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Evaluation of the impact of PGRs in bean sprouts extract on vegetative growth, total phenolics, and antioxidant activity of chili peppers, soybeans and potatoes

Mirwa Adiprahara Anggarani*, Auralia Salsabilla, Daud Zidane Ansyaddad, Ririt Wuryaningrum

Department of Chemistry, Universitas Negeri Surabaya, Surabaya 60231, Indonesia

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Abstract

This present study aims to evaluate the effect of administering natural growth regulators (PGRs) based on bean sprout extract (*Vigna radiata*) on vegetative growth, total phenolics, and antioxidant activity of chili pepper (*Capsicum frutescens* L.), soybean (*Glycine max* (L.) merrill), and potato (*Solanum tuberosum* L.) plants. Bean sprout extract was synthesized through maceration, employing 96% ethanol solvent with a ratio of solvent and simplicia at 1:5. The resulting extract was administered to the plant by means of watering starting at 7 days after planting (DAP) and continuing once every 7 days until the 13th week. Vegetative growth parameters, including plant height and number of leaves, were measured on a weekly basis. At the thirteenth week, the wet biomass, total phenolic content, and antioxidant activity were analyzed under various PGR treatments. All data were subjected to normality testing, followed by ANOVA or Kruskal–Wallis analysis. This was followed by DMRT or the relevant post-hoc tests. The results demonstrated that the application of bean sprout extract PGRs significantly enhanced plant growth, number of leaves, wet biomass, and total phenolic content in soybean plants. In addition, the application of bean sprout extract PGRs significantly enhanced the antioxidant activity of chili pepper and soybean plants. These findings highlight the advantages of bean sprout extract as a low-cost, renewable, and eco-friendly natural PGR, offering a sustainable alternative to synthetic growth regulators while enhancing plant growth and functional quality. The utilization of this natural PGR also supports eco-friendly agricultural practices and has the potential to increase horticultural crop productivity with minimal environmental impact.

Keywords: Natural growth regulators; bean sprout extract; vegetative growth; total phenolics; antioxidat activity

1. Introduction

Plant growth regulators (PGRs) are compounds applied to stimulate plant growth and development, thereby increasing crop production. PGRs are compounds administered to plants as supplementary substances to enhance the process of cell division. PGRs, when administered in low concentrations, can stimulate plant growth; in contrast, when administered in high concentrations, they in fact inhibit growth [1]. PGRs, also known as plant hormones, play a pivotal role in helping to coordinate growth, development, and responses to stimulation in horticultural plants [2]. The utilization of PGRs in plants offers several advantages, including the enhancement of the root system development, especially to accelerate root emergence in young plants. In addition, they can enhance vegetative growth, accelerate uniform fruit ripening, prevent leaf, flowers, and fruit fall, and expand the photosynthesis pathway [3].

Horticultural crops represent a significant potential for development into superior commodities, including vegetables, fruits, biopharmaceuticals, and ornamental plants [4]. Horticultural commodities play a strategic role in agricultural sector development by maintaining food balance. In line with this, horticultural crops have a potential market share, as evidenced by the increasing market demand in terms of quantity and quality requirements [5].

The horticulture subsector is a strategic component of agricultural development in Indonesia, presenting both opportunities and challenges. The horticulture subsector has been found to contribute to the National GRDP (Gross Domestic Product) on an annual basis. In 2018, the horticulture subsector contributed IDR 145,131.20 billion to the National GRDP, which then increased by 0.21 percent to IDR 153,157.80 billion in 2019. The horticulture subsector's

* Corresponding author.
Email: mirwaanggarani@unesa.ac.id
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contribution to the National GRDP also increased in 2020, increasing by 0.28 percent from 2019 to IDR 159,539.30 billion. This increase can be attributed to the growing demand for vegetables, fruit, and medicinal plants for increasingly diverse food processing as well as to meet the community's nutritional needs [6].

The low productivity of horticultural crops is determined by several factors, including environmental factors, attacks by pest organisms, genetics, soil fertility. low yields, and the cultivation techniques [7]. To address these issues, it is necessary to develop agricultural strategies by administering phytohormones or plant growth regulators to support the growth of horticultural plants [8]. Despite their natural production by plants, plant growth regulators are frequently proven to be suboptimal in terms of quantity. This can be addressed by adding exogenous plant growth regulators as a treatment. Some of these are engineered and manufactured in synthetic form [9]. However, the use of synthetic plant growth regulators has been demonstrated to exert negative effects on plant life. These negative effects include difficulty in decomposition and the generation of negative environmental impacts with prolonged and excessive utilization [10]. Consequently, it is pivotal to develop alternative solutions that utilize plant growth regulators derived from natural materials with the purpose of enhancing the productivity of horticultural plants.

