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Evaluation of Seed Cube Technology in Brinjal, Tomato and Chilli

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Seed cube technology may improve the efficient use of vegetable seed by combining quality-treated seeds with a compact growth medium for direct field establishment. The study was conducted at the Vegetable Research Station, Palur, and at farmers' fields to evaluate the feasibility and performance of seed cube technology for raising brinjal, tomato and chilli. Seed cubes were prepared using soil (700 g), sawdust (130 g), bone meal (80 g), vermicompost (40 g) and VAM (50 g) with quality-treated vegetable seeds embedded in each cube. In Experiment I, a factorial randomised block design was adopted with three solanaceous vegetable crops and two planting methods, viz. surface and subsurface planting. Surface planting recorded significantly higher field establishment (27.2 plants 20 m^{-2}), lower mortality (9.3%), a maximum number of fruits per plant (16.0), fruit yield per plant (2.44 kg), fruit set (65.6%), seed yield per plant (17.4 g) and finally the seed yield (368.9 kg ha^{-1}) than subsurface planting. Among the crops, brinjal recorded the highest field establishment (24.2 plants 20 m^{-2}), the lowest mortality (19.4%), the highest fruit set (71.1%) and the highest fruit yield (23.1 t $acre^{-1}$), while tomato recorded the highest fruit yield per plant (2.78 kg), seed yield per plant (19.7 g) and seed yield (378.9 kg ha^{-1}). In Experiment II, the technology was evaluated at five farmer-field locations for each crop. Surface planting resulted in significantly higher plant establishment (29.0 plants 20 m^{-2}), lower mortality (21.3%) and higher fruit yield per plant (2.245 kg) than subsurface planting. Brinjal recorded the highest

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plant establishment (28.5 plants 20 m^{-2}) and fruit yield (23.2 t $acre^{-1}$), whereas tomato recorded the highest fruit yield per plant (3.145 kg). The results demonstrate that surface placement of seed cubes is a promising approach for improving crop establishment and productivity in brinjal, tomato and chilli under both research-station and farmer-field conditions. The findings are consistent with recent research showing that seed enhancement and priming approaches can improve germination, seedling vigour and subsequent productivity in vegetable crops.

Keywords: Vegetable seeds; seed cube; nutri packed seeds; surface planting; tomato; brinjal; chilli.

1. Introduction

Vegetable crops such as brinjal (*Solanum melongena* L.), tomato (*Solanum lycopersicum* L.) and chilli (*Capsicum annuum* L.) are important solanaceous vegetables cultivated extensively for their nutritional, economic and culinary value. Successful vegetable production depends greatly on the availability of quality seed and rapid, uniform crop establishment. In conventional vegetable cultivation, particularly for small-seeded crops, considerable quantities of seed may be wasted during nursery raising and transplanting. Uneven germination, poor seedling establishment, mortality and the requirement for repeated sowing or transplanting can further increase production costs. Therefore, seed enhancement technologies that combine quality seed with suitable nutrient and growing media components have considerable potential for improving planting efficiency and crop establishment.

Seed enhancement encompasses several techniques, including priming, coating, pelleting, nutrient enrichment and biological treatments, which are intended to improve germination, seedling vigour, uniformity and subsequent crop performance (Kanala *et al.*, 2024; Gallegos-Cedillo *et al.*, 2024; Mohammad *et al.*, 2024). Recent reviews have emphasised that seed priming can accelerate germination, improves uniform emergence and enhance plant responses to biotic and abiotic stresses in horticultural crops (Zulfiqar, 2021; Thakur *et al.*, 2022; Dhal *et al.*, 2022; Athira *et al.*, 2022; García-Locascio *et al.*, 2024). Seed enhancement is particularly relevant to vegetable crops because their high-value production systems require uniform establishment and efficient utilisation of seed. Seed treatments can also reduce the need for gap filling and resowing and thereby improve the efficiency of subsequent crop-management operations (Barooah *et al.*, 2023; Gupta *et al.*, 2023).

