

The Effect of Seed Soaking on the Growth and Quality of Chili Peppers (*Capsicum Frutescens* L.)

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ABSTRACT. This study aimed to analyze the effect of seed soaking methods on the growth and quality of bird's eye chili peppers (*Capsicum frutescens* L.). The study was conducted in Br. Titigalar, Bangli Village, Baturiti Subdistrict, Tabanan Regency, Bali, from September 2025 to February 2026. The study used a randomized block design with one treatment factor and three replications. The treatments consisted of Bp, which involved soaking the seeds for 12 hours in warm water with an initial temperature of 50 °C; Bg, which involved soaking the seeds in warm water with an initial temperature of 50 °C supplemented with 1 mL L⁻¹ of Golden Grow; and Bc, which involved soaking the seeds in tap water supplemented with 1 mL L⁻¹ of Golden Grow. The observed variables included plant height, stem diameter, number of leaves, fruit diameter, vitamin C content, and placenta weight. The results showed that the average plant height ranged from 67.42 to 71.29 cm, the stem diameter from 8.51 to 8.73 mm, and the number of leaves from 123.64 to 134.36. Fruit diameter ranged from 10.08 to 10.40 mm, vitamin C content from 0.36 to 0.40 mg per 100 g, and placenta weight from 0.25 to 0.26 g. Based on the available significance table, all observed yield quality variables showed no significant effect ($P \geq 0.05$). These results indicate that the differences in the seed soaking methods tested did not produce consistent changes in the growth characteristics and fruit quality of cayenne peppers under the study conditions.

KEYWORDS: *Capsicum frutescens* L., Chili peppers, Fruit quality, Plant growth, Seed soaking.

I. INTRODUCTION

Bird's eye chili peppers (*Capsicum frutescens* L.) is an important horticultural commodity in Indonesia due to its high economic value and steadily increasing demand. Consumption of bird's eye chili comes not only from households but also from the hotel, restaurant, and catering sector, making this commodity a promising source of income for farmers. At the farm level, bird's eye chili can generate substantial profits in a single growing season. However, this high demand has not yet been fully met by national production capacity. Bird's eye chili production in Indonesia remains volatile and has declined in some years, meaning domestic supply has not been able to consistently meet demand (BPS, 2024). This situation indicates that increasing chili pepper productivity remains a key challenge in the development of the national horticulture sector.

One of the key factors determining the success of bird's eye chili cultivation is seed quality. Seeds with low vigor generally exhibit inconsistent germination rates, slow early growth, and low resistance to environmental stress. Seeds that degrade in quality during storage also have the potential to produce weak and inconsistent seedlings, thereby impacting cultivation efficiency and final crop yields. Raga et al. (2023) demonstrated that seeds stored under uncontrolled conditions can experience a significant decline in vigor. Therefore, seed treatment prior to planting is a crucial step for improving seed physiological quality and supporting plant growth from the early stages.

Various techniques have been developed to improve seed quality, including seed priming and thermotherapy. Soaking seeds in warm water at a specific temperature is a simple method that can help suppress seed-borne pathogens while improving physiological processes during germination. Hot water treatment is an environmentally friendly seed disinfection method suitable for sustainable agriculture (Kim et al., 2022). Hot water treatment of bell pepper seeds can increase plant vigor and yield while reducing disease incidence (Hussain et al., 2020). Xhemali et al. (2024) confirm that thermotherapy is a safe, easy-to-apply, and effective physical method for reducing both internal and external pathogen loads. These findings indicate that seed soaking treatment has the potential to serve as an effective initial strategy for improving the quality of cayenne pepper seeds.

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In addition to physical treatments, the use of biostimulants in seed soaking is also being increasingly developed. Golden Grow, which contains Indole Butyric Acid (IBA), plays a role in stimulating root formation and accelerating early plant growth. Arthur et al. (2023) note that hormone-based biostimulants are increasingly recognized for their role in enhancing plant tolerance to abiotic stress and supporting sustainable agriculture. The development of a healthy root system enhances a plant's ability to absorb water and nutrients, thereby supporting both vegetative and generative growth. On the other hand, [substance] is also beginning to gain attention as a biostimulant because it can activate physiological responses in plants. Mahmood et al. (2025) demonstrated that the application of at certain concentrations can enhance germination and strengthen the vigor of Solanaceae plants.

