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Research Article

Effect of seed coating with polymer and chemicals on longevity of maize (*Zea mays* L.)

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Abstract

High-quality seed's viability and longevity during storage are crucial for sustainable agricultural production. The present storage experiment was conducted under ambient conditions using maize composite variety "Bajaura Makka". Seeds treated with polymer and chemicals were subjected to assess the seed quality in order to know the effect of seed coating on seed longevity during storage and to identify the effective seed coating treatment for enhancing seed longevity. A total of ten treatment combinations (nine coated + one uncoated/control) packed in HDPE (high density polyethylene) interwoven bags were stored in Completely Randomized Design (CRD) in three replications for twelve months (March, 2021). These ten treatment combinations were carried over for another twelve months (13th to 24th months i.e., from March 2022 to March 2023) and observations were recorded on seed quality parameters. All the recorded seed quality parameters showed reduction with the passage of the storage period despite of various seed coating treatments. The treatments, T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg seed recorded significantly higher seed quality parameters *viz.,* germination percentage - first count (93.67%, 93.00%), germination percentage - final count (94.00%, 93.00%), rate of germination (43.30, 43.20), seedling length (33.73 cm, 33.63 cm), dry matter of seedling (60.01 mg, 59.83 mg), seedling vigour index - I (3170.93, 3128.00), seedling vigour index - II (5640.94, 5564.72), field emergence percentage (80.67%, 79.67%) and final plant stand percentage (80.67%, 79.67%), respectively over T_1 - control after 24 months of storage period. The treatment T_6 showed an increase of 8.91%, 9.30%, 8.25%, 7.45%, 7.16%, 17.45%, 17.13%, 11.52%, 11.52%, while treatment T_5 showed an increase of 8.14%, 8.14%, 8.00%, 7.14%, 6.85%, 15.86%, 15.55%, 10.14%, 10.14% over T_1 - control for seed quality parameters *viz.,* germination percentage first count, germination percentage final count, rate of germination, seedling length, dry matter of seedling, seedling vigour index - I, seedling vigour index - II, field emergence percentage and final plant stand percentage, respectively after 24 months of storage period.

Keywords: Maize, seed coating and longevity

1. Introduction

The time between seed maturation and the loss of seed viability in dry storage is referred to as seed longevity. The ability of seeds to be stored depends significantly on the storage environment, the physiological state of the seeds, and genetic factors. Seed coating technology, thus, emerged as an economical approach of seed enhancement and to reduce the speed of seed deterioration to the extent possible. Seed coating involves the placement of the enhancement material directly on the seed without obscuring the shape, size and weight. Seed coating polymers should have the following characteristics in order to function optimally; a water-based polymer, have low viscosity range, have a high concentration of solids, have an adjustable hydrophilic/ hydrophobic balance and form a hard film upon drying.

The high starch content of maize seeds, which encourages fungus and insect attack and causes a quick loss of viability and vigour, is the likely cause of their low ability to store. Considering these points, the research was conducted using the maize variety 'Bajaura Makka', an early-maturing composite, grown in *Kharif* production conditions, with plants of medium height with medium cob placement and long ears with shining orange flint seeds. The goals of study were to know the effect of seed coating on seed longevity during storage and identify the effective seed coating treatment for enhancing seed longevity.

2. Materials and Methods

The experiment was conducted in the Seed Technology Laboratory of Department of Seed Science and Technology, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur. The experiment was set up using the *Kharif* 2020 freshly harvested seeds of the composite variety of maize; "Bajaura Makka" procured from the Hill Agricultural Research and Extension Centre, Bajaura (Kullu), CSK HPKV, Palampur. In the year 2021, the procured seeds were graded, dried to around 10.0% moisture content and coated with the use of polymer, fungicides, and insecticides into ten treatment combinations (nine coated + one uncoated/ control. These were dried in shade for 72 hours at room temperature and achieved the original moisture content i.e., approximately 10.00 % and packed in interwoven HDPE (high density polyethylene) bags with the use of a Completely Randomized Design (CRD) of the experiment in three replications and stored at room temperature for twelve months in the Seed Technology Laboratory. This stored experimental material is then carried over for another twelve months (13^{th} to 24^{th} months), and bimonthly evaluation of seed quality parameters were noted over the course of a year i.e., from March 2022-2023. The coated seeds were drawn at random from the bags at bimonthly intervals for the data collection of different seed quality parameters: germination (%), rate of germination, seedling length (cm), dry matter of seedling (mg), seedling vigour index-I and II, moisture content (%), test weight (g) and field emergence (%). The statistical analysis of the data was completed with the use of OPSTAT software.

