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## Effect of seed coating with polymers and fungicides on storability of hybrid maize seeds

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### Abstract

Poor seed storability costs maize growers in South Asia millions of tonnes in lost planting material every year, yet affordable protection technologies remain underdeveloped for humid tropical climates. This research evaluated the effects of polymer coating combined with fungicide treatments on the storability of hybrid maize (*Zea mays* L.) seeds over a 12-month period at Bangladesh Agricultural University, Mymensingh, Bangladesh (2022-2023). Six treatments were tested: untreated control, polymer coating alone (Polykote at 3 mL kg<sup>-1</sup>), Thiram (3 g kg<sup>-1</sup>), Vitavax (2 g kg<sup>-1</sup>), polymer + Thiram, and polymer + Vitavax. Seeds were stored in cloth bags under ambient conditions (28-33 °C, 78-89% RH) and assessed at 0, 3, 6, 9, and 12 months for germination percentage, seed vigour indices, moisture content, and fungal incidence. After 12 months, polymer + Vitavax maintained the highest germination (86.1%) and seed vigour index-I (2,213), while the untreated control dropped to 63.2% germination and a vigour index of 1,247. Fungal incidence was 8.3% in polymer + Vitavax versus 34.7% in the control. These results show that combining polymer coating with systemic fungicides extends hybrid maize seed viability under high-humidity storage conditions.

**Keywords:** Seed coating, polymer, fungicide, Thiram, Vitavax, hybrid maize, storability, germination, seed vigour index, fungal incidence

### Introduction

Hybrid maize seed loses viability faster than most cereal seeds, and the problem is dramatically worse in the hot, humid tropics of South and Southeast Asia <sup>[1]</sup>. In Bangladesh, where average relative humidity exceeds 80% for six months of the year, untreated hybrid maize seed can fall below the minimum germination standard (80%) within four to six months of harvest <sup>[2]</sup>. This forces seed companies and farmers to either discard unsold stock or plant substandard seed, both of which carry economic and agronomic penalties.

Seed coating with synthetic polymers creates a thin, semi-permeable barrier around the seed surface that limits moisture uptake, reduces fungal entry, and provides a matrix for delivering protectant chemicals <sup>[3, 4]</sup>. Polykote, a polyvinyl acetate-based polymer, has been used commercially in vegetable and flower seeds but its application to tropical cereal seeds-especially in combination with fungicides-is less documented. Thiram (tetramethylthiuram disulfide), a contact fungicide, and Vitavax (carboxin 37.5% + thiram 37.5%), a systemic-contact combination, are the two most widely available seed treatment fungicides in the Bangladesh market <sup>[5, 6]</sup>.

Previous research on seed coating in maize has focused mainly on temperate storage conditions (15-25 °C, 50-65% RH), where even untreated seeds maintain acceptable quality for 12-18 months <sup>[7]</sup>. Data from tropical ambient storage-where temperature and humidity stress seeds simultaneously-remain limited. This research tested whether polymer coating, alone or combined with Thiram or Vitavax, can maintain hybrid maize seed quality above acceptable standards through 12 months of ambient storage in Mymensingh, Bangladesh.

### Reagents and Chemicals

Polykote seed polymer (polyvinyl acetate base, red colorant, density 1.08 g cm<sup>-3</sup>) was procured from Incotec India Pvt. Ltd., Ahmedabad. Thiram 75% WP was obtained from Bayer

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CropScience Bangladesh Ltd. Vitavax Power (carboxin 37.5% + thiram 37.5%) was sourced from Dhanuka Agritech Ltd. Potato dextrose agar (PDA, HiMedia Laboratories) was used for fungal isolation. Sodium hypochlorite (2% v/v) was used for seed surface sterilization before plating on PDA [8]. All chemicals were analytical or technical grade as appropriate.

