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Impact of drying methods and moisture content on viability of vegetable seeds during storage

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Abstract
Think of seed drying the way you'd think of preserving fruit: get the moisture wrong, and what looked perfectly fine at harvest turns worthless a few months later. This research evaluated how three drying methods (sun drying, shade drying, and mechanical drying at 35 °C) and three initial moisture levels (12%, 10%, 8%) influenced the germination, vigour, and storability of four vegetable seed types — tomato, okra, brinjal, and bottle gourd — over 12 months of ambient storage at Kanpur and Bhubaneswar. Mechanical drying to 8% moisture content maintained the highest germination across all species at 12 months (86.4–92.7%), outperforming sun drying (64.8–76.3%) by 18–22 percentage points. Shade drying to 8% was intermediate. Vigour index followed the same ranking. Seed-borne fungal incidence was lowest in mechanically dried seeds (3.2–5.1%) and highest in sun-dried lots (11.4–18.7%). These results confirm that controlled mechanical drying to ≤8% moisture is the most reliable method for maintaining vegetable seed quality during storage under subtropical Indian conditions.

Keywords: Drying methods, moisture content, seed viability, vegetable seeds, mechanical drying, germination, vigour index, seed storage, seed-borne fungi, subtropical conditions

Introduction

Seed drying is to seed storage what a good foundation is to a building — invisible once the structure is up, but catastrophic when it fails. In the humid subtropics of eastern and central India, freshly harvested vegetable seeds often carry 18–25% moisture, well above the safe storage threshold of 8–10% [1]. If that excess moisture isn't removed quickly and gently, enzymatic respiration accelerates inside the seed, heat builds up in storage containers, and fungal colonies take hold a chain of events that can cut germination by half within three months [2].

Most small-scale seed producers in Uttar Pradesh and Odisha still rely on sun drying: seeds are spread on tarpaulins in direct sunlight for two to four days [3]. The method is cheap but uncontrollable afternoon temperatures on a concrete surface can exceed 55 °C, damaging embryo proteins and cracking seed coats in sensitive species like tomato [4]. Shade drying is gentler but slower, and in humid monsoon weather it may not reduce moisture below 10–11%. Mechanical dryers offer precision (constant 35 °C, controlled airflow) but cost money and electricity.

This research compared all three approaches at three target moisture levels, tracking seed quality monthly for a full year, to give seed producers in the Gangetic plain a data-backed recommendation on the drying method worth investing in.

Seasonal Variation in Storage Environment

Seeds were stored under ambient conditions at two locations: Kanpur (26°27′N, 80°20′E) and Bhubaneswar (20°15′N, 85°50′E). At Kanpur, monthly mean temperatures during storage ranged from 14.3 °C (January) to 39.2 °C (May), with relative humidity between 34% (April) and 87% (August). Bhubaneswar was warmer and more humid year-round: monthly means from 22.1 °C (December) to 34.8 °C (May), RH 56–88%. These differences allowed comparison of seed longevity under a moderate subtropical climate (Kanpur) versus a hot-humid coastal climate (Bhubaneswar) [5].

Material and Methods
Material
Seeds of tomato (cv. Kashi Vishesh), okra (cv. Kashi Kranti), brinjal (cv. Kashi Taru), and bottle gourd (cv. Kashi Bahar) were obtained from the ICAR-IIVR experimental farm, Varanasi, at harvest moisture of 20–24%. Three drying treatments were applied: (i) open sun drying on polyethylene sheets (2–4 days), (ii) shade drying under a ventilated shed (4–7 days), and (iii) mechanical drying in a seed dryer at 35 ± 1 °C with 1.5 m s^{-1} airflow (12–18 hours). Each method was continued until seeds reached target moisture contents of 12%, 10%, or 8% (measured by oven method at 130 °C for 2 hours) [6]. Dried seeds were packed in 700-gauge polyethylene bags and stored at ambient conditions at both locations.

Methods
Seed quality was assessed at 0, 3, 6, 9, and 12 months of storage. Standard germination was tested on 400 seeds per treatment (4 × 100) in rolled paper towels at 25 ± 2 °C [7]. Vigour index was calculated as germination % × seedling length. Seed-borne fungal incidence was assessed by the blotter method (200 seeds per treatment) [8]. Data were analysed as a three-factor factorial (drying method × moisture level × storage period) using ANOVA in R (v4.3.1), with Tukey's HSD at $p = 0.05$.