Additional recent syntheses indicate that seed priming can support germination, early seedling vigour and stress resilience through a range of pre-sowing approaches (Kumar *et al.*, 2024; Koushal *et al.*, 2024; Jatana *et al.*, 2024). In chilli, nutrient seed priming with potassium nitrate and zinc oxide has been reported to influence germination and early seedling performance under laboratory and glasshouse conditions (Maphalaphathwa & Nciizah, 2025).

The concept of seed cube technology provides an alternative approach in which a small number of quality-treated seeds are embedded in a compact cube containing soil, sawdust, bone meal, vermicompost and VAM. Such a system has the potential to provide the developing seedling with a localized source of moisture, nutrients and beneficial microorganisms while simultaneously reducing seed wastage and simplifying planting. The technology may be particularly useful for home gardens and small-scale vegetable production, where farmers or consumers require only a limited number of plants rather than large quantities of seed (Panwar *et al.*, 2021).

However, the effectiveness of seed cubes depends not only on the composition of the cube but also on the method of placement in the field. Depth of placement can influence moisture availability, emergence, aeration and early seedling survival. Nevertheless, evidence on the field performance of this specific seed-cube formulation across brinjal, tomato and chilli, particularly in relation to surface versus subsurface placement under both research-station and farmer-field conditions, remains limited. Therefore, the present study was undertaken to evaluate seed cube technology in brinjal, tomato and chilli, with particular emphasis on comparing surface and subsurface planting methods and assessing their effects on field establishment, mortality, fruit production and seed yield. The study was further extended to farmer-field conditions to determine the practical performance and adaptability of the technology under real production environments.

2. Materials and Methods

The freshly prepared seed cubes for brinjal, tomato and chilli collected from the Seed Centre, TNAU, Coimbatore, formed the base material for the study. The field trial was conducted at the Vegetable Research Station, Palur, using a Factorial Randomised Block Design (FRBD). The main-plot treatments were the solanaceous vegetable crops, viz. C_1 – brinjal, C_2 – tomato and C_3 – chilli, and the subplot treatments were the planting methods, viz. T_1 – surface planting and T_2 – subsurface planting, with three replications. The following observations were recorded: field establishment at 30 DAS/planting, mortality percentage, number of plants/m^2, plant height at 30, 60 and 90 DAP, days to first flowering, days to 50% flowering, number of flowers/plant, fruit set percentage, number of pickings, number of fruits/picking, total fruit yield/plant, fruit yield/acre, seed yield/plant, seed recovery percentage and seed yield/ha.

3. Results

Seed cube technology significantly influenced field establishment, mortality, fruiting and seed yield in brinjal, tomato and chilli. T1 recorded significantly higher field establishment at 30 DAS (27.2 plants/20 m^2) and lower mortality (9.3%) than T2 (18.9 plants/20 m^2 and 37.0%, respectively). Among the crops, brinjal recorded the highest field establishment (24.2 plants/20 m^2) and the lowest mortality (19.4%), while chilli recorded the lowest establishment (21.8 plants/20 m^2) and the highest mortality (27.2%) (Table 1). T1 also recorded a highest number of fruits per plant (16.0), highest fruit yield per plant (2.44 kg) and maximum fruit set (65.6%)

than T2 (15.1, 1.97 kg and 58.8% respectively). Chilli recorded the highest number of fruits per plant (16.7), whereas tomato recorded the highest fruit yield per plant (2.78 kg), and brinjal recorded the highest fruit set (71.1%) (Table 2). Fruit yield per acre did not differ significantly between treatments, with 15.2 and 15.4 t acre^{-1} under T1 and T2, respectively. However, T1 recorded significantly higher seed yield per plant (17.4 g) and seed yield per hectare (368.9 kg) than T2 (12.0 g and 228.4 kg ha^{-1}, respectively). Among the crops, brinjal recorded the highest fruit yield (23.1 t acre^{-1}), while tomato recorded the highest seed yield per plant (19.7 g) and seed yield per hectare (378.9 kg ha^{-1}) (Table 3); chilli recorded the lowest values for most yield parameters. Significant treatment × crop interactions were observed for mortality rate, number of fruits per plant and fruit yield per plant, whereas the interactions were non-significant for field establishment, fruit set, seed yield per plant and seed yield per hectare.

