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STANDARDISATION OF HYDROPHOBIC POLYMER COATINGS FOR IMPROVING SEED QUALITY AND PHYSIOLOGICAL PERFORMANCE IN ONION

G. R. Gagana[1]*, Radha B. N.[1], K. Vishwanath[2], Krishnamma P. N.[3]

[1] Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India.
[2] AICRP on Seed (Crops), National Seed Project (NSP), University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India. Email. ID: gaganagr9741@gmail.com, radhabn29@gmail.com, vishwakoti@gmail.com,
[3]Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India. Email. ID: pnk5255@gmail.com
***Corresponding author:** G. R. Gagana, E-mail: gaganagr9741@gmail.com

ABSTRACT
Onion seed deteriorates rapidly during storage, necessitating effective coating technologies to maintain seed quality. A laboratory investigation was conducted during 2025–26 at the Department of Seed Science and Technology, GKVK, University of Agricultural Sciences, Bengaluru, to standardise hydrophobic polymer coatings for onion (*Allium cepa* L.) cv. Arka Kalyan. Eleven treatments comprising chitosan, sodium alginate and pectin (1 and 2%), methyl cellulose and methyl vinyl acetate (3 and 4 ml kg^{-1}), and an uncoated control were evaluated in a completely randomised design with three replications. Among the treatments, 2% chitosan recorded the highest germination (88.67%), seedling vigour index-I (1412), vigour index-II (195) and dehydrogenase activity (0.360 A_{480}), along with the lowest electrical conductivity (23.00 µS cm^{-1} g^{-1}). It also improved seedling growth and germination speed. Thus, 2% chitosan emerged as the most effective coating for improving onion seed quality.

KEYWORDS: Hydrophobic polymer coating, Chitosan, Onion seed, Seed coating, Seed vigour, Seed quality.

1. INTRODUCTION
Onion seeds are highly susceptible to deterioration under prolonged storage, particularly when exposed to fluctuating temperature and relative humidity. Pal et al. (2023) reported a decline in germination from an initial range of 56–96% to 31–82% following nine months of ambient storage, with more pronounced reductions under accelerated ageing. Similarly, Brar et al. (2019) documented considerable losses in seed viability and germination after approximately one year of ambient storage, together with reduced antioxidant enzyme activities and increased electrical conductivity. These observations demonstrate the limited longevity of onion seeds.
Seed ageing involves biochemical and structural changes, including increased membrane permeability, lipid peroxidation, altered enzyme activity and loss of cellular integrity. Brar *et al.* (2019) recorded reductions in dehydrogenase, catalase, superoxide dismutase and peroxidase activities during onion seed ageing, indicating weakened respiratory and antioxidant systems. Increased electrolyte leakage, reflected by higher electrical conductivity, further indicates membrane deterioration. Structural changes may also contribute to poor storability. Scanning electron microscopy by Mohamed-Yasseen *et al.* (1996) revealed seed-coat shrinkage and cracks, particularly near the hilum, which may facilitate moisture entry and microbial invasion. Seed preservation must therefore protect seed integrity without restricting germination.
Seed enhancement methods, including priming, pelleting, encrusting and film coating, improve handling and facilitate delivery of beneficial materials. Polymer film coating deposits a thin, adherent layer on the seed surface while retaining seed shape and size. It can ensure uniform treatment, reduce dust and carry plant-protection agents, micronutrients and other functional substances (Taylor *et al*., 1998). West *et al.* (1985) demonstrated that selected polymers modified water uptake and helped maintain soybean seed quality under high humidity, supporting their potential in seed management.
Coating performance depends on polymer composition, concentration, film formation and permeability. Hydrophobic formulations may restrict excessive moisture penetration; however, adequate water uptake is essential for metabolic activation and radicle emergence. In onion, Kavak and Eser (2009) showed that polymer coatings affected water uptake and germination before and after storage. Some hydrophobic coatings reduced imbibition but also restricted primary root protrusion by forming rigid films, whereas only certain formulations reduced water-vapour uptake during storage. An effective coating must therefore balance surface protection with sufficient water availability for normal germination.

