1 °C, 75 ± 5% RH). Each bag was infested with 50 adult *C. maculatus* at the start. Germination was tested bimonthly on 4 × 50 seeds per ISTA rules ^[9]. Moisture by oven-drying (103 °C, 17 h). Insect damage scored as percentage of seeds with exit holes in 200-seed subsamples. Vigour by accelerated ageing test (41 °C, 100% RH, 72 h) ^[10]. Two-way ANOVA with Tukey's HSD at $p \leq 0.05$.

Storage atmosphere monitoring

O₂ and CO₂ inside hermetic bags were measured with a Dansensor Check Point 3. By month 2, O₂ dropped to 4.3% and CO₂ rose to 6.8%. At month 6, O₂ was 1.7% and CO₂ 11.4%. PP and jute bags showed atmospheric-level gases throughout ^[11].

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Results

Table 1: Cowpea seed quality parameters across storage types over 10 months

Parameter	Mo 0	Mo 2	Mo 4	Mo 6	Mo 8	Mo 10
Germ-Herm %	96.4	94.8	93.1	91.7	89.3	87.6
Germ-PP %	96.4	91.2	84.6	76.3	68.1	58.4
Germ-Jute %	96.4	88.7	79.3	67.8	54.2	41.7
MC-Herm %	11.2	11.4	11.7	11.9	12.1	12.3
MC-PP %	11.2	12.8	13.6	14.7	15.3	16.1
MC-Jute %	11.2	13.4	14.9	16.3	17.1	18.4
Dmg-Herm %	0	0.3	0.8	1.4	2.1	3.2
Dmg-PP %	0	2.7	6.4	12.8	21.3	31.6
Dmg-Jute %	0	4.1	9.7	18.4	29.7	42.3

Herm = hermetic bag; PP = polypropylene; Germ = germination; MC = moisture content; Dmg = insect damage. Germination in hermetic bags declined only 8.8 percentage points over 10

months, compared with 38.0 in PP and 54.7 in jute (Table 1). Moisture in hermetic bags stayed below 12.5% throughout.

Table 2: Seed vigour (accelerated ageing germination %) and internal atmosphere at 10 months

Storage type	Vigour %	O ₂ %	CO ₂ %	Weight loss %
Hermetic bag	79.4	1.3	12.8	1.7
PP bag	41.8	20.7	0.4	14.3
Jute sack	28.6	20.9	0.3	21.8

Seed vigour after accelerated ageing was 79.4% in hermetic bags versus 41.8% in PP and 28.6% in jute. O₂ inside hermetic bags had dropped to 1.3% by month 10, while weight loss was

just 1.7% compared with 14.3% and 21.8% in open containers (Table 2).

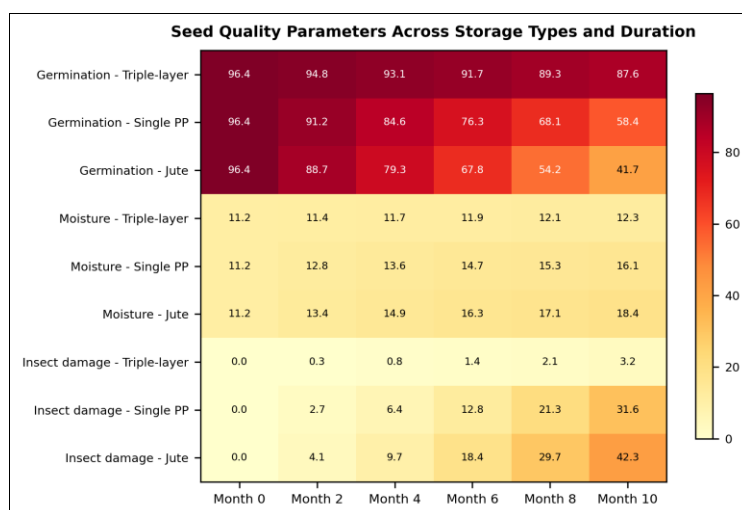


Fig 1: Heatmap of seed quality parameters across storage types and duration

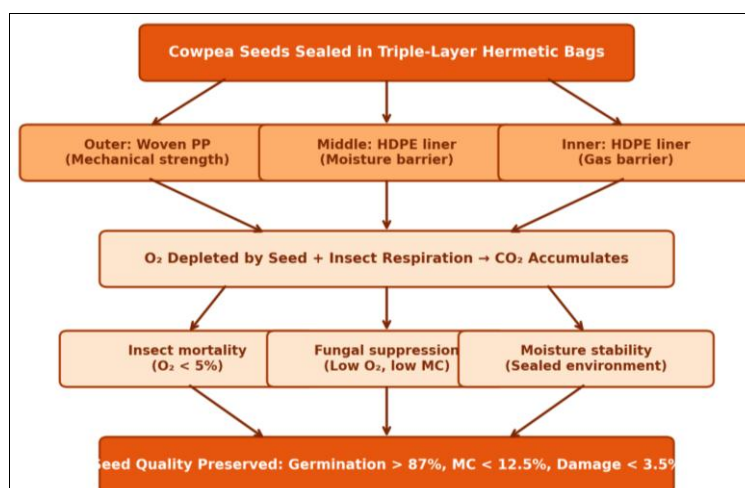


Fig 2: Process diagram showing the mechanism of seed preservation in triple-layer hermetic bags

Discussion

The 87.6% germination retained after ten months exceeds the 75% minimum for cowpea seed certification ^[12]. Rapid oxygen depletion below 5% by month 2 explains the near-complete insect suppression, as *C. maculatus* cannot survive below 3% O₂ ^[5, 13]. Jute performed worst because it permits free gas and moisture exchange, letting insects build unchecked and moisture climb above 14% ^[14]. The vigour data add a dimension often missing from hermetic trials: 79.4% vigour after accelerated ageing suggests good field establishment ^[10]. The 1.7% weight loss confirms minimal metabolic and insect-driven losses, consistent with findings in Niger and Burkina Faso ^[6, 14]. These results support hermetic bags for seed preservation in tropical smallholder systems ^[15, 16, 17].

Conclusion

Triple-layer hermetic bags maintained cowpea seed germination at 87.6% after ten months versus 58.4% in PP and 41.7% in jute. Moisture stayed below 12.5% and insect damage was limited to 3.2%. Seed vigour remained high (79.4%) and weight loss was 1.7%. Hermetic bags offer a chemical-free, low-cost solution for preserving cowpea seed viability in humid tropical conditions.

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