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Effect of Akruss 350fs Concentration and Seed Soaking Duration on Germination and Growth of Chili Plant (*Capsicum frutescens* L.) Plants

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ABSTRACT

The cultivation of chili plants (*Capsicum frutescens* L.) is vital due to their economic and nutritional value. However, seed germination and growth are influenced by factors such as pre-sowing treatments. This study investigates the effect of Akruss-350FS concentration and seed soaking duration on chili plant germination and growth. A factorial experiment was conducted using a Randomized Complete Block Design (RCBD) with three levels of Akruss-350FS concentration (0, 3, and 6 ml/L) and three soaking durations (0, 12, and 24 hours). Germination rate, percentage, plant height, leaf width, stem diameter, and number of branches were measured. Data were analyzed using ANOVA and an Honestly Significant Difference (HSD) test at a 5% significance level. Results indicated that Akruss-350FS concentration significantly affected leaf width, with the highest width observed at 6 ml/L. However, neither Akruss-350FS concentration nor soaking duration had a significant impact on germination rate, plant height, stem diameter, or number of branches. The findings suggest that while Akruss-350FS may enhance specific growth parameters, it does not universally improve all aspects of chili plant development. In conclusion, optimizing Akruss-350FS concentration can enhance certain morphological traits, but further research is needed to determine its broader impact on chili plant productivity. These results contribute to improved agronomic practices for chili cultivation.

INTRODUCTION

The cultivation of Chili Plant (*Capsicum frutescens* L.) holds significant importance in agriculture due to high market demand and nutritional benefits. However, successful germination and plant growth are influenced by various factors, including seed quality, environmental conditions, and pre-sowing treatments. Among these treatments, seed soaking has emerged as a promising technique to enhance germination rates and seedling vigor. This method involves immersing seeds in specific solutions, which can activate metabolic processes and facilitate nutrient uptake, resulting in healthier plants (Corozo-Quiñónez et al., 2023). Understanding the optimal conditions for seed soaking, including solution concentration and soaking duration, is crucial to maximizing the growth potential of *Capsicum frutescens*.

Research indicates that the concentration of growth-promoting substances used during seed soaking can significantly influence germination and subsequent plant growth. The application of organic fertilizers and biostimulants has been found to enhance nutrient availability and improve soil health, ultimately supporting better growth of chili plants (Siswanti & Lestari, 2019). Additionally, the use of mycorrhizal inoculation in combination with organic fertilizers can enhance nutrient uptake and promote root development, thereby increasing growth and yield (Pereira et al., 2016; Pradana et al., 2021). The importance of integrating various agronomic practices to optimize the growth conditions of Chili Plant is evident.

Another crucial factor affecting seed germination and growth is the duration of seed soaking. Soaking seeds for too long can lead to adverse effects such as seed rot or reduced viability, while soaking for too short a time may result in inactive seeds (Eremrena & Mensah, 2016). Therefore, determining the optimal soaking duration is essential to achieve the best results. A specific soaking duration can increase germination rates and seedling growth, indicating that a balance is needed to maximize the benefits of this technique (Tobing & Mulyaningsih, 2020).

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Physiological aspects of germination and growth of *Capsicum frutescens* seeds are influenced by various environmental factors, including temperature, humidity, and light conditions. The interaction between these factors and soaking treatments can create synergistic effects that enhance seed performance (Maryam et al., 2023). Maintaining optimal moisture levels during the soaking process can facilitate better water and nutrient uptake, making it crucial for the early stages of plant development (Tan et al., 2023). Understanding these interactions can help farmers and agricultural practitioners develop more effective Chili Plant cultivation strategies.

Influence of solution concentration and seed soaking duration on the germination and growth of Chili Plant plants is a multifaceted issue that requires attention to various agronomic practices. By optimizing soaking conditions and integrating beneficial treatments, such as mycorrhizal inoculation and organic fertilizers, it is possible to enhance the growth and yield of *Capsicum frutescens*. Future research should focus on elucidating the specific mechanisms by which these treatments affect plant development, as well as exploring the potential development of standardized protocols that can be widely adopted by chili farmers.