Chitosan, sodium alginate and pectin are film-forming polysaccharides for seed treatment, while methyl cellulose and vinyl acetate-based materials are additional coating options. Chitosan has been reported to influence seed imbibition and germination-related responses and provide protection against certain biotic and abiotic stresses (Riseh *et al*., 2024). Nevertheless, coating effects vary with material, concentration, formulation and seed characteristics. Excessive or unsuitable films may impede water uptake and gaseous exchange, making crop-specific standardisation essential. Comparative evidence on the immediate physiological and biochemical responses of onion seeds to these polymers remains limited. Germination, germination speed, seedling growth, vigour indices, electrical conductivity and dehydrogenase activity collectively assess seed performance, membrane integrity and metabolic activity. Accordingly, this study aimed to evaluate and standardise different concentrations of chitosan, sodium alginate, pectin, methyl cellulose and methyl vinyl acetate for onion (*Allium cepa* L.) cv. Arka Kalyan, based on their effects on physiological and biochemical seed quality, and to identify promising formulations for further seed-enhancement studies.

2. MATERIALS AND METHODS

2.1. Experimental site and seed material

The present investigation was performed under laboratory conditions during 2025–26 at the Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. Freshly harvested and genetically pure seeds of onion (*Allium cepa* L.) cv. Arka Kalyan, supplied by the ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, served as the experimental material.

The experimental treatments were arranged following a completely randomised design (CRD), with 11 treatment combinations and three replications. Ten treatments involved the application of five polymer materials at different concentrations or application rates, while the eleventh treatment represented the uncoated control. The treatments consisted of chitosan at 1 and 2% (T_1 and T_2), sodium alginate at 1 and 2% (T_3 and T_4), pectin at 1 and 2% (T_5 and T_6), methyl cellulose at 3 and 4 ml kg^{-1} seed (T_7 and T_8), and methyl vinyl acetate at 3 and 4 ml kg^{-1} seed (T_9 and T_{10}), respectively. T_{11} was maintained as the untreated control. The resulting experimental layout comprised 33 units, with one kilogram of seed allocated per treatment.

2.2. Preparation and application of polymer coating formulations

2.2.1. Preparation of chitosan formulation

Chitosan formulations at 1 and 2% (w/v) were prepared by gradually dissolving 1 and 2 g of chitosan, respectively, in 100 ml of 1% (v/v) acetic acid. The material was of low-to-medium molecular weight, with a degree of deacetylation exceeding 75%. The solutions were continuously stirred for 3–5 hours at room temperature until homogeneous and viscous formulations were obtained.

2.2.2. Preparation of sodium alginate and pectin formulations

Sodium alginate formulations (1 and 2%, w/v) were prepared by dissolving 1 and 2 g of the polymer, respectively, in 100 ml of distilled water, followed by stirring for 1–2 hours to obtain uniform solutions. Similarly, pectin formulations (1 and 2%, w/v) were prepared by dissolving the respective quantities in 100 ml of distilled water maintained at 40–60°C, with continuous stirring for 1–2 hours. Following coating, sodium alginate-treated seeds were immersed in 0.1 M calcium chloride solution for 30–60 seconds to facilitate ionic cross-linking. The same cross-linking treatment was employed for low-methoxyl pectin formulations.

2.2.3. Preparation of methyl cellulose and methyl vinyl acetate formulations

Methyl cellulose and methyl vinyl acetate formulations were applied at the respective rates of 3 and 4 ml kg^{-1} of seed. The formulations were prepared according to the specified application rates and used for coating the seeds.

2.2.4. Application of polymer coatings and seed drying

The prepared polymer formulations were applied to onion seeds using a laboratory-scale rotary pan seed coater. Each formulation was gradually introduced into the rotating seed mass to facilitate uniform distribution and the formation of a consistent coating layer over the seed surface. Following the coating process, the treated seeds were shade-dried under ambient laboratory conditions until the surface moisture was removed.

2.3. Assessment of seed quality parameters

The initial physiological and biochemical quality of the seed lot was assessed before the application of coating treatments. Following coating and shade-drying, the treated seeds were evaluated for the following quality parameters.

2.3.1. Seed moisture content (%)

Seed moisture content was determined on a wet-weight basis using the gravimetric high-constant-temperature oven method, following ISTA (2025). Approximately 2 g of seed was dried at 130 ± 2°C for four hours, and moisture content was expressed as a percentage of the initial seed weight.

