



RESEARCH ARTICLE

# Effect of polymer coating and storage duration on groundnut (*Arachis hypogaea* L.) seed quality

Pallabi Pattanaik<sup>1\*</sup>, Simanta Mohanty<sup>1</sup>, Sabarinathan Selvaraj<sup>1,2</sup>, Devraj Lenka<sup>1,3</sup>, Kailash Chandra Samal<sup>4</sup> & Rajkumari Bhol<sup>5</sup>

<sup>1</sup>Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar 751 003, Odisha, India

<sup>2</sup>Department of Genetics and Plant Breeding & Seed Science and Technology, M.S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi 761 211, Odisha, India

<sup>3</sup>Department of Plant Breeding and Genetics, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar 751 003, Odisha, India

<sup>4</sup>College of Horticulture, Odisha University of Agriculture and Technology, Chiplima 768 025, Odisha, India

<sup>5</sup>Department of Plant Physiology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar 751 003, Odisha, India

\*Correspondence email - [pallabipattanaik65@gmail.com](mailto:pallabipattanaik65@gmail.com)

Received: 17 September 2025; Accepted: 25 June 2026; Available online: Version 1.0: 12 August 2026

**Cite this article:** Pallabi P, Simanta M, Sabarinathan S, Devraj L, Kailash CS, Rajkumari B. Effect of polymer coating and storage duration on groundnut (*Arachis hypogaea* L.) seed quality. Plant Science Today. 2026; 13(sp5): 1-8. <https://doi.org/10.14719/pst.11829>

## Abstract

Groundnut seeds are highly nutritious, with elevated oil and protein contents that accelerate deterioration during storage. This study evaluated the effects of storage duration on the moisture content and physiological parameters of polymer-coated groundnut seeds (cv. ICGV 91114, 'Devi'). The experiment was conducted in a completely randomised design (CRD) with 14 treatments and three replications. Seeds were coated with six polymers using a seed coating machine; hydroxypropyl cellulose, methyl cellulose, ethyl cellulose, isopropenyl acetate, polyvinyl pyrrolidone and Disco AG Red L-144 at two application rates (3 and 4 kg<sup>-1</sup> seed or 3 and 4 mL kg<sup>-1</sup> seed, depending on polymer), while uncoated kernels and pods served as controls. After coating, the seeds were packed in high-density polyethylene (HDPE) bags and stored under ambient conditions for 6 months. Moisture content and physiological traits were evaluated monthly. During the first month of storage, moisture content and physiological parameters showed no significant differences among treatments. However, with increased storage duration, moisture content gradually increased while physiological parameters declined. After 6 months of storage, moisture content increased from 6.00–8.04 % and germination declined from 100–66.00 % in the uncoated controls (T2), whereas polymer-coated seeds exhibited lower moisture accumulation and reduced deterioration. Uncoated seeds and pods exhibited higher moisture content and a greater reduction in germination and vigour by the end of the storage period. In contrast, polymer-coated seeds showed slower increases in moisture content and lower rates of decline in germination and vigour. Among all treatments, Disco AG Red L-144 (T13 and T14) and polyvinyl pyrrolidone (T11 and T12) performed best, maintaining the highest germination (87.58 %) and lowest moisture content (6.67 %) after 6 months of storage were recorded in T14 (Disco AG Red L-144 at 4 mL kg<sup>-1</sup> seed) followed by T13 (86.84 % germination and 6.97 % moisture content). These findings demonstrate that polymer coatings, particularly Disco AG Red L-144 and polyvinyl pyrrolidone, effectively reduce moisture uptake and preserve seed physiological quality during ambient storage, thereby improving groundnut seed storability.

**Keywords:** coating; groundnut; polymer; seed viability; seed vigour; storability

## Introduction

Groundnut (*Arachis hypogaea* L.) (peanut) is an important food and oilseed crop renowned for its high nutritional value. Its kernels are rich in protein (approximately 25 %), oil (45–50 %), carbohydrates (18 %), antioxidants, essential minerals and vitamins. The oil contains a high proportion of unsaturated fatty acids, including essential ones such as linoleic and linolenic acids (1). Groundnut is a major oilseed crop both nationally and within the state of Odisha, where it is predominantly cultivated during the rabi season, while its cultivation during the kharif season is comparatively limited. Rabi season groundnut seeds are generally bolder and of better quality than seeds produced during the kharif season. However, storing these seeds until the next rabi season is challenging because of the

high humidity and temperatures prevailing during the monsoon accelerate seed deterioration. Limited availability and delayed supply of quality kharif seeds often compel farmers to rely on their own saved seeds or procure seeds from other farmers or seed traders, that generally provide seed of inferior quality compared with certified market seed (2, 3). The use of such low-quality seeds adversely affects crop performance, especially under unfavourable weather conditions during sowing and crop establishment and ultimately contributes to low productivity of groundnut in the state. Thus, maintaining seed viability between harvest and the next cropping season remains a major constraint to groundnut production in humid tropical regions. Similar challenges in maintaining seed quality during storage have been reported

worldwide, particularly in oilseed crops, where high temperature and humidity accelerate seed deterioration and reduce seed longevity (4, 5).

Seed viability declines progressively with increasing storage duration. Groundnut seeds, when stored at ambient temperatures, lose their viability within a few months particularly in coastal regions where high humidity and temperatures prevail for much of the year leading to their classification and is therefore as classified as a species with poor storability. This vulnerability is largely due to their thin testa, which makes the seeds more susceptible to mechanical damage and results in reduced physiological quality and storability. Moisture content, storage temperature and relative humidity are the key factors influencing seed longevity. Because seeds are hygroscopic, they readily absorb moisture from humid storage environments, which accelerates metabolic activity and is a major cause of seed deterioration. The use of such deteriorated or low-quality seed ultimately leads to poor crop stands in the field and reduced productivity (6). Therefore, developing cost-effective methods to minimise seed moisture uptake and deterioration during storage is essential.

Common strategies to maintain seed viability during storage includes conditioned storage under low temperature and low humidity, as well as the use of vapour-proof packaging materials. However, the establishment and maintenance of conditioned storage facilities are costly and vapour-proof packaging are generally not feasible for groundnut seeds, which are considered a “high-volume, low-value” commodity. An alternative approach to minimising qualitative and quantitative caused by biotic and abiotic factors during storage, while simultaneously improve seed germination, vigour, storability and marketable value is the application of synthetic polymer coatings. Seed polymer coating is a seed treatment technique in which specific materials are applied to protect seeds from environmental stress and maintain safe moisture levels during storage (7). For a polymer coating to be effective, it should be easy to apply, form a thin uniform layer, restrict moisture entry in vapour form, diffuse readily into the soil upon contact with water and be non-toxic to seedlings. Additionally, it should be environmentally friendly to support the long-term health of the soil rhizosphere (8, 9).