3. Results and Discussion

The treatments T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (94.00%) and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (93.00%) were statistically at par with each other and showed better germination percentage over T_1 - control (86.00%). The speed of endosperm reserve mobilization was slower in coated seeds due to restricted supply of oxygen within the embryo may be because the polymer coating fine particles behaved as a 'wick' or moisture attracting material which ultimately lead to the increased imbibition rates, that perhaps improves the germination and also it has been found to reduce the inhibitors leaching from layers of seed. However, the possible reasons for the gradual germination decline over the storage period may be due to ageing which results in the depletion of food reserves and synthetic activity of the embryo, and fluctuating temperature, relative humidity and seed moisture content. In the physiology of seed, the involvement of active oxygen species (AOS) is during various phases of seed i.e., seed desiccation, germination and ageing. AOS might result in the oxidative damage resulting in seed deterioration. However, cells are endowed with detoxifying enzymes and antioxidant compounds that scavenge AOS and participate in seed survival but during the aging of seed with increase in storage interval lead to significant changes in the mitochondria, the main site of ROS production due to which they are more quickly exposed to oxidative stress and reduces the activity of antioxidant system. These ROS then migrates easily through membranes over

large distances in seed and contributing to seed aging and decreased enzymatic activity which ultimately decrease the ability of the embryo to germinate. The outcomes concur with those of Chaturvedi et al. (2021) in wheat, Singh et al. (2021) in paddy and Divya (2022) in maize. Similar results were obtained for rate of germination.

After 24 months of storage, significantly higher field emergence was recorded for T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (80.67%) and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (79.67%) as compared to T_1 - control (72.33%). In the coated seeds improved the seed- soil interphase, protection against soil microorganism, diseases and pests as coating leave behind less surface of seed directly exposed and acted as a binding material to cover the minor cracks and aberrations on the seed, thereby keeping all the vital organs and storage metabolites intact, which, minimized the leakage of electrolytes. All these factors in turn help in improved germination resulting in better establishment of seedling and sustaining the field emergence. The age induced changes in the cell and cell organelles reduced the

Table 1. Treatment details

Treatment	Description
T_1	Control
T_2	Polymer coating (polykote) @ 3.0 ml/kg of seed, diluted with 5.0 ml water
T_3	Treat (tebuconazole) @ 1.0 g/kg of seed
T_4	Polymer + treat (tebuconazole) @ 1.0 g/kg of seed
T_5	Vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed
T_6	Polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed
T_7	Imidacloprid (Gaucho) @ 4.0 ml/kg of seed
T_8	Polymer + imidacloprid (Gaucho) @ 4.0 ml/kg of seed
T_9	Polymer + treat (tebuconazole) @ 1.0 g/kg seed + imidacloprid (Gaucho) @ 4.0 ml/kg of seed
T_{10}	Polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed + imidacloprid (Gaucho) @ 4.0 ml/kg of seed