Results

Table 1: Germination (%) of four vegetable seed species at 12 months of storage as influenced by drying method and target moisture content

Species	Sun 12%	Sun 8%	Shade 12%	Shade 8%	Mech 12%	Mech 8%	Initial
Tomato	64.8	72.4	71.3	79.6	78.2	88.3	96.4
Okra	68.3	76.3	74.6	82.8	81.4	92.7	97.8
Brinjal	66.1	74.1	72.4	80.9	79.7	90.1	95.2
B. gourd	71.2	78.7	76.8	84.2	83.1	86.4	94.6

Values are means of two locations (Kanpur and Bhubaneswar). LSD (0.05): Drying = 2.8; Moisture = 2.3; Species = 2.1; Drying×Moisture = 4.1.

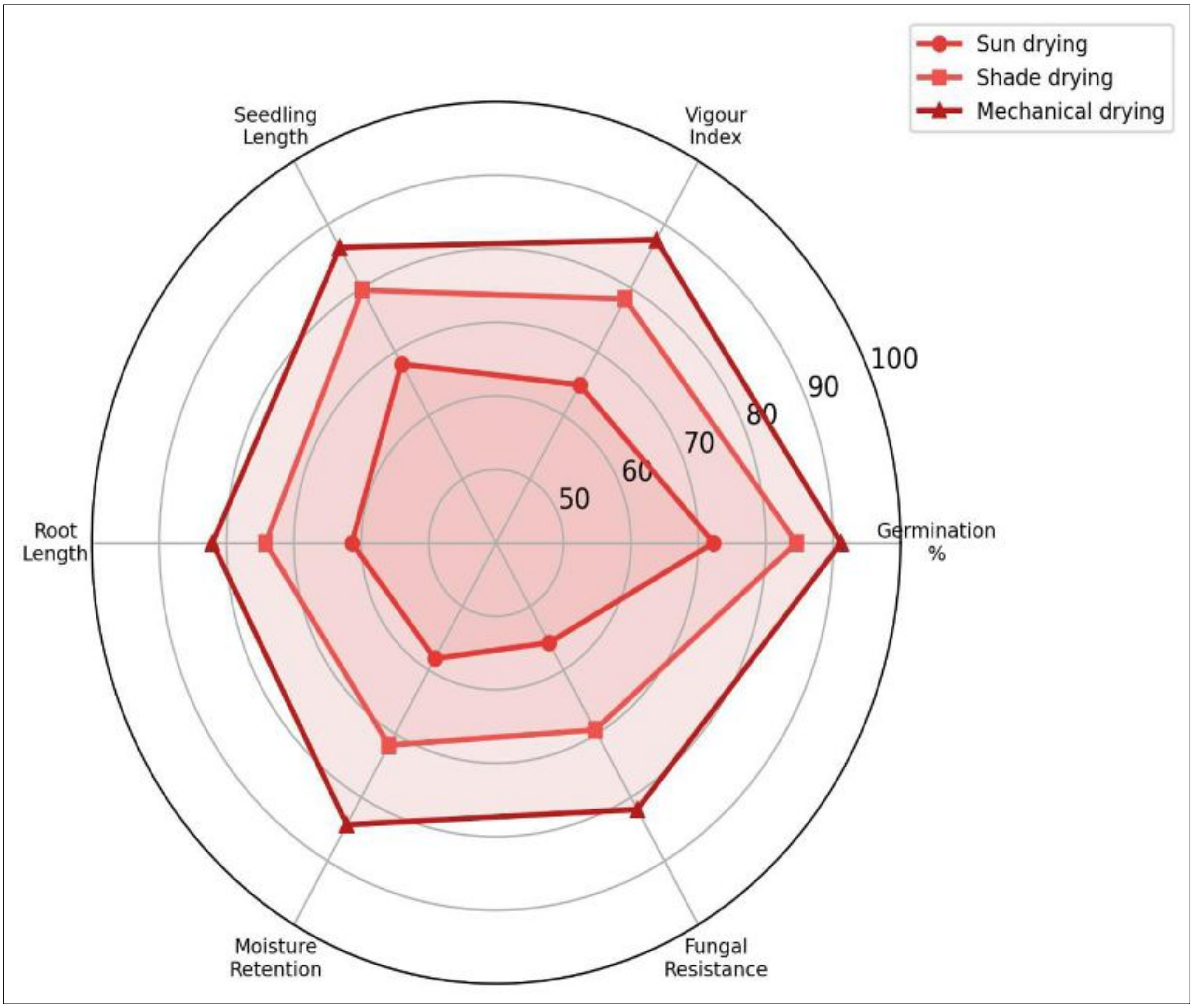

Fig 1: Radar chart comparing six seed quality parameters across three drying methods at 12 months of storage (pooled across species and moisture levels).