Polymer seed coating facilitates precise application of chemicals, reduces chemical waste and ensures dust-free handling. This is achieved through the formation of a thin, uniform film on the seed surface, which enhances the adhesion of active ingredients and minimises their loss during handling and storage (9). It is also a cost-effective method for enhancing seed storability. An additional

advantage of polymer coating is that essential inputs such as nutrients, growth hormones, insecticides and fungicides can be incorporated into the seed coat, thereby improving germination, storability and field performance. In legumes, where seeds are prone to imbibitional injury, polymer coatings help by slowing down the imbibition process. The effectiveness of seed coating depends on both the seed's moisture content at the time of treatment and the materials used in the coating. Compared with conventional methods such as conditioned storage or vapour-proof packaging, polymer seed coating represents a practical alternative for improving seed storability (10, 11). However, comparative information on the performance of different polymer coatings and coating rates in maintaining moisture content and physiological quality of groundnut seeds during ambient storage is limited. Therefore, the present study aimed to evaluate the effects of different polymer coatings and storage duration on moisture content and physiological quality of groundnut seeds under ambient storage conditions. The study also sought to identify suitable polymer coatings for improving seed storability.

## Materials and Methods

### Experiment details

Freshly harvested groundnut seeds of cultivar ICGV 91114 ('Devi'), produced during the rabi 2021–22 and 2022–23 seasons, were procured from seed producers in May 2022 and May 2023. The storage experiments were conducted from May to November in both years (2022 and 2023) at the Dr. G. V. Chalam Seed Testing Research Laboratory and the Seed Physiology Laboratory, Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar. The initial seed moisture content prior to coating and storage was 6%.

Seeds were coated using a rotary seed-coating machine (Model ASR SCT 150, Manufacturer: A-Square, Ambala associates, India) using a seed-coating machine with six polymers; hydroxypropyl cellulose, methyl cellulose, ethyl cellulose, isopropenyl acetate, polyvinyl pyrrolidone and Disco AG Red L-144, each applied at two dose levels (Table 1). Prior to coating, seeds were cleaned and conditioned to uniform moisture content. The required quantity of polymer was diluted with distilled water and applied uniformly to the seeds using a rotary seed-coating machine. Coated seeds were shade-dried to attain their original moisture content before packaging and storage. After coating, seeds were stored under ambient conditions in high-density polyethylene (HDPE) bags (700 gauge). During the storage period, the mean temperature and relative humidity were 28.9 °C and 86.7 %, respectively, in 2022 and

**Table 1.** List of treatments used for seed polymer coating in groundnut

| Treatments | Polymers with doses                                          |
|------------|--------------------------------------------------------------|
| T1         | Uncoated pods (Control)                                      |
| T2         | Uncoated                                                     |
| T3         | Polymer coating with hydroxy propyl cellulose at 3 g/kg seed |
| T4         | Polymer coating with hydroxy propyl cellulose at 4 g/kg seed |
| T5         | Polymer coating with methyl cellulose at 3 g/kg seed         |
| T6         | Polymer coating with methyl cellulose at 4 g/kg seed         |
| T7         | Polymer coating with ethyl cellulose at 3 g/kg seed          |
| T8         | Polymer coating with ethyl cellulose at 4 g/kg seed          |
| T9         | Polymer coating with isopropenyl acetate at 3 mL/kg seed     |
| T10        | Polymer coating with isopropenyl acetate at 4 mL/kg seed     |
| T11        | Polymer coating with polyvinyl pyrrolidone at 3 g/kg seed    |
| T12        | Polymer coating with polyvinyl pyrrolidone at 4 g/kg seed    |
| T13        | Polymer coating with Disco AG Red L-144 at 3 mL/kg seed      |
| T14        | Polymer coating with Disco AG Red L-144 at 4 mL/kg seed      |

29.6 °C and 77.7 %, respectively in 2023. Two uncoated treatments were also included: one with pods (control) and the other with kernels, both stored under the same conditions. Moisture content and physiological parameters were assessed at monthly intervals throughout the storage period.

### Parameters observed

Observations were recorded at monthly intervals (0–6 months) during storage for 14 treatments over 2 years, with three replications each. The parameters recorded included moisture content (%) (12), germination percentage (%) (13), vigour indices (14) and mean seedling shoot length (cm), root length (cm) and dry weight (mg) (15). Seedling length and dry weight measurements were recorded from 10 normal seedlings per replication following the International Seed Testing Association (ISTA) procedures. Seed vigour index-I was calculated as germination (%) × seedling length (cm), whereas seed vigour index-II was calculated as germination (%) × seedling dry weight (mg).

### Statistical analysis

The experiment was conducted in a completely randomised design (CRD) with 14 treatments and three replications and observations were recorded repeatedly over seven storage periods (0–6 months). Data were analysed using repeated-measures analysis of variance (RMANOVA) with the “rstatix” package in R (version 4.4.2). The effects of treatment, storage duration and their interaction were evaluated using RMANOVA. Treatment means were compared using the critical difference (CD) test at the 5 % level of significance ( $P \leq 0.05$ ). Statistical analyses were performed separately for each storage interval and on pooled data across years. Correlation analysis was performed using the “corrplot” package and principal component analysis (PCA) was carried out with the “FactoMineR” and “factoextra” packages in R.

## Results and Discussion

### Effect of storage duration on moisture content and physiological quality

At the start of storage (0 months), all treatments exhibited comparable moisture content and high physiological quality. Differences among treatments became evident with increasing storage duration, as polymer-coated seeds showed a slower rate of moisture uptake and deterioration than the controls. As the storage period increased from 0–6 months, moisture content rose gradually

across all treatments, with a markedly higher increase in the control seeds. Most changes occurred during the first 1–3 months of storage, after which the rate of increase slowed between 4 and 6 months. The slower rate of moisture increases after 3–4 months may be attributed to the attainment of equilibrium moisture content between the seeds and the surrounding storage environment. In polymer-coated seeds, the semi-permeable coating layer may have further restricted moisture exchange, contributing to greater stability during the later stages of storage. A concomitant decline in physiological quality particularly germination percentage, seedling length and vigour indices was observed over the storage period. However, at 6 months of storage, polymer-coated seeds retained significantly higher physiological quality and lower moisture content compared to the control seeds. After 6 months of storage, moisture content increased from 6.00–8.04 % in the uncoated controls, whereas polymer-coated treatments maintained lower moisture contents ranging from 6.67–7.10 %. Similarly, germination declined from 100–66.00 % in the controls but remained above 86.84 % in the best-performing treatments, namely Disco AG Red L-144 and polyvinyl pyrrolidone. Overall, similar trends were observed in both years. Moisture content increased progressively with storage duration, while germination, seedling growth and vigour parameters declined. However, polymer-coated seeds consistently maintained lower moisture content and higher physiological quality than the controls throughout the storage period, indicating consistent treatment effects across both years.