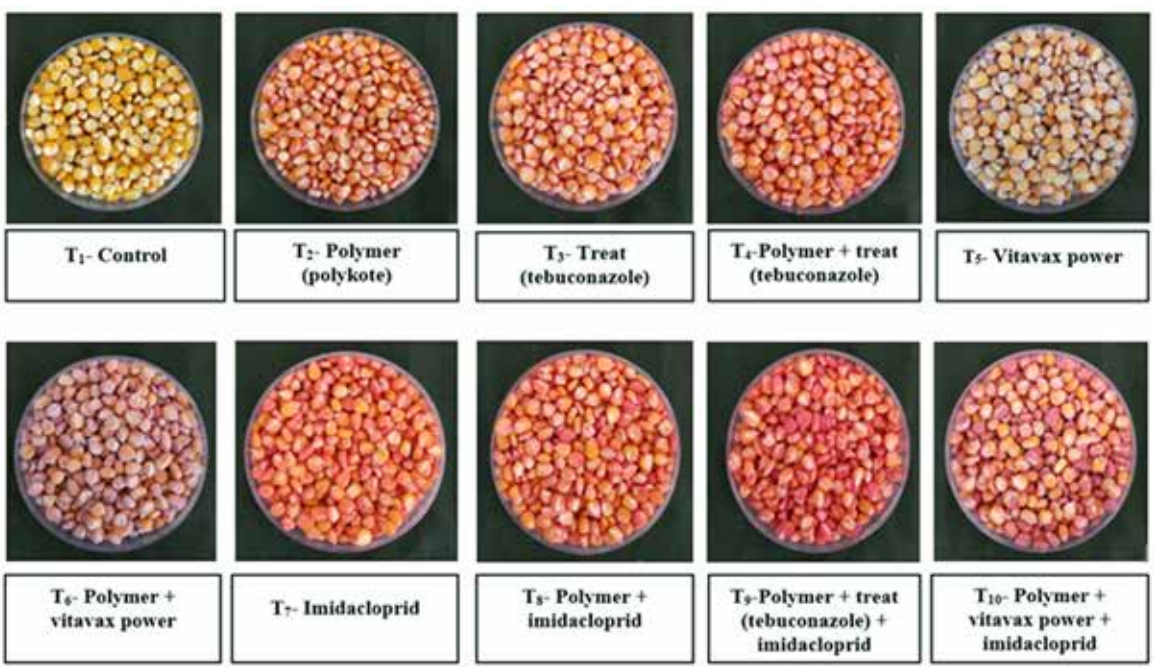

Plate 3.1 Seeds coated with polymer, fungicides and insecticide

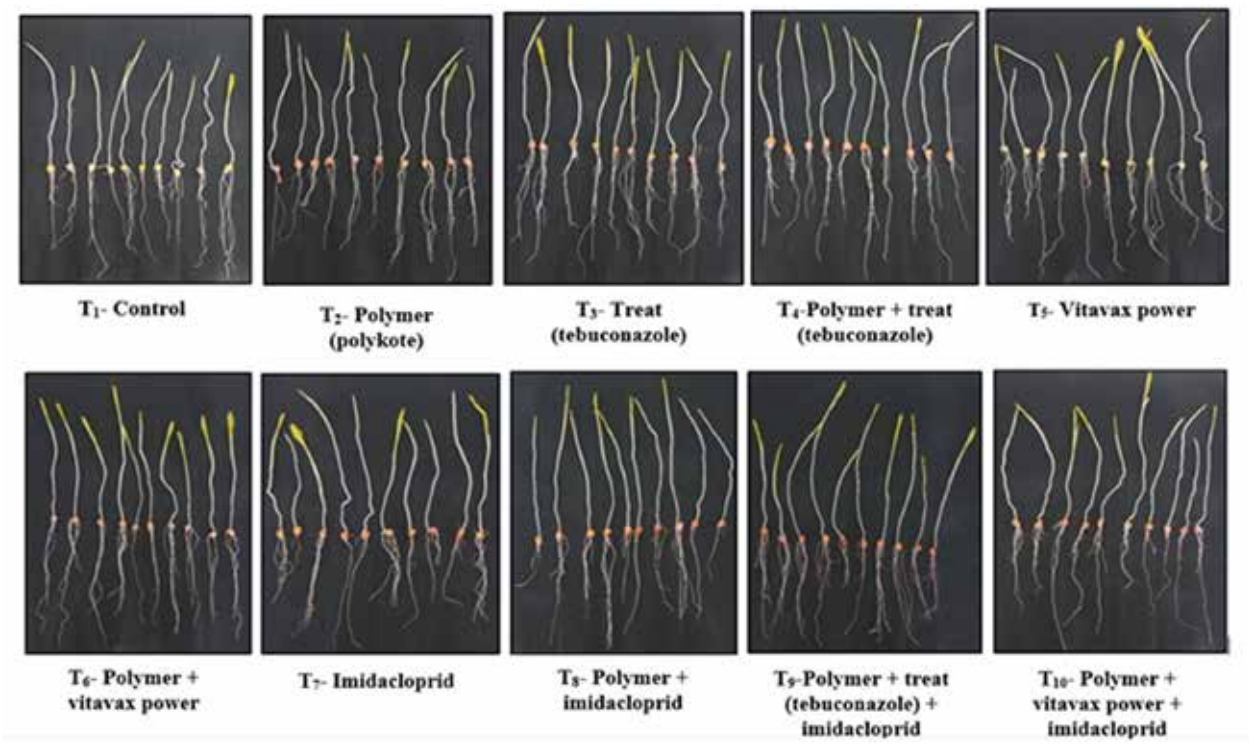

Plate 3.2 Seedling length after 14th month of storage

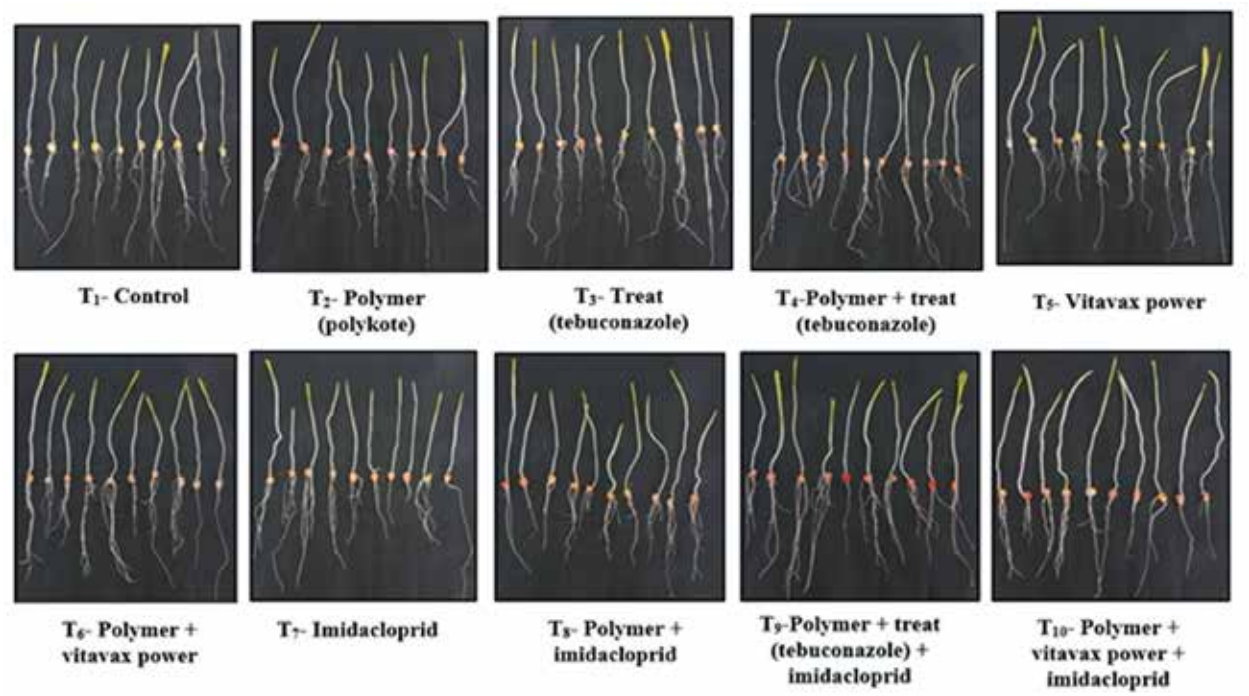

Plate 3.3 Seedling length after 24th month of storage

Table 2. Effect of seed coating treatments on germination count (first and final) percentage during storage

