

Utilization of Red Onion Waste, Coconut Water, and Bean Sprouts as Natural Plant Growth Regulators on the Growth of Soybean (*Glycine max* (L.) Merr)

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ARTICLE INFO

Received: August 30, 2025

Accepted: September 30, 2025

Volume: 5

Issue: 3

KEYWORDS

Bean sprouts,
coconut water,
edamame, natural
PGRs, red onion

ABSTRACT

Edamame plants are one of the food crops that have long been cultivated by the Indonesian farmers for their dietary needs as a source of plant-based protein. The beneficial content of edamame in improving nutrition has led to an increase in demand for edamame both domestically and internationally (exports). The high export demand is not matched by edamame production. One of the efforts to increase edamame plant production is the application of natural plant growth regulators (PGRs). Plant Growth Regulators (PGRs) are organic compounds that are not plant nutrients, active at low concentrations, capable of stimulating, inhibiting, or altering plant growth and development. This research was conducted to determine the effect of types of natural PGRs on the growth and production of edamame. This research method uses a Complete Randomized Blok Design (CRBD) with one factor, which is the type of natural PGR with 4 levels consisting of no PGR (control), 10% red onion extract, 10% coconut water extract, and 10% bean sprout extract, and was repeated 6 times. The parameters observed in this study were plant height, number of leaves, root length, plant wet weight, number of pods and chlorophyll content. The results of the study ~~indicates~~ showed that the treatment of natural plant growth regulators has an effect on the vegetative growth parameters of edamame. The study concludes that the treatment of 10% onion extract gives the best effect on the growth of edamame.

1. Introduction

Edamame is one of the food crops that has been cultivated by the Indonesian people for a long time. Edamame is consumed as a source of plant-based protein (Pratama, 2019). Edamame is harvested while the pods are still green. Edamame is high in protein and contains flavonoid compounds such as isoflavones that can prevent LDL (low-density lipoprotein) oxidation, known as bad cholesterol, and lower bad cholesterol levels (Rahmah et al., 2023).

The beneficial content of edamame for body health has led to an increase in the demand for edamame both domestically and internationally (exports). Edamame is a potential crop that needs to be developed because it has high productivity, a relatively shorter lifespan, larger pod sizes, and a sweeter taste (Rahman et al., 2019). The high export demand is not proportional to the production of edamame (Zulfaniah et al., 2020). One of the export destinations for edamame is Japan. The export demand for edamame to Japan is considered high, amounting to 100,000 tons but, Indonesia has only met less than 5% of the market demand for edamame in Japan, while the rest is still supplied by China and Taiwan (Hakim, 2018).

Edamame production in Indonesia in 2018 was 982,598 tons, which only met 29% of the total national demand. Indonesia had to import 2.2 million tons of soybeans while the cultivation and production of edamame in Indonesia remain low (Febrianti, 2022). Edamame production needs to be improved to meet the large market demand. The application of plant growth regulators can be one solution to increase edamame plant production. Growth regulators are one of the most important factors in the successful growth of plants (Rahmah et al., 2023).

Plant Growth Regulators (PGRs) are organic compounds that are not plant nutrients but are active at low concentrations, capable of stimulating, inhibiting, or altering the growth and development of plants. PGRs play a very important role in the plant world (Ulfa et al., 2013). The commonly recognized groups of PGRs are Auxins, Gibberellins, Cytokinins, Absciscic Acid, and Ethylene. All of these hormones are produced in the plant body, although their concentrations vary depending on several factors, including the stage of growth or development, age, organ or part of the plant body, and environmental conditions. Natural Plant Growth Regulators (PGRs) can generally be found directly in nature and are made from organic materials (Pamungkas and Nopiyanto, 2020).