The effects of treatments, storage duration and their interaction were evaluated for seven traits: moisture content, germination percentage, shoot length, root length, seed vigour index I, seedling dry weight and seed vigour index II. Both treatments and storage duration had significant effects ( $p < 0.05$ ) on these traits in both seasons, whereas the interaction between treatments and storage duration was not significant. Month-to-month effects were significant for all traits except shoot length and root length. Most interaction effects were non-significant (Table 2). Seed quality during storage is influenced by multiple factors, of which storage duration is the most critical, as it directly affects seed viability and vigour. In the present study, as storage progressed, seed moisture content gradually increased, which was accompanied by a reduction in germination percentage, in agreement with earlier findings, which reported similar declines in germination and seed vigour in groundnut seeds stored under high-humidity conditions (16). This decline may be attributed to increased seed respiration, membrane

**Table 2.** Repeated measure analysis of variance (RMANOVA) for treatments, months and their interactions

| Traits                   | Treatments<br>(DF = 13) | Months<br>(DF = 6) | Treatments: Months<br>(DF = 78) |
|--------------------------|-------------------------|--------------------|---------------------------------|
| <b>Year: 2022</b>        |                         |                    |                                 |
| Moisture content (%)     | 0.000***                | 0.000***           | 1.000                           |
| Germination (%)          | 0.000***                | 0.000***           | 0.199                           |
| Shoot length (cm)        | 0.000**                 | 0.858              | 1.000                           |
| Root length (cm)         | 0.000**                 | 0.837              | 1.000                           |
| Seed vigour index-I      | 0.000***                | 0.001*             | 1.000                           |
| Seedling dry weight (mg) | 0.000***                | 0.000**            | 0.958                           |
| Seed vigour index-II     | 0.000***                | 0.000***           | 0.940                           |
| <b>Year: 2023</b>        |                         |                    |                                 |
| Moisture content (%)     | 0.000***                | 0.000***           | 1.000                           |
| Germination (%)          | 0.000***                | 0.000***           | 0.078                           |
| Shoot length (cm)        | 0.000***                | 0.850              | 1.000                           |
| Root length (cm)         | 0.000***                | 0.914              | 1.000                           |
| Seed vigour index-I      | 0.000***                | 0.003*             | 1.000                           |
| Seedling dry weight (mg) | 0.000*                  | 0.000*             | 0.098                           |
| Seed vigour index-II     | 0.000***                | 0.000***           | 0.563                           |

\* Significant at  $p \leq 0.05$ ; \* Significant at  $p \leq 0.01$ .

deterioration, lipid peroxidation and oxidative damage associated with higher seed moisture content during storage. Elevated moisture levels accelerate metabolic activity and seed ageing, resulting in loss of viability and vigour. These findings support the established theory of seed deterioration, whereby increased seed moisture accelerates metabolic and oxidative processes, leading to membrane damage, reduced germination and loss of seed vigour during storage (4, 5).

Seed quality progressively deteriorates during storage and physiological traits such as germination, root length, shoot length and vigour are highly sensitive to storage duration. Storage duration significantly influenced seed physiological quality in both seasons, resulting in progressive declines in germination, seedling growth and vigour traits. In both seasons of the present study, as storage duration increased from 0–6 months, moisture content rose steadily. Changes in seed physiological traits over time were statistically significant ( $p \leq 0.05$ ) (Table 3). Germination percentage declined markedly with increasing storage duration. Shoot and root lengths remained relatively stable during the initial months but decreased after 3–4 months, with root length showing greater sensitivity and a more rapid decline than shoot length. Although shoot length and seed vigour index-I showed a declining trend with increasing storage duration, the differences were not statistically significant ( $p > 0.05$ ) in either year. In contrast, germination percentage, root length, seedling dry weight and seed vigour index-II were significantly affected ( $p \leq 0.05$ ) by storage duration (Table 3). Groundnut seeds are known to be susceptible to various forms of deterioration during storage. For example, groundnut kernels of varieties Homabay Local, Valencia Red, ICGV-SM 12991 and ICGV-SM 99568, stored for 6

months in jute and polythene bags experienced physiological damage, including reductions in germination rate and vigour of up to 9.89 % and rancidity of 1.9–2.1 %. In that study, seeds stored in jute bags had 5.9 % moisture content at 19 °C and 64 % relative humidity, while seeds stored in polythene bags had 5.0 % moisture content at the same temperature and humidity (17).

Pairwise comparisons of seed physiological parameters between storage durations (0–6 months) were conducted using pairwise t-tests at a 95 % confidence level ( $\alpha = 0.05$ ), with significance levels indicated by asterisks (Table 4). Differences were considered significant at  $P \leq 0.05$  and highly significant at  $P \leq 0.01$ . Moisture content and germination percentage changed significantly among most storage periods in both years. For shoot length, significant differences were observed in several comparisons specifically 1<sup>st</sup> month with 3<sup>rd</sup>–5<sup>th</sup> months and 2<sup>nd</sup> month with 3<sup>rd</sup>–5<sup>th</sup> months during the storage of year 2022, while significance was also evident in the year 2023 season. Similarly, root length showed significant differences across most pairwise comparisons in both years. Vigour index values exhibited significant changes with increasing storage duration, particularly in comparisons between 0 month and 3<sup>rd</sup> month or longer. Seedling dry weight also showed significant differences across many pairwise comparisons. Notably, even between the first and second months of storage, several traits exhibited statistically significant changes in both years, with germination percentage, vigour indices and seedling dry weight showing the most pronounced declines. These results indicate that even a 1 month extension in storage can significantly reduce seed physiological quality.