Figures in parenthesis indicated square root transformation values

Treatment	Months after storage													
	Germination (%)													
	First count (%)						% increase over control after 24 months of storage	Final count (%)						% increase over control after 24 months of storage
	14	16	18	20	22	24		14	16	18	20	22	24	
T_1	92.00 (9.64)	91.67 (9.63)	90.67 (9.57)	90.00 (9.54)	87.67 (9.42)	86.00 (9.33)	-	93.33 (9.71)	92.67 (9.68)	91.33 (9.61)	90.00 (9.54)	87.67 (9.42)	86.00 (9.33)	-
T_2	92.67 (9.68)	92.33 (9.66)	92.00 (9.64)	91.33 (9.61)	90.00 (9.54)	88.67 (9.47)	3.10	93.67 (9.73)	93.33 (9.71)	92.33 (9.66)	91.67 (9.63)	90.33 (9.56)	88.67 (9.47)	3.10
T_3	94.00 (9.75)	93.67 (9.73)	93.33 (9.71)	92.67 (9.68)	91.67 (9.63)	91.00 (9.59)	5.81	95.00 (9.80)	94.67 (9.78)	94.00 (9.75)	93.00 (9.70)	92.00 (9.64)	91.33 (9.61)	6.20
T_4	94.67 (9.78)	94.00 (9.75)	93.67 (9.73)	93.00 (9.70)	92.33 (9.66)	91.67 (9.63)	6.59	95.33 (9.82)	95.00 (9.80)	94.33 (9.76)	93.33 (9.71)	92.67 (9.68)	91.67 (9.63)	6.59
T_5	95.67 (9.83)	95.33 (9.82)	94.67 (9.78)	94.00 (9.75)	93.33 (9.71)	93.00 (9.70)	8.14	96.67 (9.88)	96.33 (9.87)	95.33 (9.82)	94.67 (9.78)	93.67 (9.73)	93.00 (9.70)	8.14
T_6	96.00 (9.85)	96.00 (9.85)	95.67 (9.83)	94.67 (9.78)	94.33 (9.76)	93.67 (9.73)	8.91	97.00 (9.90)	96.67 (9.88)	96.00 (9.85)	95.33 (9.82)	94.33 (9.76)	94.00 (9.75)	9.30
T_7	93.00 (9.70)	92.67 (9.68)	92.33 (9.66)	91.67 (9.63)	91.00 (9.59)	89.00 (9.49)	3.49	94.00 (9.75)	93.33 (9.71)	92.67 (9.68)	92.00 (9.64)	91.00 (9.59)	89.33 (9.50)	3.88
T_8	93.33 (9.71)	93.00 (9.70)	92.33 (9.66)	92.00 (9.64)	91.00 (9.59)	89.67 (9.52)	4.26	94.33 (9.76)	94.00 (9.75)	93.00 (9.70)	92.00 (9.64)	91.00 (9.59)	89.67 (9.52)	4.26
T_9	94.00 (9.75)	93.67 (9.73)	93.33 (9.71)	92.33 (9.66)	91.33 (9.61)	90.67 (9.57)	5.43	95.00 (9.80)	94.67 (9.78)	93.67 (9.73)	92.67 (9.68)	91.67 (9.63)	91.00 (9.59)	5.81
T_{10}	94.67 (9.78)	94.33 (9.76)	94.00 (9.75)	93.33 (9.71)	92.33 (9.66)	91.67 (9.63)	6.59	95.67 (9.83)	95.33 (9.82)	94.67 (9.78)	93.33 (9.71)	92.67 (9.68)	92.00 (9.64)	6.98
Mean	94.00 (9.75)	93.67 (9.73)	93.20 (9.71)	92.50 (9.67)	91.50 (9.62)	90.50 (9.56)	-	95.00 (9.80)	94.60 (9.78)	93.73 (9.73)	92.80 (9.68)	91.70 (9.63)	90.67 (9.57)	-
SE(m±)	0.018	0.017	0.024	0.019	0.020	0.021	-	0.013	0.015	0.020	0.016	0.022	0.020	-
CD (5%)	0.053	0.051	0.072	0.056	0.059	0.063	-	0.039	0.045	0.058	0.048	0.065	0.061	-

T1 - control, T2 - polymer coating (polykote) @ 3.0 ml/kg of seed, diluted with 5.0 ml of water, T3 - treat (tebuconazole) @ 1.0 g/kg seed, T4 - polymer + treat (tebuconazole) @ 1.0 g/kg seed, T5-vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed, T6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed, T7 - imidacloprid (Gaucho) @ 4.0 ml/kg of seed, T8 - polymer + imidacloprid (Gaucho) @ 4.0 ml/kg of seed, T9 - polymer + treat (tebuconazole) @ 1.0 g/kg seed + imidacloprid (Gaucho) @ 4.0 ml/kg of seed and T10 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4.0 ml/kg of seed