2.3.2. Germination percentage (%)

Germination was evaluated using the between-paper method as prescribed by ISTA (2025). Four replications of 100 seeds each were incubated at 25 ± 1°C and approximately 90% relative humidity. The final germination assessment was performed on the 12^{th} day, and germination percentage was calculated based on the proportion of normal seedlings.

2.3.3. Speed of germination

The speed of germination was determined from daily observations of seedling emergence using the method described by Wardle *et al.* (1991). It was calculated as the cumulative sum of the number of newly germinated seeds on each observation day divided by the corresponding number of days:

Speed of germination=$\frac{n}{d}$

where *n* represents the number of seeds germinated on a particular day and *d* represents the number of days from the beginning of the germination test.

2.3.4. Seedling growth parameters

At the final germination count, ten normal seedlings were randomly selected from each replication. Seedling length was measured from the root tip to the shoot apex and expressed in centimetres. The same seedlings were subsequently oven-dried at 85 ± 1°C for 24 hours, and their mean dry weight was recorded in milligrams.

2.3.5. Seed vigour indices

Seed vigour index-I (SVI-I): Seed vigour index-I was calculated by multiplying germination percentage by mean seedling length, following Abdul-Baki and Anderson (1973).

Seed vigour index-I (SVI-I) = Seed germination (%) ×(Seedling root + shoot length(cm))

Seed vigour index-II (SVI-II): Seed vigour index-II was computed as the product of germination percentage and mean seedling dry weight, following Abdul-Baki and Anderson (1973).

Seed vigour index-II (SVI-II) = Seed germination (%) × Mean seedling dry weight(mg)

2.3.6. Electrical conductivity (µS cm^{-1} g^{-1})

Electrical conductivity was determined following the procedure described by ISTA (2025). A sample of 100 seeds was soaked in 25 ml of distilled water and maintained at 25 ± 1°C for 24 hours. Subsequently, the electrical conductivity of the seed leachate was measured using a digital conductivity meter. The conductivity value of the distilled water was subtracted from the observed reading, and the corrected value was expressed in µS cm^{-1} g^{-1} of seed.

2.3.7. Total dehydrogenase activity (A_{480})

Total dehydrogenase activity was estimated using the tetrazolium reduction method described by Perl *et al.* (1978). Embryonic axes isolated from ten seeds were immersed in 0.5% tetrazolium chloride solution and incubated at 25 ± 1°C in darkness for four hours. The resulting red formazan was extracted using 5 ml of 2-methoxyethanol over 24 hours. The absorbance of the resulting extract was measured spectrophotometrically at 480 nm and expressed as absorbance units (A_{480}).

2.4. Statistical analysis

The experimental data were subjected to statistical analysis appropriate for a completely randomised design (CRD). Analysis of variance (ANOVA) was performed to determine the significance of differences among treatment means. The standard error of the mean (SE.m ±) and coefficient of variation (CV, %) were calculated, and treatment means were compared using the critical difference (CD) at the 5% level of significance.

3. RESULTS

Eleven polymer coating treatments, comprising different formulations and application concentrations alongside an uncoated control, were assessed to elucidate their influence on the immediate post-coating physiological and biochemical attributes of onion seeds. Prior to coating, the seed lot exhibited a moisture content of 7.45% and germination of 81.00%, with a speed of germination of 15.03. The corresponding values for mean seedling length, mean seedling dry weight, seed vigour index-I (SVI-I), seed vigour index-II (SVI-II), electrical conductivity and total dehydrogenase activity were 13.96 cm, 1.80 mg, 1216, 145, 33.00 µS cm^{-1} g^{-1} and 0.160 A_{480}, respectively (Table 1). These observations constituted the baseline against which treatment-associated variations in seed quality were assessed.

