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Comparison of the Use of Plant Growth Regulators (PGR) of Red Onion and Shallot Extracts on the Growth of Green Spinach Plants (*Amaranthus* sp.)

Yuni Fransiska*, Mirwa Adiprahara Anggarani

Chemistry Study Program, Faculty of Mathematics and Natural Science, Surabaya State University, Surabaya, Indonesia
*E-mail: yunifransiska56@gmail.com

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Abstract: Green spinach is one type of vegetable commodity that the people of Indonesia most widely consume because it has a relatively high nutritional content such as iron, vitamin C, protein, and carbohydrates. However, currently, there is a decrease in green spinach vegetable productivity in Indonesia due to several things, including cultivation techniques that could be more optimal, low seed quality, and limited application of agricultural technology. For this reason, agrarian intensification is needed by using natural plant growth regulators (PGR) to increase the growth of green spinach. Red onions and shallots are part of the allium genus, which has growth phytohormones, namely auxin and gibberellins, which have the potential to be natural PGR. This study aims to compare the use of red onion and shallot extracts in increasing the growth of green spinach plants. The research design used was a randomised group design (RGD) with variations in extract concentrations (0%, 15%, 30%, 45%). Parameters of observation of green spinach plant growth are plant height, number of leaves, leaf circumference, and wet biomass of harvested plants. The application of red onion and shallot extracts was carried out on green spinach plants aged seven days after planting (DAP) with a time interval of 1 week until 28 DAP. Observation of green spinach plant growth parameters began at the age of 14-35 DAP. Statistical analysis of the data using analysis of variance (ANOVA) and then the Duncan Multiple Range Test (DMRT) further t-test a 5% significance level. The results showed that red onion and shallot extracts affected all observed growth parameters of green spinach plants. Shallot extract with a concentration of 45% gave the best results on all green spinach plant growth parameters.

Keywords: Green Spinach Plant; Plant Growth; Plant Growth Regulators (PGR); Red Onion Extract; Shallot Extract.

Introduction

Vegetables as horticultural crops are essential food sources containing vitamins, minerals, and fibre [1]. Green spinach (Amaranthus sp.) is a type of vegetable commodity with commercial value, helps meet the body's nutritional needs, and is widely consumed by the Indonesian people [2]. Kementerian Kesehatan Republik Indonesia (2017) states that green spinach contains dietary sources such as vitamin C, an antioxidant that maintains endurance [3].

The iron content of fresh green spinach is around 8.3 mg/100g, which includes essential microelements for the body [4]. Hemoglobin (Hb) synthesis is a blood formation process requiring iron. Haemoglobin is oxygen that transports erythrocytes throughout the body and prevents anaemia. In addition to iron, green spinach contains protein, fat, carbohydrates, potassium, a marathon, rutin, purine, and vitamins A and B [5].

Spinach is a vegetable often consumed by Indonesians, with a daily consumption rate of 9.26 grams per capita [6]. From 2021 to 2022, there was a percentage increase in the consumption level of spinach vegetables by 6.14% [7]. However, based on data from the Direktorat Jenderal Holtikultura (2022), Indonesia experienced a decrease in spinach growth productivity in Indonesia by 0.52% [8]. One of the efforts to overcome this is for Indonesia to import spinach vegetables to meet the community's increasing consumption. Imports of spinach vegetables in Indonesia from 2019 to 2021 have increased, based on data from the Kementerian Pertanian Republik Indonesia (2022). In 2021, the total import of spinach was 0.07 tons, while in 2020, it was 0.02 tons [7].

The decline in productivity of green spinach vegetables in Indonesia is due to several factors, including cultivation techniques that could be more optimal, low seed quality, and limited application of technology [5][9]. Plant growth is influenced by the plant media used. Plants need nutrients and water for the growth process obtained from the planting media. In addition, to increase the quantity and quality of green spinach vegetables, it is necessary to add organic matter as a growth supplement. One of the innovations in green spinach cultivation is the addition of natural plant growth regulators (PGR).