Table 3. Effect of seed coating treatments on seedling length (cm) and dry matter of seedling (mg) during storage

Treatment	Months after storage												
	Seedling length (cm)						% increase over control after 24 months of storage	Dry matter of seedling (mg)						% increase over control after 24 months of storage
	14	16	18	20	22	24		14	16	18	20	22	24	
T_1	35.00	34.73	34.27	33.47	32.43	31.39	-	60.23	59.57	58.72	57.63	57.04	56.00	-
T_2	35.23	35.00	34.47	33.93	33.03	32.50	3.53	60.83	60.35	60.23	59.40	58.20	56.65	1.17
T_3	35.57	35.37	34.97	34.50	33.60	33.10	5.44	62.67	62.51	61.67	60.73	59.54	58.57	4.58
T_4	35.67	35.50	35.20	34.70	33.77	33.33	6.18	63.26	63.09	62.13	61.08	60.04	59.20	5.71
T_5	35.97	35.83	35.40	34.97	34.03	33.63	7.14	63.82	63.66	63.12	62.05	60.94	59.83	6.85
T_6	36.00	35.93	35.57	35.07	34.20	33.73	7.45	63.96	63.81	63.20	62.12	61.02	60.01	7.16
T_7	35.37	35.13	34.63	34.13	33.20	32.63	3.95	61.40	61.21	60.79	60.09	58.36	57.24	2.21
T_8	35.43	35.20	34.73	34.27	33.33	32.73	4.27	61.71	61.46	60.99	60.16	58.84	57.57	2.80
T_9	35.47	35.27	34.90	34.43	33.47	33.00	5.12	62.63	62.45	61.52	60.56	59.40	58.51	4.49
T_{10}	35.77	35.57	35.33	34.83	33.90	33.43	6.50	63.31	63.13	62.33	61.35	60.16	59.28	5.86
Mean	35.55	35.35	34.95	34.43	33.50	32.95	-	62.38	62.12	61.47	60.52	59.35	58.29	-
SE(m±)	0.04	0.05	0.07	0.07	0.08	0.07	-	0.20	0.18	0.21	0.18	0.20	0.21	-
CD (5%)	0.12	0.15	0.20	0.21	0.22	0.21	-	0.58	0.53	0.63	0.54	0.60	0.62	-

T_1 - control, T_2 - polymer coating (polykote) @ 3.0 ml/kg of seed, diluted with 5.0 ml of water, T_3 - treat (tebuconazole) @ 1.0 g/kg seed, T_4 - polymer + treat (tebuconazole) @ 1.0 g/kg seed, T_5-vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed, T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed, T_7 - imidachloprid (Gaucho) @ 4.0 ml/kg of seed, T_8 - polymer + imidachloprid (Gaucho) @ 4.0 ml/kg of seed, T_9 - polymer + treat (tebuconazole) @ 1.0 g/kg seed + imidachloprid (Gaucho) @ 4.0 ml/kg of seed and T_{10} - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed + imidachloprid (Gaucho) @ 4.0 ml/kg of seed

Table 4. Effect of seed coating treatments on field emergence (%) and moisture content (%) during storage

