

Effect of Seed Priming with Botanical Extracts on Growth Performance of Okra, Pea and Tomato

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Abstract: The present study entitled “Effect of Botanical Seed Priming on Growth Performance of Okra, Pea and Tomato” was carried out at Government Holkar Science College, Indore (Madhya Pradesh). The study included seed priming treatments using leaf extracts of *Moringa oleifera*, *Albizia amara*, and *Prosopis juliflora* at 3% concentration, along with an untreated control. Various growth parameters such as plant height at first picking, number of branches per plant, fresh and dry biomass, and days to 50% flowering were recorded and statistically analyzed. Significant differences among treatments were observed across all crops. Seed priming with *Moringa oleifera* leaf extract (3%) consistently showed superior performance, recording maximum plant height at first picking in okra (95.62 cm), pea (55.24 cm), and tomato (87.96 cm). It also resulted in higher branching (4.36, 5.32, and 7.58, respectively), greater fresh biomass (124.69 g, 78.82 g, and 214.52 g), and increased dry matter accumulation (38.57 g, 19.36 g, and 74.52 g) in addition, this treatment significantly reduced the time required for 50% flowering in all crops, indicating improved physiological efficiency and early establishment. Overall, the findings suggest that seed priming with *Moringa oleifera* leaf extract at 3% is a cost-effective, eco-friendly, and efficient technique to enhance growth and early vigor of vegetable crops under kitchen gardening conditions.

Keywords: Botanical seed priming, *Moringa oleifera* leaf extract, *Albizia amara*, *Prosopis juliflora*, Okra, Pea, Tomato, Growth parameters, Biomass accumulation, Flowering behaviors, Kitchen gardening

1. Introduction

Vegetables crops such as okra (*Abelmoschus esculentus*), pea (*Pisum sativum*), and tomato (*Solanum lycopersicum*) are staples in kitchen gardens because they offer high nutritional value, are easy to cultivate, and can be grown in multiple seasons, providing a steady supply of fresh produce throughout the year.

Kitchen gardening has emerged as a vital practice for enhancing food security, nutritional self-sufficiency, and mental well-being, particularly in urban and peri-urban settings amid challenges like climate variability and the COVID-19 pandemic (Acton & Gaisbauer, 2022; Galli et al., 2020).

Seed priming is one of the techniques used to get higher germination and Vigor. It is basically pre sowing seed treatment in which the seeds are hydrated and dehydrated, which modifies physiological and biochemical properties of seed (Basu,1976) Seed priming, a controlled hydration-dehydration pre-sowing treatment, activates metabolic processes to improve germination speed, uniformity, and stress tolerance without allowing radicle emergence (Paparella et al., 2015).

Previously, various chemicals, salts, and plant growth regulators have been used in seed priming to improve the seed emergence, plant growth, and the crop yield (Farooq et al., 2007) but as they were costly, they could not be utilized on a large scale. Therefore, there arose a need to search for seed priming agents of natural origin, which is also a step towards organic agriculture.

Botanical priming is new endeavor and many botanical extracts have been studied for their effect on seed and seedling parameters. (Bhateshwar et al.,2020). Botanicals contain thousands of constituents which are biologically active molecules possessing antimicrobial property. Using of

these botanicals in seed production lowers cost of production, eco-friendly, easily biodegradable and cheaper than the chemicals.

Leaves of *Albizia* spp. and *Prosopis* spp. contain diverse secondary metabolites; *Albizia amara* (locally used as “Arrapu” in some Indian reports) has been tested as a seed priming/pelleting agent and showed positive effects on germination and seedling vigor in okra and other legumes under laboratory and field conditions (Girase et al. 2019; Prakash et al. 2019). *Prosopis juliflora* extracts can show dose-dependent responses: low-concentration or formulated applications have been used beneficially in seed treatments or pelleting, while higher concentrations may produce allelopathic inhibition in some species (Prakash; Bibi et al. 2023). These species- and concentration-specific outcomes underline the need for crop-wise evaluation of botanical priming agents.