One natural ingredient with potential as a source of natural growth regulators is bean sprout extract (*Vigna radiata*). Bean sprouts have been found to contain natural growth hormones such as auxin, gibberellin, and cytokinin, as well as bioactive compounds with antioxidant activity. Bean sprouts are a commonly consumed vegetable, economical, readily available, and non-toxic. Bean sprout extract contains 96.26 ppm of cytokinin, 1.68 ppm of auxin, and 1.5 ppm of gibberellin [11]. Supporting this approach, plant extracts with high phenolic content exhibited strong antioxidant activity based on DPPH radical scavenging assays. This highlights the relevance of plant-derived extracts as functional bioactive agents [12].

Thus, it is necessary to study the use of bean sprout extract as a natural PGR in several horticultural crops including chili pepper, soybeans and potatoes. This study aims to ascertain the impact of the utilization of bean sprout extract PGRs on the vegetative growth (i.e. plant height, number of leaves, wet biomass), total phenolics, and antioxidant activity of chili pepper (*Capsicum frutescens* L.), soybeans (*Glycine max* (L.) *merrill*) and potatoes (*Solanum tuberosum* L.).

2. Materials and Methods

2.1 Tools and materials

The tools employed in this study encompassed a wide range of equipment including knives, cutting boards, trays, ovens (Kirin), blenders (Sharp), 100 mesh sieves, closed containers, vacuum filtration kits, filter paper (Whattman), centrifugators (Eppendorf), vortex (Labnet), micropipettes and *blue tips* (Brand), test tubes, spatulas, stirring rods, jars, glass bottles, scissors, label paper, shovels, stationery, polybags, paranets, moisture balances (FD-160), *rotary vacuum evaporators* (Buchi R-300), measuring cylinders, measuring flasks, rulers, analytical balances (Denver S1-234), digital balances, and UV-Vis spectrophotometers (Shimadzu UV-1800).

The materials utilized included bean sprouts, chili pepper plant seeds, soybean seeds, potato seeds, bean sprout plant extract, 96% ethanol, soil, rice husk charcoal, manure, water, sterile distilled water, gallic acid (SigmaAldrich, USA), Na_2CO_3 , *folin ciocalteu reagent* (Merck, USA), DPPH and $FeCl_3$ 1%.

2.2 Research procedures

2.2.1. Making PGRs from bean sprouts extract

The preparation of the sample involved a maceration process, employing using 96% ethanol at a ratio of 1:5 (w/v) for 72 hours. Afterward, it was filtered using a vacuum pump to obtain the filtrate and residue. The resulting filtrate was then subjected to a *vacuum rotary evaporator* at temperature ranging from 40-60˚C until a thick extract was obtained [13].

2.2.2. Administration of PGRs bean sprouts extract to plants

The thick extract was subjected to physical test and the PGRs were applied by means of sprinkling onto the growing media of chili peppers, soybeans, and potatoes. The volume of PGRs utilized was 5 mL for each plant. The application was carried out seven days after planting (DAP) coinciding with the growth stage of the chili pepper, soybeans, and potatoes. It then continued with a frequency of PGRs application once a week after the first watering in the morning with a time span of 1-2 hours after watering [14]. Subsequent observations were performed on plant's height and the number of leaves measured when the plants were 14 days after planting. These measurements were repeated with an observation interval of once a week. After harvest, chili pepper, soybeans, and potatoes were extracted and measurements of plant wet biomass, phenolic tests, and antioxidant activity were carried out.

2.2.3. Post-harvest plant biomass measurement

Wet biomass is measured by weighing the wet weight at harvest time. It is measured by weighing all parts of the plant including roots, stems, and leaves with the plant itself being free of any dirt [14].

2.2.4. Total phenolic testing of plants resulting from the application of bean sprouts extract PGRs

The steps in the phenolic test include the preparation of a standard gallic acid solution with series concentrations of 10, 20, 30, 40, and 50 ppm [13]. 1 mL of each of the concentration series of gallic acid and chili pepper, soybean, and potato extracts were mixed with 2 mL of *Folin-Ciocalteu reagent* (1:10) in a vortex for ± 1 minute and left for 10 minutes. The addition of 2 mL of Na_2CO_3 (7.5%) was followed by vortexing

and the mixture was then incubated for 30 minutes. Subsequent to this, a series of UV-Vis measurements were carried out within the range of 400-800 to obtain a standard curve of gallic acid to calculate the total phenolic extracts of chili pepper, soybean, and potato.