Figures in parenthesis indicated square root transformation values

Treatment	Months after storage													
	Field emergence (%)						% increase over control after 24 months of storage	Moisture content (%)						% decrease over control after 24 months of storage
	14	16	18	20	22	24		14	16	18	20	22	24	
T_1	80.00 (9.00)	79.00 (8.94)	78.00 (8.89)	76.33 (8.79)	74.67 (8.70)	72.33 (8.56)	-	11.37 (3.52)	12.50 (3.67)	12.47 (3.67)	11.80 (3.58)	11.90 (3.59)	11.67 (3.56)	-
T_2	82.00 (9.11)	81.33 (9.07)	79.67 (8.98)	77.67 (8.87)	76.67 (8.81)	74.33 (8.68)	2.76	11.27 (3.50)	12.27 (3.64)	12.23 (3.64)	11.57 (3.55)	11.67 (3.56)	11.53 (3.54)	-1.20
T_3	85.00 (9.27)	84.00 (9.22)	82.33 (9.13)	81.00 (9.06)	79.67 (8.98)	77.67 (8.87)	7.37	11.17 (3.49)	12.03 (3.61)	12.00 (3.61)	11.40 (3.52)	11.47 (3.53)	11.40 (3.52)	-2.31
T_4	85.00 (9.27)	84.67 (9.26)	82.67 (9.15)	81.33 (9.07)	80.00 (9.00)	77.67 (8.87)	7.37	10.80 (3.44)	11.57 (3.55)	11.53 (3.54)	10.87 (3.45)	11.00 (3.46)	10.90 (3.45)	-6.60
T_5	86.33 (9.35)	85.67 (9.31)	84.00 (9.22)	82.67 (9.15)	81.33 (9.07)	79.67 (8.98)	10.14	11.00 (3.46)	11.87 (3.59)	11.83 (3.58)	11.23 (3.50)	11.27 (3.50)	11.17 (3.49)	-4.28
T_6	87.00 (9.38)	86.33 (9.35)	84.67 (9.26)	83.33 (9.18)	82.33 (9.13)	80.67 (9.04)	11.52	10.93 (3.45)	11.83 (3.58)	11.83 (3.58)	11.17 (3.49)	11.23 (3.50)	11.07 (3.47)	-5.14
T_7	82.33 (9.13)	81.67 (9.09)	80.00 (9.00)	78.00 (8.89)	77.00 (8.83)	74.67 (8.70)	3.23	11.10 (3.48)	12.00 (3.61)	11.97 (3.60)	11.37 (3.52)	11.43 (3.53)	11.30 (3.51)	-3.17
T_8	82.67 (9.15)	82.00 (9.11)	80.33 (9.02)	78.33 (8.91)	77.33 (8.85)	75.33 (8.74)	4.15	10.73 (3.43)	11.53 (3.54)	11.50 (3.54)	10.87 (3.45)	10.93 (3.45)	10.80 (3.44)	-7.46
T_9	84.00 (9.22)	83.33 (9.18)	81.67 (9.09)	80.00 (9.00)	79.00 (8.94)	76.67 (8.81)	5.99	10.57 (3.40)	11.40 (3.52)	11.37 (3.52)	10.77 (3.43)	10.83 (3.44)	10.63 (3.41)	-8.91
T_{10}	85.33 (9.29)	84.67 (9.26)	83.00 (9.17)	81.67 (9.09)	80.67 (9.04)	78.67 (8.93)	8.76	10.53 (3.40)	11.40 (3.52)	11.33 (3.51)	10.73 (3.43)	10.80 (3.44)	10.57 (3.40)	-9.43
Mean	83.97 (9.22)	83.23 (9.18)	81.63 (9.09)	80.03 (9.00)	78.87 (8.94)	76.77 (8.82)	-	10.95 (3.46)	11.84 (3.58)	11.81 (3.58)	11.18 (3.49)	11.25 (3.50)	11.10 (3.48)	-
SE(m±)	0.015	0.014	0.020	0.021	0.028	0.021	-	0.004	0.006	0.005	0.005	0.004	0.006	-
CD (5%)	0.045	0.045	0.059	0.062	0.082	0.064	-	0.012	0.013	0.014	0.014	0.012	0.018	-

T_1 - control, T_2 - polymer coating (polykote) @ 3.0 ml/kg of seed, diluted with 5.0 ml of water, T_3 - treat (tebuconazole) @ 1.0 g/kg seed, T_4 - polymer + treat (tebuconazole) @ 1.0 g/kg seed, T_5-vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed, T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed, T_7 - imidachloprid (Gaucho) @ 4.0 ml/kg of seed, T_8 - polymer + imidachloprid (Gaucho) @ 4.0 ml/kg of seed, T_9 - polymer + treat (tebuconazole) @ 1.0 g/kg seed + imidachloprid (Gaucho) @ 4.0 ml/kg of seed and T_{10} - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2 g/kg of seed + imidachloprid (Gaucho) @ 4.0 ml/kg of seed.

Table 4. Effect of seed coating treatments on rate of germination (%) and test weight (g) during storage

Treatment	Months after storage													
	Rate of germination						% increase over control after 24 months of storage	Test weight (g)						% increase over control after 24 months of storage
	14	16	18	20	22	24		14	16	18	20	22	24	
T_1	43.23	42.87	42.27	41.60	40.77	40.00	-	282.23	283.13	283.03	282.70	282.80	282.67	-
T_2	44.23	43.70	43.03	42.40	41.63	40.93	2.33	282.43	283.30	283.23	282.83	282.97	282.80	0.05
T_3	45.40	44.90	44.23	43.60	42.80	42.13	5.33	283.00	283.63	283.53	283.30	283.50	283.23	0.20
T_4	45.70	45.13	44.67	43.97	43.10	42.43	6.08	283.23	283.87	283.77	283.47	283.67	283.43	0.27
T_5	45.97	45.70	45.20	44.47	43.60	43.20	8.00	283.47	284.33	284.27	283.63	283.83	283.60	0.33
T_6	46.07	45.83	45.27	44.53	43.73	43.30	8.25	284.00	284.60	284.53	284.13	284.27	284.10	0.51
T_7	44.40	43.97	43.27	42.70	42.03	41.10	2.75	282.60	283.10	283.00	282.93	283.17	282.93	0.09
T_8	44.57	44.03	43.43	42.93	42.10	41.27	3.17	282.73	283.33	283.20	283.13	283.33	283.07	0.14
T_9	45.33	44.70	44.07	43.43	42.70	42.03	5.08	284.40	284.80	284.73	284.50	284.60	284.47	0.64
T_{10}	45.73	45.40	44.83	44.03	43.27	42.57	6.42	284.77	285.23	285.17	284.83	284.90	284.80	0.75
Mean	45.06	44.62	44.03	43.37	42.57	41.90	-	283.29	283.93	283.85	283.55	283.70	283.51	-
SE(m±)	0.07	0.09	0.07	0.08	0.14	0.11	-	0.04	0.05	0.06	0.04	0.04	0.04	-
CD (5%)	0.22	0.26	0.22	0.23	0.41	0.32	-	0.11	0.13	0.19	0.10	0.13	0.12	-

