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BIOLOGICAL SEED TREATMENT WITH BEEJAMRUTHAM AND BEEJARAKSHA TO ENHANCE THE PHYSIOLOGICAL PERFORMANCE OF FARMER-STORED MAIZE (*Zea mays* L.) SEED

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ABSTRACT

A laboratory study was conducted to compare two farmer-accessible biological seed treatments *i.e.*, Beejamrutham and Beejaraksha, along with untreated maize seed stored under ambient conditions in a permeable cloth bag after harvest in February 2026. Seeds were primed overnight in freshly prepared formulations, shade-dried to approximately 10–12% moisture and evaluated by the between the towel method. Beejamrutham-treated seed initiated visible sprouting and produced healthy seedlings from the fifth day, whereas Beejaraksha-treated seed showed emergence about one day later but recorded the highest final germination. Beejamrutham, Beejaraksha and untreated seed recorded 94, 97 and 50% normal seedlings, respectively. Mean seedling length was 43 cm, 39 cm and 28 cm, while the corresponding seedling vigour Index-I values were 4,042, 3,783 and 1,400. As compared to the untreated control, Beejamrutham increased seedling vigour index by 188.7%, while Beejaraksha by 170.2%. The observations suggest that biological hydration treatments based on locally available natural resources would improve the physiological performance of farmer-stored maize seed. Beejamrutham appeared more favourable for rapid germination, seedling elongation and healthy crop stand, while Beejaraksha appeared more protective of final germination.

Key words : Beejaraksha, Beejamrutham, Biological seed treatment, Germination, Maize, Seed priming, Seedling vigour, Water deficit.

Introduction

Rapid and uniform germination is essential for successful crop establishment, particularly when sowing moisture is limited or rainfall is erratic which are very common during periods of El Nino and Super El Nino. Maize (*Zea mays* L.) is sensitive to inadequate moisture during germination and early establishment because low water potential delays imbibition, reserve mobilization, radicle protrusion and seedling emergence. Delayed and non-uniform emergence can expose seedlings to soil crusting, high temperature, seed-borne infection, early weed competition and progressive drying of the seed zone. Seed priming is a low-cost pre-sowing hydration treatment that permits early metabolic activation without allowing complete radicle emergence, followed by drying

to a handling-safe moisture level (Lutts *et al.*, 2016; Farooq *et al.*, 2012 and Singh *et al.*, 2015). Primed seeds may germinate faster because membrane repair, enzyme activation, mitochondrial activity and mobilisation of stored reserves begin before sowing (Lutts *et al.*, 2016 and Farooq *et al.*, 2012).

On-farm priming of maize has previously improved emergence and crop establishment in semi-arid environments, although the response depends on seed quality, soaking duration and post-sowing temperature and moisture (Murungu *et al.*, 2004 and Murungu *et al.*, 2005). Biological priming can additionally expose the seed surface to beneficial microorganisms, metabolites or protective compounds, potentially improving seed health and early stress responses (Sheikh *et al.*, 2022 and

Mastouri *et al.*, 2010). Beejamrutham and Beejaraksha are locally prepared natural-farming formulations used by farmers for seed treatment. However, comparative evidence on their effects on farmer-stored maize seed remains limited. The present pilot study therefore compared Beejamrutham and Beejaraksha treatments with an untreated control for germination, seedling length and seedling vigour under towel-germination conditions.

Materials and Methods

The experiment was conducted using seed of a fodder maize cv. African Tall. Maize seed was harvested in February 2026 and further stored under ambient room conditions in a permeable cloth bag to simulate common farmer practice. Fresh Beejamrutham and Beejaraksha were prepared using Centre for Sustainable Agriculture (CSA) field protocols (Ramanjaneyulu *et al.*, 2023). The preparation protocols for Beejamrutham and Beejaraksha used in the present study are described below.