MATERIALS AND METHODS

The research was conducted in Tolada Village, Malangke District, Luwu Utara Regency. The research was carried out from April to June 2023. The materials used in this research included Chili Plant seeds (Bara variety), Akruss-350FS, polybags, soil, and water. The tools used were hoes, machetes, buckets, measuring cups, timers, basins, plastic gutters, measuring tapes, cameras, and stationery. This research used a Randomized Complete Block Design (RCBD) with a factorial pattern. The first factor was the concentration of Akruss-350FS with three treatment levels, and the second factor was the soaking duration with three treatment levels. This resulted in nine treatment combinations. Each treatment combination consisted of three replications, resulting in 27 experimental units. Each experimental unit consisted of three plants, resulting in a total of 81 plants.

The first factor was the treatment of Akruss-350FS concentration (C) which consisted of three levels: C0: No treatment with Akruss-350FS (control) C1: Concentration of 3 mL Akruss-350FS/L water C2: Concentration of 6 mL Akruss-350FS/L water The second factor was the soaking duration (T) which consisted of three levels: T0: Soaking duration 0 hours T1: Soaking duration 12 hours T2: Soaking duration 24 hours.

Observed data were analyzed using ANOVA. If there was a significant effect, it was followed by a Honestly Significant Difference (HSD) test at a level of α - 5%. The germination rate was determined by counting the number of days required for the emergence of radicle or plumule over a certain period. According to Sutopo (2010), the formula that can be used is as follows:

$$\mathbf{LP} = \frac{\mathbf{N_1 T_1 + N_2\, T_2 \ldots +\ N_x T_x}}{\mathbf{\sum Germinating\ Seeds}}$$

Explanation:

LP = Germination Rate

N = Number of seeds germinated at a certain time unit

T = Total time between the beginning of the test and the end of a certain observation interval Germination capacity is determined by counting the number of normally germinated seeds over a certain period of time. Using Kuswanto (2001) formula as follows:

$$\mathbf{Sprout\ Power} = \frac{\mathbf{\sum Normal\ Sprouts\ Produced}}{\mathbf{\sum Sampel\ Seeds\ Tested}} \times \mathbf{100}\%$$

RESULTS AND DISCUSSION

1. Germination Rate (Days)

The average number of germinated Chili Plant seeds at 7 Days After Sowing showed that the treatment of various combinations of Akruss-350FS concentrations and soaking duration had no significant effect on the growth of Chili Plant seeds, as shown in Figure 1.

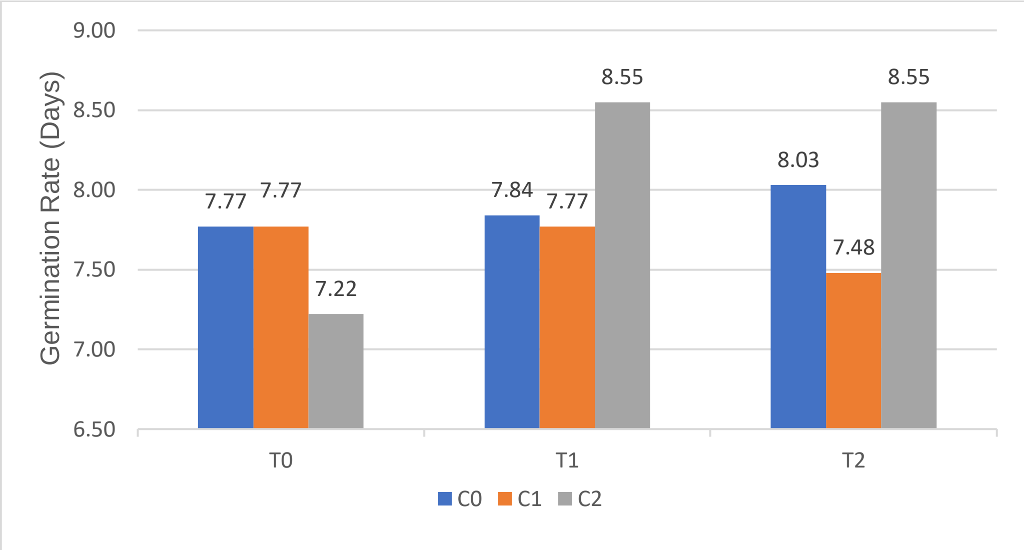

Figure 1. Mean Germination Rate of Chili Plant Seedlings at 7 Days Post-Sowing

Germination rate of Chili Plant (*Capsicum frutescens* L.) in figure 1, specifically the Bara variety, is influenced by various factors, including the concentration of the soaking solution and the duration of seed soaking. In this study, although the average germination rate did not show significant differences between treatments, specific combinations of Akruss-350FS concentration and soaking duration resulted in faster germination rates. Specifically, treatments C2T1 (6 ml for 12 hours) and C2T2 (6 ml for 24 hours) achieved a germination rate of 8.55% per day, while the slowest germination rate was recorded in treatment C2T0 (3 ml for 0 hours) with 7.22% per day. These findings indicate that specific combinations of soaking duration and concentration can enhance the physiological processes involved in seed germination.