PGR has been widely used because it is readily available, but on the other hand, it is relatively expensive and can hurt the environment [10]. Some biological materials, including the allium genus, are known to have the potential to be used for natural PGR because they are easy to obtain and more economical. Red onions and shallots are a group of the allium genus that function as a natural PGR. The growth process of shallots and red onions is relatively fast due to the content of endogenous PGR. Based on research by Kurniati et al. (2019), in allium bulbs, there is an auxin content in the form of indole acetic acid of 156.01 ppm, cytokinin in the form of zeatin and kinetin of 122.34 ppm and 140.11 ppm and gibberellin content of 230.67 ppm [11].

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As a growth hormone, Gibberellin functions in cell expansion, while auxin functions in cell division [12]. The relationship between the two hormones can affect the increase in plant cell size. PGR-containing auxin and gibberellin hormones are absorbed by plant cells so that they can stimulate the H^+ ion pump process to the plant cell wall. This process can make the enzyme pectin methylase active, which breaks the pectin bond with Ca2+ ions, so there will be flexing and elongation in the cell wall. After that, the cell will stretch due to the process of water entry into the cell, which affects the secondary growth of plants, including increasing the number and size of cells [13]. Based on the description above, using red onion and shallot extracts as natural PGR is expected to boost the growth and development of quality green spinach plants. This study aims to determine the effects of using PGR red onion extract and shallot extract on the cultivation of green spinach plants. The observed effects include plant height, number of leaves, leaf circumference, and plant wet biomass.

Research Methods

This research was conducted from January to May 2024 at the Biochemistry Laboratory, Chemistry Department, Faculty of Mathematics and Natural Sciences, Surabaya State University and Tulungagung Regency, East Jawa.

The materials used in the study were green spinach seeds obtained from agricultural stores in Tulungagung Regency, red onion and shallots from the traditional market of Tulungagung Regency, 96% ethanol, soil, husk charcoal, manure, sterile distilled water, red onion extract, shallot extract, 1% FeCl, HNO_3, 40% NaOH, CH_3COOH, H_2SO_4.

The tools used included digital scales, knives, cutting boards, ovens (Kirin), blenders (Sharp), 100 mesh sieves, sealed containers, vacuum filtration kits, test tubes, polybags, moisture balance (FD-610), Erlenmeyer (pyrex), measuring cups (Herma), rulers, analytical balance (Denver S1-234), digital balance. This study used a Randomized Group Design (RGD) with two factors: the concentration of shallots extract and the concentration of red onion extract consisting of 4 levels, namely 0% (control), 15%, 30%, and 45%, with six replications.

The research procedure for the growth of green spinach plants by giving natural PGR of red onion and shallot extracts as follows:

Preparation of Red Onion and Shallot Extract

Red onion and shallot of 10 kg each were cleaned, peeled, and then cut to a thickness of ±1 mm. Furthermore, the red onion and shallots pieces were dried indirectly in the sun for 5-7 days in the presence of protection to avoid contamination by foreign objects such as dirt from the wind. After drying, red onions and shallots were pulverised and sieved using a 100-mesh sieve to produce fine powder. The powder was then stored in airtight jars. Furthermore, the red onion and shallot powder were extracted using a maceration method of 96% ethanol polar solvent. Powder red onion of 700 g and shallot of 1000 g were soaked for 3×24 hours in ethanol solvent with a ratio of 1:5 and then filtered using a vacuum pump to obtain the residue and filtrate. The filtrate resulting from the extraction was evaporated with a vacuum rotary evaporator until a thick extract was obtained. After that, extract concentrations of 0%, 15%, 30%, and 45% were made from thick extracts of red onions and shallots using distilled water solvent.

Measurement of Moisture Content and Yield

Measure the water content of red onion and shallot extracts using a moisture balance device (FD-610). Calculate the extract yield by comparing the final weight (thick extract) with the initial weight (red onion and shallot powder) multiplied by 100%.