**Table 3.** Effects of storage period on seed moisture content and physiological parameters at each month after storage

| Storage period (Months) | Moisture content (%) |       | Germination (%) |         | Shoot length (cm) |       | Root length (cm) |       | Seed vigour index-I |        | Seedling dry weight (mg) |         | Seed vigour index-II |         |
|-------------------------|----------------------|-------|-----------------|---------|-------------------|-------|------------------|-------|---------------------|--------|--------------------------|---------|----------------------|---------|
|                         | 2022                 | 2023  | 2022            | 2023    | 2022              | 2023  | 2022             | 2023  | 2022                | 2023   | 2022                     | 2023    | 2022                 | 2023    |
| 0                       | 1.000                | 1.000 | 0.000**         | 0.288   | 0.902             | 0.543 | 0.954            | 0.873 | 0.608               | 0.709  | 0.000**                  | 0.000** | 0.000**              | 0.002*  |
| 1                       | 0.937                | 0.980 | 0.000**         | 0.157   | 0.931             | 0.495 | 0.939            | 0.830 | 0.720               | 0.619  | 0.000**                  | 0.000** | 0.000**              | 0.001*  |
| 2                       | 0.882                | 0.896 | 0.023*          | 0.022*  | 0.887             | 0.459 | 0.93             | 0.520 | 0.782               | 0.383  | 0.000**                  | 0.000** | 0.000**              | 0.000** |
| 3                       | 0.818                | 0.685 | 0.002*          | 0.011*  | 0.888             | 0.346 | 0.86             | 0.571 | 0.657               | 0.305  | 0.000**                  | 0.000** | 0.000**              | 0.000** |
| 4                       | 0.579                | 0.574 | 0.000**         | 0.007*  | 0.868             | 0.252 | 0.805            | 0.496 | 0.548               | 0.236  | 0.000**                  | 0.000** | 0.000**              | 0.000** |
| 5                       | 0.349                | 0.179 | 0.000**         | 0.000** | 0.860             | 0.212 | 0.705            | 0.371 | 0.349               | 0.070  | 0.000**                  | 0.000** | 0.000**              | 0.000** |
| 6                       | 0.018*               | 0.134 | 0.000**         | 0.000** | 0.711             | 0.133 | 0.637            | 0.245 | 0.147               | 0.019* | 0.000**                  | 0.000** | 0.000**              | 0.000** |

\* Significant at  $p \leq 0.05$ ; \* Significant at  $p \leq 0.01$ .

**Table 4.** Pairwise t-test comparison between 0–6 months after storage

| Group 1 | Group 2 | Moisture content (%) |         | Germination (%) |         | Shoot length (cm) |        | Root length (cm) |        | Seed vigour index-I |         | Seedling dry weight (mg) |        | Seed vigour index-II |        |
|---------|---------|----------------------|---------|-----------------|---------|-------------------|--------|------------------|--------|---------------------|---------|--------------------------|--------|----------------------|--------|
|         |         | 2022                 | 2023    | 2022            | 2023    | 2022              | 2023   | 2022             | 2023   | 2022                | 2023    | 2022                     | 2023   | 2022                 | 2023   |
| 0M      | 1M      | 0.003*               | 0.008*  | 1.000           | 0.006*  | 0.338             | 0.012* | 0.049*           | 0.456* | 0.535               | 0.007   | 0.332                    | 0.231  | 0.451                | 0.035* |
| 0M      | 2M      | 0.007*               | 0.001*  | 0.000**         | 0.001*  | 0.163             | 0.017* | 0.040*           | 0.035* | 0.000**             | 0.002   | 0.207                    | 0.359  | 0.008*               | 0.055  |
| 0M      | 3M      | 0.001*               | 0.002*  | 0.000**         | 0.000** | 0.076             | 0.016* | 0.035*           | 0.077  | 0.001*              | 0.000** | 0.267                    | 0.203  | 0.013*               | 0.011* |
| 0M      | 4M      | 0.001*               | 0.002*  | 0.000**         | 0.000** | 0.087             | 0.017* | 0.032*           | 0.063  | 0.000**             | 0.000** | 0.099                    | 0.260  | 0.003*               | 0.007* |
| 0M      | 5M      | 0.002*               | 0.002*  | 0.000**         | 0.000** | 0.038             | 0.016* | 0.041*           | 0.059  | 0.000**             | 0.000** | 0.060                    | 0.151  | 0.000**              | 0.003* |
| 0M      | 6M      | 0.002*               | 0.002*  | 0.000**         | 0.000** | 0.088             | 0.017* | 0.043*           | 0.058  | 0.000**             | 0.000** | 0.082                    | 0.160  | 0.000**              | 0.004* |
| 1M      | 2M      | 0.046*               | 0.000** | 0.000**         | 0.001*  | 0.056             | 0.024* | 1.000            | 0.523  | 0.000**             | 0.003*  | 0.296                    | 0.771  | 0.000**              | 0.166  |
| 1M      | 3M      | 0.002*               | 0.001*  | 0.000**         | 0.000** | 0.022*            | 0.018* | 0.030*           | 0.041* | 0.000**             | 0.000** | 0.370                    | 0.220  | 0.003*               | 0.009* |
| 1M      | 4M      | 0.002*               | 0.002*  | 0.000**         | 0.000** | 0.043*            | 0.019* | 0.028*           | 0.039* | 0.000**             | 0.000** | 0.069                    | 0.281  | 0.000**              | 0.006* |
| 1M      | 5M      | 0.002*               | 0.002*  | 0.000**         | 0.000** | 0.015*            | 0.017* | 0.039*           | 0.042* | 0.000**             | 0.000** | 0.032*                   | 0.149  | 0.000**              | 0.002* |
| 1M      | 6M      | 0.002*               | 0.002*  | 0.000**         | 0.000** | 0.059             | 0.018* | 0.042*           | 0.044* | 0.000**             | 0.000** | 0.055                    | 0.156  | 0.000**              | 0.003* |
| 2M      | 3M      | 0.418                | 0.007*  | 0.000**         | 0.000** | 0.007*            | 0.014* | 0.953            | 1.000  | 0.012*              | 0.001*  | 0.477                    | 0.265  | 0.033*               | 0.002* |
| 2M      | 4M      | 0.024*               | 0.004*  | 0.000**         | 0.000** | 0.038*            | 0.018* | 0.336            | 1.000  | 0.001*              | 0.000** | 0.040*                   | 0.307  | 0.001*               | 0.002* |
| 2M      | 5M      | 0.009*               | 0.004*  | 0.000**         | 0.000** | 0.009*            | 0.015* | 0.235            | 1.000  | 0.000**             | 0.000** | 0.021*                   | 0.554  | 0.000**              | 0.002* |
| 2M      | 6M      | 0.006*               | 0.004*  | 0.000**         | 0.000** | 0.060             | 0.017* | 0.170            | 0.785  | 0.000**             | 0.000** | 0.054                    | 0.158  | 0.000**              | 0.002* |
| 3M      | 4M      | 0.002*               | 0.003*  | 0.000**         | 0.000** | 0.128             | 0.023* | 0.025*           | 0.038* | 0.000**             | 0.000** | 0.005*                   | 0.487  | 0.000**              | 0.005* |
| 3M      | 5M      | 0.002*               | 0.003*  | 0.000**         | 0.000** | 0.010*            | 0.016* | 0.050*           | 0.044* | 0.000**             | 0.000** | 0.012*                   | 1.000  | 0.000**              | 0.004* |
| 3M      | 6M      | 0.003*               | 0.004*  | 0.000**         | 0.000** | 0.101             | 0.019* | 0.052            | 0.047* | 0.000**             | 0.000** | 0.047*                   | 0.147  | 0.000**              | 0.002* |
| 4M      | 5M      | 0.003*               | 0.004*  | 0.000**         | 0.014*  | 0.000*            | 0.01*  | 0.098*           | 0.051* | 0.000**             | 0.003*  | 0.036*                   | 1.000  | 0.000**              | 1.000  |
| 4M      | 6M      | 0.003*               | 0.004*  | 0.000**         | 0.011*  | 0.090             | 0.017* | 0.075*           | 0.053  | 0.000**             | 0.001*  | 0.118                    | 0.033* | 0.000**              | 0.002* |
| 5M      | 6M      | 0.003*               | 0.006*  | 0.000**         | 0.018*  | 0.762             | 0.027* | 0.060            | 0.056  | 0.000**             | 0.002*  | 0.307                    | 1.000  | 0.001*               | 0.167  |