2.2.5. Antioxidant activity testing of plants resulting from the application of bean sprouts extract PGRs

The steps for testing antioxidant activity include the preparation of a series of concentrations, ranging from 50 to 250 ppm, by diluting the stock solution. The concentrations were then pipetted. Each concentration A 4 mL sample was taken and placed into a centrifuge tube, followed by the addition of 1 mL of 40 ppm DPPH solution. Following this, the mixture was vortexed for 1 minute and stored for 30 minutes in a dark place. Absorbance measurements were then carried out in triplicate with UV-Vis at the maximum wavelength obtained [13]. The percentage inhibition was calculated using the following formula.

$$\%\ inhibition = \frac{A\ \text{control} - A\ \text{sample}}{A\ \text{control}}\ x\ 100\% \quad (1)$$

where $A_{control}$ is the absorbance of the control and A_{sample} is the absorbance of the test sample. Subsequently, a linearity curve was constructed between the percentage of inhibition and the sample concentration. This was done to obtain a linear equation of the form $y = ax + b$. This equation was utilized to determine the IC_{50} value for each treatment.

Data were obtained through observations on the growth and yield of chili pepper, soybean, and potato plants. The data analyzed in this study were those pertaining to the quality parameters of the test plants, namely plant height, number of leaves, wet biomass, total phenolic content, and antioxidant activity of chili pepper, soybean, and potato plants. All data were subjected to statistical analysis, beginning with a normality test. For the parameters of the number of leaves and plant height, if a Sig value was obtained, further tests were carried out using *One Way Analysis of Variance* (ANOVA) or Kruskal Wallis to ascertain the impact of the application of PGR bean sprout extract on the observed parameters of leaf number and plant height. If the results obtained were significantly different, the Kruskal-Wallis test was continued at a significance level of 5% to determine which treatment provided a significant difference in the research results.

3. Results and Discussion

3.1. Extraction and physical testing of bean sprouts (Vigna radiata) extract

Bean sprouts are plants that have undergone a germination process. Generally, they are typically derived from mung bean and soybean seeds. In this experiment, we employed bean sprouts derived from germinated mung beans (*Vigna radiata*). Mung bean sprouts have been shown to contain various natural growth hormones such as auxin, gibberellin, and cytokinin, as well as bioactive compounds with antioxidant activity.

Extraction refers to the process of separating or extracting bioactive compounds from a natural material using an appropriate solvent [15]. The principle of the maceration method is the diffusion of bioactive components from plant cells into a solvent that can dissolve certain compounds such as water, ethanol, or other organic solvents [16]. In this study, the maceration method was selected in view of its simplicity, effectiveness, and capacity to extract bioactive compounds without damaging phytohormones. Consequently, in this study, a material: solvent ratio of 1:5 was employed as a high ratio will create a high concentration gradient between the solvent and the material, thereby increasing the extract concentration.

The use of ethanol as a solvent, in conjunction with a 72-hour soaking period, was undertaken to time to optimizing the extraction results. This finding is consistent with the findings of research conducted on the subject. Ethanol, or the solvent, serves to bind compounds present in the material, while soaking time plays a role in determining the amount of compound extracted [17]. The longer the contact time between the ethanol (or solvent) and the material, the more optimal the compound binding process.

This temperature was employed to avoid the degradation of bioactive compounds present in the extract. The resulting extract was then subjected to a series of physical tests, including the measurement of water content and yield. The water content of the bean sprout extract was recorded at 6.7%, and the yield was 23.75%.

3.2. The impact of administering plant growth regulator (PGRs) extract of bean sprouts (Vigna radiata) on chili peppers (Capsicum frutescens L.), soybeans (Glycine max (L.) Merrill) and potatoes (Solanum tuberosum L.)

Growth parameter data can be collected in the form of measurements of the height and number of leaves of chili pepper, soybean, and potato plants. This objective of this observation is to ascertain the impact of the incorporation pf PGRs on the plants specifically chili pepper, soybeans, and potatoes. The following graph illustrates the results of the measurements of plant height and leaf number.

As illustrated in Fig. 1 and 2, the graphs of the number of chili pepper and soybean leaves exhibit a normal growth pattern because the increase in the number of leaves occurs gradually with the age of the plant, thereby reflecting physiological activity and growth hormone balance that remains within optimal limits, both in treatments with and without PGR. The application of Moringa leaf extract through seed priming and foliar spraying on green chili plants resulted in a significant increase in the number of leaves by up to 88.9% and plant height by 30.6% compared to the untreated control **(**$p < 0.05$**)** under a field experimental design [18]. The observed effect is presumed to be related to the presence of phytohormones such as cytokinins, auxins, and gibberellins in the extract. These hormones function as natural plant growth regulators (plant biostimulants)**,** thereby stimulating cell division and cell expansion in plants.

As demonstrated in Fig. 3, the number of leaves on potato plants decreased on the 70th day. It was due to that the potato plant has completed most of its vegetative growth and entered the tuber maturation phase. The potato plant begins to shift energy and nutrients from the leaves and stems to the underground tubers.