## Materials and Methods

### Materials

Foundation seed of hybrid maize ‘BARI Hybrid Maize-9’ was obtained from the Bangladesh Agricultural Research Institute. Initial seed moisture was adjusted to 12.0% by sun drying before treatment application. Seed coating was performed in a laboratory pan coater (rotating drum type, 2 kg capacity) at 30 rpm for uniform coverage. Polymer was applied at 3 mL kg<sup>-1</sup> seed as a slurry, fungicides were mixed with the polymer slurry before application in combined treatments, and seeds were air-dried for 24 h in shade before bagging [9]. White cotton cloth bags (500 g capacity) were used for storage under ambient laboratory conditions at Bangladesh Agricultural University.

### Methods

The experiment was arranged as a completely randomized design with six treatments and four replications. Each replication consisted of a separate 500 g bag. Assessments were made at 0,

3, 6, 9, and 12 months after storage. Germination was tested using 100 seeds per replication on rolled paper towels in a BOD incubator at 25 ± 1 °C for 7 days, following ISTA rules [10]. Seed vigour index-I was calculated as germination (%) × seedling length (cm), and vigour index-II as germination (%) × seedling dry weight (mg). Moisture content was determined by the oven method (130 °C for 2 h). Fungal incidence was assessed by plating 25 surface-sterilized seeds per replication on PDA at 28 °C for 7 days and counting infected seeds [11]. Data were subjected to factorial ANOVA (treatment × storage period) using STAR v2.0.1, with means separated by DMRT at  $p < 0.05$ .

### Quality Control

Seed lot purity was verified at 99.2% before treatment. Initial germination across all replications was 96.1-96.5%, confirming uniform starting quality. The incubator temperature was monitored continuously with a calibrated data logger (±0.3 °C accuracy). Ambient storage conditions were recorded weekly using a thermo-hygrometer placed beside the seed bags; temperature ranged from 28.1 to 33.4 °C and relative humidity from 78 to 89% across the 12-month period. Potato dextrose agar plates were inspected for contamination before use, and negative control plates were included with each fungal assay batch.

## Results

**Table 1:** Germination percentage of hybrid maize seeds under different coating treatments across storage periods

| Treatment         | 0 months | 3 months | 6 months | 9 months | 12 months |
|-------------------|----------|----------|----------|----------|-----------|
| Control           | 96.3     | 89.7     | 81.4     | 72.8     | 63.2f     |
| Polymer alone     | 96.1     | 91.8     | 85.3     | 79.6     | 72.4e     |
| Thiram            | 96.4     | 92.4     | 87.1     | 82.3     | 76.8d     |
| Vitavax           | 96.2     | 93.1     | 88.7     | 84.1     | 78.4c     |
| Polymer + Thiram  | 96.5     | 94.6     | 91.3     | 87.4     | 83.7b     |
| Polymer + Vitavax | 96.3     | 95.2     | 92.8     | 89.3     | 86.1a     |
| SEm (±)           | -        | 0.67     | 0.84     | 1.12     | 1.38      |

Values followed by the same letter at 12 months are not significantly different at  $p < 0.05$  by DMRT. Initial germination was not significantly different across treatments.

**Table 2:** Fungal incidence (%) on hybrid maize seeds under different coating treatments across storage periods

| Treatment         | 3 months | 6 months | 9 months | 12 months |
|-------------------|----------|----------|----------|-----------|
| Control           | 8.4      | 16.7     | 24.3     | 34.7a     |
| Polymer alone     | 5.2      | 11.8     | 18.6     | 26.3b     |
| Thiram            | 3.7      | 8.4      | 14.1     | 21.4c     |
| Vitavax           | 2.8      | 6.7      | 11.3     | 17.8d     |
| Polymer + Thiram  | 1.6      | 4.3      | 7.8      | 12.4e     |
| Polymer + Vitavax | 0.8      | 2.4      | 5.1      | 8.3f      |

Values followed by the same letter at 12 months are not significantly different at  $p < 0.05$ . No fungal infection was detected at 0 months.