\* Significant at  $p \leq 0.05$ ; \* Significant at  $p \leq 0.01$ .

## Effect of polymer coatings on seed quality during storage

A greater decline in seed quality was observed in untreated kernels (T2) and pods (T1), whereas polymer-coated seeds (T3–T14) showed a much lower rate of deterioration. Polymer coatings acted as semi-permeable barriers that reduce moisture exchange between the seed and the surrounding environment, thereby slowing respiration, lipid peroxidation, membrane deterioration and other metabolic processes associated with seed ageing and deterioration (8, 9, 11). The superior performance of Disco AG Red L-144 and polyvinyl pyrrolidone may be attributed to their effective film-forming properties, which create a more stable semi-permeable barrier around the seed surface and reduce moisture ingress during storage. Consequently, during the 0–6 months storage period, moisture content increased more slowly in treated seeds than in the control, enabling them to maintain superior physiological quality after 6 months of storage. All polymer-coated treatments outperformed the untreated controls after 6 months of storage.

Significant differences were observed between the controls (uncoated pods and kernels) and all polymer-coated treatments (Fig. 1). Germination percentage (%), seedling dry weight, seedling vigour index I and seedling vigour index II were significantly higher in seeds coated with Disco AG Red L-144 (T14, T13) and polyvinyl pyrrolidone (T11, T12), while the lowest values were recorded in the controls (T1 and T2). Moisture content increased gradually from 3–6 months of storage, but it was consistently higher in uncoated pods (T1) and kernels (T2) compared with all polymer-coated treatments. The lowest moisture content after 6 months was recorded in seeds coated with Disco AG Red L-144 (T14, T13) and polyvinyl pyrrolidone (T11, T12), while other polymer treatments also maintained lower moisture content than the controls. The clear separation between untreated controls (T1 and T2) and polymer-coated treatments observed in Fig. 1 further confirms the protective role of polymer coatings in preserving seed quality during ambient storage. After 6

months of storage, moisture content increased from 6.00–8.04 % in the untreated controls, whereas it remained between 6.67 % and 7.10 % in Disco AG Red L-144 (T13 and T14) and polyvinyl pyrrolidone (T11 and T12) coated seeds. Similarly, germination percentage declined from 100–66.00 % in the controls but remained above 86.84 % in the best-performing polymer treatments. These treatments also maintained higher seed vigour indices and other physiological quality parameters, indicating their effectiveness in reducing seed deterioration during storage under ambient conditions (Fig. 1).

## Comparison with previous studies

Groundnut seeds coated with polyvinyl chloride (PVC) microplastics at four dosages (0.5, 1.5, 2.5 and 3.5 %) were studied for their effects on growth, development and nitrogen (N) uptake. As a legume, groundnut forms symbiotic associations with N fixing root nodules and in this study PVC coating induced oxidative stress, resulting in increased activities of hydrogen peroxide (54.3 %), proline (72.93 %), superoxide dismutase (135.74 %), peroxidase (41.59 %) and ascorbate peroxidase (44.59 %), along with enhanced plant growth, plant height (19.52 %), plant dry weight (46.09 %), leaf number (18.86 %) and branch length (59.37 %) compared to the control (18). Similarly, coated groundnut and black gram seeds with polyvinyl alcohol resulted in higher germination rates of 88 % and 86 %, respectively (19). Coated sunflower hybrid variety KBSH-53 seeds with polykote increased germination to 92.45 % (20). Soybean seeds (cv. JS-335) coated with a combination of polymer (Disco AG SO Red L-200), fungicides (thiram and carboxin) and bioagents (mycorrhiza) and stored for 12 months exhibited higher vigour (21). Consistent with these findings, Cowpea seeds (variety Utkal Manika) treated with 12 polymers including methyl cellulose, ethyl cellulose, polyvinyl pyrrolidone, hydroxypropyl cellulose and methyl vinyl acetate at two doses (3 and 4 mL kg<sup>-1</sup>) and stored under ambient conditions for 6 months had significantly reduced moisture

|         |           | MC       | GER      | SL      | RL      | SVI      | SDW      | SVII     |
|---------|-----------|----------|----------|---------|---------|----------|----------|----------|
| 2022-23 | T1 vs T11 | 0.026*   | 0.000*** | 0.216   | 0.294   | 0.051    | 0.000*** | 0.000*** |
|         | T2 vs T11 | 0.001**  | 0.000*** | 0.106   | 0.150   | 0.021*   | 0.000*** | 0.000*** |
|         | T1 vs T12 | 0.052    | 0.000*** | 0.113   | 0.156   | 0.021*   | 0.000*** | 0.000*** |
|         | T2 vs T12 | 0.003**  | 0.000*** | 0.051   | 0.072   | 0.008**  | 0.000*** | 0.000*** |
|         | T1 vs T13 | 0.037*   | 0.000*** | 0.214   | 0.148   | 0.027*   | 0.000*** | 0.000*** |
|         | T2 vs T13 | 0.002**  | 0.000*** | 0.104   | 0.068   | 0.011*   | 0.000*** | 0.000*** |
|         | T1 vs T14 | 0.009**  | 0.000*** | 0.108   | 0.058   | 0.009**  | 0.000*** | 0.000*** |
|         | T2 vs T14 | 0.000*** | 0.000*** | 0.048*  | 0.024*  | 0.003**  | 0.000*** | 0.000*** |
| 2023-24 | T1 vs T11 | 0.081    | 0.000*** | 0.049*  | 0.057   | 0.010**  | 0.000*** | 0.000*** |
|         | T2 vs T11 | 0.009**  | 0.000*** | 0.026*  | 0.027*  | 0.003**  | 0.000*** | 0.000*** |
|         | T1 vs T12 | 0.127    | 0.000*** | 0.036*  | 0.042*  | 0.006**  | 0.000*** | 0.000*** |
|         | T2 vs T12 | 0.016*   | 0.000*** | 0.019*  | 0.020*  | 0.002**  | 0.000*** | 0.000*** |
|         | T1 vs T13 | 0.043*   | 0.000*** | 0.011*  | 0.022*  | 0.002**  | 0.000*** | 0.000*** |
|         | T2 vs T13 | 0.004**  | 0.000*** | 0.006** | 0.010** | 0.001*** | 0.000*** | 0.000*** |
|         | T1 vs T14 | 0.037*   | 0.000*** | 0.010** | 0.020*  | 0.002**  | 0.000*** | 0.000*** |
|         | T2 vs T14 | 0.004**  | 0.000*** | 0.005** | 0.009** | 0.001*** | 0.000*** | 0.000*** |

