

Low-Cost, Farmer-Friendly Substrates for Seed Germination Testing: Evidence across Major Field Crops

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ABSTRACT: Seed germination testing is a critical yet often inaccessible component of seed quality assurance, particularly for smallholder farmers who rely heavily on farm-saved or locally sourced seed. Conventional laboratory-based germination tests, though scientifically robust, remain beyond the reach of many farming communities due to cost, infrastructure, and logistical constraints. The present study evaluated the effectiveness of three substrates—germination paper, newspaper, and jute (gunny) bag—on seed quality parameters of ten economically important crops, including major cereals (wheat, paddy, and barley), pulses (green gram, chickpea, pea, lentil, and cowpea), and oilseeds (soybean and mustard). Germination percentage (GERM%), seedling dry weight (DW), shoot length (SL), root length (RL), and vigour indices (VI-I and VI-II) were recorded and statistically analysed. Results revealed that germination percentage across all three substrates was statistically at par for most crops, indicating that low-cost alternatives can provide reliable estimates of seed viability. Although germination paper produced superior seedling growth and vigour, newspaper and gunny bag substrates demonstrated consistent and dependable performance. These findings highlight the potential of low-cost, locally available substrates to serve as practical tools for on-farm and community-level seed quality assessment, thereby strengthening decentralized seed systems, supporting extension-led advisory services, and enabling evidence-based seed management decisions under resource-constrained conditions.

Keywords: Substrate, Seed quality, Decentralized seed systems, Germination testing, Seedling vigour

INTRODUCTION

Seed quality lies at the heart of agricultural productivity, resilience, and food security, particularly in smallholder-dominated farming systems where access to certified seed and formal quality assurance mechanisms remains limited. Germination percentage is a primary indicator of seed quality, reflecting the viability and physiological soundness of seeds and directly influencing crop establishment and yield outcomes. The use of poor-quality seed often results in suboptimal plant populations, inefficient use of inputs, and heightened vulnerability to climatic and market risks. Strengthening farmer access to simple and reliable seed quality assessment tools is therefore not only a technical necessity but also a policy priority for sustainable agricultural development [1].

Standard germination testing protocols, conducted under controlled laboratory conditions using prescribed substrates and equipment, provide accurate and reproducible results and form the basis of formal seed certification systems [2]. However, the centralized nature of these facilities limits their reach, particularly in remote

and resource-poor regions. Smallholder farmers, women's self-help groups, and community seed producers often lack timely access to laboratory testing services, leading to widespread use of uncertified or untested seed. This disconnect between formal seed quality assurance mechanisms and farmer-level realities underscores the need for complementary, decentralized approaches to seed testing that align with extension systems and local seed enterprises.

Low-cost and farmer-friendly germination testing methods, such as the use of newspaper and jute (gunny) bags, offer a pragmatic pathway to bridge this gap [3]. These substrates are inexpensive, widely available, and easy to use, requiring minimal technical expertise while fulfilling the basic physiological requirements for seed germination, including moisture, aeration, and suitable temperature [4]. When integrated into extension programmes and community seed bank operations, such methods can empower farmers to assess seed quality prior to sowing, optimize seed rates, and reduce the risk of crop failure.

Despite their relevance, empirical validation of these alternative substrates across multiple crop groups is limited, constraining their formal recognition within extension advisories and policy frameworks. Generating scientific evidence on their reliability is essential for mainstreaming their use in decentralized seed systems and public extension guidelines. The present study therefore evaluates the performance of germination paper, newspaper, and gunny bag substrates on germination and seedling vigour parameters across major cereals, pulses, and oilseeds. By linking laboratory rigor with field-level applicability, this research contributes to evidence-based policy formulation, supports extension-led dissemination of low-cost seed testing practices, and advances inclusive seed system development aimed at improving crop establishment, productivity, and food security.

MATERIALS AND METHODS

Seed Material

Seeds of ten crop species, namely wheat (*Triticum aestivum* L.), paddy (*Oryza sativa* L.), barley (*Hordeum vulgare* L.), green gram (*Vigna radiata* L.), chickpea (*Cicer arietinum* L.), pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.), cowpea (*Vigna unguiculata* L.), soybean (*Glycine max* L.), and mustard (*Brassica juncea* L.), were collected from the Farm Section of ICAR–National Institute for Seed Science and Technology (ICAR–NISST), Mau. The seed lots used in the experiment were freshly harvested, well cleaned, and free from visible physical damage.