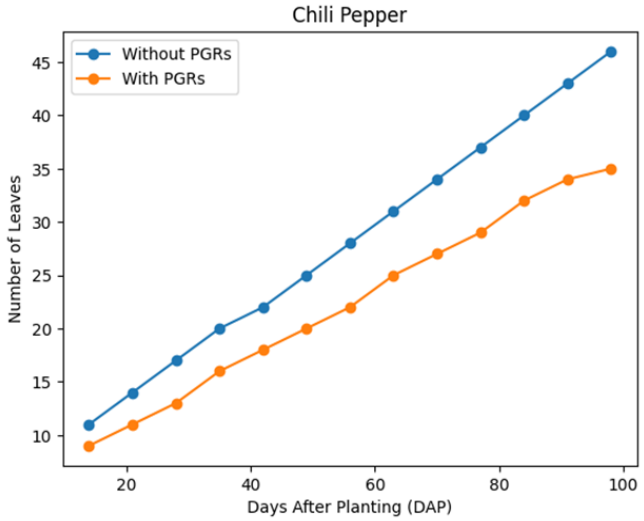

Fig. 1. Graph of the number of leaves of chili pepper plants

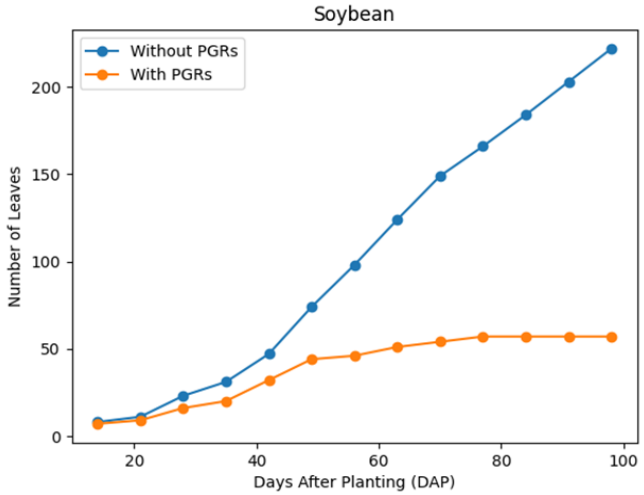

Fig. 2. Graph of the number of leaves of soybean

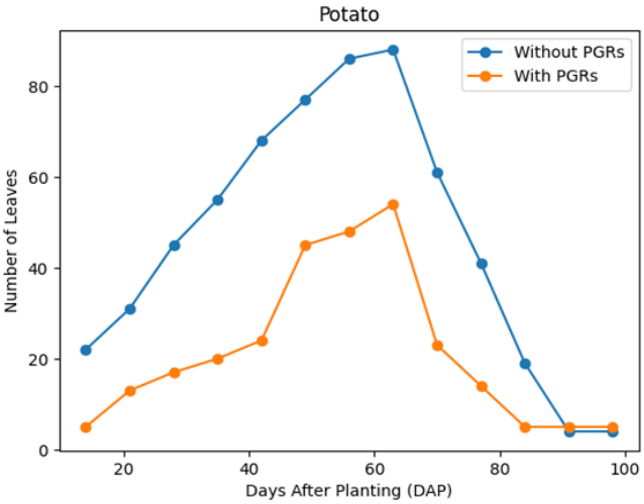

Fig. 3. Graph of the number of leaves of potato

The application of plant growth regulators (PGRs) derived from bean sprout (*Vigna radiata*) extracts exerted a positive impact on the increase of leaf number in the three tested plant species. Treatment of chili pepper, soybean, and potato plants with PGRs resulted in a higher leaf number compared to the control group that did not receive PGRs at each observation time. The most significant increase was observed in soybean plants, followed by chili peppers. A moderate increase was also observed in potatoes. This indicates that bean sprout extract contains natural auxin, gibberellin, and cytokinin compounds that can encourage vegetative growth, particularly in leaf formation. It can thus be concluded that they can be used as an environmentally friendly natural alternative to plant growth regulators. Soybean (Glycine max), a leguminous plant, has been observed to have high metabolic activity during the vegetative phase and greater sensitivity to cytokinins and gibberellins. Consequently, the exogenous application of PGRs from mung bean sprouts may synergistically enhance cell division and vegetative organ formation in soybeans. In contrast, chili pepper plants (Capsicum frutescens L.) exhibited a more moderate response. Although increases in leaf number, biomass, and antioxidant activity were observed following PGR application, these effects were not consistently statistically significant. This may be attributed to the relatively stable internal hormonal regulation of chili pepper plants, rendering them less responsive to additional exogenous hormones at the same concentration. The potato plants (Solanum tuberosum L.) exhibited the least response to the application of mung bean sprout extract PGRs. As a tuber crop, the growth of potato plants is highly determined by the hormonal balance between auxins, gibberellins, and tuberization inhibitors. The application of PGRs that do not align with the physiological requirements of the plant may result in limited or non-significant growth responses, particularly during the transition from vegetative growth to tuber formation.

