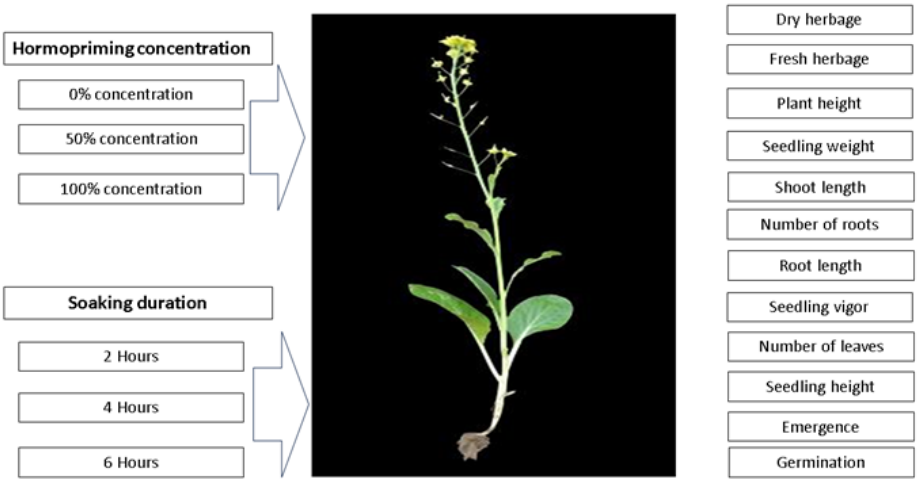
RESEARCH ARTICLE

Hormopriming and Duration of Priming Interaction on Germination, Emergence and Subsequent Growth Productivity Performance in Pechay

E.C. Taer



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Highlights

- *Ficus nota* water (FNW) soaking at 50% concentration for 4-hours significantly accelerated Pechay seed germination.
- FNW soaking at 50% concentration for 4-hours increased seedling height, root proliferation, and biomass accumulation.
- FNW soaking improved post-transplant plant height and leaf breadth but not the biomass yield.
- FNW concentration and soaking duration together enhanced Pechay germinations and early growth.

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RESEARCH ARTICLE

Hormopriming and Duration of Priming Interaction on Germination, Emergence and Subsequent Growth Productivity Performance in Pechay

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Abstract: This study investigated the potential of *Ficus nota* water (FNW) as a natural soaking agent to enhance seed germination, emergence, and subsequent growth performance in Pechay (*Brassica rapa* subsp. chinensis). Utilizing varying FNW concentrations (0%, 50%, and 100%) and seed soaking durations (2, 4, 6 hours), the research aimed to identify optimal treatment combinations for maximizing pre-transplant vigor and post-transplant productivity of Pechy. The results revealed a significant interaction between FNW concentration and soaking time, accelerating germination onset and promoting germination percentage. Notably, the 50% FNW treatment coupled with the 4-hour soaking duration expedited germination by 60% compared to the untreated control. This optimal priming combination also positively influenced seedling height, root proliferation, and biomass accumulation during the pre-transplant nursery stage. Post-transplantation, FNW-primed seedlings exhibited taller stems and broader leaves compared to non-primed controls. However, despite enhancing vegetative growth, priming did not translate into increased biomass yields, suggesting potential trade-offs in resource allocation patterns. The findings highlight the efficacy of FNW in expediting germination and enhancing nursery vigor, while underscoring the need for further investigations into the mechanisms governing the translation of early growth promotion into marketable yields under field conditions. This research contributes valuable insights into the application of natural plant extracts for optimizing seed priming protocols and potentially improving crop productivity.

