

The Effect of Peptide on the Growth and Yield of Maize (*Zea mays* L.)

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ABSTRACT: Maize (*Zea mays* L.) is a strategic food commodity whose productivity is still influenced by soil fertility and nutrient use efficiency. One alternative with the potential to improve plant growth efficiency is the use of peptides as biostimulants. This study aimed to determine the effects of various peptide concentrations on maize plant growth and yield. The study was conducted in the greenhouse of the Faculty of Agriculture at Udayana University from October 2025 to February 2026 using a one-factor randomized block design (RBD) with three treatment levels: no peptide (P0), 2 mL L⁻¹ of peptide solution (P1), and 4 mL L⁻¹ of peptide solution (P2), each repeated three times. The observed variables included plant height, stem diameter, number of leaves, leaf area, relative water content, cob weight without husk, cob diameter without husk, fresh biomass weight, and dry biomass weight. The data were analyzed using analysis of variance (ANOVA) at a 5% significance level, followed by a 5% LSD test when significant effects were found. The results of the study showed that peptide application had no significant effect on plant height, stem diameter, number of leaves, cob weight without husk, cob diameter without husk, fresh biomass weight, and dry biomass weight. Conversely, peptide application had a significant effect on leaf area and relative water content. Although not statistically significant, the 2 mL L⁻¹ treatment tended to yield higher values for these yield components than the other treatments. Overall, peptide application under greenhouse conditions with relatively optimal water and nutrient availability played a greater role in maintaining plant physiological conditions than in enhancing maize growth and yield.

KEYWORDS: Maize growth and yield, peptide

I. INTRODUCTION

Maize (*Zea mays* L.) is one of Indonesia's strategic food commodities, serving as both a food source and a raw material for the animal feed industry. However, national maize production continues to fluctuate from year to year. One of the causes is declining soil fertility due to low availability of essential nutrients, low organic matter content, and the continuous use of inorganic fertilizers, which can degrade soil quality and reduce crop productivity (Banotra et al., 2022; Chittora, 2023; Titirmare et al., 2023).

One alternative with the potential to sustainably enhance plant growth and yield is the use of peptides as biostimulants, biofertilizers, and bioprotectants. Peptides are short chains of amino acids produced through the hydrolysis of proteins from various sources, such as fish waste, poultry feathers, and plants. These compounds are known to improve nutrient uptake efficiency, stimulate plant metabolic activity, and enhance plant tolerance to environmental stress (CH Biotech R&D Co., 2023).

Various studies have shown that the application of peptides positively affects plant growth and yield. Roy et al. (2022) reported that peptides can increase nitrate uptake in plants by 70–140% under nutrient-deficient conditions. Armawan (2024) also reported that the application of a peptide, combined with a 20% reduction in NPK fertilizer dosage, increased rice yield by 22%. Furthermore, Ariani et al. (2025) found that applying peptides at a concentration of 2 mL L⁻¹ increased rice yields compared to the control, while Sahin et al. (2025) demonstrated that keratin hydrolysate, as a source of peptides, can enhance plant growth as well as the nitrogen content and levels of several essential nutrients in plant tissues.

Although the effectiveness of peptides has been widely reported for various crops, information regarding their effects on maize growth and yield remains relatively limited. Therefore, research on the application of various peptide concentrations to maize plants is needed to determine the most effective concentration for enhancing both vegetative growth and yield. The results of this study are expected to serve as a basis for developing more efficient, environmentally friendly, and sustainable maize cultivation technologies.

The Effect of Peptide on the Growth and Yield of Maize (*Zea mays* L.)

II. RESEARCH METHODOLOGY

Field Experiment Design and Treatments

This study was conducted from October 2025 to February 2026. The field experiment was conducted in the Greenhouse of the Faculty of Agriculture, Udayana University. This study uses a one-factor randomized block design with three levels: P0 = no peptide application; P1 = peptide applied at 2 ml/L of water; and P2 = peptide applied at 4 ml/L of water. There were 3 treatments, each repeated three times.

Observation Variables

The variables observed included parameters of vegetative growth and yield, namely:

1. Plant height
2. Stem diameter
3. Number of leaves
4. Leaf area
5. Relative water content
6. Weight of the cob without husk
7. Diameter of the cob without husk
8. Fresh weight of plant biomass
9. Dry weight of plant biomass

Data Analysis

The observational data were analyzed using analysis of variance (ANOVA) at a 5% significance level to determine the effect of the treatments on the observed variables. If the analysis results indicated a significant effect, a post hoc test was conducted using the Least Significant Differences (LSD) test at the 5% significance level to determine differences among treatments. All statistical analyses were performed using appropriate statistical software.

