
Phytohormone-like activity of *Volvariella volvacea* (Bull. Ex Fr.) Singer

Valentino, M. J. G.^{1*} and Bautista, N. S.²

¹Department of Biological Sciences, College of Science, Central Luzon State University, Science City of Muñoz, Nueva Ecija, 3120, Philippines; ²Plant Biology Division, Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Baños, Pedro R. Sandoval Ave, College, Laguna, Philippines.

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Abstract Results revealed the potential hormonelike activities of *V. volvacea* crude and hot water extracts influencing the growth and development of rice, corn and radish. The effect of *V. volvacea* (9.87) in the number of roots initiated in rice is comparable to those treated with auxin (11.23) and gibberellin (12.40) while in corn, *V. volvacea* (9.77) was statistically similar to gibberellin (9.03). In addition, the length of corn roots treated with *V. volvacea* crude extract (98.07mm) and *V. volvacea* hot water extract (93.65mm) exhibited auxin (87.74mm) and gibberellin (100.08mm) like activity. Meanwhile, auxin like activity was observed in rice treated with *V. volvacea* crude extracts with the length of second leaf of 109.39mm and 98.29mm, respectively. Whereas for the secondary leaf of corn, the effect of *V. volvacea* crude extract (87.89mm) and hot water extracts(84.17mm) were comparable to the effect of gibberellin (82.95mm). Cytokinin like activity was observed in *V. volvacea* hot water and crude extracts through rice coleoptile and biomass of radish assay with 16.88mm coleoptile length and cucumber cotyledon biomass of 0.164g. Lastly, the observed total chlorophyll content ranged from 65.12% to 192.67% which indicated the greening effect of *V. volvacea* extracts.

Keywords: Exopolysaccharides, Mushrooms, Mycelia biomass, Phytohormones, Submerged fermentation

Introduction

Plant hormones or phytohormones are class of naturally occurring organic substances which are synthesized during the plant metabolism which affects plant's physiological processes (growth, differentiation, development, stomatal movement) positively at lower concentration and negatively at a concentration above optimum concentrations (Chanlud and Morel, 2016; Shi *et al.*, 2017). These plant hormones (auxins, cytokinins, ethylene, gibberellins, abscisic acid, brassinosteroid and salicylates) are obtained through plant extraction, chemical synthesis as well as microbial fermentation. They are found

*Corresponding Author: Valentino, M. J. G.; Email: maryjhane.valentino@clsu2.edu.ph

not only in higher plants, but also in algae, and in plant-associated bacteria and fungi. Plant hormones are regarded also as secondary metabolites (Tarakhovskaya *et al.*, 2007; Lu and Xu, 2015; Wang *et al.*, 2015).

Nowadays, plant-fungal interactions are becoming popular due to the benefits they confer to crop productivity through improving nutrient uptake, increasing plant growth and conferring plant stress tolerance (Xu *et al.*, 2006a; De Zelicourt *et al.*, 2013). Fungi are also capable of producing protein effectors and metabolites that aids in plant immunity (Cho *et al.*, 2006). Moreover, fungi produce compounds that are like plant hormones (Shi *et al.*, 2017). Basidiomycota and Ascomycota are among the groups of fungi with known symbiotic relationship with plants (Akhtar *et al.*, 2019).

Volvariella volvacea is commonly known as straw or paddy straw mushroom and is cultivated as one of the edible and medicinal mushrooms. *V. volvacea* belongs to family Plutaceae of division Basidiomycota which are mostly found in tropical and subtropical regions (Beelman *et al.*, 2019). It contains essential elements such as potassium, phosphorus, sodium, calcium, magnesium, iron, and zinc (Martinez-Medina *et al.*, 2021). It also contains primary metabolites such as protein, fiber, carbohydrates, minerals and vitamins. Several enzymes are also present in paddy straw mushroom that are helpful for its fast growth such as endoglucanase, laccase, polyphenol oxidase, xylanase and beta glucosidase (Roy *et al.*, 2011; Surekha *et al.*, 2011; Shwetha and Sudha, 2012;).

Several studies have been conducted on its nutraceutical potentials but little to none has been conducted on its ability to produce phytohormones that could regulate plant growth. Hence, the study was conducted to evaluate the phytohormone-like activity of *V. volvacea* extracts.

Materials and methods

The crude and hot water extracts of *Volvariella volvacea* were used to determine its hormonelike like activity through its effect on coleoptile growth, stem and root elongation, stem elongation and cotyledon growth. Laboratory grade plant hormones such as gibbberelin, auxin and cytokinin (1ppm) were used as control.