Given these findings, the present study evaluated seed priming with leaf extracts of *Moringa oleifera*, *Albizia amara* and *Prosopis juliflora* (each at 3%) on growth parameters of okra (*Abelmoschus esculentus*), pea (*Pisum sativum*) and tomato (*Solanum lycopersicum*) in kitchen gardening. The measured traits-plant height at first picking, number of branches, fresh and dry biomass and days to 50% flowering-are robust indicators of early vigor and productivity, and the results are discussed with reference to the empirical and Indian literature summarized above.

2. Methodology

The experiments carried out at Government Holkar Science College, Indore (Madhya Pradesh) during 2022-2023 & 2023–2024. The experiment was laid out in a treatment-based design with 10 treatments and 3 replications in kitchen gardening. The vegetable crops seed selected for study were local variety of okra (*Abelmoschus esculentus*), pea (*Pisum sativum*) and tomato (*Solanum lycopersicum*).

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Fresh, healthy leaves of ten selected plant- *Moringa oleifera*, *Aegle marmelos*, *Albizia amara*, *Phyllanthus emblica*, *Prosopis juliflora*, *Acacia nilotica*, *Sapindus mukorossi*, *Terminalia arjuna*, and *Azadirachta indica*- were collected separately and powdered was made of separately shade dried leaves using electric grinder. Three-gram Powder was taken and dissolved in 100 ml of distilled water to make 3 per cent leaf extract followed by filtration through muslin cloth and Whatman No. 1 filter paper. Local variety seeds of tomato were sterilized with 0.1% HgCl₂ solution for 2 minutes, rinsed with distilled water, and then soaked seed 12 hours for okra and tomato and 8 hours for pea in their respective leaf extracts at room temperature. The control treatment (T₁) consisted of seeds soaked only in distilled water. After soaking, seeds were shade-dried to their original moisture content before sowing.

The experiment was laid out in a treatment-based design comprising ten treatments with three replications. Observations on growth parameters such as plant height at first picking, number of branches per plant, plant fresh weight, total dry weight and days to 50% flowering were recorded following standard procedures. The data obtained were statistically analyzed using appropriate analysis of variance (ANOVA) techniques to test the significance of treatment effects, and mean comparisons were performed at a suitable level of significance to interpret the results

3. Results and Discussion

3.1 Growth parameters of plant

The data pertaining to plant height at first picking (cm) in okra, pea and tomato as influenced by evaluation of seed priming with botanicals of some vegetables in kitchen gardening has been recorded and presented in Table 1.

Plant height at first picking (cm) in okra

The appraisal in treatments demonstrated clear variation in plant height at first picking (cm) among the treatments. The peak value was attained in T₂ (*Moringa oleifera* Leaf Extract@ 3%) at (95.62 cm), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (90.82 cm) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (85.32 cm). The least plant height at first picking (cm) (56.43 cm) was documented in T₁ (Control).

Plant height at first picking (cm) in pea

The appraisal in treatments demonstrated clear variation in plant height at first picking (cm) among the treatments. The peak value was attained in T₂ (*Moringa oleifera* Leaf Extract@ 3%) at (55.24 cm), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (53.85 cm) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (51.47 cm). The least plant height at first picking (cm) (37.52 cm) was documented in T₁ (Control).

Plant height at first picking (cm) in tomato

The appraisal in treatments demonstrated clear variation in plant height at first picking (cm) among the treatments. The peak value was attained in T₂ (*Moringa oleifera* Leaf Extract@ 3%) at (87.96 cm), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (84.62 cm) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (81.27 cm). The

least plant height at first picking (cm) (60.25 cm) was documented in T₁ (Control).