Table 1. Effect of Seed cube technology on field establishment (Nos in 20 m^2) and mortality rate % in solanaceous vegetables

Trt/Crop	Field Establishment at 30 DAS				Mortality rate %			
	Brinjal	Tomato	Chilli	Mean	Brinjal	Tomato	Chilli	Mean
T1	28.3	27.3	26.0	27.2	5.6	8.9	13.3	9.3
T2	20.0	19.0	17.7	18.9	33.3	36.7	41.1	37.0
Mean	24.2	23.2	21.8	23.1	19.4	22.8	27.2	23.1
	T	C	TxC		T	C	TxC	
SE(d)	0.444	0.638	0.903		1.33	0.84	.191	
CD	0.93	1.34	NS		3.42	1.87	2.65	

Brinjal trial at farmers field | **Chilli trial at farmers field**

Picture 1. Farmer-field evaluation of seed cube technology in brinjal (left) and chilli (right)

Further evaluations were conducted at five locations for each crop in farmers' fields. The freshly prepared seed cubes collected from the Seed Centre, TNAU, Coimbatore, formed the base material for the study. The field trials included the following treatments: T_1 – the best method of seed cube sowing identified is Surface planting as per the above experiment; and T_2 – transplanting of seedlings. The following observations were recorded: field establishment, number of plants/m^2, days to 50% flowering, number of pickings, number of fruits/picking, total fruit yield/plant and fruit yield/acre.

Under farmers' field conditions, the seed cube planting method significantly influenced plant establishment, mortality rate and fruit yield of solanaceous vegetables (Table 4). Surface planting recorded significantly higher plant establishment at 30 DAS (29.0 plants/20 m²) than subsurface planting (27.5 plants/20 m²), while mortality was significantly lower under surface planting (21.3%) than under subsurface planting (24.3%). Among the crops, brinjal recorded the highest plant establishment (28.5 plants/20 m²), whereas tomato recorded the highest mortality (23.4%) (Table 4). Surface planting also recorded significantly higher fruit yield per plant (2.245 kg) than subsurface planting (2.024 kg). Among the crops, tomato recorded the highest fruit yield per plant (3.145 kg), followed by brinjal (2.175 kg) and chilli (1.083 kg). Fruit yield per acre was also higher under surface planting (15.5 t acre^{-1}) than under subsurface planting (15.3 t acre^{-1}), although the difference between planting methods was not statistically significant based on the reported CD. Among the crops, brinjal recorded the highest fruit yield (23.2 t acre^{-1}), while tomato and chilli each recorded 11.5 t acre^{-1} (Table 5 and Fig. 1). Significant treatment × crop interactions were observed for plant establishment, mortality rate and fruit yield per plant.

4. Discussion

The present investigation demonstrated that seed cube technology has considerable potential for establishing brinjal, tomato and chilli directly in the field, with surface planting emerging as the more effective planting method under both research-station and farmer-field conditions. The response, however, varied among the three solanaceous crops, indicating the importance of crop-specific adaptation of the technology.

Table 2. Effect of Seed cube technology on number of fruits/ plant, fruit yield/plant and fruit set percentage in solanaceous vegetables

Trt/	Number of fruits /plant				Fruit yield /plant (kg)				Fruit set percentage			
Crop	**Brinjal**	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**
T1	14.7	16.5	16.9	16.0	2.77	3.37	1.20	2.44	74.7	70.1	52.0	65.6
T2	13.5	15.3	16.4	15.1	1.70	2.20	2.00	1.97	67.6	62.9	45.9	58.8
Mean	14.1	15.9	16.7	15.6	2.23	2.78	1.60	2.21	71.1	66.5	48.9	62.2
	T	**C**	**TxC**		**T**	**C**	**TxC**		**T**	**C**	**TxC**	
SE(d)	1.104	1.352	1.912		0.045	0.086	0.121		0.41	1.29	1.82	
CD	1.431	0.591	0.842		0.191	0.200	0.280		1.77	2.96	NS	

Table 3. Effect of Seed cube technology on fruit and seed yield in solanaceous vegetables

