



Viability and Vigour Response of Hybrid Melon (*Cucumis melo* L.) to Sargassum Extract Priming under Salinity Stress

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Abstract

Salinity intrusion often limits seed germination and early seedling growth in coastal agricultural areas. Organic biostimulants, such as seaweed extracts, are a possible way to reduce this problem. This study aims to evaluate the effect of *Sargassum* sp. extract on the germination and early seedling growth of hybrid melon (*Cucumis melo* L.) cv. Melani F1 under saline conditions simulated using diluted seawater (brackish water). A completely randomized design with five treatments was used: an unprimed control, and four priming treatments in which seeds were soaked for 12 h in aqueous *Sargassum* extract at 0, 1, 2, or 3%, then germinated on paper moistened with diluted seawater. Priming significantly affected fresh weight, hypocotyl length, radicle length, and vigour index, while germination percentage was unaffected. Contrast analysis showed that this effect came mainly from the difference between the control and the primed treatments as a group, with no dose-dependent effect among *Sargassum* concentrations. Notably, the control had the highest fresh weight and length measurements but the lowest vigour index. Because vigour index here reflects the proportion of seeds forming normal seedlings by the first count rather than seedling size, and because the control differed from the primed treatments in both priming exposure and germination salinity at once, this divergence likely reflects their combined effect rather than *Sargassum* concentration itself. These findings offer preliminary laboratory evidence for developing seed priming protocols with *Sargassum* extract for coastal melon cultivation.

Keywords: *Melon, Salinity Stress, Sargassum Extract, Seed Vigour, Seed Priming*

INTRODUCTION

Melon (*Cucumis melo* L.) is a horticultural commodity of substantial economic value, both for domestic consumption and export. As demand in the market continues to increase, melon production has gradually moved into coastal zones which is one such option, offering a way to put marginal and underutilized land to productive use (Wang et al., 2025). This trend fits within a wider agricultural policy push to optimize suboptimal land, a strategy intended to strengthen food security while diversifying the range of commodities grown. The hybrid melon variety Melani was selected for this study because it combines resistance to gemini virus with high fruit sweetness (12 °Brix), traits that make it well suited for open-field cultivation, including in coastal marginal areas. Among the abiotic stressors affecting plant growth, salinity is one of the most significant, working through two closely linked pathways: it creates osmotic stress that limits water uptake, and it leads to ion toxicity as Na^+ and Cl^- accumulate to excessive levels within plant tissue (Balasubramaniam et al., 2023). The combined result is a disruption to cellular homeostasis, enzymatic function, and the broader metabolic processes plants depend on to grow normally. Of the different stages in a crop's life cycle, germination tends to be the most sensitive to salt stress. High salt concentrations reduce the osmotic potential of the growth medium, limiting water imbibition and delaying radicle emergence, which in turn reduces seed viability and seedling vigour.

In melon specifically, salinity-induced reductions in germination percentage, germination rate, and early seedling growth have been reported to compromise stand establishment under

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saline conditions (Liu et al., 2023). Given uniform and vigorous germination is a requirement for successful crop establishment, mitigating salinity sensitivity at this early stage is critical for the viability of melon cultivation in coastal marginal lands. One promising approach to reduce salinity-induced germination stress is seed priming, a pre-sowing treatment that activates physiological and biochemical processes in the seed before the radicle emerges, thereby improving germination performance and stress tolerance (Jatana et al., 2024). Various priming agents have been evaluated, including synthetic osmotica as well as organic and biologically derived compounds. The use of natural biostimulants have gained increasing attention due to their sustainability and multifunctional bioactive content.