Plant fresh weight reflects overall biomass accumulation and physiological efficiency. The significantly higher fresh weight recorded under *Moringa* leaf extract priming across all three crops indicates improved water uptake, photosynthesis and metabolite synthesis. Indian researchers such as Yasmeen *et al.* (2013) and Rady *et al.* (2015) reported that *Moringa* extract enhances chlorophyll content and photosynthetic activity, leading to greater biomass accumulation. Girase *et al.* (2019) also reported increased fresh weight in okra due to plant extract treatments. The comparatively lower fresh weight in control plants may be due to slower seedling establishment and reduced nutrient utilization efficiency.

3.2 Number of branches per plant

The data pertaining to number of branches per plant in okra, pea and tomato as influenced by evaluation of seed priming with botanicals of some vegetables in kitchen gardening has been recorded and presented in Table 2.

Number of branches per plant in okra

The study reflected in treatments considerable differences in number of branches per plant, the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) secured the highest number of branches per plant (4.36), this was closely at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (4.13) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (3.92). The lowest number of branches per plant (2.21) was associated with T₁ (Control).

Number of branches per plant in pea

The study reflected in treatments considerable differences in number of branches per plant, the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) secured the highest number of branches per plant (5.32), this was closely at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (5.17) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (5.07). The lowest number of branches per plant (3.26) was associated with T₁ (Control).

Number of branches per plant in tomato

The study reflected in treatments considerable differences in number of branches per plant, the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) secured the highest number of branches per plant (7.58), this was closely at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) (7.31) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) (6.96). The lowest number of branches per plant (4.36) was associated with T₁ (Control).

Branching is an important growth trait influencing canopy development and photosynthetic efficiency. In the present study, the highest number of branches per plant in okra, pea and tomato was recorded under *Moringa oleifera* leaf extract priming (T₂), followed closely by *Albizia amara* and *Prosopis juliflora*. Increased branching under botanical priming could be associated with improved nutrient mobilization, enhanced hormonal balance and increased assimilate availability. Prakash (2019) reported that seed pelleting with botanical extracts significantly increased

branching in cluster bean, while Girase *et al.* (2019) observed improved vegetative growth in okra following botanical treatments. The poor branching in the control treatment indicates that absence of priming limits early physiological stimulation, resulting in reduced vegetative proliferation.

3.3 Plant fresh weight (g)

The data pertaining to plant fresh weight (g) in okra, pea and tomato as influenced by evaluation of seed priming with botanicals of some vegetables in kitchen gardening has been recorded and presented in Table 3.

Plant fresh weight (g) in okra

In this experiment, treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly greatest plant fresh weight (g) (124.69 g), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (118.72 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (111.39 g). In contrast, the least plant fresh weight (g) (68.25 g) was obtained in T₁ (Control).

Plant fresh weight (g) in pea

In this experiment, treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly greatest plant fresh weight (g) (78.82 g), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (75.49 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (72.63 g). In contrast, the least plant fresh weight (g) (47.69 g) was obtained in T₁ (Control).

Plant fresh weight (g) in tomato

In this experiment, treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly greatest plant fresh weight (g) (214.52 g), which was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (209.71 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (201.41 g). In contrast, the least plant fresh weight (g) (158.93 g) was obtained in T₁ (Control).

Plant fresh weight reflects overall biomass accumulation and physiological efficiency. The significantly higher fresh weight recorded under *Moringa* leaf extract priming across all three crops indicates improved water uptake, photosynthesis and metabolite synthesis. Indian researchers such as Yasmeen *et al.* (2013) and Rady *et al.* (2015) reported that *Moringa* extract enhances chlorophyll content and photosynthetic activity, leading to greater biomass accumulation. Girase *et al.* (2019) also reported increased fresh weight in okra due to plant extract treatments. The comparatively lower fresh weight in control plants may be due to slower seedling establishment and reduced nutrient utilization efficiency.

3.4 Total dry weight (g)

The data pertaining to total dry weight (g) in okra, pea and tomato as influenced by evaluation of seed priming with botanicals of some vegetables in kitchen gardening has been recorded and presented in Table 4.