***Keywords*:** *Ficus nota*, Hermetic, Allelochemicals, Growth-promoting, Hormesis

INTRODUCTION

The successful cultivation of crops pivots significantly on the initial stages of growth, particularly rapid and uniform seed germination coupled with vigorous seedling establishment, which lay the groundwork for subsequent plant health and productivity. Seed priming is a pre-sowing technique that enhances seed performance by modulating the physiological state of the seed. It involves controlled hydration, allowing seeds to undergo the initial stages of germination but preventing radicle protrusion (Indurugalla et al., 2023). This technique can improve germination rates, seedling vigor, and stress resistance in various plant species. Hormopriming, a specific type of seed soaking, involves the use of natural or synthetic hormones to prime seeds (Lutts et al., 2016). Hormones such as gibberellins, cytokinins, and auxins are commonly used in soaking to regulate growth and developmental processes, resulting in improved germination and seedling growth. For instance, Ali et al. (2020) reported enhanced germination and seedling growth in rice when seeds were soaked with salicylic acid. Similarly, Jisha et al. (2013) observed improved drought tolerance in wheat seeds soaked in abscisic acid. Additionally, Siyar et al. (2019) highlighted the potential of plant-derived compounds in hormopriming, showing significant improvements in seedling vigor and stress tolerance.

Ficus nota, commonly known as tibig, is a species of fig native to the Philippines (Ragasa et al., 2014). Its extracts have been explored for various medicinal and agricultural purposes. Recent studies suggest that *Ficus nota* extracts possess bioactive compounds that could be used as natural priming agents (Ragasa et al., 2014; Bertoletti et al., 2018; Prasad et al., 2022). These compounds may enhance seed germination and seedling growth by modulating physiological and biochemical pathways.

Alongside the choice of soaking agent, the duration of seed soaking is a critical factor influencing priming efficacy. Optimal soaking times are essential, as exceeding the "safe limit" can lead to seed or seedling damage due to premature germination (Harris et al., 1999). Recent findings underscore the significance of this parameter, suggesting that higher water volumes can yield equivalent results at shorter durations, and vice versa (Tanwar et al., 2023). Conversely, excessively long priming durations or high-water volumes may adversely affect seed performance (Tanwar et al., 2023). Therefore, identifying the ideal combination of priming agent concentration and soaking duration is crucial for maximizing the benefits of seed priming.

Pechay (*Brassica rapa* subsp. chinensis), a culturally and culinarily important vegetable with a brief growing season, presents an opportune target for exploring seed priming strategies to enhance productivity. Rapid and uniform germination, coupled with efficient seedling establishment, is critical for Pechay cultivation, as its productivity heavily relies on these initial growth stages. However, limited research has focused on the application of seed priming

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techniques, particularly using natural extracts like *Ficus nota* extract, to enhance early growth in Pechay.

In this study, we explored the potential of *Ficus nota* extracts as pre-soaking solutions for seed treatment of pechay (*Brassica rapa*) seeds. Pre-soaking, unlike traditional seed priming, involves immersing seeds in water or a solution to hydrate them before sowing. This process can improve seed germination and seedling establishment by ensuring uniform moisture uptake. Our objective was to investigate the effects of *Ficus nota* plant extracts on seed germination, seedling growth, and stress tolerance in pechay crop. We hypothesized that pre-soaking pechay seeds with *Ficus nota* extracts would enhance their physiological and biochemical responses, leading to improved agricultural performance.

MATERIALS AND METHODS

Study Locale

The investigation aimed to evaluate the efficacy of *Ficus nota* water extract as a seed germination, emergence enhancer, growth and yield for Pechay under nursery conditions. The study was conducted at Surigao del Norte State University - Mainit Campus from April to May 2022, located in the province of Surigao del Norte, Caraga region, Philippines (geographical coordinates: 9.4250° N, 125.5147° E). The study site consists of a tropical rainforest climate, characterized as Type II, with distinct wet and dry seasons. The temperature ranges from an average minimum of 22.2°C to a maximum of 32.0°C throughout the year, providing a relevant climatic context for the study.

Experimental Design

A 3 × 3 factorial experiment with a completely randomized design (CRD) and five replications per treatment was conducted. Two predictor variables were considered: the concentration of FNW and the duration of seed soaking. FNW concentrations (0%, 50%, and 100%) were prepared in distilled water, and soaking durations were set at two, four, and six hours. Nine treatment combinations were administered to Pechay seeds, and their impact on pre- and post-transplant performance was systematically observed and analyzed.

Extraction of *Ficus nota* Water

Ficus nota water was extracted from intact and healthy foliage. A robust branch with green leaves was chosen from a thriving *Ficus nota* tree, excluding dead or discolored parts. After a thorough cleaning process, the leaves were arranged in a sealed plastic bag exposed to daylight for six hours. The condensed moisture droplets were collected, transferred to a vial with cap, and stored at 4°C for subsequent use.