Observation of the number of leaves was implemented by counting the fully developed leaves on each plant. The data obtained were the difference in the number of leaves per day after planting (DAP). To determine the significance value (Sig.) of the effect of the addition of bean sprout extract PGRs on the growth of chili pepper, soybean, and potato plants, a statistical analysis was conducted using a normality test. Based on the normality test, the significance value (Sig.) was obtained which was found to be less than the 5% level of significance (0.05). Therefore, the Kruskal-Wallis test was then conducted. The findings of this study demonstrated that the administered treatment exhibited a significant impact (P value 0.003 < 0.05) on the number of leaves of chili pepper, soybean, and potato plants at a 95% confidence level. Consequently, a multiple comparison test was conducted using *Dunn-Bonferroni*. The results of the *Dunn-Bonferroni test* are presented in Table 1.

Table 1. The results of the *Dunn-Bonferroni test*

Types of Plants	Sig. (2-tailed)	Adj.Sig. (Bonferroni)	Information
Chili peppers – Potatoes	0.551	1,000	No different significant
Chili Peppers – Soybeans	0.003	0.008	Significantly Different (p < 0.05)
Potatoes- Beans Soyabeans	0.017	0.050	Marginally significant difference (p = 0.05)

Table 1 depicts that the addition of bean sprout PGRs to soybean plants exhibited a significant impact on the increase of the number of leaves when compared to the addition of PGRs to chili pepper and potato plants which exhibited no significant difference in the number of leaves.

Based on the measurement of the height parameters of three plants, the following data were then obtained.

As demonstrated in Fig. 4 and 6, the graphs of the height of chili and potato plants appeared normal after administration of 5 mL of Moringa leaf extract PGR, thereby indicating that both plants remained in the active vegetative phase that was still responsive to growth hormones. Conversely, Fig. 5 shows that the graph of soybean plants treated with PGR did not show an increase in plant height at the age of 63, 70, 77, 84, 91, and 98 DAP. This was presumably because the plants have entered the generative phase and have high hormone sensitivity, thus rendering the addition of PGR ineffective. The administration of natural PGRs had no significant effect on soybean plant height at certain growth phases [19].