Increased germination rate with specific soaking durations is consistent with previous research showing that seed soaking can facilitate the softening of the seed coat and activate the metabolic processes necessary for germination. Increasing the soaking duration to a certain point can accelerate germination, but excessive soaking can lead to reduced or even detrimental effects (Nithyadevi et al., 2022). This suggests that the optimal soaking duration is crucial to maximizing germination rates, as excessive soaking can cause seed damage or reduced viability.

Concentration of the soaking solution plays a significant role in the germination process. In this study, the use of 6 mL of Akruss-350FS appeared to be effective in promoting faster germination rates compared to lower concentrations. Standardization of the seed-to-solution ratio and soaking duration for optimal seed priming is essential (Malarkodi et al., 2021). The physiological benefits of using the appropriate concentration include increased water and nutrient uptake, which are crucial for the early stages of plant development.

Interaction between soaking duration and concentration also highlights the need for a balanced approach to seed treatment. Although treatments C2T1 and C2T2 showed promising results, it is important to consider the potential risks associated with excessive soaking, as indicated by the slower germination rate in treatment C2T0. This emphasizes the need for further research to determine the optimal soaking conditions to maximize germination rates without compromising seed viability. Additionally, these findings suggest that the physiological response of seeds to soaking treatments can vary significantly based on the specific characteristics of the chili variety being studied.

2. Germination Percentage (%)

The average observation results of the germination percentage of *Capsicum frutescens* seeds at 7 days after sowing.

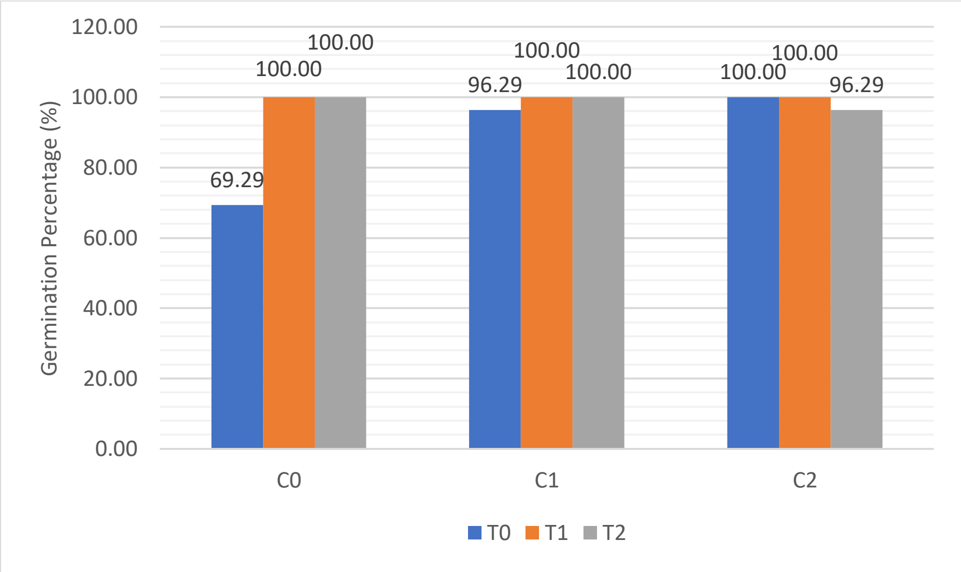

Figure 2. Average percentage of germination of bird's eye chili plants

The germination rate of Capsicum frutescens var. Bara was not significantly different between different combinations of Akruss-350FS concentrations and soaking durations, as shown in Figure 2. Treatments C0T1 (0 mL/12 hours), C0T2 (0 mL/24 hours), C1T1 (3 mL/12 hours), C1T2 (3 mL/24 hours), C2T0 (6 mL/0 hours), and C2T1 (6 mL/12 hours) had the highest germination rate of 100%.