**Fig. 1.** Effect of polymer coating on seed moisture content and other physiological parameters of groundnut seeds, in case of control (T2 and T1) and polymer coated treatments (T14, T13, T12 and T11) after 6 months of storage.

MC: moisture content; GER: germination (%); SL: seedling length; RL: root length; SVI: seed vigour index-I; SDW: seedling dry weight; SVII: seed vigour index-II.

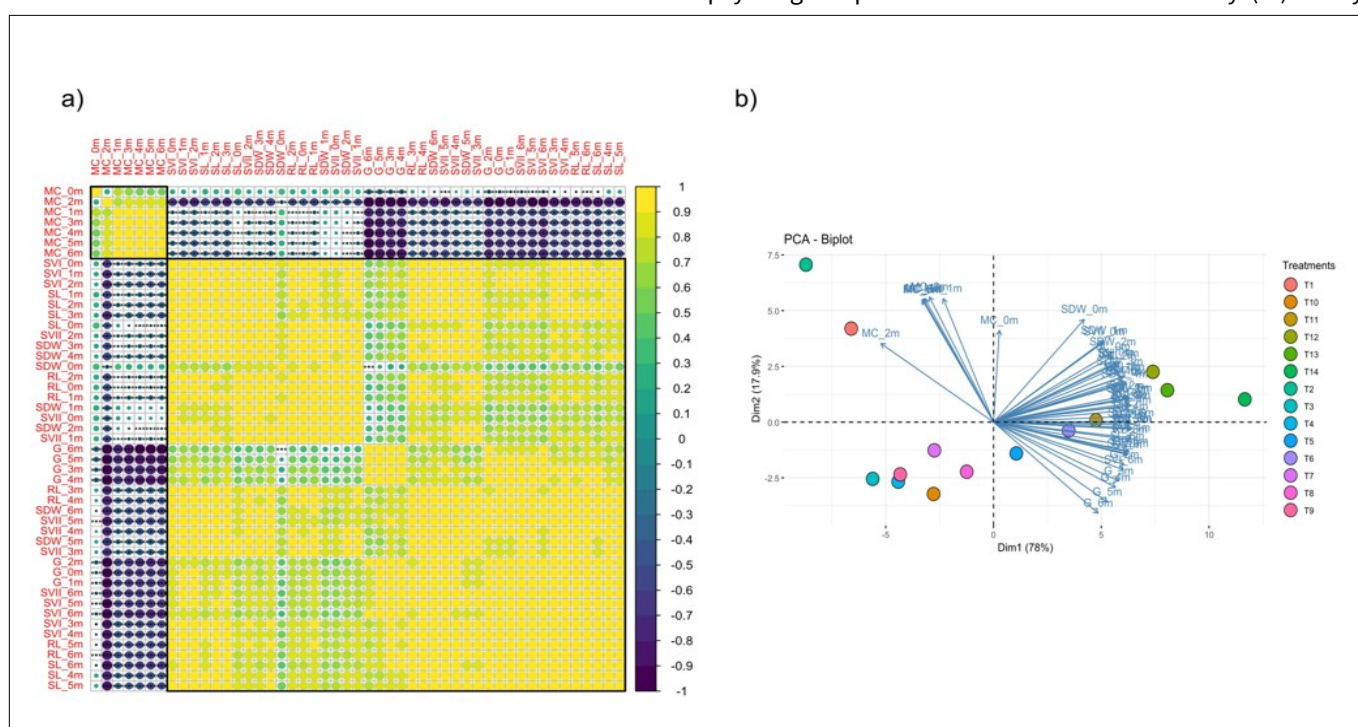
absorption and higher germination (up to 80.50 %) and vigour indices compared with untreated seeds (72 % germination). Among all treatments, polyvinyl pyrrolidone and methyl cellulose at 4 mL kg<sup>-1</sup> recorded the best results (22). The present findings are therefore in close agreement with earlier reports in soybean, sunflower, cowpea and black gram, indicating that polymer seed coatings improve storability maintaining seed physiological quality and slowing physiological deterioration during storage (10, 20, 22, 23).