Seaweed extract is one of particularly potential material. It contains various bioactive compounds and nutrients that can enhanced physiological processes, like germination, and early plant growth. Neto et al. (2020) demonstrated that seaweed extract can be applied as a priming agent through a seed-soaking method and examined its effects on germination and vegetative growth. This indicated that seaweed extract could be a useful natural option for treating seeds. Brown seaweed *Sargassum* sp., which is abundant along coastal areas, represents a promising and locally available biostimulants resource. *Sargassum* extract is known to contain phytohormones such as alginates, auxins and cytokinins, also various micronutrients that have been associated with enhanced seed metabolic activity, antioxidant response, and stress resilience in several crop species (Torres-Narváez et al., 2025). *Sargassum* is naturally abundant in coastal areas, using its extract an accessible and affordable option to serve as a priming agent. It applies a locally available resource to solve a problem that is specific to that same coastal environment.

However, there is limited experimental evidence on how *Sargassum* extract works as a priming agent, particularly for hybrid melon seeds under simulated salinity, and how the response changes with concentration. Moreover, it is still uncertain how much extract is needed to produce a beneficial effect without causing osmotic or phytotoxic damage. This study therefore examines how hybrid melon seeds respond, in terms of viability and vigour, to different concentrations of *Sargassum* sp. extract under simulated salinity in a controlled laboratory setting. The findings are intended to provide preliminary laboratory evidence as a basis for future protocol development, rather than a directly usable priming protocol.

LITERATURE REVIEW

Salinity interferes with melon seed germination in two ways: it restricts water uptake through osmotic pressure, and it disrupts membrane integrity and enzymatic activity as excess Na^+ and Cl^- accumulate in the tissue. Seed priming offers a way around this—by triggering pre-germinative metabolic activity before the radicle even emerges, seeds are able to germinate faster and more evenly once they're sown. This has drawn attention to biologically derived priming agents, seaweed extracts in particular, since their mix of carbohydrates, amino acids, minerals, phenolics, and hormone-like compounds can do more than just hydrate the seed—they can actively stimulate it (Torres-Narváez et al., 2025). Similar priming benefits under saline conditions have been reported in other cucurbits: in squash (*Cucurbita maxima*), priming with KNO_3 and GA_3 improved germination and seedling growth under NaCl stress (Tarchoun et al., 2024), while in melon itself, seed priming with NaCl was shown to increase germination under salinity by more than 15% (Dolu et al., 2025). These findings support the idea that priming-based strategies, including biostimulant extracts, are a relevant approach for cucurbit crops facing saline conditions.

Germination percentage and seedling vigour are not only research outcomes but also standard parameters used in official seed quality testing. According to the International Seed Testing Association (ISTA, 2023), germination testing is the primary method for determining seed viability, while vigour indices—based on seedling growth traits such as length and weight—are

used as more sensitive indicators of seed performance, particularly under suboptimal conditions. Because vigour tests are more responsive to physiological differences than the standard germination test alone, they are considered useful for detecting subtle treatment effects, such as those induced by biostimulant priming, that a simple germination count might not capture.

Brown macroalgae like *Sargassum* are a good example of this potential. They contain water-soluble polysaccharides and other bioactive compounds that have been tied to antioxidant activity, growth regulation, and stress signaling ([Kergosien et al., 2023](#); [Shukla et al., 2019](#)). What complicates things, though, is that these effects come from a mix of many constituents rather than one dominant compound, so how the extract is prepared ends up mattering a great deal. Han et al. (2022), for example, found that *Sargassum horneri* extracts made through boiling, soaking, autoclaving, and ethanol extraction each produced a different biostimulant response in the red alga *Neopyropia yezoensis*—suggesting that extraction method shapes bioactivity in ways that may not even generalize across target organisms.

The application of *Sargassum* extract as a seed-priming agent is thus based on the interaction between metabolic activation during hydration and the biostimulatory activity of its bioactive constituents, which may support osmotic adjustment, antioxidant defense, and stress signaling under saline conditions ([Deolu-Ajayi et al., 2022](#); [Kergosien et al., 2023](#)). This response is not expected to scale proportionally with concentration, since increasing extract concentration may shift the balance among stimulatory, nutritional, and potentially inhibitory components ([Ali et al., 2021](#); Han et al., 2022). Accordingly, this study evaluates hybrid melon seed responses to different concentrations of aqueous *Sargassum* sp. extract applied via seed soaking under simulated salinity, using germination-related parameters and early seedling growth as complementary indicators of priming efficacy.