Chemical Compound Content Test of Extract

Phenolic Test

The phenolic test was conducted by preparing a sample of red onion and shallot extracts of 1 mL each and then putting it into a test tube. Ten drops of FeCl 1% were added to each test tube. If a concentrated green colour is formed, it indicates the presence of phenolic compounds [14].

Tryptophan Test

In the tryptophan test, samples of red onion and shallot extracts, as much as 2 mL each, were put into test tubes. Then, concentrated HNO3, as much as 1 mL, was added to each test tube and heated for 1 minute in a water bath. After that, it was cooled, and 40% NaOH was added to the test tube. The extract is positive for tryptophan if a yellow ring or clot is formed [15].

Terpenoid Test

Samples of red onion and shallot extracts were put into a 2 mL test tube each and added with 2 mL chloroform. Then, ten drops of anhydrous CH3COOH and three drops of concentrated H2SO4 were added. If the colour changes to red, it indicates the presence of terpenoid compounds in the sample [16].

Green Spinach Planting

After the preparation of the PGR concentration is complete, preparations for planting are made. Green spinach seeds are prepared by sowing until they are 14 days old. Green spinach planting media is made from a mixture of husk charcoal, manure, and soil (1:1:2) put into a 20x20 cm polybag. Green spinach seedlings with 3-4 leaf blades are transplanted to the planting media 14 days after sowing.

PGR Application

The application of PGR of red onion and shallot extracts with a concentration variation of 0%, 15%, 30%, and 45% was carried out by water as much as 5 mL with an interval of 1 week from the age of 7 DAP to the age of 28 DAP. In addition, the maintenance of green spinach plants was also carried out by controlling pests and diseases and watering every day. Green spinach plants were watered with 250 mL of water in the morning.

Observation of Green Spinach Growth

Green spinach plant growth was observed at 14-35 DAP after applying PGR of red onion and shallot extracts. Growth observation parameters included the number of leaves, plant height, leaf circumference, and plant wet biomass. Plant height, number of leaves, and leaf circumference were measured at one-week intervals until harvest using a ruler measuring instrument. Plant wet biomass was weighed at harvest age or 35 DAP using a digital scale measuring instrument.

Results and Discussion

This study aims to determine the effects of red onion and shallot extract as natural plant growth regulators (PGR) on the growth of green spinach plants. The results showed an increase in the growth of green spinach plants, namely plant height, number of leaves, leaf circumference, and plant wet biomass. Treating red onion and shallot PGR application on green spinach plants significantly affects all observation times. The effect of PGR can be seen in green spinach plants at all observation times. Red onion and shallot extracts contain phytohormones that can stimulate the energy of food reserves and increase the process of cell division, elongation, and differentiation, which will affect the growth process of green spinach plants.

Parameters that can be used to determine the quality of a viscous extract include water content and yield. Determination of the water content of red onion and shallot extracts using moisture balance produced a water content of 17.8% and a shallot extract of 22.7%. Calculate the yield of red onion and shallot extracts by comparing the weight of the thick extract with the weight of the powder before extraction and multiplying by 100%. The red onion and shallot extracts yield was 52.63% and 48.22%, respectively. The quality requirement for the water content of thick extracts is 5-30%, and the yield is said to be good if it has a value of more than 10% [17]. Moisture content can determine the purity of an extract because the higher the moisture content of the extract is easily damaged and quickly decays due to microbial growth in the extract [18]. According to Pratiwi (2019), the higher the percentage of yield produced, the greater the value of the extract [19].

Chemical compound content testing was conducted to determine the bioactive compounds' content in red onion and shallot extracts. The chemical compound content tests were phenolic, tryptophan, and terpenoid. The test uses several methods, including reagents, to detect the class of compounds to be tested. The results of the chemical compound content test of thick extracts of red onion and shallots can be seen in Table 1.