Although the benefits of thermotherapy, biostimulants, and have been widely reported separately, studies on the combination of seed soaking with the application of on cayenne peppers remain limited. Most studies also remain focused on germination and early growth, while the effects on vegetative growth, yield, yield quality, and soil fertility have not been thoroughly investigated. In fact, the integration of seed treatments and biostimulants has the potential to become a simple, easy-to-apply cultivation technology that supports sustainable improvements in bird's eye chili production efficiency.

This study aims to analyze the effect of seed soaking methods on the growth and fruit quality of bird's eye chili (*Capsicum frutescens* L.). The results of this study are expected to provide a scientific basis for the development of more productive, efficient, and sustainable bird's eye chili cultivation technologies.

II. MATERIALS AND METHODS

Research Location

This study was conducted in Br. Titigalar, Bangli Village, Baturiti Subdistrict, Tabanan Regency, from September 2025 to February 2026.

Experimental Design

The study used a randomized block design (RBD) with a split-plot arrangement, consisting of 1 factor and 3 replications. The first factor, as a subplot, was the seed soaking method prior to sowing (B), which consisted of 3 levels, namely:

- Bp = Seeds were soaked for 12 hours following the farmers' method, using warm water with an initial temperature of 50°C, with the temperature not maintained at a constant level.
- Bg = Seeds were soaked for 12 hours in warm water with an initial temperature of 50°C (temperature not maintained at a constant level) supplemented with 1 mL L⁻¹ of Golden Grow (GG).
- Bc = Seeds were soaked in tap water with 1 mL L⁻¹ of Golden Grow (GG) and for 12 hours.

Materials and Equipment

This study utilized various supporting materials that played a crucial role in each stage of the experiment. The main material was Korawa hybrid cayenne pepper seeds, which served as the test subjects for three treatments: Bp, Bg, and Bc. Distilled water was used as the medium for dissolving and soaking the seeds. The base fertilizers applied included burnt rice husks, cow manure, chemical fertilizers, and organic compost to support soil fertility and plant growth. The tools used are conventional soil-tilling tools such as hoes, sickles, and others.

Land Preparation and Planting

Bird's eye chili seeds were selected using a floatation test; the seeds that sank were chosen as high-quality seeds and sun-dried before treatment. The seeds were divided into three treatment groups: Bp (soaking in warm water at an initial temperature of 50°C for 12 hours), Bg (soaking in warm water with an initial temperature of 50°C supplemented with 1 mL L of Golden Grow (GG) for 12 hours), and Bc (soaking in tap water supplemented with 1 mL L⁻¹ of GG for 12 hours).

Seeds are sown in seedling trays at a rate of one seed per hole. Seedlings with 2–3 leaves are transplanted into poly bags filled with a mixture of soil, rice husk charcoal, and organic fertilizer. The seedlings are sprayed with Golden Grow Daun at a concentration of 1 mL L⁻¹ at 7 and 14 days after being transplanted into the polybags. The seedlings are ready for field planting approximately 20–25 days after being transplanted into the polybags or when they have at least five fully developed leaves.

The research plot was cleared of weeds and plant debris, then tilled using a mini-tractor to a depth of 25–30 cm. A base fertilizer consisting of mature organic fertilizer and NPK was applied 7–10 days before planting, followed by the construction of raised beds 100–120 cm wide and the installation of black-and-silver plastic mulch. Planting holes were made in a zigzag pattern with a planting spacing of 50 × 50 cm.

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Observations and Observed Variables

1. Plant Height, Stem Diameter, and Number of Leaves

The observed growth variables included plant height, number of leaves, and stem diameter. Plant height was measured weekly from planting until harvest using a ruler or measuring tape from the base of the stem to the highest growing point. The number of leaves was observed by counting the fully expanded leaves on each plant. Stem diameter was measured using a vernier caliper on the main stem above ground level. All observations were conducted periodically to evaluate the plants' vegetative growth response to the treatments administered.