Germination percentage of *Capsicum frutescens* var. Bara in this study revealed that varying concentrations of Akruss-350FS and soaking durations did not significantly influence germination rates, with the highest observed being 100% for several specific treatments. Previous research has demonstrated that soaking duration can notably affect seed germination rates. [1] While increasing soaking duration up to a certain point enhances germination speed, excessive soaking can lead to reduced germination rates due to potential seed damage or loss of viability (Nithyadevi et al., 2022). This suggests that the soaking durations employed in this study might have been optimal for *Capsicum frutescens* seeds, enabling them to achieve maximum germination without adverse consequences.

The chemical composition of the soaking solution plays a pivotal role in seed germination. Chemical treatments can enhance germination rates by breaking seed dormancy and improving water uptake (Ali & Aziz, 2021). In the context of Akruss-350FS, it likely possesses properties that support seed hydration and metabolic processes essential for germination. Additionally, pre-soaking treatments can significantly boost germination rates by improving the seed's ability to absorb water and nutrients (Ishiaku et al., 2023).

Interestingly, treatments without Akruss-350FS (C0T1 and C0T2) also achieved 100% germination, suggesting that the seeds may possess intrinsic qualities that promote germination under optimal soaking conditions, regardless of chemical treatments. Seeds exhibit high germination rates when subjected to adequate hydration without additional chemical treatments (Biaou et al., 2022).

Consistent germination percentage across various combinations of soaking durations and concentrations might indicate a threshold effect where seeds have reached their maximum germination potential under the tested conditions. This phenomenon is supported by the work of Salleh and Pa'Ee, who found that certain seed species exhibit stable germination rates across a range of soaking conditions, suggesting a resilience in their germination response salleh (Salleh & Pa'ee, 2021).

Germination percentage of *Capsicum frutescens* var. Bara highlights the intricate relationship between chemical treatments, soaking duration, and seed viability. The observed 100% germination across several treatments underscores the potential for optimizing seed soaking protocols to enhance germination rates effectively. Future research could delve deeper into the biochemical pathways activated during soaking and their implications for seedling vigor and growth.

3. Plant Height (cm)

Average height of chili plants at 30 days after planting showed that the various combinations of Akruss-350FS concentrations and soaking durations did not have a significant effect on seed germination. The average plant height can be seen in the diagram below.

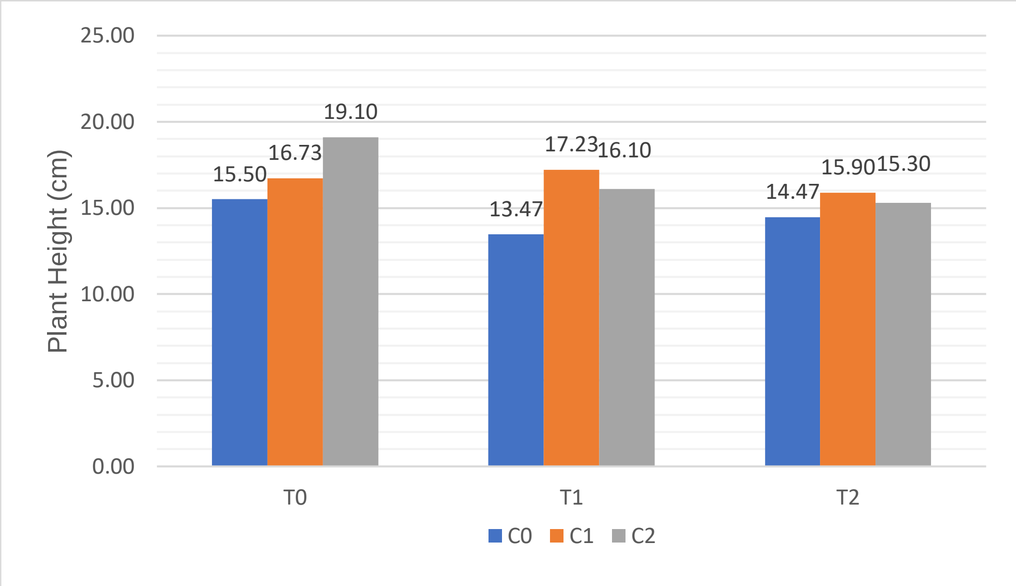

Figure 3. Average Height of Bird's Eye Chili Plants

The results presented in Figure 3 indicate that the average height of Bara chili plants at 30 days after planting varied significantly across different treatments of Akruss-350FS concentration and soaking time. The highest average height of 19.10 cm was recorded for treatment C2T0 (6 mL/0 hours), while the lowest was noted for treatment C0T1 (0 mL/12 hours) at 13.47 cm. This variation can be attributed to several factors related to the concentration of the growth regulator and the duration of soaking.