Total dry weight (g) in okra

The assessment showed that treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly highest total dry weight (g) (38.57 g). This was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (37.82 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (36.52 g). The significantly lowest total dry weight (g) (20.36 g) was obtained in T₁ (Control).

Total dry weight (g) in pea

The assessment showed that treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly highest total dry weight (g) (19.36 g). This was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (18.63 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (18.02 g). The significantly lowest total dry weight (g) (13.42 g) was obtained in T₁ (Control).

Total dry weight (g) in tomato

The assessment showed that treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recorded the significantly highest total dry weight (g) (74.52 g). This was at par with the treatment T₄ (*Albizia amara* Leaf Extract@ 3%) showing (71.65 g) and the treatment T₆ (*Prosopis juliflora* Leaf Extract@ 3%) showing (68.87 g). The significantly lowest total dry weight (g) (20.36 g) was obtained in T₁ (Control).

Dry matter accumulation is a reliable indicator of net photosynthate production and translocation. The highest total dry weight observed under T₂ treatment suggests that *Moringa* leaf extract priming enhanced carbon assimilation and efficient partitioning of assimilates into plant tissues. Similar increases in dry matter production following botanical priming have been reported by Prakash (2019) and Bibi *et al.* (2023), who emphasized that low concentrations of botanical extracts promote growth by activating enzymatic systems. The lowest dry weight in control plants further confirms the positive role of botanical priming in enhancing physiological efficiency.

3.5 Days to 50% flowering

The data pertaining to days to 50% flowering in okra, pea and tomato as influenced by evaluation of seed priming with botanicals of some vegetables in kitchen gardening has been recorded and presented in Table 5.

Days to 50% flowering in okra

The results revealed significant variation in days to 50% flowering among the treatments, with the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recording the lowest value (42.69), which was at par with T₄ (*Albizia amara* Leaf Extract@ 3%) with (47.36) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) with (49.25). In contrast, T₁ (Control) exhibited the highest days to 50% flowering (58.42).

Days to 50% flowering in pea

The results revealed significant variation in days to 50% flowering among the treatments, with the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recording the lowest value (37.85), which was at par with T₄ (*Albizia amara* Leaf Extract@ 3%) with (39.26) and T₆ (*Prosopis juliflora* Leaf

Extract@ 3%) with (39.89). In contrast, T₁ (Control) exhibited the highest days to 50% flowering (43.28).

Days to 50% flowering in tomato

The results revealed significant variation in days to 50% flowering among the treatments, with the treatment T₂ (*Moringa oleifera* Leaf Extract@ 3%) recording the lowest value (38.63), which was at par with T₄ (*Albizia amara* Leaf Extract@ 3%) with (41.36) and T₆ (*Prosopis juliflora* Leaf Extract@ 3%) with (41.85). In contrast, T₁ (Control) exhibited the highest days to 50% flowering (45.35).

Earliness in flowering is a desirable trait, particularly in kitchen gardening. In the present study, seeds primed with *Moringa oleifera* leaf extract exhibited significantly fewer days to 50% flowering in all three crops. Early flowering under botanical priming may be attributed to faster vegetative growth, improved nutrient status and hormonal regulation. Similar reductions in flowering time due to botanical treatments have been reported by Girase *et al.* (2019) in okra and Yasmeen *et al.* (2013) in vegetable crops. Delayed flowering in control plants may be due to slower physiological development caused by lack of seed priming.

Table 1: Effect of seed priming on plant height at first picking (cm) in okra, pea and tomato.