Table 1. Initial physiological and biochemical quality attributes of onion seeds before Coating

Parameter	Observation
Seed moisture content (%)	7.45
Germination (%)	81.00
Speed of germination	15.03
Mean seedling length (cm)	13.96
Mean seedling dry weight (mg)	1.80
Seed vigour index-I	1216
Seed vigour index-II	145

Parameter	Observation
Electrical conductivity (μS cm^{-1} g^{-1})	33.00
Total dehydrogenase activity (A_{480})	0.160

3.1. Seed moisture content

Following polymer application and subsequent shade-drying, seed moisture content varied within a relatively narrow range of 7.14–7.45% across the evaluated treatments (Table 2). Chitosan @ 2% (T_2) registered the lowest moisture content (7.14%), followed by sodium alginate @ 2% (T_4: 7.24%). In contrast, the uncoated control (T_{11}) retained the highest moisture content (7.45%). Despite these numerical differences, the treatment effects were statistically non-significant, indicating that the coating formulations did not significantly alter seed moisture content at the immediate post-treatment assessment.

Table 2. Effect of hydrophobic polymer coatings on seed moisture content (%) and speed of germination of onion seeds

Treatments	Seed moisture content (%)	Speed of germination
T_1: Chitosan @ 1%	7.26	20.42
T_2: Chitosan @ 2%	7.14	21.31
T_3: Sodium alginate @ 1%	7.35	17.47
T_4: Sodium alginate @ 2%	7.24	21.29
T_5: Pectin @ 1%	7.42	15.93
T_6: Pectin @ 2%	7.37	17.91
T_7: Methyl cellulose @ 3 ml	7.29	20.40
T_8: Methyl cellulose @ 4 ml	7.27	18.58
T_9: Methyl vinyl acetate @ 3 ml	7.40	15.10
T_{10}: Methyl vinyl acetate @ 4 ml	7.30	20.03
T_{11}: Control (uncoated)	7.45	15.03
Mean	**7.32**	**18.50**
SE.m±	**0.20**	**0.49**
CD (5%)	**NS**	**1.44**
CV (%)	**4.67**	**4.56**

NS: non-significant

3.2. Germination percentage

Germination response exhibited significant variation among the polymer coating treatments (Figure 1). The maximum germination percentage was obtained with chitosan @ 2% (T_2: 88.67%), followed by sodium alginate @ 2% (T_4: 86.00%). Both treatments demonstrated superior germination performance relative to the uncoated control, which recorded 81.00%. The minimum germination response was observed in the control, although it remained statistically comparable with methyl vinyl acetate @ 3 ml (T_9: 81.33%). The results thus revealed a distinct treatment-dependent response, with the higher-concentration chitosan and sodium alginate formulations exhibiting the most favourable germination performance.

3.3. Speed of germination

The speed of germination was significantly influenced by the polymer coating treatments (Table 2). Chitosan @ 2% (T_2) recorded the highest value (21.31), closely followed by sodium alginate @ 2% (T_4: 21.29), with both treatments being statistically on par. The next highest values were registered in chitosan @ 1% (T_1: 20.42), methyl cellulose @ 3 ml (T_7: 20.40) and methyl vinyl acetate @ 4 ml (T_{10}: 20.03). Conversely, the uncoated control exhibited the lowest speed of germination (15.03), closely followed by methyl vinyl acetate @ 3 ml (T_9: 15.10). The comparatively higher values associated with T_2 and T_4 indicate a more rapid germination response under these formulations.

3.4. Seedling growth parameters

Significant treatment-induced differences were evident in both mean seedling length and seedling dry weight (Table 3). Chitosan @ 2% (T_2) produced the greatest mean seedling length (15.92 cm), which was statistically comparable with sodium alginate @ 2% (T_4: 15.83 cm). Chitosan @ 1% (T_1) also exhibited a relatively higher seedling length of 15.59 cm. At the lower end of the response range, the uncoated control recorded the shortest seedlings (13.92 cm), remaining statistically on par with methyl vinyl acetate @ 3 ml (T_9: 13.96 cm) and pectin @ 1% (T_5: 14.04 cm).

A similar treatment response was observed for mean seedling dry weight. The highest dry weight (2.20 mg) was attained under both chitosan @ 2% (T_2) and sodium alginate @ 2% (T_4). These were followed by chitosan @ 1% (T_1), methyl cellulose @ 3 ml (T_7) and methyl vinyl acetate @ 4 ml (T_{10}), each recording 2.10 mg. The uncoated control registered the lowest seedling dry weight (1.80 mg), followed by methyl vinyl acetate @ 3 ml (T_9: 1.90 mg).