RESEARCH METHODOLOGY

Raw and Material

Hybrid melon (*Cucumis melo* L.) cv. Melani F1 was used in this study. *Sargassum* was collected from Yogyakarta south's coast. The study used a completely randomized design with five treatments such as an unprimed control (no soaking), and four priming treatments consisting of seed soaking in aqueous *Sargassum* extract at 0% (K1), 1% (K2), 2% (K3), or 3% (K4). Each treatment was replicated five times, resulting in 25 experimental units in total, with each unit consisting of 25 seeds. Coastal agricultural areas are typically exposed to brackish water — a mixture of seawater and freshwater with a lower salinity level — rather than full-strength seawater. Diluted seawater was therefore used in this study to provide a more realistic representation of salinity stress for coastal melon cultivation, rather than an extreme, undiluted salinity treatment. Seawater was diluted with tap water to a target salinity of 5,000 ppm, corresponding to typical brackish water conditions in coastal agricultural zones.

Preparation of Sargassum Extract

The *Sargassum* extract was prepared using an aqueous extraction method with modifications based on [Fitriyah et al. \(2022\)](#). 10 g of powdered *Sargassum* was mixed with 300 mL of distilled water at a solid-to-liquid ratio of 1:30 (w/v), homogenized, and heated in a water bath at 85 °C for 2 h to facilitate the release of bioactive compounds. The suspension was then cooled to room temperature and centrifuged at 4,000 rpm for 10 min, modifying the procedure of [Fitriyah et al. \(2022\)](#) from 6,000 rpm for 5 minutes, to achieve effective separation while minimizing mechanical stress on bioactive compounds. The resulting supernatant was carefully collected and further purified by vacuum filtration using a Büchner funnel, filter flask, vacuum pump, and appropriate filter paper to remove residual fine particles. The resulting filtrate was collected as the

crude aqueous Sargassum extract and used as the active ingredient for biostimulant formulation.

Germination Test

Seeds assigned to the priming treatments (K1–K4) were soaked in their designated Sargassum extract concentration for 12 h at room temperature, then drained before testing. Control seeds were not soaked. The seeds were germinated using the between-paper method. Each experimental unit consisted of 25 seeds arranged in a zigzag pattern. Paper for the priming treatments was moistened with diluted seawater (5,000 ppm, obtained by diluting seawater with tap water), while paper for the control was moistened with tap water. The first count was conducted on day 4, and the final count on day 8, after sowing. The germination test was carried out under controlled laboratory conditions at a temperature of $25 \pm 2^\circ\text{C}$ for eight days. The first count was performed on the 5th day after sowing, while the final count was conducted on the 14th day. Normal seedlings were evaluated according to ISTA seed testing standards. Germination percentage was calculated based on the proportion of normal seedlings at the final count. The vigour index was determined based on the percentage of normal seedlings at the first count, while germination rate was calculated using the germination rate formula. Fresh weight of normal seedlings (g) was measured by weighing all normal seedlings in each replicate on an analytical balance immediately after the final count. Dried weight of normal seedlings (g) was determined by oven-drying all normal seedlings from each replicate at 80°C for 24 h, followed by weighing on an analytical balance.

Data Analysis

The recorded data were compiled and tabulated for statistical analysis. Data were subjected to Analysis of Variance (ANOVA) at $\alpha=0.05$ using STAR (Statistical Tool for Agricultural Research) software. Significant differences among treatment means were further evaluated using Duncan's Multiple Range Test (DMRT). Orthogonal contrast analysis was used to determine specific group differences and dose-response trends.