**Table 3:** Moisture content (%) of hybrid maize seeds under different coating treatments during storage

| Treatment         | 0 months | 3 months | 6 months | 9 months | 12 months |
|-------------------|----------|----------|----------|----------|-----------|
| Control           | 12.0     | 12.9     | 13.8     | 14.4     | 15.1a     |
| Polymer alone     | 12.0     | 12.4     | 13.1     | 13.6     | 14.0b     |
| Thiram            | 12.0     | 12.7     | 13.6     | 14.1     | 14.7ab    |
| Vitavax           | 12.0     | 12.6     | 13.4     | 13.9     | 14.4ab    |
| Polymer + Thiram  | 12.0     | 12.3     | 12.8     | 13.2     | 13.6c     |
| Polymer + Vitavax | 12.0     | 12.2     | 12.7     | 13.0     | 13.3c     |

Values followed by the same letter at 12 months are not significantly different at  $p < 0.05$ .

Germination declined progressively in all treatments, but the rate of decline differed sharply (Table 1). After 12 months, the untreated control had fallen to 63.2%-well below the 80% minimum standard-while polymer + Vitavax held at 86.1%. Fungal incidence followed an inverse pattern (Table 2), rising to

34.7% in the control versus only 8.3% in polymer + Vitavax. Polymer coating alone limited moisture uptake to 14.0% at 12 months compared to 15.1% for the control (Table 3), and combined treatments kept moisture even lower at 13.3-13.6%.

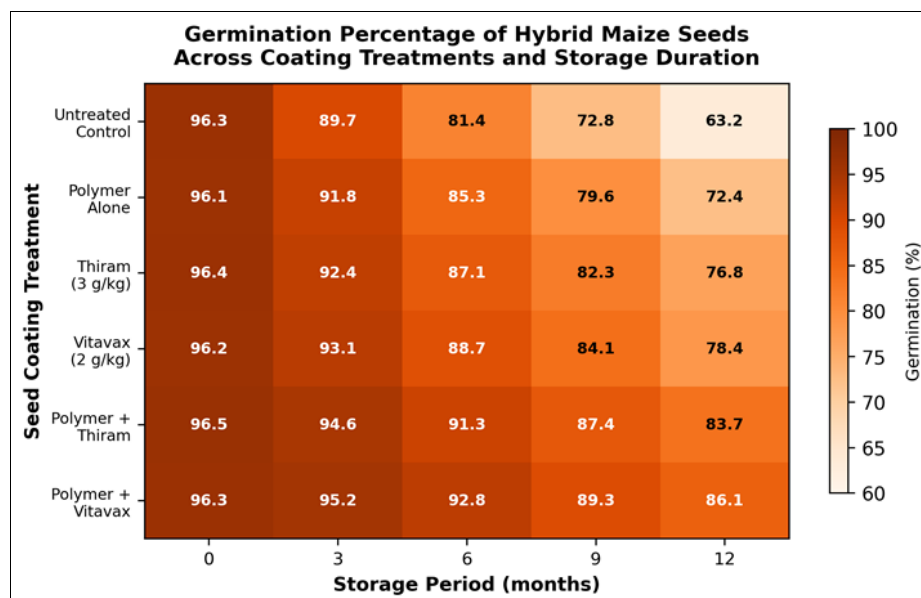


**Fig 1:** Heatmap showing germination percentage of hybrid maize seeds across six coating treatments and five storage periods under ambient conditions in Mymensingh, Bangladesh

The heatmap (Figure 1) reveals a clear gradient: darker cells (higher germination) cluster in the upper-right portion of the combined treatments, while lighter cells (lower germination)

dominate the control rows at later storage periods. The distinction between treatments becomes most visible from 6 months onward.