2. Fruit Diameter, Vitamin C Content, and Placenta Weight

The observed fruit quality variables included fruit diameter, vitamin C content, and placenta weight. Fruit diameter was measured when the fruit had reached harvest maturity. Measurements were taken using a vernier caliper at the center of the fruit, with the instrument positioned perpendicular to the fruit's longitudinal axis. Measurement results are expressed in millimeters (mm). Vitamin C content was analyzed in fresh fruit after harvest using iodometric titration or spectrophotometry, and then expressed as a percentage (%) as an indicator of the fruit's nutritional quality. The weight of the placenta is determined by carefully separating the placental tissue from the fruit, then weighing it using an analytical balance and expressing the result in grams per fruit. These two parameters are used to evaluate the effect of the treatments on the quality of cayenne peppers, both in terms of nutritional value and internal fruit characteristics.

Data Analysis

The research data were analyzed using analysis of variance (ANOVA) based on a one-factor randomized block design at a significance level of 5%. If the analysis results indicated a significant effect ($P < 0.05$), a post-hoc Least Significant Difference (LSD) test was conducted at the 5% level to compare differences between treatments. All statistical analyses were performed using IBM SPSS Statistics version 26 (or the statistical software you use).

III. RESULTS

Significance of the Effect of Seed Soaking on Observed Variables

Table 1 shows the significance of the seed soaking treatment (B) on various observed variables. Based on the analysis of variance, the seed soaking treatment (B) did not have a significant effect on plant height, stem diameter, number of leaves, fruit diameter, vitamin C content, or placenta weight.

Table 1. Significance of the Effect of Seed Soaking (B) on Observed Variables.

No.	Variable	Seed Soaking Treatment (B)
1.	Plant Height (cm)	ns
2.	Stem Diameter (mm)	ns
3.	Number of Leaves (leaves)	ns
4.	Fruit Diameter (mm)	ns
5.	Vitamin C Content (%)	ns
6.	Placenta Weight (grams)	ns

Notes: ns : No Significant Effect ($P \geq 0.05$) * : Significant Effect ($P < 0.05$) ** : Highly Significant Effect ($P < 0.01$) td : Not Statistically Analyzed

1. Plant Height, Stem Diameter, and Number of Leaves

Based on the results of vegetative observations of cayenne pepper plants, the seed soaking treatment had no significant effect on plant height, stem diameter, or the number of leaves on cayenne pepper plants (Table 2).

Table 2. Plant Height (cm), Stem Diameter (mm), and Number of Leaves in the Seed Soaking Treatment (B)

Treatment	Plant Height (cm)	Stem Diameter (mm)	ber of Leaves (pieces)
Bp	69.78 a	8.73 a	132.29 a
Bg	71.29 a	8.60 a	123.64 a
Bc	67.42 a	8.51 a	134.36 a
BNT 5%	6.11	0.42	14.60

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Note: Numbers followed by the same letter in the same column indicate no significant difference based on the BNT test at the 5% significance level.

The results show variation in mean values among the seed soaking treatments. The tallest plant height was observed in treatment Bg at 71.29 cm, while treatment Bc yielded the lowest value at 67.42 cm. Stem diameter ranged from 8.51 to 8.73 mm, with the highest value observed in Bp. The highest number of leaves was recorded in Bc at 134.36, while Bg produced 123.64 leaves. Based on the significance table, these three growth variables were found to be not significantly different ($P \geq 0.05$).

3. Fruit Diameter, Vitamin C Content, and Placenta Weight

Based on observations of the quality and quantity of the bird's eye chili harvest, the seed soaking method had no significant effect on any of the fruit quality parameters tested, including fruit diameter, vitamin C content, and placenta weight (Table 3.)

Table 3. Fruit Diameter, Vitamin C Content, and Placenta Weight of Bird's Eye Chili Peppers

Treatment	Fruit Diameter (mm)	Vitamin C Content (mg/100g)	Placenta Weight (g)
Bp	10.37 a	0.40 a	0.26 a
Bg	10.40 a	0.40 a	0.25 a
Bc	10.08 a	0.36 a	0.26 a
BNT 5%	0.71	0.04	0.27

Note: Numbers followed by the same letter in the same column indicate no significant difference based on the BNT test at the 5% significance level.