FINDINGS AND DISCUSSION

Effect of Sargassum Extract on Melon Seedling Growth Parameters

The application of different priming treatments resulted in variable responses among the measured growth parameters of melon seedlings. The analysis of variance showed that the priming treatments had a significant effect ($p < 0.05$) on several growth parameters, namely fresh weight of normal seedlings, mean hypocotyl length, mean radicle length, and vigour index. This indicates that the priming treatment influenced the early vegetative growth and seedling vigour of melon. In contrast, no significant effect was observed on dried weight of normal seedlings, germination percentage, maximum growth potential, abnormal seedlings, dead seeds, and fresh ungerminated seeds ($p > 0.05$). This suggests that the priming treatments did not substantially alter the seed's ability to germinate, but instead affected the developmental performance of the seedlings that emerged successfully.

Table 1. Analysis of variance of melon seedling responses to different priming treatments

Parameter	Significant	CV
Fresh weight of normal seedlings	*	15.31
Dried weight of normal seedlings	ns	15.64

Parameter	Significant	CV
Mean hypocotyl length	*	26.26
Mean radicle length	*	19.40
Germination percentage (%)	ns	7.84
Maximum Growth Potential (%)	ns	7.55
Vigour index (%)	*	20.23
Abnormal seedlings (%)	ns	29.54
Dead seeds (%)	ns	34.94
Fresh ungerminated seeds (%)	ns	32.80

*Note: Significant at $p < 0.05$; ns = not significant. CV = coefficient of variation

Priming treatment significantly affected fresh weight of normal seedlings, mean hypocotyl length, mean radicle length, and vigour index of melon seedlings (Table 2). The no-priming control without salinity stress exhibited higher fresh weight of normal seedlings and mean radicle length, although it was not significantly different from the 3% Sargassum extract treatment. The control produced the significantly highest mean hypocotyl length 5.91 cm. In contrast, an opposite trend was observed for the vigour index, where the control had the significantly lowest value compared to all salinity-treated groups. These results suggest that Sargassum extract, particularly at 3%, helped mitigate the negative effects of salinity stress on seedling growth, especially in terms of seedling biomass.

Table 2. Mean responses of melon seedlings to different priming treatments for parameters significantly affected by treatment.

Treatment	Fresh weight of normal seedlings (g)	Mean hypocotyl length (cm)	Mean radicle length (cm)	Vigour index (%)
Control (no priming)	3.84 a	5.91 a	6.99 a	28.00 b
0% Sargassum extract	2.82 c	3.24 b	5.16 b	56.00 a
1% Sargassum extract	2.86 c	2.72 b	5.00 b	64.00 a
2% Sargassum extract	3.09 bc	3.06 b	4.94 b	64.00 a
3% Sargassum extract	3.55 ab	4.02 b	5.72 ab	54.40 a

Note: Values followed by different letters within the same column indicate significant differences according to Duncan's Multiple Range Test (DMRT) at $\alpha = 0.05$.

The highest and most consistent radicle emergence was observed in the untreated control (Control; $70.00 \pm 10.00\%$), which was not exposed to salinity stress. All salinity-treated groups exhibited a reduction in mean radicle emergence ($26.67\text{--}43.33\%$), with K1 and K2 showing relatively high variability among replicates ($SD = 15.28$ and 20.82 , respectively), whereas K3 and K4 exhibited lower variability, indicating a more consistent response ($SD = 5.77$ for both). This pattern suggests that higher concentrations of Sargassum extract ($2\text{--}3\%$) tended to produce a more stable germination response under saline conditions, although radicle emergence remained lower than that observed under non-saline conditions.

Table 3. Mean and standard deviation of mean radicle emergence (%) of melon seeds under different priming treatments

Treatment	Mean radicle emergence (%)	SD
Control (no priming)	70.00	10.00
0% Sargassum extract	26.67	15.28
1% Sargassum extract	33.33	20.82
2% Sargassum extract	43.33	5.77
3% Sargassum extract	33.33	5.77

Note: Values are presented as mean $\pm$ standard deviation (SD)

Orthogonal Contrast Analysis

Orthogonal contrast analysis was conducted to identify the specific source of treatment variation. Four contrasts were evaluated: C0 compared the unprimed control with all priming treatments; C1 compared water priming with the Sargassum treatments; C2 compared 1% Sargassum with the higher concentrations; and C3 compared 2% and 3% Sargassum extract.