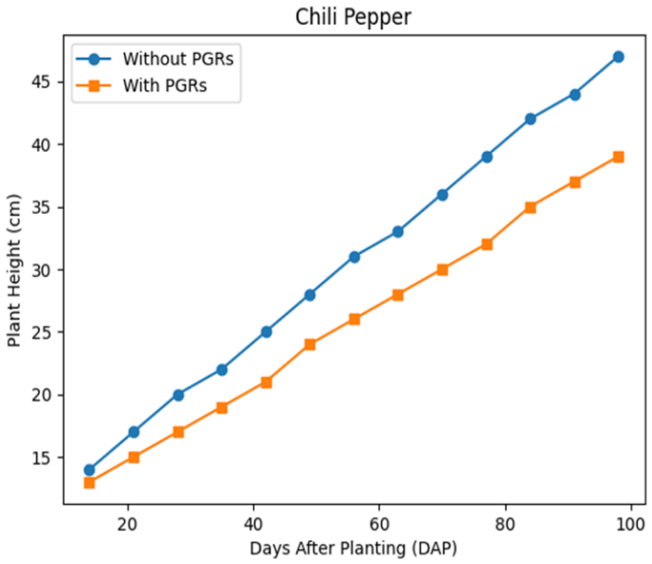

Fig. 4. Graph of the plant height of chili pepper

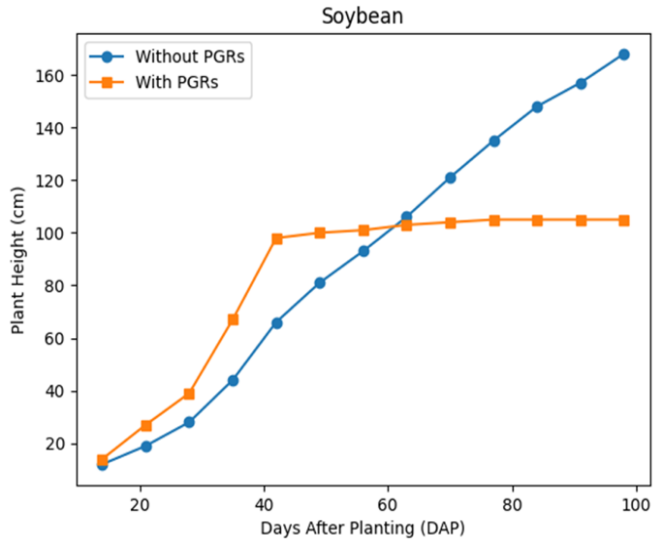

Fig. 5. Graph of the plant height of chili pepper

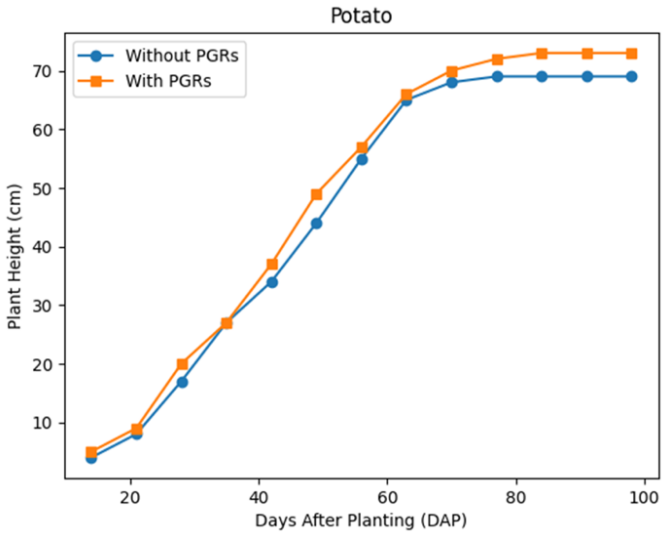

Fig. 6. Graph of the plant height of potato

As demonstrated in Fig. 4, 5, and 6, a normality test was conducted to ascertain the significance of the effect of bean sprout extract PGRs on the height growth of chili pepper, soybean, and potato plants. The results indicated that the data were not normally distributed (Sig. < 0.05). Consequently, the analysis was continued using the Kruskal–Wallis test, which yielded a p-value of 0.956 (> 0.05). The mean/median soybean plant height with and without PGR application exhibited a negligible discrepancy (mean ranks of 39.36 vs. 39.64), indicating that the actual effect of the PGR on plant height was nearly zero. This result demonstrated that bean sprout extract PGRs did not have a significant effect on the plant height growth parameter of chili pepper, soybean, and potato at the 95% confidence level. The lack of significance of the bean sprout extract PGR on the height of chili pepper, soybean, and potato plants suggests that the PGRs contained in the extract, at the concentration and application frequency used in this study, could not meaningfully modify plant height growth. Application at excessively high concentrations can disrupt cellular functions, thereby inhibiting plant growth, whereas at excessively low concentrations the effect of PGR application may not be apparent [20]. Therefore, PGRs should be applied to plants at an appropriate concentration.

The measurements of plant biomass was performed during the harvesting process. This was achieved by weighing all plant components using a digital balance. The measurement of wet biomass measurements indicated the accumulation of plant growth, allowing for the assessment of the effect of PGRs addition on increasing plant biomass. The data obtained were the masses of all plant parts in grams. The results of the statistical analysis of wet biomass are shown in Table 2.

As illustrated in Table 2, the incorporation of bean sprout extract PGRs was effective in optimally increasing the biomass growth of chili pepper, soybean, and potato plants. The application of bean sprout extract PGRs to soybean plants had a significant impact, while no such impact was observed on chili pepper and potato plants. The measurement of biomass in this study was based on the fresh weight of the plants. This parameter was utilized to represent the direct physiological response of plants to PGR application. Despite the influence of

tissue water content on fresh biomass, it remains a relevant indicator of early vegetative growth. Nevertheless, fresh biomass results should be interpreted with caution and it is recommended that dry biomass be measured in future studies to obtain a more accurate representation of structural plant growth.

Table 2. Effect of bean sprouts extract PGRs on plant wet biomass

Types of Plants	Wet Biomass of Plants (grams)	
	Without PGRs	With PGRs
Chili pepper	58 [ab]	73.5 [bc]
Soya bean	3.25 ± 1.70 [a]	103.25 ± 15.45 [b]
Potato	60.5 ± 12.06 [a]	83.75 ± 8.77 [abc]

Note: numbers with the same letter in the same column indicate insignificant differences based on the DMRT test at the 5% level.

The total phenolic content of chili pepper, soybean, and potato was analyzed. The purpose of total phenolic content testing is to determine the concentration of phenolic compounds as an indicator of plant physiology and secondary metabolite production capacity. The extraction of the plants was initiated with the utilization of ethanol solvent. The total phenolic content testing in this study employed the *Folin-Ciocalteu* method. The working principle of the *Folin-Ciocalteu* method is based on the reduction-oxidation reaction, where the hydroxyl group in the phenolic compound reduces the molybdate and tungstate complex in the *Folin-Ciocalteu reagent,* forming a blue compound complex. The intensity of this complex can be measured spectrophotometrically. In this study, gallic acid reagent was utilized as a standard because it represents the reduction activity of phenolic compounds. The total phenolic content can be expressed as the equivalent mass of gallic acid (mg equivalent of gallic acid per g of water fraction) [21].