Trt/	Fruit yield /ac (t)				Seed yield /plant (g)				Seed yield /ha (kg)			
Crop	**Brinjal**	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**
T1	22.5	11.6	11.4	15.2	18.6	22.4	11.3	17.4	412.0	429.7	265.0	368.9
T2	23.7	11.2	11.2	15.4	13.5	16.9	5.7	12.0	254.2	328.1	103.0	228.4
Mean	23.1	11.4	11.3	15.3	16.1	19.7	8.5	14.7	333.1	378.9	184.0	298.7
	T	**C**	**TxC**		**T**	**C**	**TxC**		**T**	**C**	**TxC**	
SE(d)	1.08	1.24	1.75		1.01	1.19	1.68		20.79	23.67	33.47	
CD	4.65	2.86	4.03		4.35	2.74	NS		89.44	54.6	NS	

Table 4. Effect of Seed cube technology on No. of plants (Nos in 20 m^2) and mortality rate % in solanaceous vegetables at farmer's field

Trt/Crop	No. of plants in 20 m^2 at 30 DAS				Mortality rate %			
	Brinjal	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**
Surface planting	29.4	28.8	28.8	29.0	20.1	22.0	22.0	21.3
Sub surface planting	27.7	27.3	27.7	27.5	24.0	24.9	24.0	24.3
Mean	28.5	28.0	28.2	28.3	22.0	23.4	23.0	22.8
	T	C	TxC		T	C	TxC	
SE(d)	1.074	1.315	1.86		2.064	2.753	5.308	
CD	2.014	1.988	2.001		3.912	4.001	9.840	

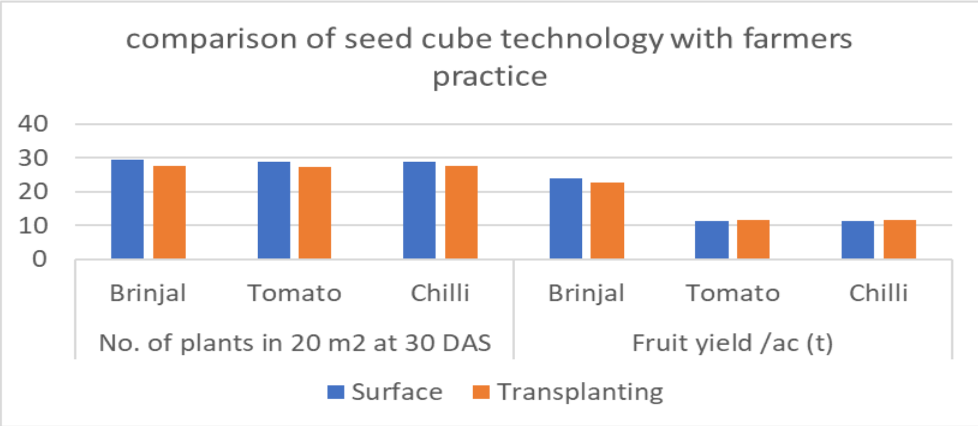

Fig. 1. Effect of Seed cube technology on mortality rate % and fruit yield in solanaceous vegetables at farmer's field

Table 5. Effect of Seed cube technology on fruits yield in solanaceous vegetables

Trt/Crop	Fruit yield /plant (kg)				Fruit yield /ac (t)			
	Brinjal	**Tomato**	**Chilli**	**Mean**	**Brinjal**	**Tomato**	**Chilli**	**Mean**
Surface planting	2.278	3.261	1.195	2.245	23.8	11.3	11.4	15.5
Sub surface planting	2.071	3.029	0.971	2.024	22.6	11.7	11.6	15.3
Mean	2.175	3.145	1.083	2.134	23.2	11.5	11.5	15.4
	T	C	TxC		T	C	TxC	
SE(d)	0.056	0.069	0.198		0.650	0.796	1.126	
CD	0.134	0.154	0.323		1.124	1.774	2.025	

In the research-station experiment, surface planting recorded significantly higher field establishment at 30 DAS, with a mean of 27.2 plants/20 m², compared with only 18.9 plants/20 m² under subsurface planting (Table 1). Correspondingly, mortality was substantially lower under surface planting (9.3%) than under subsurface planting (37.0%). The superiority of surface placement suggests that seed cubes placed near the soil surface experienced more favourable conditions for emergence, possibly because of improved aeration and reduced resistance to shoot emergence. Excessive depth can impose greater mechanical resistance on emerging seedlings and may also influence the availability of oxygen and moisture around the germinating seed.