Experimental Procedure

Packs of Pechay seeds from a certified local seed store were used. Three FNW concentrations (0%, 50%, and 100%) were prepared and seeds were immersed in the solutions for two, four, or six hours. The seeds were then placed in pre-labeled plastic boxes with germination medium. After reaching 50% germination, boxes were supplemented with a sand and vermicompost mixture. After a 10-day nursery stage, Pechay seedlings were transplanted into polyethylene pots with a standardized potting medium.

Pre-transplant Data Collection

The T50, which represents the days to reach 50% germination, was monitored, and germination percentage was determined by counting radicle-emerged seeds. Seedling height, vigor index, root length, number of roots and shoots, and fresh weight were assessed. The percentage of germination was calculated following the formula,

$$\%\ Germination\ = \frac{Number\ of\ plants\ germinated}{Total\ seeds\ sown}\ 100$$

The seedling height was assessed by selecting ten sample plants randomly from each treatment replication. To calculate the Seedling Vigor Index (VI), the measured root and shoot length was divided by 100 and then multiplied by the percentage germination as per the formula:

$$Vigor\ Index\ (VI) = \frac{Root\ length + Shoot\ length}{100} x\ \%\ GP\ (10\ DAS)$$

The seedling's root length, number of roots and shoots, and fresh weight was determined by collecting three sample seedlings randomly from each experimental unit, weighing them at 10 DAS, and manually counting their leaves and roots respectively at 10 DAS.

Post-transplant Data Collection

The study involves post-transplantation measurements of plant height, true leaf enumeration, and maximum leaf width at 7, 14, 21, 28, and 35 DAT. Yield evaluation is done by harvesting the entire above-ground vegetative section of five randomly selected Pechay plants within each treatment replicate, 35 days post-transplantation. Fresh biomass yield is determined by immediately weighing the harvested shoots and then drying them for two days under partial shade followed by oven drying until a constant weight is achieved.

Statistical Analysis

The gathered pre- and post-transplant indices of Pechay from each experimental unit were accurately organized in MS Excel Software for Windows. Subsequently, an Analysis of Variance (ANOVA) was applied to discern the individual and interactive effects of the independent variables, namely FNW concentration and seed priming duration. To ascertain statistically significant differences between treatment means, Tukey's HSD Range Test was employed at a significance level of $p \leq 0.05$. All statistical computations were performed utilizing SPSS software version 26 for Windows, ensuring methodological rigor and reliability in the analysis of the experimental data.

RESULTS AND DISCUSSION

T50 and Germination Percentage

The investigation examined the influence of FNW concentration and seed soaking duration on the germination rate and overall emergence percentage of Pechay seeds within nursery conditions (Table 1). The outcomes

demonstrated significant primary effects for both FNW concentration (P<.01) and soaking duration in reaching T50 (P<0.05). Additionally, a noteworthy interaction between these variables affected the germination percentage on day 2 (P<0.1). Subsequent analyses revealed that the 4-hour soaking in 50% FNW resulted a significantly higher mean germination by day 2 compared to other treatments and to the control group (0% FNW) exhibiting the lowest germination rate at day 2. This observation is consistent with prior research suggesting the favorable impact of seed pre-soaking in natural plant extracts on seed germination and initial growth across diverse species (Abo-El-Kheer et al., 2019; Shumaila et al., 2023; Xạ et al., 2023).

Regarding the germination percentage by day 3, FNW concentration and its interaction with soaking time exerted significant effects, while soaking duration alone did not. Specifically, FNW concentrations at 50% and 100% facilitated enhanced day 3 germination (55.56% and 53.33%, respectively) compared to control untreated seeds (0% FNW) with a germination percentage of 34.44%. The expedited germination and heightened emergence percentage observed with FNW priming can be ascribed to bioactive compounds inherent in *Ficus nota*, such as phenols, flavonoids, and tannins, which are acknowledged to stimulate physiological processes implicated in seed germination and early seedling growth (Peng et al., 2004;). Similar trends were noted for day 4 germination, ranging from 72.22% with 50% FNW to 55.56% with 0% FNW samples.