Experimental Treatments and Substrates

Three germination substrates were evaluated across all ten crops:

- (i) standard germination paper,
- (ii) old newspaper (non-glossy, ink-safe), and
- (iii) jute (gunny) bag (clean and dry).

The experiment was conducted under controlled laboratory conditions using a completely randomized design with five replications for each crop–substrate combination.

Germination Test Procedures

Standard germination tests were conducted following ISTA procedures [5, 6]. For the laboratory method, seeds were placed between moist germination paper sheets, rolled carefully, and kept inside a seed germinator under

optimal conditions of temperature and relative humidity. For practical relevance, it was noted that these methods can also be performed at room temperature under shaded conditions, provided adequate moisture is maintained.

In the newspaper method, seeds were wrapped in moistened newspaper sheets and kept in a shaded, moist environment as described by ISTA [4]. In the gunny bag method, seeds were placed inside moist jute bags, which were then kept under shaded conditions and regularly monitored to ensure uniform moisture throughout the germination period. In all three methods, optimum moisture levels were maintained consistently.

Each treatment consisted of 100 seeds per replication. Seedlings were evaluated at the final count as per crop-specific germination duration: 7 days for barley and mustard, 8 days for wheat, green gram, chickpea, and pea, 10 days for lentil, and 14 days for paddy [5].

Germination Percentage

At the final count, the number of normal seedlings was recorded and germination percentage was calculated using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds}} \times 100$$

Mean values were expressed in percentage.

Seedling Growth Parameters

Root Length (cm)

Ten normal seedlings were randomly selected from each replication at the final count. Root length was measured from the tip of the primary root to the base of the hypocotyl and expressed in centimetres.

Shoot Length (cm)

The same ten seedlings were used for shoot length measurement. Shoot length was measured from the base of the primary leaf to the base of the hypocotyl and expressed in centimetres.

Seedling Dry Weight (g)

After recording shoot and root lengths, the selected seedlings were placed in paper covers, shade-dried for 4 h, and then oven-dried at 80 ± 2 °C for 24 h. The dried seedlings were cooled in a desiccator for 30 min, and dry weight was recorded using an electronic balance. Mean values were expressed as g per 10 seedlings.

Vigour Indices

Seed vigour indices were calculated following the method of Abdul-Baki and Anderson (1973). Mean values were expressed as whole numbers.

Vigour index I = Germination (%) × [Root length (cm) + Shoot length (cm)]

Vigour index II = Germination (%) × Seedling dry weight (g)

Statistical Analysis

The experiment was conducted with five replications to ensure adequate degrees of freedom for statistical analysis. Data were analysed using appropriate statistical procedures, and treatment means were compared using standard error of mean [SE (m) ±], standard error of difference [SE (d) ±], critical difference at 5% level of significance [C.D. (5%)], and coefficient of variation (C.V. %).

RESULTS AND DISCUSSION

The performance of three germination substrates—germination paper, newspaper, and jute (gunny) bag—

was evaluated across cereals, pulses, and oilseeds to assess their influence on germination and seedling vigour parameters. Overall, substrate type exerted a pronounced effect on seedling growth and vigour traits, while germination percentage remained statistically at par in most crops, indicating that alternative low-cost substrates can reliably estimate planting value.

Cereal Crops

In paddy, germination percentage did not differ significantly among substrates (Plate 1, Table 1), although germination paper recorded numerically higher germination (76%), shoot length (9.12 cm), and vigour index II (4.45). Significant differences were observed for root length and vigour index I, with germination paper producing the longest roots (14.89 cm) and highest vigour index I (1827.86). Newspaper consistently recorded the lowest root length (10.01 cm) and vigour index I (1405.62), while the jute bag performed intermediately, indicating its moderate suitability for seedling development.