Table 1 shows that red onion and shallot extracts contain phenolic compounds, tryptophan, and terpenoids. Phenolic test results on red onion and shallot extracts showed positive results marked by a change in colour from solid brown to solid black. The test results are from the research of Hidayah and Anggarani (2022), which states that red onions contain a phenolic compound of 2.381 mgGAE/g [20]. According to Puspita's study (2022), shallots contain phenolic compounds of 3.45 mgGAE/g [21]. The content of phenolic compounds in the allium genus can act as antioxidants [22].

Table 1. Chemical Compound Content Test Results of Red Onion and Shallot Extracts.

Chemical Compound	Identification Result		Description
	Red Onion	Shallot	
Phenolic	+	+	Forms a deep black color
Tryptophan	+	+	Formed yellow ring and yellow mixture
Terpenoid	+	+	Forms red color

The tryptophan test results on red onion and shallot extracts showed positive results, indicated by a yellow ring in the red onion extract and yellow discolouration in the shallot extract. The tryptophan test had positive results, and we identified auxin compounds in red onion and shallot extracts. This is because indole-3-acetic acid (IAA) auxin is mainly synthesised from L-tryptophan through indol-3-pyruvate (IPA) [23]. IAA auxin is highly dependent on the amino acid component tryptophan as the precursor of IAA synthesis [24]. The chemical structure of the auxin hormone indole-3-acetic acid (IAA) can be seen in Figure 1.

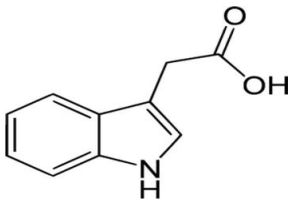

Figure 1. Indole-3-Acetic Acid (IAA). [25]

Positive results of the terpenoid test identify the presence of gibberellin compounds in red onion and shallot extracts because gibberellin is included in the terpenoid group of chemical compounds formed from isoprene units with five carbon atoms [26]. Terpenoids are the most widely found secondary metabolites in almost all plants. According to Yang et al. (2020), some terpenoid compounds play an essential role in plant growth and development, such as gibberellins, which are plant hormones that regulate plant development [27]. The chemical structure of the gibberellin hormone can be seen in Figure 2.

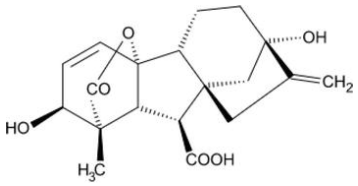

Figure 2. Gibberellin. [25]

The hormone auxin in PGR affects the process of cell division, elongation, and differentiation, as well as the formation of xylem and phloem networks. Hence, it affects the growth process of plant stems and roots. In addition, the content of the hormone gibberellin in PGR also plays a role in stem elongation and leaf growth [13]. The results of the

PGR application of red onion and shallot extracts on plant height parameters can be seen in Table 2.

Table 2 shows that the PGR treatment of red onions and shallots affects green spinach plant height parameters. There is an increase in plant height at each increase in the concentration of PGR used. Red onion and shallot extracts with a concentration of 45% gave the best results and were significantly different compared to the concentrations of 30% and 15%. The increase in plant height with the application of 45% shallot extract produced the best plant height growth compared to red onion extract at the same concentration. The plant height value produced by applying red onion and shallot extract is 45.4 cm and 46.5 cm, respectively. The use of 45% concentration is the most effective concentration used in green spinach plants, which causes the physiological process of green spinach plants to take place properly and can support the growth process of green spinach plants.

Table 2. Average Plant Height (cm) of Green Spinach Resulting from Red Onion and Shallot Extract PGR Application.