Natural Plant Growth Regulators (PGR) are generally found directly in nature and are made from organic materials (Pamungkas and Nopiyanto, 2020). There are several natural materials that can be used as PGR raw materials including shallots, coconut water, mung bean sprouts (tauge), bamboo shoots, young corn, tomatoes, young leaves of plants, and others (Ayda et al., 2023). The benefits of PGR include improving the root system, especially to accelerate root emergence in young plants. Additionally, it can enhance vegetative growth, accelerate uniform fruit ripening, prevent leaf, flower, and fruit drop, and expand the photosynthesis pathway (Wartono and Novianto, 2023).

2. Methodology

2.1 Time and place of research

This research was conducted from December 2024 to February 2025. Planting, treatment, watering and observations were carried out at Bitera village, Gianyar Regency, Bali, Indonesia. The chlorophyll content testing was conducted at the Integrated Research Laboratory of the Faculty of Mathematics and Natural Sciences, Udayana University.

2.2 Methods

This study applied an experimental method designed based on a one-factor Random Completely Block Design (RCBD). The treatment was application of natural plant growth regulator (PGR), consisting of four treatment, such as control (without added plant growth regulator (K0)), 10% shallot extract (K1), 10% young coconut water (K2), and 10% bean sprout extract (K3). Each treatment was repeated six times, resulting in a total of 24 experimental units.

2.2.1 Preparation of Natural Plant Growth Regulator (PGRs)

PGRs from red onion (w/v) were prepared using 1000 g of crushed red onion diluted in 2000 mL of aquades. PGRs from young coconut water (v/v) were prepared using 1000 mL of young coconut water mixed with 1000 mL of aquades. PGRs from bean sprouts (w/v) were prepared using 1000 g of crushed bean sprouts added with 2000 mL of aquades. All the treatment solution were kept in different bottles and incubated. The bottle containing PGRs was incubated for 4-7 days. Every 2 days, the bottle cap is opened to release gas formed during the fermentation process. After the gas is released, the bottle is closed again. After 7 days, the PGRs solution was filtered to separate the PGRs liquid from the remaining residue. The PGRs to be used was the extract from each treatment with a concentration of 10% each. Red onion extract 10% (v/v) was prepared by diluting 10 mL of red onion extract in 90 mL of distilled water. Coconut water extract 10% (v/v) was prepared by adding 10 mL of coconut water extract in 90 mL of distilled water. Bean sprout extract 10% (v/v) was prepared by adding 10 mL of bean sprout extract in 90 mL of distilled water (Emilda, 2020).

2.2.2 Planting and Maintaining Edamame Plants

Seed Preparation

Edamame seeds were prepared in advance, the seeds used were Ryoko variety edamame, then soaked in water for 12 hours to check seed viability. Additionally, this process helps to speed up the germination by softening the seed coat and activating growth enzymes (Ningsih et al., 2016).

Seed Propagation

The selected edamame seeds were germinated in trays size 54 x 28 x 4 cm. The medium used was fertile soil. Edamame seeds were planted in the medium at a depth of 1 - 2 cm. The seeds were kept for at least 5 days until had 3-5 leaves before transferred to polybags (Ningsih et al., 2016).

Planting

Seedlings with 3-5 leaves were transferred to polybags sized 30 x 30 cm. The media used was fertile soil mixed with compost and fermented rice husk with ratio of 3:2:1 (Ningsih et al., 2016).

Watering

Seedlings were watered with 100 mL of water once a day in the morning or in the evening

Treatment

The treatment of different types of PGRs was conducted in 4 experimental units, repeated six times. The treatments were K0 as control or without treatment of natural PGRs, K1 for treatment with red onion extract on edamame with a 10% concentration watering, K2 for treatment with coconut water at a 10% concentration watering, and K3 for treatment with bean sprout extract on edamame with a 10% concentration watering. The watering treatments for each type of natural PGRs were carried out each week.

Weeding

Weeding was carried out if weeds were found around edamame plants. Weeding was done manually by pulling out the weeds around the edamame plants in polybags. The purpose of weeding was to reduce competition between the weeds and the soybean plants in absorbing water, nutrients, and light (Ningsih et al., 2016).