In wheat, germination percentage remained statistically at par across substrates, though numerically higher

Table 1. Seed quality parameters as influenced by germination test substrate in cereal crops

Substrate	GERMI %	DW	SL	RL	VI-I	VI-II
1. Paddy						
Germination Paper	76.00	0.059	9.12	14.89	1827.86	4.45
Newspaper	74.80	0.057	8.78	10.01	1405.62	4.26
Jute bag	72.80	0.059	8.78	12.90	1578.82	4.27
C.D. (p=0.05)	NS	NS	NS	1.61	226.31	NS
SEm (±)	2.10	0.002	0.24	0.51	72.64	0.22
SEd (±)	2.97	0.003	0.35	0.73	102.73	0.32
C.V. (%)	6.31	8.02	6.23	9.20	10.12	11.69
2. Wheat						
Germination Paper	88.00	0.206	14.73	20.29	3084.16	18.10
Newspaper	82.00	0.153	11.34	13.94	2072.29	12.51
Jute bag	84.40	0.176	14.27	19.87	2885.87	14.83
C.D. (p=0.05)	NS	0.011	1.30	1.62	332.73	1.22
SEm (±)	1.91	0.004	0.41	0.52	106.80	0.39
SEd (±)	2.70	0.005	0.59	0.73	151.04	0.55
C.V. (%)	5.04	4.47	6.93	6.47	8.90	5.81
3. Barley						
Germination Paper	88.40	0.224	18.44	22.85	3654.58	19.90
Newspaper	81.60	0.159	15.76	15.98	2596.22	13.04
Jute bag	80.40	0.221	16.32	17.88	2749.25	17.73
C.D. (p=0.05)	NS	0.019	1.65	2.53	483.77	3.18
SEm (±)	3.12	0.006	0.53	0.81	155.28	1.02
SEd (±)	4.41	0.009	0.75	1.14	219.60	1.44
C.V. (%)	8.36	6.67	7.05	9.60	11.57	13.53

GERMI= Germination %, DW=Dry wt., SL=Shoot length, RL=Root length, VI-I=Vigour Index I, VI-II=Vigour Index-II, NS=Non-significant