PGR Concentration		Time Observation			
		14 DAP	21 DAP	28 DAP	35 DAP
	0%	9 ± 0.83^{a}	12.1 ± 1.10^{a}	17.9 ± 0.58^{a}	27.5 ± 0.52^{a}
Red Onion	T1 (15%)	12.3 ± 1.44^{b}	15.1 ± 0.83^{b}	23.8 ± 0.87^{b}	37.2 ± 0.94^{b}
	T2 (30%)	13.3 ± 1.50^{b}	18.3 ± 1.08^{c}	26.3 ± 0.98^{c}	42.1 ± 0.86^{c}
	T3 (45%)	14.8 ± 0.93^{de}	19.2 ± 1.21^{c}	31.3 ± 0.87^{e}	45.4 ± 1.20^{e}
Shallot	P1 (15%)	12.9 ± 0.40^{bc}	15.8 ± 0.80^{b}	24.3 ± 1.03^{b}	37.9 ± 0.58^{b}
	P2 (30%)	13.9 ± 0.33^{cd}	18.7 ± 1.84^{c}	28.0 ± 1.22^{d}	43.6 ± 0.87^{d}
	P3 (45%)	15.3 ± 0.90^{e}	19.8 ± 1.91^{c}	32.7 ± 0.93^{f}	46.5 ± 0.72^{f}

Description: Values followed by the same letter indicate no significant difference (α=5%) in the DMRT test

Plant height is a growth parameter that determines the growth response of green spinach plants to natural PGR extracts of red onion and shallots at different concentrations. Natural PGR can trigger tissue growth, especially in the growing area, so plant growth increases according to the dose. Red onions and shallots contain auxin and gibberellin hormones that support plant growth.

Indole acetic acid (IAA) initiates cell elongation and cell division by affecting cell wall flexibility and stimulating plant height growth. The gibberellin hormone in red onions and shallots functions to encourage the formation of amylase enzymes that hydrolyse starch. This can increase cell osmosis pressure and sugar content so that water will enter the cell, resulting in cell elongation and increased plant length [28].

Table 3. Average Number of Leaves of Green Spinach Resulting from the Application of Red Onion and Shallot Extract PGR.

PGR Concentration		Time Observation			
		14 DAP	21 DAP	28 DAP	35 DAP
	0%	4.83 ± 0.75^{a}	5.83 ± 0.75^{a}	7.67 ± 0.81^{a}	10.0 ± 0.63^{a}
Red Onion	T1 (15%)	5.83 ± 0.75^{b}	7.33 ± 1.21^{b}	10.0 ± 0.89^{b}	13.0 ± 1.26^{b}
	T2 (30%)	6.00 ± 0.63^{b}	7.50 ± 1.05^{b}	10.3 ± 1.21^{b}	13.5 ± 1.38^{bc}
	T3 (45%)	6.33 ± 0.81^{b}	8.00 ± 0.63^{b}	11.0 ± 1.26^{b}	14.5 ± 1.64^{be}
Shallot	P1 (15%)	5.83 ± 0.75^{b}	7.50 ± 1.05^{b}	10.3 ± 1.21^{b}	13.17 ± 0.75^{b}
	P2 (30%)	6.17 ± 0.75^{b}	7.83 ± 0.75^{b}	10.67 ± 1.03^{b}	13.67 ± 1.21^{bc}
	P3 (45%)	5.83 ± 0.75^{b}	8.17 ± 0.75^{b}	11.33 ± 0.81^{b}	15.00 ± 1.26^{c}

Description: Values followed by the same letter indicate no significant difference (α=5%) in the DMRT test

The measurement of leaf count is conducted on fully bloomed green spinach plants, as it is considered one of the most crucial growth parameters. According to Table 3, the number of leaves in green spinach plants increased in each PGR concentration treatment of red onion and shallot extract from 14-35 DAP. It was observed that there was no significant difference in the treatment of PGR concentration at the age of 14-28 DAP. In contrast, at the age of 35 DAP, significantly different results were obtained for the 45% shallot extract concentration on the number of green spinach leaves. The highest average number of leaves, 15.00, was obtained from applying shallot PGR at a 45% concentration. Similarly, the use of red onion extract also produced the best average number of leaves at a 45% concentration, with an average of 14.5.