Beejamrutham was prepared using 5 kg of fresh cow dung, 5 L of cow urine, 50 g of lime powder, and 20 L of water. Fresh cow dung was dissolved in 20 L of water, after which cow urine and lime were added and mixed thoroughly. The mixture was incubated under shade for 12 h, with stirring twice during the incubation period. After incubation, the mixture was filtered through a muslin cloth, and the freshly prepared Beejamrutham was used immediately without storage.

Beejaraksha was prepared using 100 g of fine red soil or termite mound soil, 100 g of wood ash or cow dung ash, 20 g of asafoetida powder, 20 g of turmeric powder, and 10 mL of cow urine. The dry ingredients were thoroughly mixed, followed by the gradual addition of cow urine to obtain a uniform mixture. The preparation was shade dried to obtain a fine powder and stored in an airtight container under dry conditions. For seed treatment, the seeds were lightly moistened with rice gruel or jaggery slurry, coated with 10 g of Beejaraksha per kg of seed.

Three treatments were designated as T₁: Seeds soaked in Beejamrutham for 30 minutes; T₂: Seed coated with Beejaraksha; and T₃: untreated seed. After soaking, treated seeds were shade-dried until moisture content returned to approximately 10–12%. These treatments were done in 3 sets of seed samples, and seed quality assays were done in 5 replications.

The seed physiological quality was evaluated using 100 seeds per treatment in 5 replications using the germination towel method under room temperature (22–26°C) and ambient conditions for 12 days by following the applicable seed-testing protocol (ISTA, 2022). First count was taken on 6th day and final count was taken on

12th day after seeds put for germination. Normal seedlings, abnormal seedlings, dead seeds and ungerminated hard seeds were counted. Germination percentage was calculated by the percentage of normal seedlings. Mean seedling length was recorded in centimeters. Seedling vigour index-I (SVI-I) was calculated as germination percentage × mean seedling length (Abdul-Baki and Anderson, 1973).

Results

The two biological treatments substantially improved all major descriptive indicators relative to the untreated control (Table 1). Beejamrutham produced 94% normal seedlings, 3% abnormal seedlings, 1% dead seed and 2% ungerminated hard seed. Beejaraksha produced 97% normal seedlings, 1% abnormal seedling, no dead seed and 2% hard seed. In contrast, the untreated control produced only 50% normal seedlings, accompanied by 18% abnormal seedlings and 30% dead seed. Thus, the final germination percentage increased by 88% with Beejamrutham and by 94% with Beejaraksha relative to the control.

Biological seed treatments markedly improved the germination and seedling performance of farmer-stored maize seed compared with the untreated control. Beejaraksha recorded the highest percentage of normal seedlings (97%), followed by Beejamrutham (94%), whereas only 50% normal seedlings were observed in the untreated control. Relative to the control, normal germination increased by 94% under Beejaraksha treatment and by 88% under Beejamrutham treatment.

Beejaraksha also produced the lowest proportion of deteriorated or non-viable seed. No dead seeds were recorded in this treatment, while abnormal seedlings and hard seeds accounted for only 1 and 2%, respectively. Beejamrutham treatment resulted in 3% abnormal seedlings, 1% dead seed and 2% hard seed. In contrast, the untreated control recorded 18% abnormal seedlings and 30% dead seeds, although the proportion of hard seeds remained 2% in all treatments. These observations indicate that the reduction in germination of untreated seed was primarily associated with seed mortality and abnormal seedling development rather than physical dormancy or hardness.

Beejamrutham-treated seedlings attained the greatest mean seedling length of 43 cm, representing an increase of 53.6% over the untreated control. Beejaraksha-treated seedlings reached a mean length of 39 cm, which was 39.3% greater than the control value of 28 cm. Thus, although Beejaraksha produced the highest final germination percentage, Beejamrutham was more

effective in promoting seedling elongation.

The combined effect of germination and seedling growth was reflected in seedling vigour index-I. Beejamrutham recorded the highest SVI-I of 4,042, followed by Beejaraksha with 3,783 and the untreated control with 1,400. Beejamrutham increased SVI-I by 188.7%, while Beejaraksha increased it by 170.2% over the untreated control.