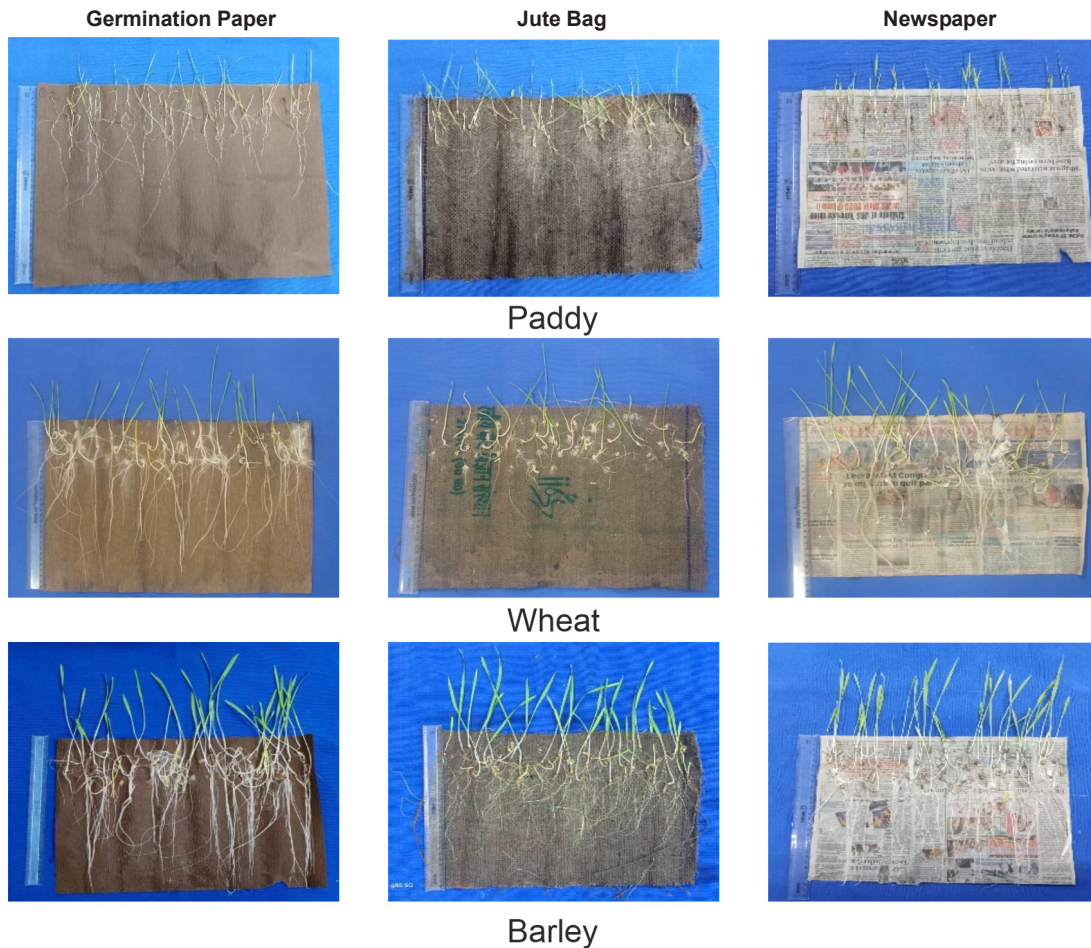


Figure 1. Germination test by using different substrate in cereal crops

values were recorded in germination paper (88%), followed by jute bag (84.40%) and newspaper (82.00%) (Figure 1, Table 1). Significant differences were observed for shoot length, root length, and vigour indices. Germination paper produced the longest shoots (14.73 cm), roots (20.29 cm), and the highest vigour indices (VI-I: 3084.16; VI-II: 18.10). Newspaper resulted in comparatively weaker seedlings, while the jute bag showed values close to germination paper for shoot and root length but slightly lower vigour index II due to reduced dry matter accumulation.

Similarly, in barley, germination percentage did not differ significantly across substrates, though germination paper recorded the highest value (88.40%). Significant variation was observed for seedling growth and vigour parameters (Figure 1, Table 1). Germination paper produced superior shoot length (18.44 cm), root length (22.85 cm), vigour index I (3654.58), and vigour index II (19.90). Newspaper

resulted in the lowest seedling growth and vigour, while the jute bag exhibited intermediate performance and was statistically comparable to germination paper for seedling dry weight.

Pulse Crops

In green gram, substrate effects were more pronounced. Germination paper recorded numerically higher germination (76%), significantly longer roots (16.97 cm), and the highest vigour indices (VI-I: 2274.91; VI-II: 18.01) (Figure 2, Table 2). Newspaper resulted in the lowest germination and seedling vigour, whereas the jute bag demonstrated moderate performance, outperforming newspaper in root growth and vigour indices. Statistical analysis confirmed significant differences for germination percentage, root length, and vigour indices.

In chickpea, most parameters showed non-significant differences across substrates, except for root length and

Table 2. Seed quality parameters as influenced by germination test substrate in pulse crops

Substrate	GERMI %	DW	SL	RL	VI-I	VI-II
1. Green gram						
Germination Paper	76.00	0.238	12.91	16.97	2274.91	18.01
Newspaper	70.00	0.186	12.25	9.54	1527.82	13.01
Jute bag	70.40	0.214	12.29	13.53	1817.20	15.07
C.D. ($p=0.05$)	3.84	NS	NS	2.05	260.82	3.12
SEm (\pm)	1.23	0.016	0.71	0.66	83.72	1.00
SEd (\pm)	1.74	0.022	1.01	0.93	118.40	1.41
C.V. (%)	3.82	16.56	12.80	11.05	9.99	14.58
2. Chickpea						
Germination Paper	90.40	0.372	15.18	19.95	3185.28	33.62
Newspaper	84.40	0.347	12.10	12.27	2060.00	29.25
Jute bag	86.80	0.356	13.93	17.38	2717.78	30.87
C.D. ($p=0.05$)	NS	NS	NS	1.40	487.08	NS
SEm (\pm)	2.83	0.009	1.18	0.45	156.34	1.18
SEd (\pm)	4.01	0.013	1.67	0.63	221.10	1.66
C.V. (%)	7.27	5.57	19.24	6.09	13.17	8.44
3. Pea						
Germination Paper	85.60	0.463	10.14	26.37	3129.83	39.68
Newspaper	79.60	0.279	7.15	16.35	1874.79	22.21
Jute bag	82.00	0.379	9.74	18.35	2302.85	31.12
C.D. ($p=0.05$)	NS	0.031	1.46	1.56	324.90	4.31
SEm (\pm)	2.21	0.010	0.47	0.50	104.28	1.38
SEd (\pm)	3.13	0.014	0.66	0.71	147.48	1.96
C.V. (%)	6.01	5.90	11.66	5.51	9.57	9.99
4. Lentil						
Germination Paper	80.40	0.123	13.58	16.92	2454.98	9.89
Newspaper	80.80	0.097	10.86	12.68	1899.74	7.85
Jute bag	80.80	0.110	12.68	15.64	2283.87	8.88
C.D. ($p=0.05$)	NS	0.012	1.01	1.47	213.13	1.24
SEm (\pm)	1.88	0.004	0.32	0.47	68.41	0.39
SEd (\pm)	2.66	0.005	0.46	0.67	96.75	0.56
C.V. (%)	5.22	7.66	5.88	7.03	6.91	10.02
5. Cow pea						
Germination Paper	95.20	0.914	16.84	22.28	3725.73	86.95
Newspaper	88.40	0.601	10.24	19.67	2638.50	53.20
Jute bag	94.40	0.793	13.42	20.62	3214.00	74.97
C.D. ($p=0.05$)	5.73	0.094	0.99	0.49	139.52	10.04
SEm (\pm)	1.84	0.030	0.31	0.15	44.78	3.22
SEd (\pm)	2.60	0.043	0.45	0.22	63.33	4.56
C.V. (%)	4.44	8.76	5.26	1.69	3.13	10.05