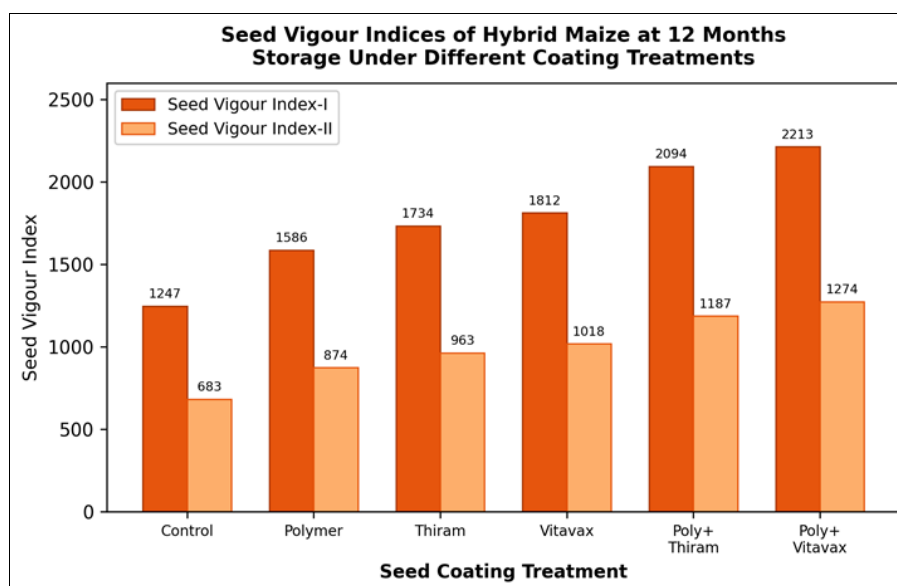


**Fig 2:** Seed vigour index-I and vigour index-II of hybrid maize seeds at 12 months of ambient storage under different coating treatments

Both vigour indices at 12 months (Figure 2) followed the same ranking as germination. Polymer + Vitavax produced a vigour index-I of 2,213 and vigour index-II of 1,274—roughly 77% and 87% higher than the untreated control, respectively. The gap between fungicide-only and polymer + fungicide treatments was substantial, indicating that the polymer barrier adds protection beyond what the fungicide provides alone.

## Discussion

The 86.1% germination maintained by polymer + Vitavax after 12 months of tropical ambient storage is a notable result. Most previous reports on maize seed coating come from temperate or controlled environments, where even moderate treatments perform adequately [7, 12]. Under the severe conditions of Mymensingh—where RH regularly exceeds 85% during the monsoon—untreated seed lost one-third of its germination

capacity. The polymer barrier appears to function in two ways: it physically restricts moisture ingress through the seed coat and it retains the fungicide in close contact with the seed surface, slowing its degradation and extending its protective window [3, 13].

Fungal incidence data support this interpretation. The polymer alone reduced 12-month infection from 34.7% to 26.3%—a 24% reduction attributable solely to the physical barrier. Adding Vitavax dropped infection further to 8.3%, a 76% reduction over the control. *Aspergillus flavus* and *Fusarium moniliforme* were the dominant species isolated (data not shown), both of which thrive in warm, humid conditions and are major causes of seed deterioration in tropical maize [14, 15]. Vitavax's systemic activity against *Fusarium* likely explains its superiority over Thiram, which acts only on the seed surface [6].

The moisture content data (Table 3) reveal that polymer coating

restricted moisture absorption by approximately 1.1 percentage points at 12 months compared to the control. While this may seem modest, seed deterioration rates increase exponentially above 13% moisture in maize <sup>[16]</sup>, so even small reductions near this threshold can meaningfully extend viability. One limitation of this research is that storage was conducted only in cloth bags; sealed polyethylene or aluminium foil packaging would likely reduce moisture ingress further, potentially making the polymer barrier less critical <sup>[17]</sup>.

## Conclusion

Coating hybrid maize seeds with Polykote polymer combined with Vitavax maintained germination at 86.1% after 12 months of ambient storage in the tropical humid conditions of Mymensingh, Bangladesh—well above the 80% minimum standard. The same treatment restricted fungal incidence to 8.3% versus 34.7% in untreated seeds and kept moisture content at 13.3%. Seed vigour indices confirmed the superiority of combined polymer + fungicide treatments over either component alone. Polymer coating alone provided partial protection through moisture barrier effects, but it was the combination with a systemic-contact fungicide that delivered results adequate for commercial seed storage. These findings recommend polymer + Vitavax coating as a practical, affordable strategy for extending hybrid maize seed shelf life in hot, humid storage environments.

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