Concentration of Akruss-350FS plays a crucial role in plant growth. Treatment C2T0, which utilized a concentration of 6 mL without soaking, likely provided an optimal level of growth-promoting substances that stimulated cellular processes associated with height increase. Research has shown that appropriate concentrations of growth regulators can enhance plant height by promoting cell elongation. The absence of the growth regulator in treatment C0T1 limited the growth potential of the plants, resulting in a significantly lower average height. This aligns with findings that indicate the positive effects of nitrogen fertilization and growth regulators on the biomass and overall growth of chili plants (Kamnqa et al., 2020).

Soaking time can influence the effectiveness of the growth regulator. The lack of soaking in treatment C2T0 may have allowed for immediate absorption and utilization of the growth regulator by the plants, leading to enhanced growth responses. Conversely, treatment C0T1, which involved a prolonged soaking time without the application of the growth regulator, may have resulted in nutrient leaching or reduced availability of essential growth factors, thereby stunting plant growth (Mulia et al., 2024). This suggests that the timing and method of application of growth regulators are critical for maximizing their effectiveness.

Interaction between the growth regulator and environmental conditions cannot be overlooked. Factors such as soil nutrient availability, moisture levels, and light exposure can significantly affect the growth response of chili plants. The application of organic fertilizers and biostimulants has been shown to improve soil health and enhance the growth of chili plants by increasing nutrient availability and promoting beneficial microbial activity (Priyadi et al., 2022). The combination of a suitable concentration of Akruss-350FS and optimal environmental conditions likely contributed to the superior growth observed in treatment C2T0.

Significant difference in plant height between the treatments can be attributed to the optimal concentration of Akruss-350FS in treatment C2T0, which facilitated enhanced growth through effective nutrient uptake and cellular processes. In contrast, the lack of growth regulator in treatment C0T1 limited the plants' growth potential.

4. Leaf Width (cm)

Average leaf width of chili plants at 30 days after planting showed that the various combinations of Akruss-350FS concentrations and soaking durations had a significant effect on chili seed growth.

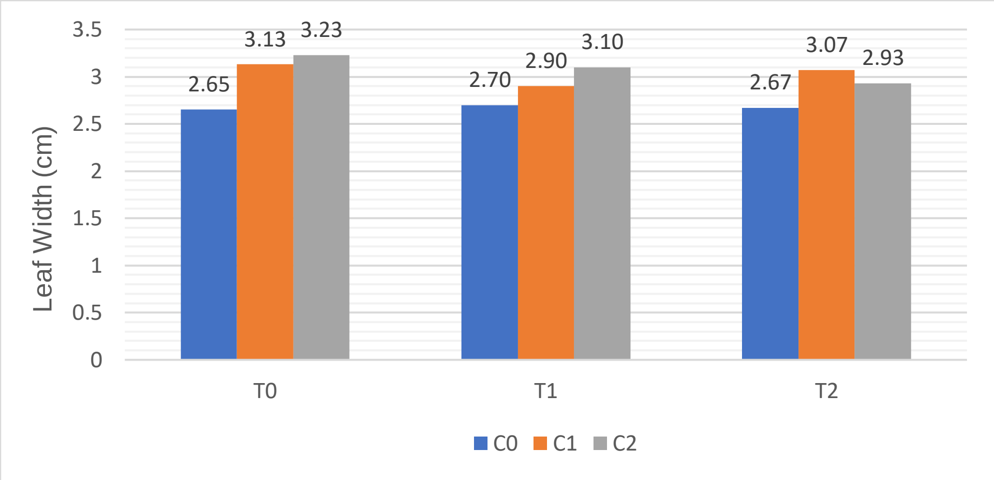

Figure 4. Average Leaf Width of Chili Plants

Results presented in Figure 4 demonstrate a significant difference in the average leaf width of Bara chili plants subjected to various combinations of Akruss-350FS concentrations and soaking durations. Specifically, treatment C2T0 (6 mL/0 hours) exhibited the highest average leaf width of 3.23 cm, while treatment C0T0 (0 mL/0 hours) recorded the lowest at 2.65 cm. This variation can be explained through several physiological and biochemical mechanisms influenced by the application of growth regulators and environmental factors.