Visual observations indicated that Beejamrutham-treated seed initiated sprouting earlier and developed vigorous seedlings more rapidly than Beejaraksha-treated seed. Beejaraksha emergence occurred approximately one day later, but the treatment ultimately produced the highest final germination and no seed mortality. The treatments therefore displayed contrasting, but potentially complementary responses: Beejamrutham was associated with faster early development and greater seedling elongation, while Beejaraksha was associated with superior final germination and seed survival.

Because replicate-level observations were not available for statistical analysis, the treatment differences should be interpreted as descriptive trends rather than statistically demonstrated effects. The numerical data nevertheless show a large and biologically meaningful improvement in the performance of both biologically treated seed lots relative to the untreated control.

Discussion

The pronounced improvement in maize germination and seedling vigour following Beejamrutham and Beejaraksha treatment indicates that farmer-accessible biological seed treatments would help restore or enhance the physiological performance of seed stored under ordinary ambient conditions. Maize seed used in the study had been stored in a permeable cloth bag, a practice commonly followed by farmers, where seed remains exposed to fluctuations in temperature and relative humidity. Such storage conditions may progressively reduce membrane integrity, metabolic efficiency and resistance to seed-associated microorganisms. The low germination, high mortality and high proportion of abnormal seedlings in the untreated control suggest that the seed lot had undergone some degree of deterioration during storage.

Effect of Beejamrutham on germination speed and seedling growth

Beejamrutham produced the longest seedlings and the highest seedling vigour index. This response is consistent with the established physiological basis of seed priming. Controlled hydration permits the early phases of

germination to begin before sowing, including membrane reorganization, repair of cellular damage, enzyme activation, mitochondrial recovery and mobilization of stored carbohydrates, proteins and other reserves. When primed seed is subsequently rehydrated during germination, it may complete these processes more rapidly than untreated seed, shortening the lag phase before radicle protrusion and seedling development as reported in blackgram (Bhargavi *et al.*, 2018), greengram and cowpea (Bhoi *et al.*, 2025), finger millet (Soniya *et al.*, 2022), paddy (Jahnavi and Sathiyarayanan 2025), mahogany (Rahul *et al.*, 2025).

The greater seedling length under Beejamrutham treatment suggests that the treatment affected not only final germination but also the rate and extent of early seedling growth. The formulation contains cow dung, cow urine and lime suspended in water. It may therefore expose seed to soluble mineral nutrients, organic compounds and microorganisms during hydration. These components could potentially influence reserve mobilization, microbial colonization or early metabolic activity. However, the present experiment did not analyze the nutrient composition, microbial population, pH or biochemical characteristics of Beejamrutham. The greater seedling growth should therefore not yet be attributed conclusively to nutritional or microbial stimulation.

The observed response may have resulted partly from the hydration treatment itself. A water-primed control was not included in the experiment; consequently, the independent effects of hydration and the biological ingredients cannot be separated. Future experiments should compare Beejamrutham with hydropriming, sterilized Beejamrutham and untreated dry seed to determine whether the response arises from hydration, nutrients, microorganisms or interactions among these factors.

Protective response associated with Beejaraksha

Beejaraksha produced the highest final germination, the lowest abnormal seedling percentage and no dead seeds. This pattern suggests a possible protective effect on seed viability and seedling development. The formulation contains red or termite-mound soil, ash, turmeric, asafoetida and cow urine. Ash may modify surface moisture and pH, while turmeric and asafoetida contain compounds that have traditionally been associated with antimicrobial activity. The coating may also provide a physical barrier between the seed surface and potentially harmful microorganisms (Godika *et al.*, 2022; Sajeena *et al.*, 2016 and Srusti *et al.*, 2024).

Nevertheless, the present study did not conduct seed-health testing or identify seed-associated fungi and bacteria. It is therefore not possible to establish whether the reduction in dead and abnormal seeds resulted from pathogen suppression, physical coating, altered surface conditions or another physiological effect. Blotter tests, agar-plate assays, pathogen identification and microbial profiling would be necessary to confirm the proposed protective function.