Gallic acid standards were prepared at several concentrations, namely 10, 20, 30, 40, and 50 ppm [13]. In this experiment, 1 mL of each A series of gallic acid concentrations and extracts of chili pepper, soybeans, and potatoes were mixed with 2 mL of *Folin-Ciocalteu reagent* (1:10) and added with 2 mL of Na_2CO_3 (7.5 %). This aimed to create an acidic environment, enabling phenolic compounds to experience proton dissociation into phenolate ions

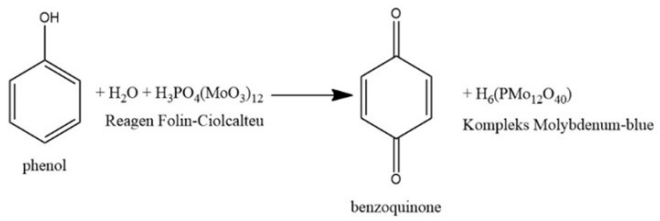

Fig. 7. The chemical reaction that occurs between phenol compounds and *Folin-Ciocalteu reagent* [22]

Phenolic compounds were oxidized by the *Folin-Ciocalteu reagent to form a* blue *molybdenum* complex allowing it to be measured with a *UV-VIS spectrophotometer.* The phenolic compound was then measured with UV-Vis absorbance in the range of 400-800 to obtain a standard curve of gallic acid to calculate the total phenolic extracts of chili pepper, soybeans, and potatoes.

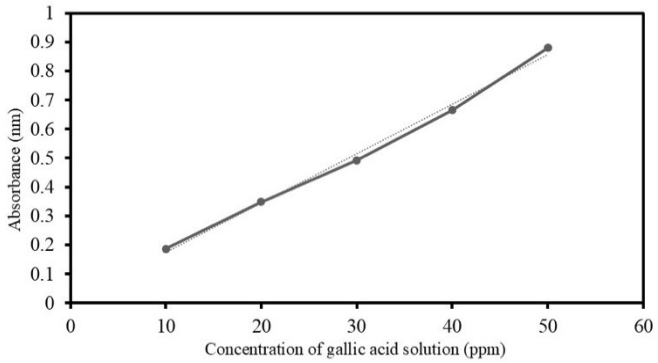

Fig. 8. Gallic acid standard curve

As demonstrated in Fig. 8, a linear equation was obtained, namely $y = 0.017x + 0.0031$ with an R^2 of 0.9944. The R value approaching 1 indicates a linear relationship between gallic acid concentration and absorbance. This equation was utilized to calculate the total phenolic content in each plant and antioxidant activity, based on the absorbance value data of triplicate test samples with a UV–Vis spectrophotometer. The results of the statistical analysis of total plant phenolics are presented in Table 3.

Table 3. Effect of Bean Sprouts Extract PGRs on Total Phenolic Plants

Type of Treatment	Total Plant Phenolics (mg GAE/g)	
	Without PGRs	With PGRs
Chili pepper	10.5 [a]	15.7 [e]
Soya bean	8.5 ± 0.07 [a]	24.3 ± 0.07[g]
Potato	12.1 ± 0.06 [b]	12.0 ± 7.39[ab]

Note: numbers with the same letter in the same column indicate insignificant differences based on the DMRT test at the 5% level.

Statistical analysis, employing the DMRT test, demonstrated that the application of bean sprout extract growth regulators (PGRs) did not significantly impact total phenolics in chili pepper and potato plants. However, in soybean plants, total phenolics increased from low in the treatment without PGRs to medium in the treatment with PGRs. The significant increase in total phenolic content and antioxidant activity observed in soybean plants suggests that soybeans may exhibit a higher metabolic responsiveness to exogenous PGR application. Soybean (*Glycine max*) has been shown to have an active phenylpropanoid pathway, particularly during the vegetative phase, which plays a central role in phenolic biosynthesis. The application of PGRs may have acted as a mild physiological stimulus, triggering secondary metabolite production as part of an adaptive response rather than merely promoting growth through hormonal regulation.

Furthermore, extracts from chili peppers, soybeans, and potato harvests were also tested for antioxidant activity. Antioxidants are chemical compounds that can counteract the effects of free radicals. Free radicals are defined as unstable

atoms or molecules [23]. The objective of antioxidant activity testing is to ascertain the capacity of the sample in counteracting free radicals. Antioxidant activity in this study was measured using the DPPH (2,2-*diphenyl*-1-*picrylhydrazil*) method. The DPPH method is a quantitative analysis technique used to determine antioxidant activity in counteracting free radicals. It is commonly employed method due to that fact that the reaction of DPPH radicals is relatively stable (see Fig. 2), requires a short time, is inexpensive and uses a small amount of sample tested [24].