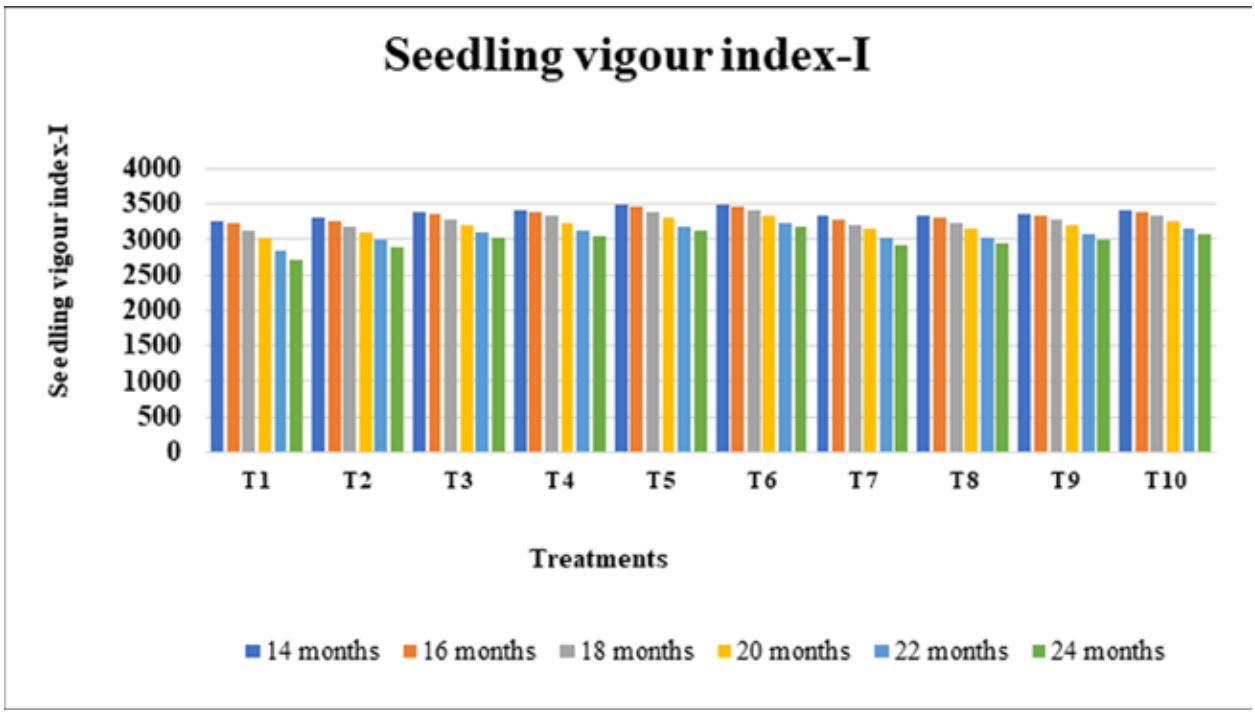

Fig.1. Effect of seed coating on seedling vigour index-I during storage

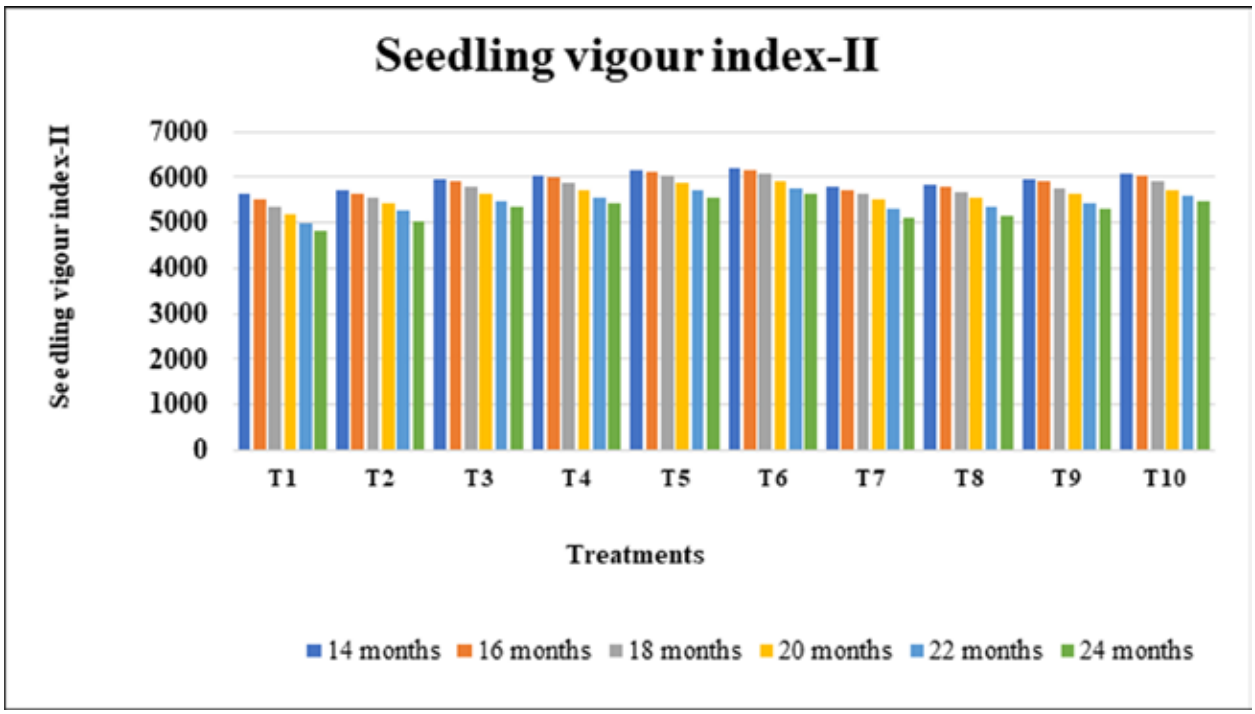

Fig.1. Effect of seed coating on seedling vigour index-II during storage

metabolic ability of the cell to repair the aging damages due to protein inactivation, resulting in the weakening of cellular membrane and integrity during seed storage. As a result, there is increased electrolyte leakage leading to fall in field emergence. Also, the reduced capacity of seed to germinate in the natural soil conditions may also be a reason for reduced field emergence. The similar results were stated by Sharma et al. (2017) in HQPM 1 hybrid maize and Rathinavel (2015) in cotton.

Significantly higher seedling length (cm) was recorded for T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (33.73 cm) and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (33.63 cm) as compared to T_1 - control (31.39 cm). The shielding provided by coating may have kept the metabolites secure for a longer time and transformed these into vigourous growth. Also, high initial germination rate and seedling growth resulted in better seedling length. The reduction in seedling length may be attributed to depletion of the nutrients in the endosperm due to natural ageing. This decreased the germination and could have hindered seedling growth.

Ultimate demonstration of physiological vigour i.e., dry matter of seedling (mg) was recorded maximum for T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (60.01 mg) and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (59.83 mg) as compared to T_1 - control (56.00 mg) after 24 months of storage. Majorly, the reserve metabolites, enzyme activities and growth regulators have an impact on this physiological event. A gauge of the seed's viability can be done using the dry matter of the seedlings by calculating the rate at which seed reserves are mobilized from the seed to the embryo.

At the end of storage, better seedling vigour index - I and II was recorded for T_6 - polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (3170.93, 5640.94) and T_5 - vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (3128.00, 5564.72) as compared to T_1 - control (2699.83, 4816.00). Viability is preceded by a loss of vitality. One trusted gauge of the potential of seed lots is the computed vigour index, which encompasses all aspects and attributes of the seed performance. Vigour decline is due to ageing of seeds, usage of food reserves, reduced germination, seedling length and dry matter. Maintenance of higher vigour index was recorded in treated seeds due to synergistic action of polymer and chemicals.