The slightly later emergence observed under Beejaraksha treatment may be associated with the coating layer surrounding the seed. A coating could temporarily slow water uptake or gaseous exchange, resulting in marginally delayed initial emergence while protecting the seed during the germination period. Such a mechanism could explain why Beejaraksha germinated later but produced the highest final germination. This interpretation remains hypothetical and should be tested by measuring imbibition rate, electrical conductivity, time to radicle protrusion and mean germination time.

Reduction in abnormal seedlings and seed mortality

The untreated seed produced 18% abnormal seedlings and 30% dead seeds, compared with only 1–3% abnormal seedlings and 0–1% mortality under the biological treatments. This reduction is important because standard germination percentage alone may not fully describe seed-lot performance. A seed may initiate germination but fail to develop into a normal seedling because of damaged embryonic tissues, weak roots or shoots, infection or inadequate reserve mobilization (Bhargavi *et al.*, 2018; Bhoi *et al.*, 2025; Soniya *et al.*, 2022; Rahul *et al.*, 2025; Godika *et al.*, 2022; Sajeena *et al.*, 2016).

The lower abnormality and mortality observed after treatment suggest that biological priming improved either physiological repair, protection against microorganisms, or both. Priming can allow repair of membranes, DNA and proteins before radicle emergence. Biological treatments may additionally alter the seed-surface microbiome or suppress harmful organisms. The present findings are compatible with both mechanisms, but they cannot distinguish between them.

Seedling vigour and relevance under moisture-deficit conditions

Seedling vigour index-I was nearly three times greater under Beejamrutham treatment and approximately 2.7 times greater under Beejaraksha as compared to the untreated control. Vigorous seedlings generally possess greater capacity for rapid emergence, early root growth and establishment under suboptimal seedbed conditions

(Murungu *et al.*, 2004; Murungu *et al.*, 2005; Harris *et al.*, 1999; Finch-Savage and Bassel, 2016; Paparella *et al.*, 2015 and Lutts *et al.*, 2016). Under moisture-limited environments, rapid radicle extension may allow seedlings to access transient water present below the drying surface layer. Uniform emergence can also reduce exposure to soil crusting, high surface temperatures, early weed competition and progressive loss of seed-zone moisture.

These characteristics are relevant to erratic rainfall and moisture-deficient sowing conditions. However, the germination test was conducted in moist towels under favourable laboratory conditions and did not impose water stress. The present experiment therefore demonstrates enhanced germination and seedling vigour, but it does not directly establish drought tolerance, water-stress resistance or improved field survival.

The ability of treated seedlings to withstand water deficit must be verified under controlled stress conditions. Suitable approaches include germination at graded osmotic potentials using polyethylene glycol, emergence tests in soil maintained at different moisture levels, pot experiments involving controlled drying cycles and replicated farmer-field trials. Measurements should include emergence speed, seedling survival, root length and volume, shoot and root dry matter, relative water content, membrane stability, chlorophyll, antioxidant activity, plant population and final yield.

Differential functions of the two formulations

The results indicate a potentially useful functional distinction between the treatments. Beejamrutham produced the greatest seedling length, highest vigour index and earlier visible sprouting, suggesting a stronger priming or growth-promoting response. Beejaraksha produced the highest final germination and no mortality, suggesting a stronger seed-protection response.

This differentiation may have practical relevance. Beejamrutham could be useful where rapid and uniform emergence is the main objective, whereas Beejaraksha may be useful when stored seed is at risk of deterioration or seed-associated infection. A sequential or integrated treatment may also be considered, but compatibility should first be evaluated. Combining the formulations without testing could alter hydration, coating, microbial viability or seed-surface conditions and may not necessarily provide an additive benefit.

Treatment duration and post-treatment drying

The effectiveness of priming depends strongly on seed genotype, initial seed quality, seed age, soaking duration, temperature, formulation concentration and

drying procedure. Excessive hydration can permit radicle emergence or cause oxygen deficiency, solute leakage and vigour loss. Inadequate drying can reduce storability and encourage fungal development.