Hot water extraction

Ten grams of dried fruiting body of *V. volvacea* were submerged and extracted in 100 mL of distilled water and was maintained in water bath at 80-90

C for 2 hours. Then the extracts were filtered using Whatman filter paper No. 2 and the filtrate was kept refrigerated until use.

Crude extraction

Fruiting body of the *V. volvacea* were surface sterilized and blot dried with paper towel. After which, the fruiting body was osteorized using blender and was placed in an amber bottle and kept refrigerated until use.

Bioassay of the hormone-like activity

Protocol for bioassays for the detection of phytohormones were adapted from the works of Voytsehovska *et al.* (2010) and Tsygankova *et al.* (2016) with modifications.

Rice and corn root initiation/ inhibition test

Seeds were soaked in different treatments for 24 hours and were germinated for three days. and were subjected to different treatments for 14 days. Then, the number of roots initiated were counted and the length of roots were measured using a digital vernier caliper.

Growth of decapitated coleoptiles

Rice and corn seeds were incubated 35 cm below green, fluorescent light for 3 to 4 hours. Then the seeds were incubated in a dark room for three days. Starting at 3 mm below the coleoptile tip or at 2 mm below the coleoptile node, sections of 2 mm initial length were cut and placed in a test tube with 1.5 ml of different treatments. Then the coleoptiles were allowed to grow for 48 hours in dark room at 25°C. Coleoptiles were measured using a vernier caliper.

Rice and corn coleoptile elongation test

Thirty viable rice and corn seeds were soaked in different treatment for 24 hours and placed in a dish lined with filter paper flooded with 5 ml of different treatments. It was then incubated at 25 – 28°C and will be allowed to germinate for seven days. The length of coleoptiles was measured using a digital vernier caliper.

Rice and corn secondary leaf elongation test

Rice seeds and corn seeds were allowed to germinate in a dish lined filter paper flooded with distilled water. After 24 hours of incubation, seeds with 1mm coleoptile were transferred to a filter paper immersed in 9 ml different treatment and control solutions. The seeds were allowed to grow under ordinary daylight conditions at 28°C. Each treatment was added with 0.5 ml of distilled water every 24 hours. The blades of the second leaf were measured using digital vernier caliper after 14 days of incubation.

Radish cotyledon biomass test

Seeds were placed in a dish lined with paper towel moistened with 5 ml of distilled water and were germinated in dark condition at room temperature for 96 hours. Then the cotyledons were removed from the seedlings using sterile scalpel. Then the cotyledons were incubated for 3 days. The index of average biomass (mg) of the cotyledons were determined on the 3rd day of incubation.

Cucumber cotyledon greening bioassay

Cucumber (*Cucumis sativus* L.) seeds were used for the cotyledon greening bioassay. Seeds undergone viability testing, surface sterilization, rinsing and were germinated on a tissue paper saturated with sterile distilled water in a dish for 7 days in a room temperature at dark condition. After 7 days, cotyledons were excised under green dim light. By weighing, cotyledons were placed in a dish containing 10 mL of respective treatments and controls, then was returned to dark for 20 hours. The chlorophyll content was analyzed using spectrophotometer and the values were computed using the following formula:

$$\text{Chlorophyll A} = \frac{12.7(\text{Absorbance}_{663}) - 2.69(\text{Absorbance}_{645}) \times \text{Final Volume (mL)}}{1000 - \text{Fresh Weight of Coleoptile}}$$
$$\text{Chlorophyll B} = \frac{22.9(\text{Absorbance}_{645}) - 4.68(\text{Absorbance}_{663}) \times \text{Final Volume (mL)}}{1000 - \text{Fresh Weight of Coleoptile}}$$
$$\text{Total Chlorophyll} = \text{Chlorophyll A} + \text{Chlorophyll B}$$

Statistical analysis

Data were expressed as mean±SD with three replications each. Treatments were laid out in a complete randomized design and differences were evaluated using one-way analysis of variance (ANOVA) and was completed by a Tukey's HSD test. Data values of $p < 0.05$ was considered significant.

Results

Plant growth regulators can modify plant physiology by interfering with the biosynthesis, metabolism, or translocation of plant hormone that may enhance or delay the development of the plant.

In this study rice, corn, radish and cucumber were used as experimental plants. Different parameters which are known as indicators of plant growth were evaluated such as the length of coleoptiles, decapitated coleoptiles, secondary leaf and roots, number of roots initiated, biomass of the radish cotyledons and the amount of chlorophyll (chlorophyll a, chlorophyll b, and total chlorophyll content) were measured.