The hygroscopic nature of seed favours the water absorption and desorption under the influence of temperature and relative humidity of the air around it, thence resulting in constant fluctuations in the moisture content and test weight of seed. At the end of storage period, the lowest moisture content (%) was recorded in T_{10} - polymer + vitavax power (containing thiram 37.5% and carboxin, 37.5%) @ 2.0 g/kg of seed + imidacloprid (Gaucho) @ 4.0 ml/kg seed (10.83%), which was at par with T_9 - polymer + treat (tebuconazole) @ 1.0 g/kg seed + imidacloprid (Gaucho) @ 4.0 ml/kg seed (10.87%), while the highest moisture content was recorded in T_1 - control (11.97%). Seeds when exposed to a certain quantity of air humidity, they acquire a distinct and recognizable moisture content known as equilibrium moisture content (no net increase or decrease in seed moisture). As temperature decreases, the equilibrium moisture content of a certain type of seed at a given relative humidity tends to rise. Thus, relative humidity and, to a lesser extent, temperature have a role in maintaining the moisture content of seeds during storage. The pores in the seed coat are sealed when seeds are treated with polymer and chemicals, keeping water out and providing protection from physical injury. Similar results were obtained by Chaturvedi et al. (2021) in wheat and Divya (2022) in maize.

4. Conclusion

All the observed seed quality parameters showed reduction with the passage of the storage period. The seeds coated with polymer + vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg of seed (T_6) and vitavax power (containing thiram 37.5% and carboxin 37.5%) @ 2.0 g/kg seed (T_5) deteriorate at slower pace as manifested with higher seed longevity. The study stated that for maintaining seed longevity during storage, both these can be applied to maize seeds and be used for maize crop production. The combination of polymer and chemicals seed coating showed capability of maintaining germination above Indian Minimum Seed Certification Standards (IMSCS) and higher seed quality parameters over untreated control up to 24 months of storage.

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Conflict of Interest

Author declares that they have no conflict of interests.

Ethical Compliance Statement

NA

Author's Contribution

Conceptualization of research (SD, KCD, RK, RKK); Designing of the experiments (KCD, RK, RKK, SD); Contribution of experimental materials (KCD, SD, RK, RKK); Execution of field/lab experiments and data collection (SD, KCD, RK, RKK); Analysis of data and interpretation (KCD, RK, RKK, SD); Preparation of the manuscript (SD, KCD, RK, RKK).

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