Enhanced leaf width observed in treatment C2T0 can be attributed to the optimal concentration of Akruss-350FS, which likely facilitated increased cell division and expansion. Growth regulators, such as those found in Akruss-350FS, are known to promote physiological processes that enhance leaf development, including the stimulation of chlorophyll synthesis and the enhancement of photosynthetic efficiency (Lob et al., 2023; Magaña-López et al., 2022). The increase in leaf area, as a result of wider leaves, allows for greater light interception, which is crucial for photosynthesis and overall plant vigor. This is consistent with findings that demonstrate how biostimulants can positively affect leaf morphology and plant growth by enhancing nutrient uptake and metabolic activity (Novitasari et al., 2023; Nurbailis et al., 2023).

Conversely, treatment C0T0, which lacked both the growth regulator and soaking, likely resulted in suboptimal physiological conditions for leaf development. The absence of Akruss-350FS may have limited the plant's ability to synthesize essential growth hormones, leading to reduced leaf expansion and overall growth (Yanti et al., 2023). Additionally, without the soaking treatment, the plants may not have been able to maximize nutrient absorption, further contributing to their reduced leaf width. Research indicates that the application of growth regulators can significantly enhance the physiological responses of plants, leading to improved growth parameters, including leaf area and width (Saputri et al., 2023; Toscano et al., 2021)

Interaction between the growth regulator and environmental factors such as soil moisture and nutrient availability plays a critical role in plant development. The application of Akruss-350FS in treatment C2T0 likely improved the plant's ability to absorb water and nutrients, which are essential for cell division and growth (Tobing et al., 2023). Studies have shown that adequate nutrient supply, particularly nitrogen, is vital for leaf development, as it is a key component of chlorophyll and amino acids necessary for protein synthesis (Soesanto et al., 2021; Tammu et al., 2021). Therefore, the combination of Akruss-350FS and optimal environmental conditions in treatment C2T0 likely created a synergistic effect that enhanced leaf width.

Significant difference in leaf width between the treatments can be attributed to the effective concentration of Akruss-350FS in treatment C2T0, which promoted physiological processes conducive to leaf expansion. In contrast, the lack of growth regulator and soaking in treatment C0T0 limited the plants' growth potential. Future research should further explore the interactions between growth regulators, nutrient availability, and environmental conditions to optimize chili plant growth.

The table below (Table 1) provides numerical data on the impact of varying concentrations of Akruss-350FS (C) on the leaf width of chili plants at 30 days after planting.

Table 1. Mean and Post-hoc Test Results of Leaf Width (cm) under Different Akruss-350FS Concentrations (C) in Chili Plants at 30 Days After Transplanting.

Treatment	Average Leaf Width (cm)	HSD 5%
C0	8,02[b]	0,50
C1	9,10[a]	
C2	9,27[a]	

Note: Numbers followed by different letters (a, b) indicate that the results are significantly different according to the 5% Honestly Significant Difference (HSD) test.

Results presented in Table 1 indicate that varying concentrations of Akruss-350FS significantly influenced the leaf width of chili plants at 30 days after planting. Specifically, treatment C1 and C2, which involved different concentrations of Akruss-350FS, resulted in significantly wider leaves compared to the control (C0). Treatment C2 achieved the highest average leaf width of 9.27 cm, followed by C1 at 9.10 cm.

This increase in leaf width can be attributed to the role of growth regulators in enhancing physiological processes associated with leaf expansion. Growth regulators, such as those found in Akruss-350FS, stimulate cell division and elongation, leading to increased leaf size. Additionally, these regulators enhance chlorophyll synthesis and other essential processes for plant growth (Koyama & Smith, 2022; Popović et al., 2023; Salem et al., 2022; Septisetyani et al., 2024).

Concentration-dependent effects of Akruss-350FS explain the differences in leaf width among treatments. The higher concentration in treatment C2 likely provided optimal conditions for leaf expansion, resulting in the greatest leaf width. Research has shown that growth regulators can enhance growth responses within a non-toxic range (Chang et al., 2022; Novitasari et al., 2023).

Interaction between growth regulators and environmental factors also plays a crucial role. Adequate nutrient supply and favorable soil conditions, when combined with growth regulators, can significantly enhance leaf area and width by improving nutrient uptake and promoting beneficial microbial activity (Liu et al., 2019; Ozawa et al., 2023; Patel et al., 2024; Yu et al., 2020).