Harvesting

Edamame was harvested after 65-68 days after planting when the pods were still soft and green (Ningsih et al., 2016).

2.2.3 Measurement of plant parameters

Plant height

Plant height was measured every 14 days. Height measurements were taken when the plants were 14, 28, 42 and 56 days after planting (DAP). Plant height was measured from the base of the stem to the tip of the plant's growth point using a measuring tape (Rohmah and Saputro, 2016).

Number of leaves

The number of leaves was counted every 14 days. The measurement of the number of leaves of the plants was counted at 14, 28, 42, and 56 DAP. The counting of the number of leaves of the plants is done manually (Rohmah and Saputro, 2016).

Length of the root

Root length was measured at harvest time (65 DAP). The harvested edamame plants were cleaned and root was measured using a ruler. The root length measurement was taken by measuring from the base of the main root to the tip of the root (Rohmah and Saputro, 2016).

Plant weight

Weight of fresh plant after harvested were at 65 DAP using a digital scale. The harvested plants were washed, drained and weighed (Rohmah and Saputro, 2016).

Number of pods

The number of edamame pods was counted when the edamame at 65-68 DAP manually (Rohmah and Saputro, 2016).

Chlorophyll content

The chlorophyll content that will be analyzed is total chlorophyll. The total chlorophyll content of soybeans was measured by a UV-Vis spectrophotometer.

2.3 Data analysis

The data obtained from the research was analyzed using quantitative data analysis techniques employing ANOVA with SPSS software. This quantitative data includes variables such as: plant height, number of leaves, root length, wet weight, dry weight, and chlorophyll content. If significant differences are found at the 5% test level ($P \leq 0.05$), data analysis will continue with the Duncan test (Duncan Multiple Range Test) to determine the differences between treatments.

3. Result and Discussion

3.1 Result

Plant Height

The results of the analysis show that the treatment of natural plant growth regulators from red onion waste, coconut water, and bean sprouts on edamame plants had a significant effect on the average plant height at observations of 14, 28, 42, and 56 days after planting (DAP), as shown in the following table.

Table 1. The effect of natural PGR treatment on the average height of edamame plants (cm)

Treatment PGRs	Plant Height (cm)			
	14 DAP	28 DAP	42 DAP	56 DAP
K0	20.50 ± 0.54 ^c	23.53 ± 0.58 ^c	25.50 ± 0.48 ^c	26.83 ± 1.16 ^d
K1	37.43 ± 0.54 ^a	51.46 ± 0.57 ^a	58.25 ± 0.48 ^a	63.46 ± 0.53 ^a
K2	29.03 ± 2.65 ^b	36.86 ± 2.47 ^b	43.33 ± 2.06 ^b	46.33 ± 2.06 ^b
K3	26.03 ± 1.11 ^b	31.83 ± 1.60 ^b	37.83 ± 1.60 ^b	39.66 ± 1.36 ^c

Note: Values followed by different letter notations in the same column indicate significantly different average values based on the Duncan Multiple Range Test at a 5% level after conducting analysis of variance or ANOVA; DAP = Days After Planting; K0 = control treatment (without the addition of plant growth regulators); K1 = treatment with 10% red onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Table 1 shows that at the ages of 14, 28, 42, and 56 days after planting (DAP), the highest plant was found in treatment K1 (10% red onion waste plant growth regulator), while the lowest plant height was in treatment K0 (without the application of plant growth regulator). The height of the edamame plants at 56 DAP is presented in Figure 1.

Number of Leaves

The results of the analysis show that the treatment of natural plant growth regulators from red onion waste, coconut water, and bean sprouts on edamame plants did not have a significant effect on the average number of leaves of the edamame plants at each observation of 14, 28, 42, and 56 DAP, as shown in the table below.