GERMI= Germination %, DW=Dry wt., SL=Shoot length, RL=Root length, VI-I=Vigour Index I, VI-II=Vigour Index-II, NS=Non-significant

vigour index I. Germination paper recorded the highest germination (90.40%), longest roots (19.95 cm), and maximum vigour indices (VI-I: 3185.28; VI-II: 33.62), followed by the jute bag. Newspaper consistently recorded lower values, indicating comparatively weaker seedling establishment.

In pea, germination percentage was statistically at par across substrates; however, seedling growth and vigour varied significantly (Figure 2, Table 2). Germination paper produced the longest roots (26.37 cm), highest dry weight (0.463 g), and superior vigour indices (VI-I: 3129.83; VI-II: 39.68). Newspaper resulted in the poorest



Chickpea



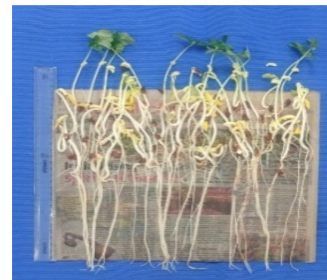
Moong



Lentil



Pea



Cowpea

Figure 2. Germination test by using different substrate in pulse crops

performance, while the jute bag showed intermediate values with appreciable improvement over newspaper.

In lentil, germination percentage remained uniform across substrates (80.40–80.80%), corroborating earlier findings [4]. Significant differences were observed for shoot length, root length, dry weight, and vigour indices. Germination paper consistently recorded higher seedling growth and vigour, while newspaper showed the lowest values. The jute bag again occupied an intermediate position, supporting its reliability as an alternative substrate.

In cowpea, germination paper recorded significantly higher germination (95.20%), which was statistically at par with the jute bag (94.40%). Germination paper produced the longest shoots (16.84 cm), roots (22.28 cm), highest dry weight (0.914 g), and maximum vigour indices (VI-I: 3725.73; VI-II: 86.95). Newspaper resulted in reduced seedling growth and vigour, while the jute bag maintained moderate to high values, reflecting its suitability for larger-seeded pulses.

Oilseed Crops

In soybean, germination percentage did not differ significantly among substrates, remaining within the range of 86.00–88.00 (Figure 3, Table 3). However, significant differences were observed for all seedling growth and vigour parameters. Germination paper recorded the highest shoot length (17.19 cm), root length (19.36 cm), dry weight (0.365 g), and vigour indices (VI-I: 3217.38; VI-II: 32.15). Newspaper showed the lowest

performance, while the jute bag showed intermediate values.

In mustard, germination percentage was uniformly high across substrates (93.6–94.8%), but significant variation was observed in seedling growth and vigour parameters (Figure 3, Table 3). Germination paper produced superior shoot length, root length, dry weight, and vigour indices. The jute bag recorded the highest germination percentage but lower vigour index I due to reduced shoot length, while newspaper showed comparatively lower dry matter accumulation and vigour.

Across all crop groups, germination paper consistently produced superior seedling growth and vigour, reflecting optimal moisture retention and aeration. However, germination percentage—the primary criterion used by farmers to judge planting value—remained statistically at par among substrates in most crops. This indicates that newspaper and jute bag substrates can reliably be used for on-farm germination testing.