Significant differences in leaf width can be attributed to the effective application of Akruss-350FS, which promotes physiological processes conducive to leaf expansion. The higher concentrations in treatments C1 and C2 resulted in greater leaf widths compared to the control, demonstrating the importance of growth regulators in enhancing plant morphology.

5. Stem Diamter (mm)

Observations on the average stem diameter of Chili Plant plants at 45 days after planting showed that the treatment of various combinations of Akruss-350FS concentration and soaking duration on the growth of Chili Plant seeds had no significant effect.

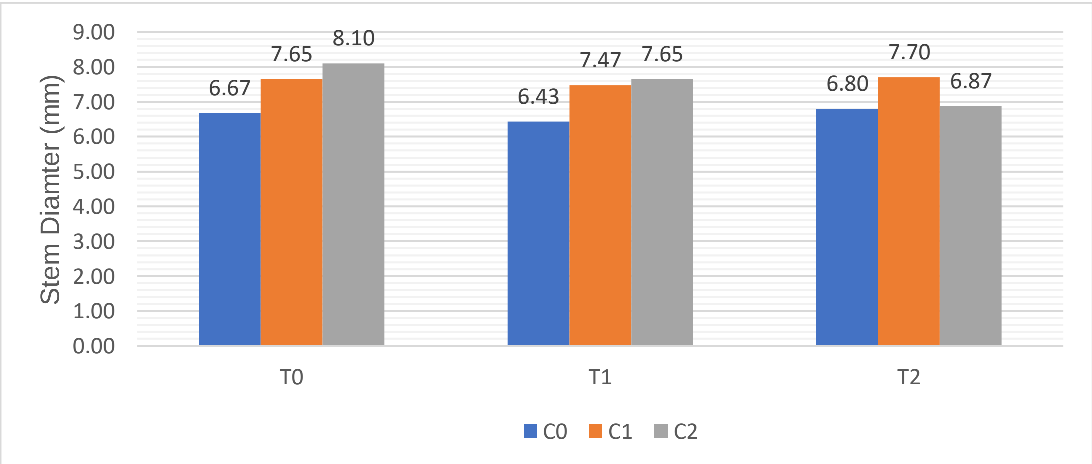

Figure 5. Average Stem Diameter of Chili Plants

The findings regarding the average stem diameter of the 'bara' variety of Chili Plant under various treatment combinations of Akruss-350FS concentration and soaking duration revealed no significant effect on stem diameter across the treatments. Specifically, the C1T1 treatment (3 mL/12 hours) yielded the highest average stem diameter of 4.05 mm, while the C0T2 treatment (0 mL/24 hours) resulted in the lowest at 3.38 mm. This observation is consistent with existing literature suggesting that varying concentrations and soaking durations can influence plant growth parameters, including stem diameter, although not always significantly.

Stem diameter can be influenced by several factors, including the application of growth regulators and environmental conditions. Plant growth regulators such as gibberellins have been shown to affect stem growth, often leading to increased elongation but potentially reduced diameter in some species (Muniandi et al., 2018). In the context of 'bara' Chili Plant, the lack of significant variation in stem diameter across treatments may indicate that the concentrations and soaking durations used were insufficient to elicit a measurable response, or that the genetic predisposition of the variety limits the extent of growth modulation.

External conditions of the plant play a crucial role in determining growth outcomes, although they do not directly address the influence of treatments on stem diameter (Fajardo et al., 2020). This suggests that while external treatments can influence growth, the inherent genetic traits of the 'bara' variety may limit the effectiveness of such treatments on stem diameter. Certain treatments can inhibit growth rather than promote it, particularly under stress conditions (Morino et al., 2020). This could imply that the Akruss-350FS treatments may not have provided the necessary conditions for optimal growth in stem diameter, especially if the plants were already under physiological stress.

The physiological responses of plants to various treatments can vary widely among different cultivars. The response of Chili Plant to fertilization and nutrient management indicates that specific combinations of organic and inorganic fertilizers can enhance growth traits, including stem diameter (Astika et al., 2022). The effectiveness of these treatments can depend on the specific cultivar and its genetic predispositions, as well as the environmental context in which it is grown.