The interaction between FNW concentration and soaking time (P<.01) on germination and emergence could be attributed to several mechanisms. Firstly, the uptake and diffusion dynamics of bioactive compounds in FNW into the seeds may be influenced by both concentration gradients and soaking periods, as posited by the Resource Availability (RA) hypothesis (Peng et al., 2004). Secondly, bioactive compounds could instigate specific metabolic processes involved in germination, with higher FNW levels potentially compensating for shorter durations in activating these pathways, aligning with the Growth/Differentiation Balance (GDB) hypothesis (Peng et al., 2004). Thirdly, FNW may contain plant growth regulators or compounds mimicking hormonal activity, and the interaction could be related to optimal hormonal signaling, as supported by the findings of Lutts et al. (2016) on hormopriming. Furthermore, the combination of FNW concentration and soaking time may influence seed coat permeability (Ferreira & Aqüila, 2000), affecting water and metabolite uptake crucial for germination. Lastly, the interaction could modulate oxidative stress and antioxidant mechanisms (Oliveira et al., 2019), which play a role in seed germination and early growth. These potential mechanisms may act synergistically, underscoring the intricate interplay between priming agent concentration and exposure duration in eliciting desired germination and emergence responses.

Examining germination percentages across the nine treatments revealed significant impacts of FNW level and the interaction between FNW and soaking time, particularly, 50% FNW demonstrated the highest mean emergence percentage, whereas untreated seeds exhibited the lowest emergence. This finding aligns with previous research by Jisha et al. (2013) and Bradford (1986), indicating that seed priming enhances pre-germination metabolism, resulting in quicker and more uniform germination percentage compared to unprimed seeds.

FNW priming at a 50% concentration with a 4-hour soaking duration, notably accelerated germination and emergence onset, requiring only three days compared to controls in pechay seeds. Wang et al. (2022) have reported that low concentrations of plant extracts can foster seed germination and seedling growth, while high concentrations may hinder these processes. The observed promotion of germination could be attributed to the presence of allelochemicals stimulating pre-germination metabolic processes, enhancing enzyme activities, and modulating hormone levels, as suggested by Pandey (1994), Kohli et al. (1997), Bajaj et al. (2004), and Shikha et al. (2016).

Pre-transplant Height, Leaves and Vigor of Pechay Seedlings

Table 2 illustrates the effects of varying concentrations of FNW and soaking durations on seedling height, leaf count, and vigor of Pechay under nursery conditions. The findings reveal a significant impact of FNW concentrations on

Table 1: Effect of *Ficus nota* water (FNW) priming treatment and seed soaking duration on percentage germination rate by days 2, 3 and 4, and overall germination percentage of Pechay under nursery conditions.

Treatments		T50			Germination %
		Day 2	Day 3	Day 4	
% FNW	0% FNW	22.2^{a}	34.5^{a}	55.6^{a}	82.2^{ab}
	50% FNW	32.1^{b}	55.6^{b}	72.20^{b}	84.5^{b}
	100% FNW	34.4^{b}	53.33^{a}	71.10^{b}	77.8^{a}
Soaking Period	2-hrs	30.0^{ab}	47.8	70.00	85.6^{b}
	4-hrs	33.3^{b}	51.1	70.00	77.8^{a}
	6-hrs	25.5^{a}	44.3	62.00	81.1^{ab}
p-value	% FNW	0.000**	0.000**	0.000**	0.030*
	Soaking period	0.034*	0.118	0.191	0.010
	% FNW × Soaking Period	0.000**	0.000**	0.000*	0.000**

Column means of different superscript letters are significant at 0.05 level. **; significant at p<0.01 and *; significant at p<0.05.

seedling height, with those treated with 50% FNW reaching greater heights of 40.46 ± mm compared to untreated control plants 28.99 ± mm. This observation aligns with previous studies indicating that water-extracted plant extracts can stimulate vigorous seedling growth Erasto et al., 2022). Primed seeds often yield well-established plants with superior growth characteristics, such as increased height and leaf area (Erasto et al., 2022). Masangwa et al. (2017) demonstrated that plant extract seed treatment enhances the germination process and promotes advanced ultrastructural development in *Syzygium* and *Agapanthus* embryonic roots. Similarly, Nadeem et al. (2020) observed significant modifications in barnyard seedling fresh weight with the application of water extracts of safflower leaves, stems, and fruits, attributing it to a hermetic effect that enhances seedling length and thickness, thereby affecting fresh weight at lower concentrations. Moreover, Moles et al. (2009) and Wright et al. (2017) noted a positive correlation between plant height and seed mass, underscoring its significance in a plant's ability to compete for light. The bioactive compounds present in FNW likely promote cell elongation and division processes governing seedling height (Chen & Arora, 2011).