Surface planting also produced better reproductive performance. The mean number of fruits per plant was 16.0 under surface planting compared with 15.1 under subsurface planting. Similarly, fruit yield per plant increased from 1.97 kg under subsurface planting to 2.44 kg under surface planting. Fruit set was also higher under surface planting (65.6%) than under subsurface planting (58.8%). The differences in the number of fruits per plant, fruit yield per plant and fruit set were statistically significant according to the reported CD values, demonstrating that improved early establishment under surface planting was associated with better subsequent crop performance.

Among the crops, chilli produced the highest number of fruits per plant (16.7), while tomato recorded the highest fruit yield per plant (2.78 kg). Brinjal recorded the highest fruit set (71.1%) (Table 2). The contrasting responses among crops may be associated with inherent differences in plant architecture, flowering behaviour, fruit size and reproductive efficiency. The improved reproductive performance under surface planting can be related to better plant establishment and reduced early mortality, which would provide a greater number of productive plants and better utilisation of available resources.

A notable advantage of surface planting was observed in seed production. Surface planting recorded significantly higher seed yield per plant (17.4 g) than subsurface planting (12.0 g) and higher seed yield per hectare (368.9 kg ha^{-1}) than subsurface planting (228.4 kg ha^{-1}) (Table 3). The improved seed yield under surface planting may have resulted from better early establishment, lower mortality and improved reproductive performance. The significant treatment effect on seed yield per plant and seed yield per hectare supports the practical value of selecting the appropriate planting depth for seed cube technology. The treatment × crop interaction was non-significant for seed yield, suggesting that the superiority of surface planting for seed production was relatively consistent across the three crops.

4.1 Performance under Farmer-field Conditions

The farmer-field evaluation provided important confirmation of the research-station findings. Surface planting recorded 29.0 plants/20 m² at 30 DAS, compared with 27.5 plants/20 m² under subsurface planting. Mortality was also lower under surface planting (21.3%) than under subsurface planting (24.3%) (Table 4). Surface planting also produced significantly higher fruit yield per plant (2.245 kg) than subsurface planting (2.024 kg) (Table 5). The composition of the seed cube used in the present study—soil, sawdust, bone meal, vermicompost and VAM—also provides a potentially useful combination of physical support, organic matter, nutrients and beneficial microbial activity. The importance of nutrient enrichment and beneficial microorganisms in seed enhancement is supported by recent research on seed pelleting and biological seed treatments (Lamichhane *et al.*, 2022; Jeephet *et al.*, 2024; Jaiman *et al.*, 2020; Kangsopa *et al.*, 2024). Seed coating with beneficial microorganisms has also been reported to improve germination, seedling vigour and plant growth in tomato, demonstrating the potential of integrating biological components with seed-based technologies (Righini *et al.*, 2021; Mohan Raj & Sundareswaran, 2021; Zhang *et al.*, 2022; Palakshappa *et al.*, 2022; Kangsopa *et al.*, 2025).

5. Conclusion

Overall, the results demonstrate that surface placement of seed cubes is superior to subsurface placement for achieving better early establishment, reduced mortality and improved fruit and seed production, particularly under the conditions of the present study. The technology also showed adaptability under farmer-field conditions. The findings are in agreement with the general evidence that enhanced seeds and integrated seed-treatment approaches can improve germination, establishment and subsequent crop productivity. Further multi-location studies across different seasons, with different cube compositions, numbers of seeds per cube, irrigation regimes and economic analyses, would be useful for standardising the technology before it is recommended on a large scale.

6. Limitations

The study was limited to three solanaceous crops and compared only surface and subsurface placement of a single seed-cube formulation. The research-station trial used three replications, while the farmer-field evaluation covered five locations for each crop. Seasonal variation, alternative cube compositions, different numbers of seeds per cube, irrigation regimes and economic performance were not evaluated. Consequently, the findings should be interpreted within the tested conditions. Future multi-location and multi-season studies incorporating formulation, irrigation and cost–benefit comparisons would strengthen the basis for wider standardisation and recommendation.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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