The newspaper and gunny bag methods offer distinct advantages: they are low-cost, locally available, recyclable, and require no specialized equipment or technical expertise. These attributes make them highly suitable for rural and resource-constrained settings, enabling farmers to assess seed quality at the village level [4]. While these methods have minor limitations—such as susceptibility to fungal contamination under excess moisture and limited temperature control—their

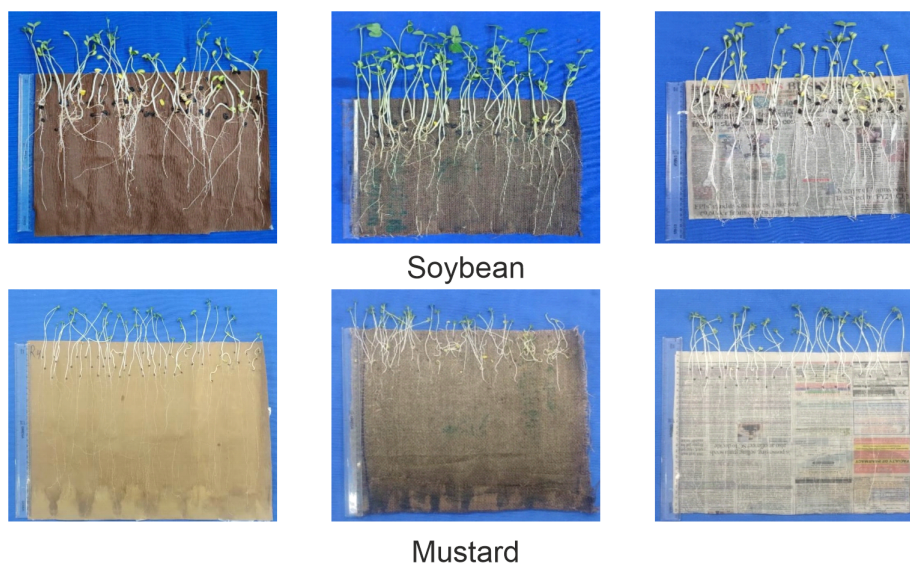


Figure 3. Germination test by using different substrate in oilseed crops

Table 3. Seed quality parameters as influenced by germination test substrate in oilseed crops

Substrate	GERMI %	DW	SL	RL	VI-I	VI-II
1. Soybean						
Germination Paper	88.00	0.365	17.19	19.36	3217.38	32.15
Newspaper	87.60	0.279	11.56	13.74	2203.95	24.64
Jute bag	86.00	0.330	12.53	15.93	2450.40	28.43
C.D. (p=0.05)	NS	0.033	2.29	1.89	353.46	4.78
SEm (±)	2.64	0.011	0.73	0.60	113.45	1.53
SEd (±)	3.73	0.015	1.04	0.86	160.44	2.17
C.V. (%)	6.77	7.32	11.97	8.31	9.66	12.08
2. Mustard						
Germination Paper	94.000	0.047	11.280	20.932	3,028.252	4.436
Newspaper	93.600	0.036	9.860	20.286	2,820.816	3.404
Jute bag	94.800	0.044	8.110	20.848	2,747.096	4.140
C.D. (p=0.05)	NS	0.004	0.662	NS	178.631	0.442
SEm (±)	1.211	0.001	0.212	0.248	57.338	0.142
SEd (±)	1.713	0.002	0.300	0.350	81.088	0.201
C.V. (%)	2.877	7.408	4.873	2.677	4.474	7.951

GERMI= Germination %, DW=Dry wt., SL=Shoot length, RL=Root length, VI-I=Vigour Index I, VI-II=Vigour Index-II, NS=Non-significant

simplicity and accessibility outweigh these constraints for preliminary seed quality assessment.

CONCLUSION

The present study demonstrates that newspaper and gunny (jute) bag substrates constitute effective, economical, and farmer-friendly alternatives to standard germination paper for assessing seed germination across a wide range of cereals, pulses, and oilseeds. Although germination paper consistently produced superior seedling growth and vigour parameters, germination percentage—the most critical indicator of planting value—remained statistically comparable across all substrates in most crops. This establishes the reliability of low-cost substrates for practical seed viability evaluation at the farm level.

These alternative methods reduce dependence on centralized laboratory facilities and empower farmers to make informed decisions regarding seed selection, seed rate adjustment, and crop planning. While they are not intended to replace certified laboratory testing for formal seed quality assurance, they serve as valuable grassroots tools for preliminary seed assessment. To enhance adoption, agricultural extension systems should actively

promote these methods through hands-on demonstrations, farmer training programmes, and integration into community seed banks and seed distribution initiatives. From a policy perspective, incorporating such low-cost, decentralized seed testing approaches into extension advisories can strengthen local seed systems, improve crop establishment, and contribute to resilient and self-reliant farming communities.

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