Interestingly, the application of 100% FNW did not lead to further enhancement in seedling height, suggesting a stimulatory influence of lower concentrations of plant extracts but an inhibitory effect at higher concentrations, known as the hermetic effect. Several studies have reported observing this phenomenon at lower concentrations of various plant extracts. For example, Nadeem et al. (2020) found that lower concentrations of water extracts from different parts of the safflower plant (*Carthamus tinctorius*) significantly positively affected the fresh weight of barnyard grass seedlings, likely due to a hermetic effect enhancing seedling length and thickness. Maqbool et al. (2021) also reported a hermetic effect at a 10% concentration of an extract, maximizing germination percentage, shoot/root length, and fresh weight in their study. The mechanisms underlying the hermetic effect may involve the presence of specific allelochemicals or compounds that can promote cell division, elongation, root growth, and branching at lower doses, thereby improving water and nutrient uptake, as well as photosynthesis (Cheema et al., 2013). However, higher concentrations of the same extracts often exhibit inhibitory or suppressive effects on growth parameters (Cheema et al., 2013; Radwan et al., 2019).

In terms of leaf production, marginal differences were observed, ranging from 1.59 to 1.69 leaves per seedling under various FNW priming conditions. However, ANOVA tests indicated no statistically significant impact of the FNW soaking on Pechay leaf number. While FNW priming did not significantly affect leaf number in this study, previous research has demonstrated the ability of plant extracts to enhance leaf production. For instance, Ahmad et al. (2020) reported increased leaf counts in Moringa seedlings treated with specific plant extracts such as liquorice combined with peat moss. In contrast, seedling vigor index was significantly influenced by FNW priming, particularly with seedlings treated with 50% FNW ($P<.01$).

The promotion of seedling vigor by the 50% FNW treatment aligns with the proposed role of bioactive compounds in stimulating pre-germination metabolic processes, enhancing enzyme activities, and modulating hormone levels (Pandey, 1994; Chetti et al., 1997; Kohli et al., 1997; Bajaj et al., 2004; Shikha et al., 2016). Increased vigor indices with pre-soaking treatments have also been reported in various crop species (Araujo Neto et al, 2018; Al-Khafajy et al., 2022; Mishra et al., 2023)

The mechanisms behind the enhanced seedling vigor could involve the presence of growth-promoting allelochemicals in FNW that stimulate physiological processes such as increased amylase production, leading to more efficient mobilization of seed reserves and rapid seedling establishment (Cayuela et al., 1996; Lee & Kim, 2000). Furthermore, the optimal 50% FNW concentration may have facilitated better water uptake and imbibition, reduced lag time and promoting uniform, vigorous germination (Bradford, 1986).

Pre-transplant Roots, Shoot and Biomass Weight of Pechay Seedlings

Table 3 depicts the impact of FNW treatment on various growth parameters of Pechay nursery seedlings. The results do not indicate that FNW level, soaking duration, nor did their interaction significantly influence radical length or shoot elongation ($P>0.5$). These contrasts with findings from other studies where plant extracts were

Table 2: Effect of *Ficus nota* water (FNW) priming levels and seed soaking duration on growth attributes regarding height, foliage and vigor of Pechay seedlings at nursery pre-transplant stage

	Treatments	Seedling height (mm)	No. of leaves	Seedling vigor
% FNW	0% FNW	28.99[a]	1.59	28.99[a]
	50% FNW	40.46[b]	1.69	40.46[b]
	100% FNW	33.01[a]	1.60	33.01[ab]
Soaking	2-hrs	35.24	1.69	34.89
period	4-hrs	32.51	1.59	30.88
	6-hrs	33.71	1.6	34.09
p-value	% FNW	0.001*	0.68	0.001*
	Soaking period	0.531	0.700	0.531
	% FNW × Soaking Period	0.139	0.211	0.139