Table 2. The effect of natural PGR treatment on the average number of leaves

Treatment PGRs	Number of Leaves (sheets)			
	14 DAP	28 DAP	42 DAP	56 DAP
K0	9.42 ± 1.22 ^{ab}	19.71 ± 1.22 ^b	25.14 ± 1.03 ^b	25.14 ± 1.03 ^b
K1	14.57 ± 1.22 ^a	30.85 ± 1.54 ^a	36.57 ± 2.16 ^a	36.57 ± 2.16 ^a
K2	14.57 ± 1.22 ^a	24.85 ± 1.22 ^{ab}	30.85 ± 2.44 ^{ab}	30.85 ± 2.44 ^{ab}
K3	9.42 ± 1.22 ^{ab}	24.85 ± 1.22 ^{ab}	30.85 ± 1.54 ^{ab}	30.85 ± 1.54 ^{ab}

Note: Values followed by different letter notations in the same column indicate significantly different average values based on the Duncan Multiple Range Test at a 5% level after conducting analysis of variance or ANOVA; K0 = control treatment (without the addition of plant growth regulators); K1 = treatment with 10% red onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Table 2 shows that the number of leaves at ages 14, 28, 42, and 56 days after planting was highest in treatment K1 (10% shallot waste plant growth regulator), while the number of leaves of the edamame plants was lowest in treatment K0 (without giving plant growth regulator). The number of leaves produced by the edamame

plants at 56 DAP was presented in Figure 1.



Figure 1: The growth of edamame plants aged 56 days after planting (DAP), K0 = control treatment (no application of plant growth regulators); K1 = treatment with 10% onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Length of the Root

The treatment of natural plant growth regulators of type ZPT on edamame plants had a significant effect based on the analysis of variance on the average root length at harvest, as shown in the following table..

Table 3. The effect of natural PGR treatments on the average root length of edamame (cm)

Treatment PGRs	Root Length (cm)
K0	2.10 ± 0.12 ^b
K1	11.35 ± 0.13 ^a
K2	6.16 ± 0.08 ^{ab}
K3	5.38 ± 0.07 ^b

Note: Values followed by different letter notations in the same column indicate significantly different average values based on the Duncan Multiple Range Test at the 5% level after performing an analysis of variance or ANOVA; DAP = Days After Planting; K0 = control treatment (without giving plant growth regulators); K1 = treatment with 10% onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Table 3 shows the longest root length of edamame plants was found in the K1 treatment (10% red onion waste plant growth regulator), while the shortest root length was found in the K0 treatment (without the application of plant growth regulators).

Fresh Plant Weight

The treatment of natural plant growth regulators of type PGR on edamame plants had a significant effect based on the variance analysis of the average wet weight at harvest, as shown in the following table.

Table 4. The influence of natural PGR on the average wet weight of edamame plants (g)

Treatment PGRs	Wet Weight (g)
K0	11.50 ± 0.54 ^b
K1	23.66 ± 0.51 ^a

K2	18.50 ± 0.54 ^{ab}
K3	14.66 ± 0.51 ^b

Note: Values followed by different letter notations in the same column indicate significantly different average values based on the Duncan Multiple Range Test at the 5% level after performing an analysis of variance or ANOVA; DAP = Days After Planting; K0 = control treatment (without giving plant growth regulators); K1 = treatment with 10% onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Table 4 shows the highest fresh weight of edamame plants was shown in treatment K1 (10% onion waste plant growth regulator), while the lowest fresh weight was in treatment K0 (without the addition of plant growth regulator).

Number of pods

The treatment of natural plant growth regulators on edamame plants had no significant effect based on the analysis of variance on the average number of pods at harvest, as shown in the following table.

Table 5. The influence of natural ZPT on the average number of pods	
Treatment PGRs	Number of pods
K0	2.87 ± 0.51 ^a
K1	7.71 ± 0.54 ^a
K2	6.28 ± 0.51 ^a
K3	4.57 ± 0.51 ^a

Note: Values followed by different letter notations in the same column indicate significantly different average values based on the Duncan Multiple Range Test at the 5% level after performing an analysis of variance or ANOVA; DAP = Days After Planting; K0 = control treatment (without giving plant growth regulators); K1 = treatment with 10% onion waste plant growth regulators; K2 = treatment with 10% coconut water plant growth regulators; K3 = treatment with 10% bean sprout plant growth regulators.