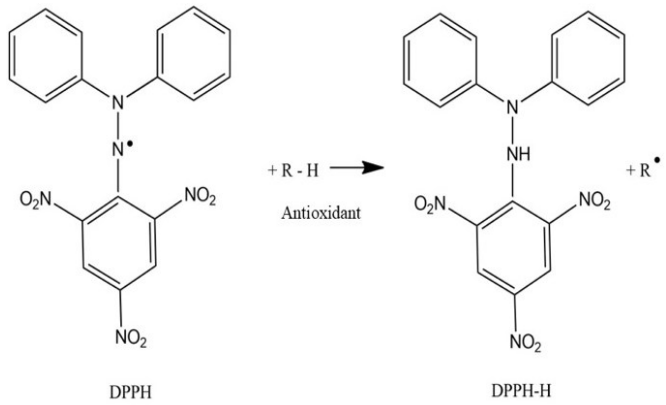

Fig. 9. DPPH reduction reaction of antioxidant compounds [25]

As demonstrated in Fig. 9, the structure of the DPPH compound consists of a nitrogen atom that has an unpaired electron [26]. The DPPH compound exhibits a purple coloration and is characterized as reactive but stable [27]. The basic principle of this method is the capture of hydrogen radicals from the sample being tested to DPPH free radicals. This process results in the compound becoming a non-radical compound, as evidenced by the color change from deep purple to yellow. The working principle of the DPPH method is that antioxidant compounds donate hydrogen atoms (H) to DPPH radicals, causing a change in the properties of DPPH to those of a non-radical [28]. Based on measurements of a 40 ppm DPPH solution using a UV-Vis spectrophotometer instrument, a maximum wavelength of 517 nm was obtained. The wavelength obtained was then utilized to determine the absorbance value of the sample. After the absorbance value of each sample was obtained, the level of resistance to DPPH radical absorption and the IC_{50} value or % inhibition was determined. The results of the statistical analysis of the IC_{50} values of chili pepper, soybeans, and potatoes are presented in Table 4.

Table 4. Effect of bean sprout PGRs on IC_{50} values of plants

Types of Plants	IC_{50} (ppm)	
	Without PGRs	With PGRs
Chili pepper	216.1 ^{g}	123.8 ^{c}
Soya bean	464.5 ±1.73 ^{g}	196.5 ± 0.77 ^{a}
Potato	167.6 ± 0.94 ^{e}	180.2 ± 0.46 ^{f}

Note: numbers with the same letter in the same column indicate insignificant differences based on the DMRT test at the 5% level.

The results of statistical analysis using the DMRT test, indicated that the addition of bean sprout extract PGRs exerted an effect on antioxidant activity. In chili pepper and soybean plants, the treatment with the addition of PGRs exhibited a significant increase in antioxidant activity, as indicated by a decrease in the IC_{50} value. The category of antioxidant activity in chili peppers changed from a state of very weak in the treatment without PGRs to a state of moderate following the incorporation of PGRs. The application of leaf extract to chili plants resulted in an enhancement of their physiological quality, including the content of bioactive compounds and antioxidant status. Despite the absence of direct IC_{50} values for plant tissues in the available literature, the increase in phenolic compounds and leaf antioxidant capacity indicates enhanced free radical scavenging activity in chili tissues, which is conceptually correlated with a reduction in IC_{50} [18]. Meanwhile, in soybean plants, an increase was also observed ranging from very weak to weak. Accordingly, the incorporation of bean sprout extract PGRs proved to have a significant impact on the enhancing antioxidant activity in chili pepper and soybean plants. Conversely, in potato plants, there was no change in the category of antioxidant activity, indicating that the treatment did not have a significant impact.

4. Conclusion

The results of the research conducted provide evidence for the proposition that bean sprout extract (*Vigna radiata*) has the potential to serve as a natural source of PGRs that is effective in enhancing the productivity of several types of horticultural crops, particularly chili pepper, soybean, and potatoes. The application of PGR (Plant Growth Regulator) mung bean sprout extract has a significant impact on the number of leaves, wet biomass, and total phenolics in soybean plants. The application of Moringa leaf extract increased biochemical parameters, including phenolic compounds and antioxidants, which are relevant to the antioxidant activity of plant tissues [29]. Furthermore, the application of PGRs bean sprout extract also had a significant impact on the antioxidant activity of chili pepper and soybean plants. The application of PGRs bean sprout extract, however, did not exhibit a significant impact on the increase of the height of chili pepper, soybeans, and potatoes. The application of PGRs bean sprout extract also did not have a significant impact on the increase of the number of leaves, wet biomass, and total phenolics of chili pepper and potato plants. In line with that, the application of PGRs bean sprout extract did not exert a significant impact on the antioxidant activity of potato plants. Thus, PGRs bean sprout extract has the most potential for use in soybean farming. This finding indicates that the bioactive compounds present in bean sprouts play an important role in supporting plant growth.

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