Collectively, these observations establish the comparatively favourable influence of T_2 and T_4 on early seedling growth and dry matter accumulation.

3.5. Seed vigour indices

The polymer coating treatments exerted a significant influence on both seed vigour index-I and seed vigour index-II (Table 4). Chitosan @ 2% (T_2) consistently ranked first, recording the highest SVI-I (1412) and SVI-II (195). Sodium alginate @ 2% (T_4) occupied the next position, with corresponding values of 1362 and 189, respectively. In contrast, the uncoated control exhibited the lowest vigour indices, registering 1127 for SVI-I and 146 for SVI-II. Methyl vinyl acetate @ 3 ml (T_9) recorded corresponding values of 1135 and 155, indicating comparatively lower vigour than the leading coating treatments. The concordant response of both indices further substantiated the superior performance of chitosan @ 2% and sodium alginate @ 2% in terms of germination and subsequent seedling development.

3.6. Electrical conductivity of seed leachate

Electrical conductivity of the seed leachate differed significantly among the evaluated treatments (Table 4). The minimum conductivity was observed in chitosan @ 2% (T_2: 23.00 µS cm^{-1} g^{-1}), indicating the lowest electrolyte leakage among the treatments. Chitosan @ 1% (T_1) and sodium alginate @ 2% (T_4) followed closely, each recording 24.67 µS cm^{-1} g^{-1}. Conversely, the uncoated control exhibited the maximum electrical conductivity (33.33 µS cm^{-1} g^{-1}), followed by methyl vinyl acetate @ 3 ml (T_9: 31.33 µS cm^{-1} g^{-1}). The relatively lower conductivity values observed in T_2, T_1 and T_4 were indicative of comparatively reduced electrolyte leakage from the seeds.

Table 3. Effect of hydrophobic polymer coatings on mean seedling length (cm) and mean seedling dry weight (mg) of onion seeds

Treatments	Mean seedling length (cm)	Mean seedling dry weight (mg)
T_1: Chitosan @ 1%	15.59	2.10
T_2: Chitosan @ 2%	15.92	2.20
T_3: Sodium alginate @ 1%	15.26	2.00
T_4: Sodium alginate @ 2%	15.83	2.20
T_5: Pectin @ 1%	14.04	2.00
T_6: Pectin @ 2%	15.30	2.00
T_7: Methyl cellulose @ 3 ml	15.54	2.10
T_8: Methyl cellulose @ 4 ml	15.31	2.00
T_9: Methyl vinyl acetate @ 3 ml	13.96	1.90
T_{10}: Methyl vinyl acetate @ 4 ml	15.46	2.10
T_{11}: Control (uncoated)	13.92	1.80
Mean	**15.10**	**2.04**
SE.m±	**0.30**	**0.06**
CD (5%)	**0.88**	**0.17**
CV (%)	**3.42**	**4.75**

Table 4. Effect of hydrophobic polymer coatings on seed vigour index-I, seed vigour index- II and electrical conductivity (µS cm^{-1} g^{-1}) of onion seeds

Treatments	Seed vigour index-I	Seed vigour index-II	Electrical conductivity
T_1: Chitosan @ 1%	1315	177	24.67
T_2: Chitosan @ 2%	1412	195	23.00
T_3: Sodium alginate @ 1%	1251	164	27.00
T_4: Sodium alginate @ 2%	1362	189	24.67
T_5: Pectin @ 1%	1146	163	27.00
T_6: Pectin @ 2%	1253	164	26.00
T_7: Methyl cellulose @ 3 ml	1310	177	25.00
T_8: Methyl cellulose @ 4 ml	1260	165	25.33
T_9: Methyl vinyl acetate @ 3 ml	1135	155	31.33
T_{10}: Methyl vinyl acetate @ 4 ml	1277	174	25.33
T_{11}: Control (uncoated)	1127	146	33.33
Mean	**1259**	**170**	**26.61**
SE.m±	**23.31**	**5.46**	**0.70**
CD (5%)	**68.79**	**16.12**	**2.06**
CV (%)	**3.21**	**5.57**	**4.53**