Table 4. Mean responses of melon seedlings to different priming treatments for parameters significantly affected by treatment in orthogonal contrast analysis

Parameter	Pr (>F)			
	C0	C1	C2	C3
Fresh weight of normal seedlings	0,0058	0,1867	0,1023	0,1503
Dried weight of normal seedlings	0,3297	0,4057	0,7922	0,6488
Mean hypocotyl length	<0,000	0,954	0,1502	0,1414
Mean radicle length	0,0036	0,9144	0,5852	0,2668
Germination percentage (%)	0,1713	0,5483	0,1758	0,361
Maximum growth potential (%)	0,5271	0,9405	0,6737	0,6737
Vigour index (%)	<0,000	0,3987	0,4257	0,1744
Abnormal seedlings (%)	0,1858	0,2349	0,0987	0,7424

Dead seeds (%)	0,722	0,6464	0,5175	0,8218
Fresh ungerminated seeds (%)	0,0593	0,5259	0,8218	0,2496

Note: Values are p-values from orthogonal contrast analysis. Bold values indicate significant differences at $p < 0.05$. C0 = K0 vs. K1–K4 (no priming vs. all priming treatments); C1 = K1 vs. K2–K4 (water priming vs. Sargassum biostimulant); C2 = K2 vs. K3–K4 (1% vs. 2–3% Sargassum); C3 = K3 vs. K4 (2% vs. 3% Sargassum)

The orthogonal contrast analysis provided further insight into the sources of variation among the priming treatments (Table 4). Contrast C0, which compared the unpriming control (K0) with all priming treatments (K1–K4), was significant for fresh weight of normal seedlings, mean hypocotyl length, mean radicle length, and vigour index. These findings indicate that the primary source of variation in these parameters was associated with the application of priming treatment rather than differences among the priming solutions or Sargassum concentrations. In contrast, C0 was not significant for dried weight of normal seedlings, germination percentage, maximum growth potential, abnormal seedlings, dead seeds, or fresh ungerminated seeds ($p > 0.05$). This indicates that the presence of priming did not consistently affect all measured seedling parameters.

Contrast C1, comparing water priming (K1) with the combined Sargassum treatments (K2–K4), was not significant for any of the evaluated parameters ($p > 0.05$). This suggests that the responses obtained from water priming were not statistically different from those obtained following Sargassum application. Similarly, C2, comparing 1% Sargassum with the 2–3% concentrations, and C3, comparing 2% with 3% Sargassum, were not significant for any parameter. Therefore, the present results provide no sufficient statistical evidence that increasing Sargassum concentration from 1% to 2% or 3% progressively enhanced melon seedling growth or germination-related responses.

Overall Discussion

The results of the analysis of variance, DMRT, and orthogonal contrast analysis consistently indicated that the variation observed in melon seedling growth parameters was predominantly attributable to the presence or absence of priming treatment, rather than to the type of priming solution or the concentration of Sargassum extract applied. Contrast C0, which compared the non-soaked control with all priming treatments, was significant for fresh weight of normal seedlings, mean hypocotyl length, mean radicle length, and vigour index. In opposition to this, contrasts C1, C2, and C3, which respectively compared the priming solution type and the different Sargassum concentration levels, showed no significant differences for any of the parameters evaluated. Overall, these results indicate that priming, rather than the extract or its concentration, was what improved early seedling growth. Neither the extract nor its concentration showed a statistically detectable effect under the tested salinity level. This lines up with earlier work suggesting that seaweed-based biostimulants don't necessarily work in a dose-dependent way; their effectiveness can shift depending on the biological material used and the specific experimental setup ([Makhaye et al., 2021](#)).