Column means of different letters are significant at 0.05 level, * Significant

found to impact shoot length. For instance, Ahmad et al. (2020) reported increased shoot length in Moringa seedlings treated with specific plant extracts like liquorice combined with peat moss. However, Popoola et al. (2020) found that shoot extracts of *Euphorbia heterophylla* had a stronger inhibitory effect on seed germination and seedling growth in cowpea varieties than root extracts of selected weeds. Root growth was more sensitive to the increasing concentration of plant aqueous extracts, possibly due to the roots being in continuous contact with the extracts (Alam, 1990). The growth and yield of wheat were proportional to the concentration of aqueous extracts (Shah et al., 2017), with root and shoot length being more sensitive (Turk & Tawaha, 2002). The lack of significant effects of FNW level, soaking duration, or their interaction on radical length (root length) or shoot elongation in Pechay seedlings in the present study suggests that the effectiveness of bioactive compounds in plants may vary depending on factors such as concentration, composition, plant sensitivity, exposure timing, and environmental interaction. This effect is likely due to improved nutrient uptake and metabolic activity in the roots as reported by many authors who demonstrated the beneficial effects of seed soaking in plant extracts on root development and biomass production (Al-Khafajy et al., 2022; Wang et al., 2022; Liu et al., 2022; Nahar & Nitu, 2023).

However, root count and seedling dry weight were notably affected by FNW concentration. In comparison to the control, Pechay primed with 50% FNW exhibited the highest root numbers (~36% higher) (7.60) and heaviest biomass (~27% greater). (50.00). The increased root proliferation and biomass accumulation observed with 50% FNW priming could be attributed to the presence of growth-promoting allelochemicals that stimulated physiological processes like amylase production, leading to more efficient mobilization of seed reserves and rapid seedling establishment (Cayuela et al., 1996; Lee & Kim, 2000). Additionally, the optimal concentration may have facilitated better water uptake and imbibition, reduced lag time and promoting uniform, vigorous germination (Bradford, 1986). This positive impact on root growth and biomass aligns with findings from Masangwa et al. (2017), who reported that plant extract seed treatment enhanced ultrastructural development in embryonic roots, including the presence of vacuoles, mitochondria with cristae, and fewer lipids and protein bodies, indicating advanced metabolic activity. No further gains were observed at 100% FNW, suggesting a stimulatory plateau at the 50% concentration. This observation of a hormetic effect, where lower concentrations of plant extracts promote growth while higher concentrations inhibit it, is consistent with numerous studies across various plant species (Cheema et al., 2013; Radwan et al., 2019; Nadeem et al., 2020; Maqbool et al., 2021).

Plant Height of Transplanted Pechay

The level of FNW priming significantly influenced Pechay height after transplanting to 35 days after transplanting (Table 4). The 50% FNW treatment resulted in taller plants compared to 0% and 100% FNW treatments, with the most pronounced effect seen over 12% taller than the non-primed control (Table 4). These findings align with numerous previous studies reporting increased seedling height and overall vigor in response to plant extracts containing bioactive compounds such as phenols, flavonoids, and tannins (Adhikari et al., 2021; Erasto et al., 2022; Wahocho et al., 2023). The stimulatory effects of these compounds on cell division, elongation, and metabolic processes involved in growth could explain the enhanced Pechay height observed with optimal FNW priming (Peng et al., 2004; Chen & Arora, 2011;). Additionally, the modulation of oxidative stress and antioxidant mechanisms by FNW bioactives may contribute to improved seedling vigor and subsequent height (Oliveira et al., 2019). The initial lack of height response could be due to the plants allocating resources towards root development and establishment, which then translates to enhanced shoot growth once transplanted.