3.7. Total dehydrogenase activity

Total dehydrogenase activity exhibited discernible variation among the polymer coating treatments (Fig. 2). The highest enzymatic activity was recorded in chitosan @ 2% (T_2: 0.360 A_{480}), followed by sodium alginate @ 2% (T_4: 0.300 A_{480}) and chitosan @ 1% (T_1: 0.260 A_{480}). The uncoated control recorded the lowest activity (0.160 A_{480}), while methyl vinyl acetate @ 3 ml (T_9) exhibited a marginally higher value of 0.170 A_{480}. The comparatively elevated dehydrogenase activity in T_2 and T_4 was consistent with their favourable performance across the germination and seedling vigour parameters.

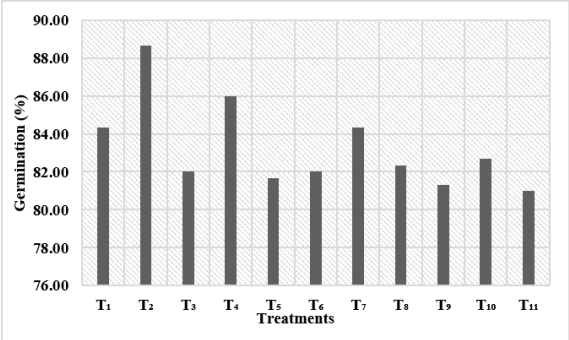


Figure 1. Effect of hydrophobic polymer coatings on germination (%) of onion seeds after coating with polymers

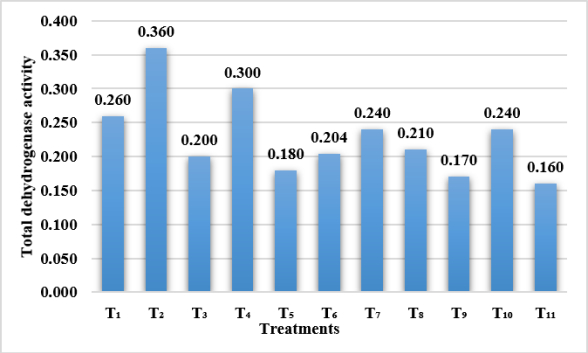


Figure 2. Effect of hydrophobic polymer coatings on total dehydrogenase activity (A_{480}) of onion seeds after coating with polymers

3.8. Identification of promising polymer coating formulations

An integrated assessment of the physiological and biochemical responses identified six polymer coating treatments as promising candidates for subsequent evaluation under storage and accelerated ageing conditions. These comprised chitosan @ 2% (T_2), sodium alginate @ 2% (T_4), chitosan @ 1% (T_1), methyl cellulose @ 3 ml (T_7), methyl cellulose @ 4 ml (T_8) and methyl vinyl acetate @ 4 ml (T_{10}). Among the evaluated formulations, chitosan @ 2% demonstrated the most consistent superiority across the assessed seed quality attributes, followed by sodium alginate @ 2%. Chitosan @ 1% also exhibited a favourable response across several parameters. In comparison, pectin @ 1% (T_5), pectin @ 2% (T_6) and methyl vinyl acetate @ 3 ml (T_9) generally displayed relatively lower performance for several physiological and biochemical attributes. Accordingly, the six selected formulations were advanced for further investigation to establish their performance during storage and under accelerated ageing conditions.

4. DISCUSSION

4.1. Influence of polymer coatings on seed moisture content

Seed moisture content remained statistically comparable among treatments (7.14–7.45%) following coating and shade-drying. This uniformity suggests that post-coating drying, rather than the inherent moisture-barrier properties of the polymers, primarily influenced the initial moisture status. The ability of these coatings to regulate moisture exchange during storage therefore requires further investigation under controlled environmental conditions. Comparable observations in freshly coated onion seeds were reported by Kavak and Eser (2009).

4.2. Influence of polymer coatings on germination and speed of germination

Chitosan @ 2% (T_2) and sodium alginate @ 2% (T_4) exhibited superior germination and speed of germination, highlighting the importance of polymer composition and application concentration. The improved response may be associated with favourable seed–water interactions during imbibition and the biological properties of chitosan. However, these mechanisms were not directly investigated. The comparatively lower performance of the control and methyl vinyl acetate @ 3 ml (T_9), relative to the leading treatments, further indicates formulation-dependent responses. Similar benefits of chitosan-based and polymer-coated seed treatments have been reported by Riseh *et al.* (2024), Vij *et al.* (2025) and Kavak and Eser (2009).