For the fruit quality variable, fruit diameter ranged from 10.08 to 10.40 mm. The highest value was observed in the Bg treatment (10.40 mm), followed by Bp (10.37 mm) and Bc (10.08 mm). The vitamin C content for each treatment was 0.40 mg 100 g⁻¹ for Bp and Bg, and 0.36 mg 100 g⁻¹ for Bc. Placenta weight ranged from 0.25 to 0.26 g. Based on the available significance table, fruit diameter, vitamin C, and placenta weight showed no significant effect ($P \geq 0.05$).

IV. DISCUSSION

The absence of a significant effect of seed soaking methods on all observed variables indicates that the differences between treatments Bp, Bg, and Bc were not strong enough to produce a consistent growth response in cayenne pepper plants. Nevertheless, descriptively, treatment Bg produced the tallest plant height and the largest fruit diameter. This response can be attributed to the processes of imbibition and seed metabolic activation during soaking. Seed priming allows seeds to initiate the physiological process of germination before planting, thereby potentially improving vigor and early growth. Studies on *Capsicum annum* have shown that priming can enhance germination, radicle and plumule growth, as well as seedling vigor. Granata et al. (2024) also demonstrated that the priming response in *Capsicum* is influenced by the type of treatment and the dose level used.

The use of warm water to treat Bp and Bg also has physiological and phytosanitary bases. Heat treatment can affect the surface condition of seeds and suppress some seed-borne organisms, but its effectiveness depends heavily on the combination of temperature and treatment duration. Research by Ruchika et al. (2023) on bell peppers showed that certain thermophysical treatments can improve growth and yield and reduce the incidence of several diseases. However, that study used a controlled combination of temperature and duration, whereas in this study, the water temperature was not maintained at a constant level for 12 hours. This difference may explain why the growth response to the warm water treatment did not show any significant differences.

The addition of Golden Grow to Bg and Bc also did not result in any significant differences in growth variables. Biostimulants can influence growth by regulating physiological processes, but plant response is highly dependent on the active ingredient, dosage, method of application, environmental conditions, and the plant's nutritional status. Research findings on chili peppers indicate that biostimulants can enhance growth, yield, and quality, but the response is not always consistent across all cultivation conditions. For example, a study on bell peppers showed that some commercial biostimulants produced only limited effects on growth and yield when plants received an adequate fertilization regimen (Steffen et al., 2022).

In this study, the highest number of leaves was observed in the Bc treatment, while the tallest plant height was observed in the Bg treatment. These differing patterns indicate that vegetative growth does not always increase simultaneously across all

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traits. Plant height is more closely related to stem elongation and canopy development, whereas the number of leaves reflects the formation of vegetative organs. Therefore, small differences between treatments may appear descriptively without resulting in statistically significant differences.

Fruit quality also showed no significant effect. Fruit diameter differed by only about 0.32 mm between the highest and lowest values, while vitamin C content ranged from 0.36 to 0.40 mg 100 g⁻¹. Placenta weight was also relatively uniform. The stability in fruit quality may be due to the fact that fruit characteristics are influenced by genetic factors, fruit development, water and nutrient availability, and environmental conditions. Research on biostimulants in chili peppers indicates that the application of biostimulants can influence growth characteristics and fruit quality, but the magnitude of the response depends on the formulation and application system (Agliassa et al., 2021)

V. CONCLUSION

Based on the research results, the seed soaking methods Bp, Bg, and Bc did not have a significant effect on growth variables (plant height, stem diameter, number of leaves) or fruit quality (fruit diameter, vitamin C content, placenta weight) of cayenne peppers ($P \geq 0.05$). Descriptively, the Bg treatment tended to produce the highest plant height and fruit diameter, while the Bc treatment produced the highest number of leaves; however, these differences did not show a statistically consistent response. These results indicate that the combination of warm water and Golden Grow in the Bg treatment warrants further investigation. Future studies are recommended to maintain a constant water temperature throughout the treatment, evaluate variations in soaking duration, and increase the number of replicates to obtain clearer and more consistent responses.

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