Tr. No.	Treatment Details	Plant height at first picking (cm)		
		Okra	Pea	Tomato
T ₁	Control	56.43	37.52	60.25
T ₂	<i>Moringa oleifera</i> Leaf Extract@ 3%	95.62	55.24	87.96
T ₃	<i>Aegle marmelos</i> Leaf Extract@ 3%	67.58	46.68	79.78
T ₄	<i>Albizia amara</i> Leaf Extract@ 3%	90.82	53.85	84.62
T ₅	<i>Phyllanthus emblica</i> Leaf Extract@ 3%	63.23	44.23	67.75
T ₆	<i>Prosopis juliflora</i> Leaf Extract@ 3%	85.32	51.47	81.27
T ₇	<i>Acacia nilotica</i> Leaf Extract@ 3%	80.69	49.69	78.79
T ₈	<i>Sapindus mukorossi</i> - Leaf Extract@ 3%	70.26	47.75	72.56
T ₉	<i>Terminalia arjuna</i> Leaf Extract@ 3%	75.42	48.21	75.69
T ₁₀	<i>Azadirachta indica</i> Leaf Extract@ 3%	60.10	42.42	65.42
	Sem (±)	3.52	2.517	2.696
	CD (5%) =	10.38	7.43	7.95
	CV (%) =	8.18	9.14	6.19

Table 2: Effect of seed priming on number of branches per plant in okra, pea and tomato.

Tr. No.	Treatment Details	Number of branches per plant		
		Okra	Pea	Tomato
T ₁	Control	2.21	3.26	4.36
T ₂	<i>Moringa oleifera</i> Leaf Extract@ 3%	4.36	5.32	7.58
T ₃	<i>Aegle marmelos</i> Leaf Extract@ 3%	2.94	4.54	6.24
T ₄	<i>Albizia amara</i> Leaf Extract@ 3%	4.13	5.17	7.31
T ₅	<i>Phyllanthus emblica</i> Leaf Extract@ 3%	2.78	4.36	6.05
T ₆	<i>Prosopis juliflora</i> Leaf Extract@ 3%	3.92	5.07	6.96
T ₇	<i>Acacia nilotica</i> Leaf Extract@ 3%	3.74	4.91	6.74
T ₈	<i>Sapindus mukorossi</i> - Leaf Extract@ 3%	3.25	4.68	6.37
T ₉	<i>Terminalia arjuna</i> Leaf Extract@ 3%	3.57	4.82	6.58
T ₁₀	<i>Azadirachta indica</i> Leaf Extract@ 3%	2.56	4.16	5.79
	Sem (±)	0.15	0.14	0.24
	CD (5%) =	0.44	0.41	0.72
	CV (%) =	7.77	5.18	6.56

Table 3: Effect of seed priming on plant fresh weight (g) in okra, pea and tomato.

Tr. No.	Treatment Details	Plant fresh weight (g)		
		Okra	Pea	Tomato
T ₁	Control	68.25	47.69	158.93
T ₂	<i>Moringa oleifera</i> Leaf Extract@ 3%	124.69	78.82	214.52
T ₃	<i>Aegle marmelos</i> Leaf Extract@ 3%	90.53	62.35	180.63
T ₄	<i>Albizia amara</i> Leaf Extract@ 3%	118.72	75.49	209.71
T ₅	<i>Phyllanthus emblica</i> Leaf Extract@ 3%	85.46	59.78	175.86
T ₆	<i>Prosopis juliflora</i> Leaf Extract@ 3%	111.39	72.63	201.41
T ₇	<i>Acacia nilotica</i> Leaf Extract@ 3%	106.47	69.74	195.37
T ₈	<i>Sapindus mukorossi</i> - Leaf Extract@ 3%	95.63	64.58	184.48
T ₉	<i>Terminalia arjuna</i> Leaf Extract@ 3%	100.47	66.82	190.75
T ₁₀	<i>Azadirachta indica</i> Leaf Extract@ 3%	79.75	56.71	170.34
	Sem (±)	4.98	3.25	6.86
	CD (5%) =	14.70	9.59	20.23
	CV (%) =	8.79	8.60	6.31

Table 4: Effect of seed priming on total dry weight (g) in okra, pea and tomato.