### Correlation analysis

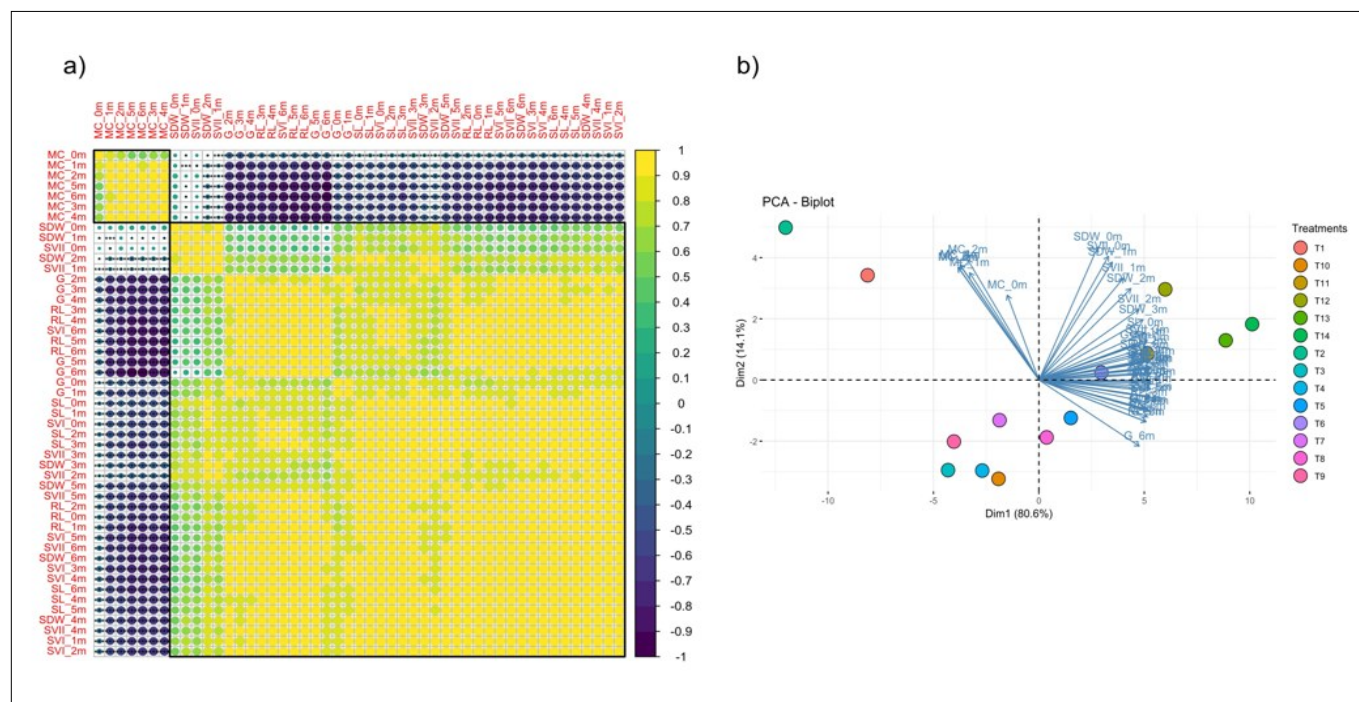
Correlation analysis was conducted for moisture content and physiological traits (germination %, shoot length, root length, seedling dry weight and vigour indexes) recorded from 0–6 months after storage. The correlation matrix was reordered using a hierarchical clustering algorithm, which revealed that formation of two major clusters across both seasons (Fig. 2). The first cluster consisted of moisture content traits only, which showed a negative correlation with all other traits, except moisture content at 0 month storage in 1<sup>st</sup> season (2022) and a consistently negative correlation with all traits in 2<sup>nd</sup> season (2023). The second cluster comprised of germination percentage, seedling length, root length, seedling dry weight, seedling vigour index I and seedling vigour index II, all of which were positively correlated with one another in both seasons. These relationships indicate that higher seed moisture content is generally associated with reduced performance of the other traits, while the remaining parameters exhibit strong positive interdependence. Overall, similar correlation patterns were observed in both 2022 and 2023, indicating that increased seed moisture content was consistently associated with reduced germination, seedling growth and vigour. This negative association may be attributed to enhanced metabolic activity, membrane deterioration, lipid peroxidation and accelerated seed ageing under higher moisture conditions, which collectively impair seed physiological quality during storage (6, 10, 17).

### Principal component analysis (PCA)

In the first season (2022), the first two principal components (PC1 and PC2) explained 95.9 % of the total variance (PC1 = 78 %, PC2 = 17.9 %) (Fig. 2). Moisture content traits were oriented to the left side of the biplot, clearly separated from the other traits and showed negative associations with most of the traits except MC at 0 MS. In contrast, germination percentage, seedling length, root length, seedling dry weight, seedling vigour index I and seedling vigour index II clustered on the right side, indicating strong positive correlations among them across storage periods. Treatments T1 and T2 were positioned near the MC traits, suggesting higher seed moisture content and consequently lower germination and vigour. Conversely, treatments T12, T13 and T14 aligned closely with vigour-related traits, indicating superior performance under storage conditions. In 2<sup>nd</sup> season (2023), PC1 and PC2 explained 94.7 % of the total variance (PC1 = 80.6 %, PC2 = 14.1 %) (Fig. 2, 3). Moisture content traits were oriented to the left side of the biplot, distinctly separated from the other traits and showed negative associations with all traits. Similar to the previous first season (2022), remaining traits clustered together on the right side, reflecting strong positive correlations across storage periods. Treatments T1 and T2 were positioned near the MC traits, suggesting higher seed moisture content reduce vigour, whereas treatments T11, T12, T13 and T14 aligned with vigour-related traits, indicating better performance under storage conditions. Overall, PCA revealed highly consistent patterns across both years, with the first two principal components explaining 95.9 % and 94.7 % of the total variation in 2022 and 2023, respectively. Moisture content was negatively associated with germination, seedling growth and vigour traits, whereas Disco AG Red L-144 and polyvinyl pyrrolidone-coated treatments clustered with desirable physiological attributes. These results confirm the effectiveness of polymer coatings in maintaining seed quality during ambient storage. Moisture content of polymer coated soybean seeds under storage, resulted negative significant correlation with all the physiological qualities that is, germination (%), seedling length and vigour index. These polymers were useful in improving the physiological qualities of seeds and their storability (20). A key



**Fig. 2.** Correlation and principal component analysis of year 2022.



**Fig. 3.** Correlation and principal component analysis of year 2023.

novelty of this study is the comparative evaluation of 6 polymer coatings and the identification of Disco AG Red L-144 and polyvinyl pyrrolidone as superior treatments for maintaining groundnut seed quality during storage.

## Conclusion

Polymer-coated groundnut seeds maintained significantly higher germination and vigour, along with lower moisture accumulation during storage compared with untreated controls, demonstrating the effectiveness of polymer coatings in preserving seed quality under ambient conditions. Among the polymers evaluated, Disco AG Red L-144 and polyvinyl pyrrolidone consistently exhibited superior performance, indicating their potential for practical use in groundnut seed storage and seed production systems. However, the present study was conducted under ambient storage conditions for a 6-month period; therefore, further validation under diverse environments and longer storage durations is required before large-scale recommendation. Future research should evaluate the performance of polymer coatings under diverse climatic conditions and varying seed moisture levels, as well as explore their integration with bio-agents and other seed enhancement technologies to further improve seed storability and quality. The applicability of these coatings across different oilseed and crop species also warrants investigation.

## Acknowledgements

The authors are thankful to the Department of Seed Science and Technology, College of Agriculture, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar for providing the scope and opportunity for conducting the research. The facilities and support provided by OUAT, Bhubaneswar are gratefully acknowledged.

## Authors' contributions

Conceptualisation was done by SM. Material preparation,

conduction of experiment and data collection were performed by PP and SM. Data analysis was done by SS and PP. The manuscript was prepared by PP and edited by SS and SM. DL, KCS and RB contributed to the result's interpretation and offered criticism. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interests to declare.