Priming likely made a difference because of imbibition—the initial hydration process that initiates pre-germinative metabolism, sometimes called germination Phase II. During this phase, hydrolytic enzymes are reactivated, damaged cell membranes are repaired, and nucleic acid and protein synthesis resume ([Paparella et al., 2015](#)). Because the vigour index in this study reflects the proportion of seeds forming normal seedlings by the first count, rather than seedling size, the control's notably lower vigour index is consistent with its lack of prior metabolic activation: without priming, imbibition and the associated metabolic processes only began once seeds were placed in

the germination medium, likely resulting in slower early emergence compared to the primed treatments. This pattern is consistent with the significant C0 contrast. Increasing Sargassum concentration, however, had no further detectable effect on this response.

Radicle emergence told a similar story to the vigour index data. The control had both the highest and most consistent emergence ($70.00 \pm 10.00\%$), whereas every salinity-treated group showed reduced emergence (26.67–43.33%)—a result that fits with how osmotic pressure restricts water uptake during imbibition under saline conditions (Traye et al., 2026). In simple terms, radicle emergence just refers to the moment the embryonic root first breaks through the seed coat, marking the shift from a dormant seed to an actively growing seedling. Interestingly, K3 and K4 (2–3% Sargassum) showed less variability between replicates ($SD = 5.77$) compared to K1 and K2 ($SD = 15.28$ and 20.82), hinting at a more consistent response at higher Sargassum concentrations—even though this didn't translate into a statistically significant dose effect on the main growth parameters.

LIMITATIONS AND FURTHER RESEARCH

Several limitations of this study should be considered when interpreting the results, alongside directions for future research that could address them. First, the control treatment was confounded: it differed from the Sargassum-primed treatments in two factors simultaneously—priming exposure and exposure to salinity during germination. As a result, the significant C0 contrast cannot be attributed specifically to either soaking or mild salinity alone, and the improvement in vigour index in primed treatments may reflect their combined effect rather than the action of Sargassum extract itself. Future studies should include an additional control soaked in non-saline water, allowing the effects of soaking and salinity to be statistically separated.

Second, several parameters showed relatively high coefficients of variation ($CV = 20\text{--}35\%$, Table 1), particularly abnormal seedlings, dead seeds, fresh ungerminated seeds, and vigour index. High variability of this kind reduces the statistical power to detect smaller, concentration-dependent effects of Sargassum extract, meaning that the absence of a significant dose-response relationship in this study may partly reflect limited detection power rather than a true absence of effect. Future studies should consider increasing the number of replicates or seeds per replicate to improve precision and better distinguish concentration-dependent responses.

Third, brackish water was chosen to simulate salinity stress precisely because it reflects real conditions in coastal farming, where plants typically deal with mild-to-moderate salinity from seawater mixing with freshwater rather than extreme salt levels. This choice comes with a trade-off, though: the stress intensity ended up being too mild to meaningfully suppress growth in the negative control, which made it harder to pick up any real differences between Sargassum concentrations. This isn't an isolated finding either—other work has shown that Sargassum extract's biostimulant effect can disappear under mild salinity even when it's clearly present in non-stressed conditions (Sariñana-Aldaco et al., 2022). More broadly, biostimulants in general tend to show their effects more clearly under moderate-to-severe stress rather than mild stress (Franzoni et al., 2022). Testing higher salinity levels in future work would help confirm whether Sargassum extract genuinely has potential as a way to ease salinity stress in melon seeds.

Finally, radicle emergence was recorded descriptively and not included in the formal statistical analysis, limiting the strength of conclusions that can be drawn from this parameter. Future studies should incorporate radicle emergence into the formal statistical framework, for example by recording emergence time-course data suitable for survival or time-to-event analysis.

CONCLUSION AND FURTHER RESEARCH

Overall, these results suggest that under the mild salinity used in this study, the boost in melon seedling vigour came mainly from the priming process itself, not from the Sargassum extract or its concentration. That doesn't mean Sargassum has no potential, though—it just didn't show a statistically detectable effect at this particular stress level, and things could well look different under more severe salinity, closer to what extreme coastal conditions actually involve. Future work should try a broader range of salinity levels alongside different Sargassum concentrations, which would help pin down the threshold where its biostimulant effect actually starts to show. It would also be worth running field trials under real coastal saline conditions, just to see whether these lab-based findings hold up outside a controlled setting.

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