Tr. No.	Treatment Details	Total dry weight (g)		
		Okra	Pea	Tomato
T ₁	Control	20.36	13.42	50.36
T ₂	<i>Moringa oleifera</i> Leaf Extract@ 3%	38.57	19.36	74.52
T ₃	<i>Aegle marmelos</i> Leaf Extract@ 3%	30.41	16.24	59.71
T ₄	<i>Albizia amara</i> Leaf Extract@ 3%	37.82	18.63	71.65
T ₅	<i>Phyllanthus emblica</i> Leaf Extract@ 3%	28.75	15.96	57.82
T ₆	<i>Prosopis juliflora</i> Leaf Extract@ 3%	36.52	18.02	68.87
T ₇	<i>Acacia nilotica</i> Leaf Extract@ 3%	35.69	17.69	66.58
T ₈	<i>Sapindus mukorossi</i> - Leaf Extract@ 3%	32.71	16.74	61.25
T ₉	<i>Terminalia arjuna</i> Leaf Extract@ 3%	33.48	17.36	63.57
T ₁₀	<i>Azadirachta indica</i> Leaf Extract@ 3%	26.63	15.68	55.74
	Sem (±)	2.10	1.00	2.55
	CD (5%) =	6.20	2.95	7.53
	CV (%) =	11.35	10.23	7.02

Table 5: Effect of seed priming on days to 50% flowering in okra, pea and tomato.

Tr. No.	Treatment Details	Days to 50% flowering		
		Okra	Pea	Tomato
T ₁	Control	58.42	43.28	45.35
T ₂	<i>Moringa oleifera</i> Leaf Extract@ 3%	42.69	37.85	38.63
T ₃	<i>Aegle marmelos</i> Leaf Extract@ 3%	54.81	41.81	43.76
T ₄	<i>Albizia amara</i> Leaf Extract@ 3%	47.36	39.26	41.36
T ₅	<i>Phyllanthus emblica</i> Leaf Extract@ 3%	56.79	42.48	44.23
T ₆	<i>Prosopis juliflora</i> Leaf Extract@ 3%	49.25	39.87	41.85
T ₇	<i>Acacia nilotica</i> Leaf Extract@ 3%	51.87	40.36	42.58
T ₈	<i>Sapindus mukorossi</i> - Leaf Extract@ 3%	53.68	41.67	43.47
T ₉	<i>Terminalia arjuna</i> Leaf Extract@ 3%	52.75	40.75	42.93
T ₁₀	<i>Azadirachta indica</i> Leaf Extract@ 3%	57.93	42.72	44.64
	Sem (±)	2.75	1.055	1.206
	CD (5%) =	8.11	3.11	3.56
	CV (%) =	9.06	4.46	4.87

4. Conclusion

The present investigation clearly demonstrated that seed priming with botanical leaf extracts significantly influenced the growth and developmental parameters of okra, pea, and tomato under kitchen gardening conditions. Among all treatments, seed priming with *Moringa oleifera* leaf extract at 3% consistently proved superior by enhancing plant height at first picking, number of branches per plant, fresh and dry biomass accumulation, stem dry weight at 50% flowering, and by reducing the number of days to 50% flowering in all three crops. Treatments with *Albizia amara* and *Prosopis juliflora* leaf extracts also showed appreciable improvements over the control, though their effects were comparatively lower than *Moringa oleifera*. The untreated control consistently recorded the poorest performance across all parameters. Overall, the findings highlight that botanical seed priming, particularly with *Moringa oleifera* leaf extract at 3%, is a simple, sustainable, and eco-friendly technique that can be effectively adopted in kitchen gardening to improve crop vigor, biomass production, and early flowering, thereby contributing to enhanced productivity and resource-efficient vegetable cultivation.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

5. Future Suggestions

- 1) Further studies should be conducted to evaluate the effect of botanical seed priming across different agro-climatic zones and soil types.
- 2) The influence of varying concentrations and combinations of botanical extracts on growth and yield parameters may be explored.
- 3) Long-term studies should be undertaken to assess the residual and cumulative effects of botanical seed priming on soil health and crop productivity.
- 4) Yield, quality, and economic analyses should be included to strengthen the practical applicability of botanical priming in kitchen gardening.