6. Number of Branches

Observations on the average number of branches of Chili Plant plants at 45 days after planting showed that the treatment of various combinations of Akruss-350FS concentration and soaking duration on the growth of Chili Plant seeds had no significant effect

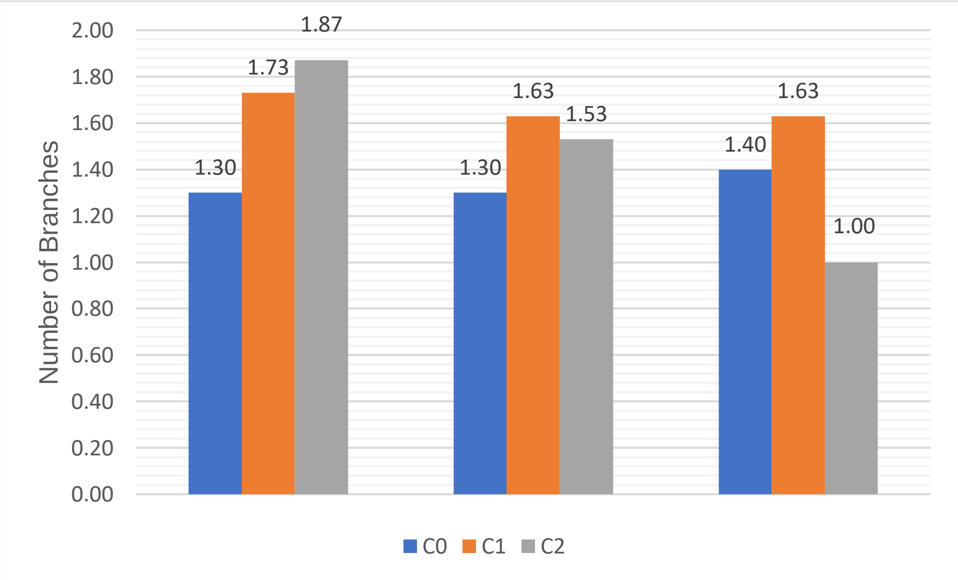

Figure 6. Average Number of Branches of Chili Plant

Table 6 above shows the results of the average number of branches in 'bara' variety Chili Plant plants, which are influenced by various concentrations of Akruss-350FS and soaking times, obtaining fluctuating results. The results showed that treatment C2T0 (6 mL/0 hours) produced the highest average number of branches, which was 1.87, while the lowest yield was observed in treatment C2T2 (0 mL/12 hours) with only 1.00 branch. This suggests that the concentration of Akruss-350FS and the duration of soaking may not significantly affect branching, but certain combinations can promote growth.

Research has shown that various factors, including nutrient availability and environmental conditions, can affect the growth and branching of Chili plants. The application of organic and inorganic fertilizers has been shown to improve the growth and yield of Chili Plant, indicating that nutrient management plays an important role in optimizing plant development (Astika et al., 2022). In addition, the physiological responses of plants to different treatments can vary, as seen in studies where factors such as soil properties and pruning techniques have been shown to significantly affect growth parameters (Jaya et al., 2023).

The genetic characteristics of Chili Plant varieties also contribute to their growth performance. High heritability traits associated with growth, such as plant height and fruit weight, have been documented in various studies, suggesting that genetic factors may also play a role in the observed branching patterns (Amas et al., 2023). This is consistent with the findings that indicate the importance of selecting superior and adaptive varieties for improved production outcomes (Anshori et al., 2024).

The lack of significant differences in the number of branches between treatments may also reflect the natural resilience of the 'bara' variety to variations in growth conditions. The adaptability of Chili Plant to various environmental stresses and nutrient deficiencies emphasizes the need for robust cultivation practices to increase productivity (Agustina et al., 2022; Pahlevi et al., 2021). The treatments of Akruss-350FS concentration and soaking time did not produce significant differences in branching; the overall growth of Chili Plant plants is influenced by a complex interaction between genetic, environmental, and management factors.

CONCLUSIONS

Based on the results obtained from the research conducted, it can be concluded that Soaking seed concentration with Akruss-350FS on the germination and growth of cayenne pepper plants on the parameters of leaf width and leaf length showed a significant effect at a concentration of 6 ml. Soaking seed duration with Akruss-350FS on the germination and growth of cayenne pepper plants on the parameters of plant height, stem diameter and number of branches showed no significant effect. There was no interaction between the concentration of Akruss-350FS and the soaking time of seeds on the germination and growth of cayenne pepper plants.

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