4.3. Influence of polymer coatings on seedling growth

Chitosan @ 2% (T_2) and sodium alginate @ 2% (T_4) produced greater seedling length and dry weight, indicating improved early seedling development. These responses may be associated with efficient metabolic reactivation, mobilisation of stored reserves and subsequent seedling growth. Conversely, the comparatively lower growth observed in the control and T_9 corresponded with their weaker germination performance. Similar improvements in seedling establishment following suitable polymer-based treatments have been discussed by Riseh *et al.* (2024) and Vij *et al.* (2025).

4.4. Influence of polymer coatings on seed vigour indices

Both seed vigour indices were highest under chitosan @ 2% (T_2), followed by sodium alginate @ 2% (T_4). Their superior performance reflects the combined contribution of higher germination, greater seedling length and increased dry matter accumulation. Conversely, the lower vigour indices in the control and T_9 corresponded with their comparatively weaker germination and seedling growth. These findings reinforce the influence of polymer composition and application concentration on seed vigour, as also reported by Kavak and Eser (2009), Riseh *et al.* (2024) and Vij *et al.* (2025).

4.5. Influence of polymer coatings on membrane integrity and dehydrogenase activity

Lower electrical conductivity in T_2, T_1 and T_4 indicated comparatively reduced electrolyte leakage and better membrane integrity. In addition, higher dehydrogenase activity in T_2 and T_4 suggested greater respiratory metabolic activity during seed germination. The association of lower electrolyte leakage with higher dehydrogenase activity supports the superior physiological performance of these treatments. Conversely, the control and T_9 exhibited higher electrolyte leakage and lower dehydrogenase activity. These observations are consistent with the importance of membrane stability and respiratory metabolism in seed vigour, as discussed by Hwang and Sung (1991), Riseh *et al.* (2024) and Xing *et al.* (2025).

4.6. Identification of promising polymer formulations

Considering the collective physiological and biochemical responses, chitosan @ 2% (T_2) emerged as the most promising formulation, followed by sodium alginate @ 2% (T_4) and chitosan @ 1% (T_1). Methyl cellulose @ 3 and 4 ml (T_7 and T_8) and methyl vinyl acetate @ 4 ml (T_{10}) were also identified for further evaluation. The comparatively weaker performance of methyl vinyl acetate @ 3 ml and certain pectin treatments highlights the formulation-specific nature of coating effectiveness. These selected treatments warrant further assessment under storage and accelerated ageing conditions to establish their potential for maintaining seed quality over time.

5. CONCLUSION

Polymer coating treatments significantly influenced several immediate physiological and biochemical attributes of onion seeds (cv. Arka Kalyan), with responses varying according to polymer type and application concentration. Chitosan @ 2% was identified as the most effective treatment, recording the highest germination, speed of germination, seedling growth, vigour indices and dehydrogenase activity, together with the lowest electrical conductivity. Sodium alginate @ 2% and chitosan @ 1% also exhibited favourable responses. Methyl cellulose @ 3 and 4 ml and methyl vinyl acetate @ 4 ml were identified as additional promising formulations. Seed moisture content remained statistically unaffected by the treatments following shade-drying. Overall, chitosan @ 2% emerged as the most promising formulation for improving the immediate seed quality of onion. Further storage and accelerated ageing studies are essential to establish its effectiveness in maintaining seed viability and vigour during storage.

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Author Contributions

G. R. Gagana, S.R.: Undertook experimental investigations, data recording, and preliminary evaluation of results.; Radha, B. N.: Formulated the research concept, designed the methodological framework, and provided comprehensive technical guidance.; K. Vishwanath: Extended laboratory assistance for conducting the experimental work. Krishnamma P. N.: Provided technical assistance for laboratory analysis.

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Consent to participate

All authors consented to participate in the article (Radha BN -on behalf of all coauthors).

Consent to publish

All authors gave their consent for the article to be published if it was accepted (Radha BN, on behalf of all coauthors).

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