Prolonged 4–6-hour FNW exposure amplified the height stimulation induced by 50% FNW (129.28) but reduced height stimulation by 100% FNW concentration. (126.71). The reduced height stimulation at higher 100% FNW levels suggests a concentration threshold beyond which the promoting effects of bioactive compounds may be diminished or inhibited, potentially due to phytotoxicity or resource allocation trade-offs (Mbega et al., 2012; Popoola

Table 3: Influence of *Ficus nota* water (FNW) treatment concentrations and seed priming times on early seedling root traits, shoot measures and biomass of nursery-grown Pechay prior to transplantation

	Treatments	Root length (mm)	No. of roots	Shoot length	Seedling weight
% FNW	0% FNW	17.23	4.87[a]	48.47	36.27[a]
	50% FNW	21.33	7.60[b]	50.27	50.00[b]
	100% FNW	23.80	6.40[ab]	50.07	46.73[ab]
Soaking	2-hrs	19.73	6.53	48.33	43.20
period	4-hrs	20.73	6.93	47.87	47.67
	6-hrs	22.00	5.40	52.60	42.13
p-value	% FNW	0.091	0.007*	0.912	0.026*
	Soaking period	0.735	0.162	0.531	0.514
	% FNW × Soaking Period	0.230	0.821	0.117	0.932

Column means of different letters are significant at 0.05 level, * Significant

et al., 2020). Furthermore, the amplified height response with prolonged FNW exposure aligns with proposed mechanisms involving optimal uptake and diffusion dynamics of bioactive compounds, as well as hormonal signaling patterns influenced by both concentration and exposure duration (Peng et al., 2004; Lutts et al., 2016).

In contrast, some studies have reported negligible or inhibitory effects of plant extracts on seedling height, highlighting the context-specific nature of these responses based on extract composition, concentration, target species, and experimental conditions (Popoola et al., 2020; Radwan et al., 2019).

Leaf breadth of transplanted Pechay

The two-way ANOVA tests revealed that the application of 50% FNW had a significant impact on Pechay leaf width at 35 days after transplanting, resulting in significantly broader leaves compared to both 0% (103.33) and 100% FNW (104.72). This observation of increased leaf dimensions in response to optimal plant extract priming aligns with previous reports highlighting the positive effects of bioactive compounds on leaf growth and development (Ahmad et al., 2020; Lee & Kim, 2000; Wahocho et al., 2023). The enhanced root development and biomass accumulation during the pre-transplant phase likely provided a strong foundation for continued growth and improved nutrient uptake post-transplantation. The stimulatory influence of FNW bio actives such as phenols and flavonoids on cell division, expansion, and metabolic processes involved in leaf morphogenesis could contribute to the observed leaf broadening (Peng et al., 2004; Chen & Arora, 2011). Additionally, the modulation of hormonal signaling pathways and resource allocation patterns by these compounds may play a role in enhancing leaf architecture (Mbega et al., 2012).

Soaking duration did not show a notable effect on leaf width. While some studies have reported positive impacts of optimized priming durations on leaf growth parameters (Wahocho et al., 2023), the lack of a significant effect in the current study suggests that FNW concentration may be the primary determinant of leaf broadening in Pechay, potentially overshadowing the influence of soaking time within the tested range. The impact of FNW remained consistent across soaking times, and although it did not influence early leaf width, a 50% FNW concentration substantially increased mature Pechay leaf breadth over non-primed controls across all soaking periods. The consistent leaf broadening effect of 50% FNW across soaking durations further reinforces the crucial role of priming agent concentration in modulating leaf morphology. The absence of an early impact on leaf width suggests that the growth-promoting effects of FNW bio actives may manifest later in the developmental stages, potentially through sustained influences on cellular processes and resource allocation patterns influencing mature leaf architecture (Peng et al., 2004; Mbega et al., 2012).

Number of Leaves of Transplanted Pechay

The number of leaves on transplanted Pechay did not exhibit significant differences between different levels of FNW or seed soaking durations, and the interaction effect between these factors was also deemed non-substantial. Consequently, FNW priming treatment and duration did not have considerable impacts on Pechay foliar development post-transplanting until harvest under nursery conditions. This lack of a significant effect on leaf number contrasts with some previous studies reporting positive influences of plant extracts and seed priming on leaf production (Lee & Kim, 2000; Ahmad et al., 2020; Wahocho et al., 2023). The observed response could be attributed to the specific composition and concentrations of bioactive compounds present in FNW, which may primarily target other aspects of growth and development, such as cell elongation, resource allocation patterns, or stress response mechanisms, rather than directly influencing leaf initiation and production rates. Additionally, the experimental conditions, including soil characteristics, nutrient availability, and environmental factors, could potentially modulate or overshadow the effects of FNW priming on foliar development. It is also plausible that the impact of FNW priming on leaf initiation may manifest at different developmental stages or under specific environmental conditions not captured in the current study.