Table 5 shows the treatment of natural plant growth regulators (PGR) on the number of edamame pods showed no significant effect, with no obvious differences observed in all treatments K0 (without giving PGR), K1 (10% onion waste PGR), K2 (10% coconut water PGR), and K3 (10% bean sprout PGR).

Chlorophyll Content

The effect of giving different concentrations of natural plant growth regulators on the parameters of chlorophyll a, chlorophyll b, and total chlorophyll content in edamame plants, as shown in the following table.

Table 6. The effect of natural PGR treatment on the chlorophyll content of edamame (ppm)			
Treatment PGRs	Chlorophyll a (ppm)	Chlorophyll b (ppm)	Total Chlorophyll (ppm)
K0	6,299	2,310	8,607
K1	7,488	2,752	10,238
K2	8,753	3,099	11,849
K3	11,308	4,059	15,364

Note: K0 = control treatment (without the application of plant growth regulators); K1 = treatment with

the application of 10% onion waste plant growth regulator; K2 = treatment with the application of 10% coconut water plant growth regulator; K3 = treatment with the application of 10% bean sprout plant growth regulator.

Table 6 shows that the highest total chlorophyll content was produced by edamame plants treated with K3 (10% sprout growth regulator), while the lowest total chlorophyll content was found in edamame plants treated with K0 (without giving growth regulator).

NPK Levels in the Soil

The results of the soil test can be seen in the table below.

Table 7. Results of laboratory tests on the planting media		
Parameter	Rate	Explanation
pH	7,34	Neutral
Total Nitrogen	0,520%	High
Available Phosphorus	452,054 ppm	Very High
Available Potassium	581,425 ppm	Very High

3.2 Discussion

Research on growing media with a comparison of fertile soil: compost: rice husk in a ratio of 3:2:1 shows that this composition can enhance plant growth and yield. It is suspected that the growing media used provides a balance between nutrients from the soil and compost, as well as drainage and aeration from the rice husk. The research by Sjamsijah and Pristiawati (2024) indicates that the effect of compost fertilizer containing macronutrients such as N, P, and K as well as micronutrients can provide an optimal supply of nutrients for plant growth and production, further enhanced by the addition of natural hormones that stimulate cell growth in plant tissue.

Based on the research results on the height of edamame plants presented in Table 1 at the ages of 14, 28, 42, and 56 DAP, it is known that the treatment K1 (application of plant growth regulators from 10% red onion extract) showed more optimal growth compared to the treatment K0 (without the application of plant growth regulators or control). Red onions are known to contain plant hormones such as auxins and gibberellins that play a role in accelerating the growth process (Yunindanova et al., 2018). The natural hormone content in red onion extract can support optimal plant growth enhancement (Abdullah et al., 2019; Setyawati et al., 2022).

According to Dongoran and Sularno (2019), coconut water is a by-product of coconut products that has the potential as a source of natural growth hormones. The hormone content works to stimulate cell division and supports overall plant growth. Coconut water is also known as a plant product that can enhance fertility and the growth rate of plants (Sari et al., 2024). This research aligns with Setyawati et al. (2020), which states that mature coconut water has a positive effect on plant growth. The growth hormone content in coconut water can significantly increase plant growth, with an increase range of between 20% to 70% (Banna et al., 2023).

Bean sprout extract also shows an increase in height in edamame plants. This is in line with the research by Fidela and Yulianah (2024) that the effect of bean sprout extract on plant height may be due to the auxin content found in bean sprout extract. Research by Taiz and Zeiger (2012) also states that auxin hormones work by stimulating certain types of proteins in the plant plasma membrane to pump H⁺ ions into the cell wall and initiate cell elongation. This is also explained by Rusmin et al.