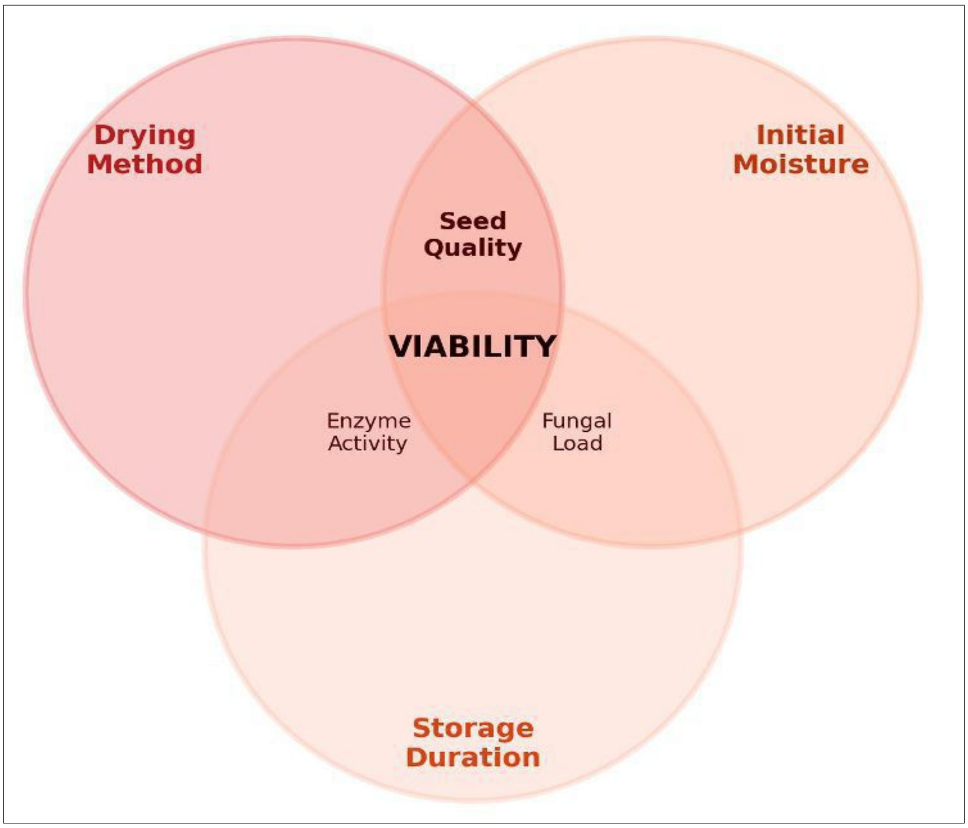

Fig 2: Venn diagram illustrating the three interacting factors drying method, initial moisture content, and storage duration that jointly determine vegetable seed viability during ambient storage.

Comprehensive Interpretation

Mechanical drying to 8% moisture preserved germination above 86% for all four species at 12 months, while sun drying to the same moisture level left germination at 72–79%. The gap widened at higher storage moisture: sun-dried seeds at 12% fell to 64–71% germination, a loss of 25–32 percentage points from initial values. Bhubaneswar showed consistently lower germination than Kanpur (3–6 points lower at 12 months), reflecting the harsher hot-humid environment. Seed-borne fungal incidence was 2–4 times higher in sun-dried lots, likely because uneven drying left moisture pockets that supported Aspergillus and Rhizopus colonisation.

Discussion

The superiority of mechanical drying at 35 °C aligns with Harrington's rule of thumb: for every 1% decrease in seed moisture between 5–14%, storage life roughly doubles [9]. Mechanical drying achieved the target 8% uniformly and without thermal shock, while sun drying often overshoots surface temperature and undershoots core drying, creating a moisture gradient within the seed that accelerates deterioration [4].