**Ethical issues:** None

## References

- Anyasor GN, Ogunwenmo KO, Oyelana OA, Ajayi D, Dangana J. Chemical analysis of groundnut (*Arachis hypogaea*). *Pak J Nutr.* 2009;8(3):269–72. <https://doi.org/10.3923/pjn.2009.269.272>
- Shasani S, Banerjee PK, De HK, Panda S. Constraints in adoption of groundnut cultivation technology by the farmers of Odisha. *Indian J Ext Educ.* 2020;56(2):39–44.
- Mishra S, Atibudhi HN, Mishra RK, Swain D. Production dynamics of groundnut in Odisha. *Econ Aff.* 2024;69(4):1653–63.
- Kameswara Rao N, Dulloo ME, Engels JMM. A review of factors that influence the production of quality seed for long-term conservation in genebanks. *Genet Resour Crop Evol.* 2017;64(5):1061–74. <https://doi.org/10.1007/s10722-016-0425-9>
- Wang W, He A, Peng S, Huang J, Cui K, Nie L. The effect of storage condition and duration on the deterioration of primed rice seeds. *Front Plant Sci.* 2018;9:172. <https://doi.org/10.3389/fpls.2018.00172>
- Manik A, Amaregouda A, Meena MK, Dhanoji MM, Shakuntala NM, Khan H. Effect of storage environment and packaging materials in groundnut seeds (*Arachis hypogaea* L.). *Biol Forum.* 2023;15(10):152–8.
- Zhang K, Khan Z, Yu Q, Qu Z, Liu J, Luo T, et al. Biochar coating is a sustainable and economical approach to promote seed coating technology, seed germination, plant performance and soil health. *Plants.* 2022;11(21):2864. <https://doi.org/10.3390/plants11212864>
- Lawrencia D, Wong SK, Low DYS, Goh BH, Goh JK, Ruktanonchai

- UR, et al. Controlled release fertilizers: a review on coating materials and mechanism of release. *Plants*. 2021;10:238–63. <https://doi.org/10.3390/plants10020238>
9. Mallick S, Mohanty S, Das S, Beura JK, Jyothi GBN. Effect of polymer coating on seed quality during storage of groundnut seeds. *Pharma Innov J*. 2022;11(11):1396–401.
  10. Ramya D, Sujatha P, Raghavendra K, Keshavulu K, Ramesh T. Antioxidants and polymer coating for soybean (*Glycine max* (L.) Merr.) seed longevity enhancement. *Ind Crops Prod*. 2024;210:118083. <https://doi.org/10.1016/j.indcrop.2024.118083>
  11. Mishra SN, Shraddha S, Para PK, Sharma L, Bhandari VVS. A review: combination of fungicide, polymer coating and packaging materials to improve germination rate and uniformity of seedling emergence of different seeds during storage. *Int J Environ Clim Change*. 2023;13(8):2142–57. <https://doi.org/10.9734/ijecc/2023/v13i82173>
  12. International Seed Testing Association. Grinding in ISTA moisture testing. Bassersdorf (Switzerland): ISTA; 2008–09.
  13. International Seed Testing Association. International rules for seed testing. Wallisellen (Switzerland): ISTA; 2023.
  14. Abdul Baki AA anderson JD. Vigor determination in soybean seed by multiple criteria. *Crop Sci*. 1973;13:630–3. <https://doi.org/10.2135/cropsci1973.0011183X001300060013x>
  15. Kumar V, Poonia RC, Chaudhary K. Assessment of the seed vigour potential in different varieties of wheat. *Int J Curr Microbiol Appl Sci*. 2018;7(7):354–61. <https://doi.org/10.20546/ijcmas.2018.707.043>
  16. Fagbohun ED, Faleye OS. The nutritional and mycoflora changes during storage of groundnut (*Arachis hypogaea*). *Int J Agron Agric Res*. 2012;2(6):15–22.
  17. Mutegi CK, Wagacha JM, Christie ME, Kimani J, Karanja L. Effect of storage conditions on quality and aflatoxin contamination of peanuts (*Arachis hypogaea* L.). *Int J Agric Sci*. 2013;3(10):746–58. <https://doi.org/10.5539/ijf.v2n5p10>
  18. Shanker U, Chaithra H, Kartik R, Venkatesan SP. Inhibition of peanut (*Arachis hypogaea* L.) growth, development and promotion of root nodulation including plant nitrogen uptake triggered by polyvinyl chloride microplastics. *ACS Omega*. 2025;10(18):18668–81.
  19. Raja K, Prabhu C, Subramanian KS, Govindaraju K. Electrospun polyvinyl alcohol (PVA) nanofibers as carriers for hormones (IAA and GA3) delivery in seed invigoration for enhancing germination and seedling vigour of agricultural crops (groundnut and black gram). *Spinzer*. 2020;78(5):1–12. <https://doi.org/10.1007/s00289-020-03435-6>
  20. Kumar V, Lokesh GY, Gowda B, Ganiger BS, Mathad RC. Enhancing the seed longevity of hybrid sunflower (KBSH-53) by coating with synthetic polymer additives. *Int J Pure Appl Biosci*. 2017;5(3):964–8. <https://doi.org/10.18782/2320-7051.2759>
  21. Hilli JKS, Malik R, Vijayakumar AV, Hunje R. Effect of seed coating polymers on performance in soybean (*Glycine max* L.) var. JS335. *Int J Plant Sci*. 2021;16(1):52–8. <https://doi.org/10.15740/HAS/IJPS/16.1/52-58>
  22. Samal A, Mohanty S, Das S, Das BC, Beura JK. Polymer coating of cowpea seeds (*Vigna unguiculata*) for improving its storability and performance. *Pharma Innov J*. 2021;10(9):592–7.
  23. Kumar J, Nisar K, Kumar J, Nisar K, Kumar MBA, Walla S, et al. Development of polymeric seed coats for seed quality enhancement of soybean *Glycine max*. *Indian J Agric Sci*. 2011;77(11).

#### Additional information

**Peer review:** Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

**Reprints & permissions information** is available at [https://horizonpublishing.com/journals/index.php/PST/open\\_access\\_policy](https://horizonpublishing.com/journals/index.php/PST/open_access_policy)

**Publisher's Note:** Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Indexing:** Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc. See [https://horizonpublishing.com/journals/index.php/PST/indexing\\_abstracting](https://horizonpublishing.com/journals/index.php/PST/indexing_abstracting)

**Copyright:** © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (<https://creativecommons.org/licenses/by/4.0/>)

**Publisher information:** Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.