Leaves are crucial in photosynthesis, generating energy and food for optimal plant growth. Therefore, supplementing natural PGR is essential to support leaf growth despite endogenous PGR in plants [29]. The auxin and gibberellin hormones in red onions and shallots can stimulate young plant roots, improve the root system, inhibit leaf, flower, and fruit fall processes, and expedite leaf and maturation growth [30]. Consequently, the application of exogenous PGR to plants has a significant impact on leaf development.

The circumference of green spinach leaves is measured by placing a thread on the side of the leaf and then measuring it with a ruler. Table 4 shows that applying PGR treatment using red onion and shallot extracts can increase the circumference of green spinach plant leaves from the early growth stage until the harvest period. The results of the PGR treatment varied significantly with each concentration. The treatment using a 45% concentration of shallot extract yielded the best results, with a maximum circumference of 33.58 cm, while the 45% red onion PGR treatment produced a circumference of 32.95 cm.

Leaf circumference is a vital parameter for assessing plant growth and development. The presence of auxin

hormone in the PGR cell differentiation process accelerates the synthesis of new proteins, impacting the growth and development of plant organs, including leaf circumference [31]. Red onion and shallot extracts enhance plants' nutrient uptake, increasing leaf circumference. Improved nutrient absorption facilitates tissue development and the formation of larger organs, leading to faster and more substantial leaf formation.

Table 4. Average Leaf Circumference (cm) of Green Spinach Resulting from the Application of Red Onion and Shallot Extract PGR

PGR Concentration		Time Observation			
		14 DAP	21 DAP	28 DAP	35 DAP
	0%	7.97 ± 2.38^{a}	10.23 ± 1.25^{a}	16.9 ± 0.93^{a}	22.30 ± 1.34^{a}
Red Onion	T1 (15%)	10.42 ± 1.07^{b}	12.58 ± 1.30^{b}	18.88 ± 0.81^{b}	29.37 ± 0.76^{b}
	T2 (30%)	11.30 ± 1.21^{bc}	12.82 ± 1.44^{b}	20.45 ± 0.87^{c}	31.76 ± 1.22^{c}
	T3 (45%)	11.67 ± 1.73^{bc}	14.08 ± 2.87^{bc}	22.83 ± 0.75^{d}	32.95 ± 1.31^{cd}
Shallot	P1 (15%)	11.05 ± 1.43^{bc}	13.15 ± 1.52^{bc}	19.97 ± 0.77^{bc}	29.95 ± 0.67^{b}
	P2 (30%)	12.08 ± 1.39^{bc}	13.92 ± 1.28^{bc}	20.91 ± 0.90^{c}	32.30 ± 0.85^{cd}
	P3 (45%)	13.13 ± 1.60^{c}	15.12 ± 1.12^{c}	23.75 ± 1.57^{d}	33.58 ± 1.33^{d}

Description: Values followed by the same letter indicate no significant difference (α=5%) in the DMRT test

Table 5. Average Wet Biomass (g) of Green Spinach Resulting from the Application of Red Onion and Shallot Extract PGR

PGR Concentration	Wet Biomass (g)	
	Red Onion PGR	Shallot PGR
T0 (0%)	15.83 ± 7.22^{a}	15.83 ± 7.22^{a}
T1 (15%)	28.00 ± 5.59^{b}	29.50 ± 7.39^{bc}
T2 (30%)	31.17 ± 2.71^{bc}	38.17 ± 10.61^{cd}
T3 (45%)	45.00 ± 6.45^{d}	47.50 ± 12.13^{d}

Description: Values followed by the same letter indicate no significant difference (α=5%) in the DMRT test

Plant wet biomass is a crucial parameter for plant growth. To measure the damp biomass of plants, all parts of the plant are harvested and quickly weighed before the plant's water content evaporates significantly [32]. Wet biomass measurements were conducted using digital scales on all green spinach plants after harvesting and soil removal. Table 5 illustrates an increase in the wet biomass of green spinach plants at each concentration of red onion and shallot extract PGR. Notably, the treatment of red onion and shallot extracts yielded significantly different results. For instance, the wet biomass of green spinach plants treated with 45% shallot extract exhibited the largest wet biomass, measuring 47.50 g, compared to the same concentration of red onion extract.