Biomass Yields of Transplanted Pechay

Despite improvements in height and leaf size, there was no proportional increase in biomass accumulation (Table 5). The study findings reveal an unexpected observation regarding the relationship between increased plant size,

Table 4: Mean of plant height, number of leaves and leaf breadth of Pechay seedlings treated with *Ficus nota* water (FNW) levels and soaking times during post-transplant under nursery condition

	Treatments	Plant height (mm)	No. of leaves	Leaf breadth
% FNW	0% FNW	124.57[a]	9.11	103.33[a]
	50% FNW	129.28[c]	9.00	113.06[b]
	100% FNW	126.71[b]	8.73	104.72[a]
Soaking	2-hrs	125.79[a]	9.07	105.06
Period	4-hrs	127.62[b]	8.89	109.83
	6-hrs	127.14[b]	8.89	106.22
p-value	% FNW	0.001**	0.132	0.002*
	Soaking period	0.001**	0.566	0.214
	% FNW × Soaking Period	0.001**	0.613	0.437

Column means of different letters are significant at 0.05 levels, ** Highly significant, * Significant

such as height and leaf area, and biomass production, which typically show a positive correlation (Adhikari et al., 2021; Ogbuehi et al., 2013).

This observation contrasts with the anticipated outcome, suggesting potential explanations for this discrepancy. Firstly, resource allocation trade-offs may occur, where enhanced growth in specific plant parts, like the stem and leaves, diverts resources away from overall biomass accumulation (Peng et al., 2004; Mbega et al., 2012). Secondly, limitations in carbon assimilation or nutrient uptake efficiency could hinder the conversion of increased vegetative growth into proportional biomass gains (Ahmad et al., 2020). Additionally, developmental stage-specific responses might play a role, where the impact of FNW priming on biomass accumulation may manifest at different growth phases not captured in the current study).

In our study, we observed significant enhancements in the vegetative growth of transplanted Pechay, which was evident through improved leaf expansion, root development, stem elongation, and biomass yield. It is important to note that while biomass yield in this context primarily represents the shoot, the term "enhanced vegetative growth" encompasses a broader range of growth parameters. The improved biomass yield observed is not only a reflection of shoot growth but also the result of synergistic improvements in root development and overall plant health. Enhanced root systems contribute to better nutrient and water uptake, which in turn supports more robust above-ground growth. Therefore, the observed increase in biomass yield is integrally linked to comprehensive vegetative growth improvements, encompassing both above-ground and below-ground plant parts.

CONCLUSIONS

This study investigated the efficacy of FNW as a potential pre-soaking agent for enhancing seed germination, seedling vigor, and subsequent growth performance in Pechay (*Brassica rapa* subsp. chinensis). The results show that a 50% FNW concentration and a 4-hour soaking duration significantly accelerate germination rates by 60% compared to the untreated control. FNW's bioactive compounds, such as phenols, flavonoids, and tannins, stimulate physiological processes involved in seed germination, cell division, and elongation, enhancing early growth parameters. However, the study found no direct increase in biomass yields after transplantation, suggesting potential trade-offs in resource allocation. The study also highlights the interplay between priming agent concentration and exposure duration, affecting germination and early growth dynamics. The findings provide insights into the relationship between morphological modifications and productivity in FNW-primed Pechay cultivation, offering potential for optimizing priming protocols and extending cultivation periods.

DECLARATION OF CONFLICT OF INTEREST

The author declares no conflicts of interest associated with this research paper.

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Table 5: Mean of biomass yields of Pechay seedlings treated with *Ficus nota* water (FNW) levels and soaking times during post-transplant under nursery condition

	Treatments	Fresh (g)	Dried (g)
% FNW	0% FNW	370.00	62.00
	50% FNW	385.33	66.67
	100% FNW	372.07	55.47
Soaking period	2-hrs	377.60	60.53
	4-hrs	370.93	55.33
	6-hrs	378.87	68.67
p-value	% FNW	0.756	0.762
	Soaking period	0.929	0.695
	% FNW × Soaking Period	0.380	0.931

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