The manuscript currently reports Beejamrutham treatment for 30 minutes and Beejaraksha as a coating treatment, followed by shade drying to 10–12% moisture. These details should be maintained consistently throughout the paper. The earlier description of “overnight soaking” should be corrected unless that was the actual procedure followed. Similarly, the manuscript contains conflicting statements regarding visible sprouting beginning on the second day or fifth day. The original observation sheets should be checked before submission.

Treated seed should preferably be sown soon after drying. Additional storage studies are needed before recommending that biologically treated seed be retained

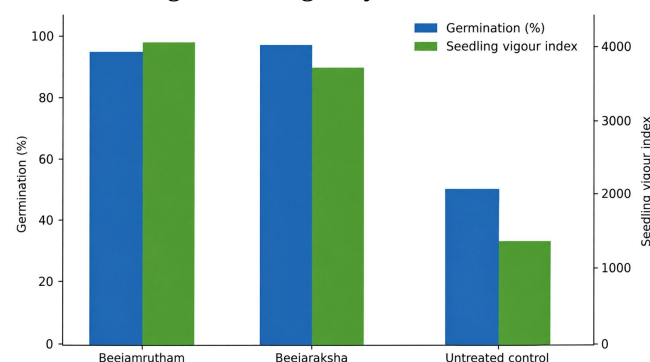


Fig. 1 : Germination percentage and seedling vigour index-I of maize following Beejamrutham, Beejaraksha and untreated control treatments.

for extended periods. Germination and vigour should be assessed at defined intervals after treatment to determine whether the benefits persist or decline.

Practical and research implications

The magnitude of improvement over the untreated control justifies further investigation of both formulations as low-cost seed-quality enhancement options for farmer-stored maize. Their ingredients are locally accessible, and the treatments may be suitable for decentralized use if preparation, dosage, hygiene, drying and application procedures are standardized.

A subsequent experiment should use a randomized design with adequate replication and multiple seed lots or maize genotypes. Recommended treatments include untreated dry seed, water priming, Beejamrutham, Beejaraksha and, after compatibility testing, a combined or sequential treatment. Assessments should include germination speed, mean germination time, seedling vigour indices, seed health, biochemical markers and performance under controlled moisture stress. Multi-location field validation should ultimately determine whether improvements observed in the laboratory translate into better crop establishment and yield under farmers' conditions.

Overall interpretation

Both Beejamrutham and Beejaraksha substantially improved the descriptive performance of farmer-stored maize seed. Beejamrutham was superior for seedling elongation and overall seedling vigour, while Beejaraksha



Fig. 2 : Pictorial depiction of seedling performance of maize following Beejamrutham, Beejaraksha and untreated control treatments.

Table 1 : Germination and seedling vigour of maize seed after biological seed treatments.

Treatment	Normal seedlings (%)	Abnormal seedlings (%)	Dead seeds (%)	Hard seeds (%)	Seedling length (cm)	SVI-I
Beejamrutham	94	3	1	2	43	4,042
Beejaraksha	97	1	0	2	39	3,783
Untreated control	50	18	30	2	28	1,400

SVI-I = germination percentage $\times$ mean seedling length. Values are descriptive observations from one aggregated 100-seed working sample per treatment; replicate-level data were not available.

was superior for final germination and reduction of seed mortality. The findings support further development of biological seed-treatment protocols based on local natural resources. At present, they should be described as promising treatments for improving germination and seedling vigour, rather than as proven technologies for drought tolerance (Ramanjaneyulu *et al.*, 2023).

Conclusion

Treatment followed by shade-drying improved the descriptive germination and seedling-vigour performance of farmer-stored maize seed. Beejamrutham showed the highest seedling elongation and seedling vigour index, whereas Beejaraksha showed the highest final germination and no seed mortality. The treatments are promising for low-cost seed enhancement, but replicated laboratory and water-stress field validation is essential before recommending them as technologies for drought tolerance.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data availability

The descriptive dataset supporting this short communication is maintained by the Centre for Sustainable Agriculture and may be made available by the corresponding author, subject to institutional approval.

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