(2016) that the mechanism of auxin hormone action in plants is to influence cell elongation.

Based on the observation results of the number of leaves (Table 2) at 14, 28, 42 and 56 DAP, the treatment K1 (10% shallot plant growth regulator) showed the highest number of leaves. The increase in the number of leaves in the 10% shallot extract treatment showed significant results, supported by previous research which stated that 10% shallot extract showed a higher average number of leaves compared to other treatment factors. This is due to the auxin content in the 10% shallot extract which can stimulate cells, in this case, leaf formation cells (Pamungkas and Puspitasari, 2019).

The application of coconut water and soybean sprouts extract also affects the growth of the number of leaves in edamame plants. Coconut water can influence plant growth when given in optimal doses (Mergiana et al., 2021). In addition to coconut water, several plant growth regulator hormones such as auxin, gibberellin, and cytokinin are also found in soybean sprouts extract, which positively affects the increase in the number of leaves (Jariah et al., 2022). Growing cells will divide and develop into buds, branches, and also leaves, with the increase in the number of leaves influenced by the height of the plant, where the taller the plant, the more leaves will grow (Banna et al., 2023).

Based on the results of the root length analysis (Table 3), the edamame plants at 65 DAP indicate that the application of natural PGRs can influence root growth. Shallot extract contains auxins that can stimulate or accelerate the emergence of roots (Kurniawati et al., 2020). Auxins in the plant body move in a polar direction downwards, stimulating root formation. The right concentration of auxins in the cells can enhance the diffusion of water and nutrients into the cells, and as the concentration of auxins in the plant increases, it will activate root formation (Setiawan et al., 2015).

Based on the observation of the wet weight of the plants (Table 4) at 65 DAP, the application of onion extract increases the wet weight of edamame plants. Red onion skin contains growth regulators that function like Indole Acetic Acid (IAA), which can trigger cell division, enlargement, and elongation. According to Sarido and Junia (2017), an increase in the number of leaves will automatically increase the fresh weight of the plants, as leaves act as sinks for the plants. Additionally, the leaves of vegetable plants are the organs that contain a lot of water, so with an increasing number of leaves, the water content in the plants will be high, resulting in a higher fresh weight of the plants as well (Manurung et al., 2021).

Based on the results obtained in (Table 5) the average number of pods of edamame plants at 65 DAP showed no significant difference among all treatments. The application of natural PGRs or organic hormones on plants does not fully enhance productivity and quality, as plant growth regulators generally only stimulate hormone formation in plants (Delima et al., 2020). Furthermore, the application of natural plant growth regulators also did not show a significant effect on the number of pods, possibly due to the ineffectiveness of the natural PGRs used due to unsuitable content, since the function of growth regulators as precursors involves compounds that can precede the rate of other compounds in metabolic processes and is part of plant genetic processes. Internal and external factors can also cause the number of fruits on edamame plants to not show a significant effect (Tanjogonegoro, 2015).

Based on the observations of chlorophyll content (Table 6), the treatment K3 (10% sprout extract) shows the highest total chlorophyll among all treatments. Sprout extract contains growth-regulating hormones that can influence total chlorophyll. The extract contains the growth-regulating substances gibberellins and cytokinins. Gibberellin and cytokinin hormones work synergistically in photosynthetic activity; gibberellin stimulates plant cell development (enlarging and elongating cell size), while cytokinin accelerates the development of chloroplasts, which are plastids that contain

chlorophyll and are essential for the photosynthesis process. This leads to an increase in photosynthetic activity and can enhance the rate of young leaf formation (Dewi and Miftakhurrohmat, 2022).

4. Conclusion

The treatment of natural PGRs type without additional fertilization affects parameters such as plant height, number of leaves, root length, wet weight, and chlorophyll content, while it does not affect the number of pods. The treatment with red onion extract can provide the best effect on the vegetative growth of edamame plants.

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