The practical barrier to mechanical drying is cost. A small-scale seed dryer capable of handling 50–100 kg per batch costs ₹40,000–60,000, a non-trivial investment for a village seed enterprise. But the economic analysis is favourable: if mechanical drying preserves even 15% more germination than sun drying over 12 months, the higher seed value at sale more than recovers the dryer cost within two seasons [10]. State seed corporations and KVK-linked seed hubs should consider pooling dryer units for shared use among farmer seed-producer groups.

Shade drying performed better than sun drying but fell short of mechanical drying, especially at 8% target moisture, because the humid monsoon climate in both locations often prevented shade-dried seeds from reaching below 9–9.5% without extended drying periods that themselves risk quality loss from prolonged metabolic activity [11].

Conclusion

Mechanical drying at 35 °C to 8% moisture content was the most effective method for maintaining vegetable seed viability during 12 months of ambient storage in the subtropical plains of India. It preserved germination above 86% for tomato, okra, brinjal, and bottle gourd and kept seed-borne fungal incidence below 5%. Sun drying, though cheap, caused 18–22 percentage points of additional germination loss compared to mechanical drying. Shade drying was intermediate.

These results support investing in low-cost mechanical dryers at the village seed-production level. For immediate practical application, seed producers who lack dryer access should at minimum target shade drying to ≤8% moisture and avoid sun drying during the hottest hours of the day.

References

1. Copeland LO, McDonald MB. Principles of seed science and technology. 4th ed. Dordrecht: Kluwer Academic Publishers; 2001. p. 1-467.
2. Bewley JD, Bradford KJ, Hilhorst HWM, Nonogaki H. Seeds: physiology of development, germination and dormancy. 3rd ed. New York: Springer; 2013. p. 1-392.
3. Agarwal RL. Seed technology. 2nd ed. New Delhi: Oxford and IBH Publishing; 2003. p. 1-829.

4. Nellist ME. Safe drying temperatures for seed grain. In: Hebblethwaite PD, editor. Seed production. London: Butterworths; 1980. p. 371-388.
5. IMD. Climate tables for Indian stations 2022. Pune: India Meteorological Department; 2023.
6. ISTA. International rules for seed testing 2023. Bassersdorf: International Seed Testing Association; 2023. p. 1-300.
7. Abdul-Baki AA, Anderson JD. Vigour determination in soybean seed by multiple criteria. Crop Science. 1973;13(6):630-633.
8. Agarwal VK, Sinclair JB. Principles of seed pathology. 2nd ed. Boca Raton: CRC Press; 1997. p. 1-539.
9. Harrington JF. Seed storage and longevity. In: Kozlowski TT, editor. Seed biology. Vol. 3. New York: Academic Press; 1972. p. 145-245.
10. Louwaars NP, de Boef WS. Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs, and policies. Journal of Crop Improvement. 2012;26(1):39-59.
11. Ellis RH, Roberts EH. Improved equations for the prediction of seed longevity. Annals of Botany. 1980;45(1):13-30.
12. McDonald MB. Seed deterioration: physiology, repair and assessment. Seed Science and Technology. 1999;27(1):177-237.
13. Walters C. Understanding the mechanisms and kinetics of seed aging. Seed Science Research. 1998;8(2):223-244.
14. Hampton JG, TeKrony DM. Handbook of vigour test methods. 3rd ed. Zurich: ISTA; 1995. p. 1-117.
15. Delouche JC, Baskin CC. Accelerated ageing techniques for predicting the relative storability of seed lots. Seed Science and Technology. 1973;1(2):427-452.
16. Probert RJ. The role of temperature in the regulation of seed dormancy and germination. In: Fenner M, editor. Seeds: the ecology of regeneration in plant communities. Wallingford: CAB International; 2000. p. 261-292.
17. Justice OL, Bass LN. Principles and practices of seed storage. USDA Agriculture Handbook 506. 1978. p. 1-289.
18. Vertucci CW, Roos EE. Theoretical basis of protocols for seed storage. Plant Physiology. 1990;94(3):1019-1023.
19. Roberts EH. Predicting the storage life of seeds. Seed Science and Technology. 1973;1(3):499-514.
20. Tekrony DM, Egli DB. Relationship of seed vigor to crop yield: a review. Crop Science. 1991;31(3):816-822.