- 5) Molecular and physiological studies may be carried out to understand the underlying mechanisms through which botanical extracts enhance plant growth.

performance and crop establishment: A review. *South African Journal of Botany*, 155, 132–141.

- [15] Yasmeen, A., Basra, S. M. A., Farooq, M., Rehman, H., & Hussain, N. (2013). Exogenous application of moringa leaf extract modulates antioxidant enzymes and improves plant growth. *Plant Growth Regulation*, 69(3), 225–233.

References

- [1] Acton, V., & Gaisbauer, F. (2022). Urban gardening during the COVID-19 pandemic: A pathway to food security and well-being. *Urban Forestry & Urban Greening*, 67, 127446.
- [2] Anonymous. (2025). Impact of botanical-based formulations as seed priming on germination and seedling quality in okra (*Abelmoschus esculentus* L.). *Plant Archives*, 25(1), 97–102.
- [3] Bibi, S., Ahmad, M., Shah, A. H., & Rahman, K. (2023). Allelopathic effects of the invasive species *Prosopis juliflora* on seed germination and seedling growth of crop plants. *Agronomy*, 13(2), 590.
- [4] Basu R.N., (1976), Physico-chemical control of seed deterioration. *Seed Research*. 4(1):15-23.
- [5] Bhatishwar, D. C., Prabha D., Jangid, D. and Mohammad, S. (2020.) Effect of Seed Priming with Botanicals on Plant Growth and Seed Yield of Lentil (*Lens culinaris* M.), *International Journal of Current Microbiology and Applied Sciences* 9(7): 3484-3499
- [6] Farooq, M., Basra, S. M. A. and Ahmad, N. (2007). Improving the performance of transplanted rice by seed priming. *Plant Growth Regulator*, 51, 129–137.
- [7] Fuglie, L. J. (2001). *The miracle tree: Moringa oleifera-Natural nutrition for the tropics*. Church World Service, Dakar. 68.
- [8] Girase, I. P., Rai, P., Bara, B. M., & Singh, B. (2019). Effect of plant extracts on seed germination behaviour and vigour of okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Current Microbiology and Applied Sciences*, 8(8), 830–835.
- [9] Khan, S., Basra, S. M. A., Afzal, I., Wahid, A., & Farooq, M. (2022). Application of *Moringa oleifera* leaf extract as a seed priming agent improves rice performance under water deficit conditions. *Plants*, 11(3), 341.
- [10] Paparella, S., Araújo, S. S., Rossi, G., Wojtyła, Ł., Gawroński, P., & Carbonera, D. (2015). Seed priming: From models to crop production: A review. *Plants*, 4(4), 902-925.
- [11] Prakash, M., Pallavamallan, S., Sathiyarayanan, G., & Rameshkumar, S. (2019) (2019). Effect of seed pelleting with botanicals on germination and seedling growth of cluster bean (*Cyamopsis tetragonoloba* L.). *Legume Research – An International Journal*, 42(5), 646–650.
- [12] Rady, M. M., Varma, C. B., & Howladar, S. M. (2015). Common bean (*Phaseolus vulgaris* L.) seedlings overcome salinity stress via moringa leaf extract application. *Scientia Horticulturae*, 165(1-4), 63-70.
- [13] Sardar, H., Raza, M. A. S., Yasmeen, A., Saleem, M. F., Hussain, S., & Ahmad, S. (2021). Foliar application of moringa leaf extract improves growth, physiological and biochemical attributes of plants under stress conditions. *Scientia Horticulturae*, 288, 110376.
- [14] Soares, T. F. S. N., Medeiros, A. D., & Silva, L. J. (2023). Seed priming as a strategy to increase seed