III. RESULTS

The Effect of Peptide on Plant Height and Stem Diameter

Based on the data in Table 1, plant height ranged from 222.01 to 228.14 cm. Although the numerical treatment P2 (4 mL⁻¹ water) produced the tallest plants at 228.14 cm, this value was not significantly different from those of P0 (222.01 cm) and P1 (226.41 cm). Similarly, for stem diameter, all treatments showed no significant differences. Stem diameters ranged from 15.79 to 16.35 mm, with the highest value in treatment P0 (16.35 mm) and the lowest in treatment P2 (15.79 mm). Observations of plant height and stem diameter are presented in Table 1.

Table 1. Plant Height and Stem Diameter under Peptide Concentration Treatments

Treatment	Plant height (cm)	Stem Diameter (mm)
P ₀	222.01 a	16.35 a
P ₁	226.41 a	16.29 a
P ₂	228.14 a	15.79 a
LSD 5%	7.45	0.65
Note:	numbers followed by the same letter in the same column indicate no significant difference based on the 5% LSD test.	

The Effect of Peptide on Number of Leaves, Leaf Area, and Relative Water Content.

The results of the analysis in Table 2 show that the number of leaves across all treatments was relatively similar, ranging from 15.00 to 15.17 leaves. This indicates that the application of the peptide did not affect leaf formation in maize plants. Regarding leaf area, treatment P0 produced the highest leaf area of 401.05 cm², which was significantly different from P2 (341.74 cm²) but not significantly different from P1 (380.52 cm²). Treatment P1 was also not significantly different from P2. These results indicate that an increase in peptide concentration tends to reduce leaf area.

Conversely, relative leaf water content increased with peptide application compared to the control. Treatments P1 and P2 yielded relative water contents of 86.24% and 86.26%, respectively, which were significantly higher than that of P0 (84.66%), but not significantly different from each other. This indicates that peptide application helps maintain the water status of leaf tissue, even though it does not increase leaf number.

The Effect of Peptide on the Growth and Yield of Maize (*Zea mays* L.)

Table 2. Number of Leaves, Leaf Area, and Relative Water Content under Peptide Concentration Treatments

Treatment	Number of leaves	Leaf area (cm ²)	Relative water content
	(unit)		(%)
P ₀	15.00 a	401.05 a	84.66 b
P ₁	15.17 a	380.52 ab	86.24 a
P ₂	15.17 a	341.74 b	86.26 a
LSD 5%	0.68	56.85	0.22

Note: numbers followed by the same letter in the same column indicate no significant difference based on the 5% LSD test.

The Effect of Peptide on Weight of the Cob Without Husk and Diameter of the Cob Without Husk

The weight of the cobs without husks ranged from 15.90 to 27.23 g. Numerically, treatment P₁ produced the highest cob weight at 27.23 g, followed by P₂ at 20.71 g and P₀ at 15.90 g; however, there were no significant differences among the three treatments. The same pattern was observed for the diameter of the cobs without husks. Cobs ranged in diameter from 18.74 to 22.00 mm, with the highest value recorded in treatment P₁ at 22.00 mm, followed by P₂ at 21.19 mm and P₀ at 18.74 mm. Although there was a numerical trend toward increased peptide treatments, the increase was not statistically significant. Data on the weight of the cobs without husks and the diameter of the cobs without husks are presented in Table 3.

Table 3. Weight of the Cob Without Husk and Diameter of the Cob Without Husk under Peptide Concentration Treatments

Treatment	Weight of the cob without husk (g)	Diameter of the cob without husk (mm)
P ₀	15.90 a	18.74 a
P ₁	27.23 a	22.00 a
P ₂	20.71 a	21.19 a
LSD 5%	13.86	7.38

Note: numbers followed by the same letter in the same column indicate no significant difference based on the 5% LSD test.

The Effect of Peptide on Fresh Weight of Plant Biomass and Dry Weight of Plant Biomass

The fresh weight of the biomass ranged from 185.75 to 211.75 g. The highest value was observed in treatment P₀ at 211.75 g, while the lowest was in treatment P₂ at 185.75 g. Meanwhile, the dry weight of the biomass ranged from 94.26 to 102.27 g. Treatment P₀ produced the highest dry weight of biomass at 102.27 g, followed by P₁ at 101.08 g and P₂ at 94.26 g. These results indicate that the application of peptides at concentrations up to 4 mL L⁻¹ of water did not significantly affect maize biomass accumulation under either fresh or dried conditions. However, biomass weight tended to decrease with increasing peptide concentration; nevertheless, this difference was not statistically significant.

Table 4. Fresh Weight of Plant Biomass and Dry Weight of Plant Biomass under Peptide Concentration Treatments

Treatment	Fresh weight of plant biomass (g)	Dry weight of plant biomass (g)
P ₀	211.75 a	102.27 a
P ₁	192.75 a	101.08 a
P ₂	185.75 a	94.26 a
LSD 5%	73.68	10.12

Note: numbers followed by the same letter in the same column indicate no significant difference based on the 5% LSD test.