The average wet biomass of green spinach plants treated with PGR red onion and shallots increased at each concentration. Providing exogenous PGR to plants increases endogenous plant hormones, accelerating water absorption and promoting plant cell enlargement [33]. As plant cells absorb water during the enlargement process, the plant's et weight also increases [32].

Using red onion and shallot extracts as natural PGR has enhanced green spinach plants' growth, increased plant height, number of leaves, leaf circumference, and overall plant wet biomass. Between the ages of 14-21 DAP, there was no significant difference in the average growth of green spinach plants treated with the two types of PGR. However, at the observation age of 28 DAP, a noticeable difference in the impact of PGR application began to emerge. This is because the PGR absorbed by green spinach plant cells began to be effectively used at that age to support the growth of green spinach plants. This may be because plant metabolism and other compounds still process the PGR that plants have absorbed [34]. Various studies have demonstrated the efficacy of shallot and red onion extracts as natural PGR.

According to Paelongan's research (2023), 25% shallot extract PGR has the most significant impact on the height of cocoa seedlings [35]. Furthermore, applying 10% red onion extract yields optimal results regarding the number of leaves, plant height, number of tillers, and rhizome weight of turmeric plants [36]. Meanwhile, 30% shallot extract significantly affects the number of tillers, leaves, plant height, and wet biomass weight in leek plants [37].

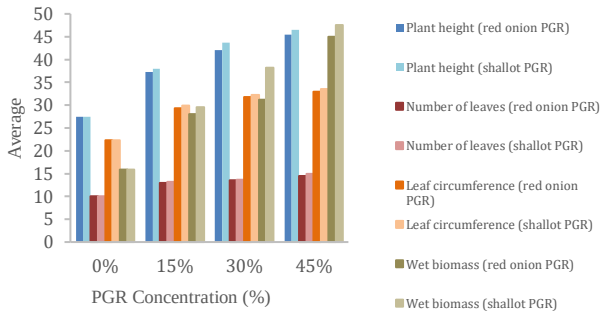

Figure 3. Graph the Average Growth of Green Spinach at Each Concentration Level of PGR.

The results of the statistical analysis indicated that applying different concentrations of red onion and shallot extracts to green spinach plants significantly impacted plant height, leaf circumference, and plant wet biomass but did not significantly affect the number of plant leaves. This variation in impact could be attributed to the uneven distribution of plant growth processes among different plant organs, as plants prioritise allocating elements towards the growth of certain plant parts [38].

It was found that the most effective PGR application was the 45% concentration of PGR shallot extract, which demonstrated superior growth promotion in green spinach

plants compared to red onion extract at the same concentration. Some studies mention that using PGR shallot extract affects the production and height of green mustard plants and the growth of pakcoy plants [39][40]. Research conducted by Ponisri *et al*. (2022) states that shallot extract at a concentration of 40% significantly affects shoot growth, leaf length, and the number of leaves in *Aquilaria malaccensis* stems [41]. This can be attributed to the higher phytohormone content in shallot, which influences plant growth and the production of metabolite compounds. The use of red onion and shallot extracts as natural PGR effectively promoted the development of green spinach plants, with nearly all observed parameters being influenced by the extracts.

Conclusion

According to the research, it has been demonstrated that utilising red onion and shallot extracts as natural PGR can enhance the growth of green spinach plants, including increasing plant height, number of leaves, leaf circumference, and wet biomass. The growth improvement of green spinach plants is evident across various concentrations of red onion and shallot extracts. Notably, the 45% concentration of shallot extract has a highly significant impact, producing the best results in all green spinach plant growth parameters. This includes a plant height of 46.5 cm, several leaves of 15.00, a leaf circumference of 33.58 cm, and a plant wet biomass of 47.50 grams.

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