IV. DISCUSSION

The application of peptides at various concentrations resulted in different responses in terms of growth parameters and yield in maize plants. The absence of significant differences in plant height and stem diameter among the peptide treatments suggests that the applied peptides did not provide sufficient additional metabolic energy or sufficient nutrient availability to promote stem elongation, particularly given that greenhouse nutrient and water conditions were relatively adequate for all treatments. Peptides can improve nutrient uptake efficiency and stimulate plant metabolic activity (CH Biotech R&D Co., 2023), but the success of these

The Effect of Peptide on the Growth and Yield of Maize (*Zea mays* L.)

effects is highly dependent on the plants' initial nutrient status; in plants that are already growing optimally, additional peptides tend not to elicit a significant additional growth response. This is consistent with the findings of Sobiech et al. (2025), who reported that the increase in maize plant height resulting from the application of a new biostimulant was only significant under water-deficient conditions, whereas under optimal conditions the effect was not always consistent. Regarding stem diameter, it was observed that higher concentrations of the peptide led to a decrease in stem diameter, although this difference was not statistically significant based on the 5% LSD test.

The relatively uniform number of leaves across all treatments indicates that this variable is controlled more by the plant's genetic factors than by the application of biostimulants; thus, peptide application did not alter the pattern of maize leaf formation. In contrast, leaf area decreased significantly at the highest peptide concentration (P2) compared to the control. The decrease in leaf area at a peptide concentration of 4 mL L⁻¹ indicates that this concentration did not elicit an optimal growth response. This phenomenon is believed to be related to the hormetic response of biostimulants, a condition in which increasing the dose beyond the optimal range causes the effectiveness of growth stimulation to decline (Trejo-téllez et al., 2020). Thus, higher peptide concentrations do not always result in better growth responses in maize plants.

On the other hand, relative water content increased significantly in the P1 and P2 treatments compared to the control. These results reinforce the role of peptides as biostimulants that help maintain the water status of plant tissues. Roy et al. (2022) reported that peptides can increase the rate of nitrate uptake by 70–140% under nutrient-limited conditions, thereby supporting cellular metabolism, including osmotic adaptation. Furthermore, for the observed variables of weight and cob diameter (without husk), the highest values were observed in treatment P1 (2 mL/L), followed by P2, and the lowest in P0. This pattern is consistent with the findings of Ariani et al. (2025), who reported that applying peptides at a concentration of 2 mL/L increased rice yields compared to the control. The lack of significant differences in this study is likely due to greenhouse conditions that imposed relatively minimal environmental stress, thereby limiting the potential for increased yield components in response to the peptides.

The fresh weight and dry weight of plant biomass tended to decrease as peptide concentration increased, although the differences among treatments were not statistically significant. This trend is consistent with the decrease in leaf area at the highest concentration, which is closely related to reduced photosynthetic surface area and biomass accumulation. This decrease in biomass at high peptide doses may also be attributed to hormesis, whereby an excess dose of biostimulant in plants already under optimal nutrient conditions can slightly suppress growth efficiency. Furthermore, the increase in relative leaf water content in the P1 and P2 treatments indicates a reallocation of metabolic energy toward osmotic adaptation and tissue protection mechanisms, as described by Leporino et al. (2024) in tomato plants treated with protein hydrolysate, such that some of the energy that would ideally be used for vegetative growth is redirected to maintain cellular water status. Thus, the peptides in this study appear to function more as agents that maintain the plant's physiological status rather than as direct stimulators of biomass growth under non-stress conditions.

Overall, the results of this study indicate that the effectiveness of peptides as biostimulants is determined not only by the applied concentration but also by environmental conditions and the plants' physiological status. Under greenhouse conditions with relatively optimal water and nutrient availability, peptides were not yet able to significantly increase maize vegetative growth or yield components. However, the increase in relative leaf water content indicates that peptides still play a role in maintaining the plant's physiological status by preserving tissue water balance. These findings suggest that the potential of peptides as biostimulants is likely to be maximized when applied to plants under stress, such as drought or nutrient limitation; therefore, further research under field conditions and various levels of environmental stress is needed to optimize their use in sustainable maize cultivation.

V. CONCLUSION

This study showed that the application of peptides at concentrations of 2 mL L⁻¹ and 4 mL L⁻¹ of water had no significant effect on plant height, stem diameter, number of leaves, cob weight without husk, cob diameter without husk, fresh biomass weight, and dry biomass weight of maize plants. Peptide application had a significant effect on leaf area and relative leaf water content, where the 4 mL L⁻¹ treatment reduced leaf area, while the 2 mL L⁻¹ and 4 mL L⁻¹ treatments increased relative leaf water content compared to the control. Although not statistically significant, the 2 mL L⁻¹ treatment tended to yield higher values for yield components than the other treatments. Overall, the application of peptide under greenhouse conditions with optimal water and nutrient availability played a greater role in maintaining plant physiological conditions than in enhancing maize growth and yield.

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The Effect of Peptide on the Growth and Yield of Maize (*Zea mays* L.)

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