Root initiation and elongation

Plant roots function for anchorage, storage and absorption of water and nutrients from the soil and its development such as primary and lateral root growth corresponds to cell proliferation and elongation. Lateral root developed from the primary root and affects the root system architecture and increases the surface area for absorption of nutrients into the soil as well as for anchorage

Rice

The observed length and number of roots initiated in rice is shown in Table 1. The highest number of roots were recorded in rice treated with gibberellin with 12.40, followed by auxin of 11.23 and *V. volvacea* crude extract of 9.87, whereas the least number of roots were noted in distilled water treated seeds of 1.0. Statistically, the effect of auxin and gibberellin was comparable to both *V. volvacea* crude and hot water extracts.

Meanwhile, for the length of the roots initiated in rice, the longest root formed were measured in gibberellin treated rice seeds with 172.18mm, followed by auxin treated rice seeds of 112.63mm and *V. volvacea* crude extract treated rice seeds of 89.40mm and the shortest roots formed were observed in cytokinin treated rice of 12.74mm. Statistical analysis revealed that the effect of *V. volvacea* extracts to rice were significantly lower compared to gibberellin and auxin treated rice, and were significantly higher than cytokinin.

Table 1. Length and number of roots initiated in rice as influenced by different treatments

Treatments	Number of roots	Length (mm)
<i>V. volvacea</i> crude extract	9.87±2.13 ^a	89.40±9.63 ^c
<i>V. volvacea</i> hot water extract	8.37±2.43 ^a	87.38±5.21 ^c
Auxin	11.23±3.40 ^a	112.63±12.25 ^b
Gibberellin	12.40±1.22 ^a	172.18±10.20 ^a
Cytokinin	3.53±1.4 ^b	12.74±2.00 ^d
Distilled water	1.0±0.12 ^b	82.19±4.32 ^c

*Treatments with different letters are significantly different at 0.05 level of significance

Corn

The length and the number of roots initiated in corn is presented in Table 2. Corn treated with auxin had the highest mean number of roots of 18.70, followed by corn treated with *V. volvacea* crude extract of 9.77 and corn treated with gibberellin of 9.03. Among which, roots treated with gibberellin had the longest roots initiated with a mean of 100.08mm, followed by corn treated with *V. volvacea* crude extract 98.07mm and corn treated with *V. volvacea* hot water extract of 93.65mm. The least length of roots of 45.44mm was recorded in corn treated with cytokinin. Statistical analysis revealed that the effect of *V. volvacea* crude extract to the corn is comparable to the effect of gibberellic acid in terms of number of roots initiated while the effect of both *V. volvacea* hot water and crude extracts were comparable to the effect of auxin and gibberellin for the elongation of the corn roots.

Table 2. Length and number of roots initiated in corn as influenced by different treatments

Treatments	Number of roots	Length of roots
<i>V. volvacea</i> crude extract	09.77±1.12 ^b	98.07± ^a
<i>V. volvacea</i> hot water extract	5.37±0.78 ^c	93.65± ^a
Auxin	18.70±1.99 ^a	87.74± ^a
Gibberellin	9.03±1.00 ^b	100.08± ^a
Cytokinin	1.0±0.11 ^c	45.44 ± ^b
Distilled water	3.70±0.21 ^d	54.47± ^b

*Treatments with different letters are significantly different at 0.05 level of significance

Elongation of Secondary Leaf in Rice and Corn

The length of the secondary leaf in rice and corn is shown in Table 3. In rice, the longest secondary leaf was recorded in gibberellin treated seedlings of 111.89mm followed by auxin of 109.39 mm and the *V. volvacea* crude extract of 98.29 mm while the least of 24.33 mm was observed in cytokinin treated rice. The effect of *V. volvacea* crude extract on rice is comparable to auxin.

For the corn leaf, *V. volvacea* crude extract had the highest measured secondary leaf of 87.89mm which is statistically comparable to secondary leaf of corn treated with hot water extract and gibberellin with 84.17mm and 82.95mm, respectively.

Table 3. Length of Rice and Corn secondary Leaf as influenced by different treatments

Treatments	Leaf rice	Corn leaf
<i>V. volvacea</i> crude extract	98.29±11.02 ^{bc}	87.89±6.45 ^a
<i>V. volvacea</i> hot water extract	92.79±9.23 ^c	82.95±5.01 ^a
Auxin	109.39±7.27 ^{ab}	40.48±4.85 ^b
Gibberellin	111.89±10.00 ^a	84.17±8.32 ^a
Cytokinin	25.33±2.01 ^d	25.88±2.03 ^c
Distilled water	94.34±5.74 ^b	32.80±6.00 ^{bc}

Mean±SD with the same letter superscript is not significantly different at 5% significance

Coleoptile elongation

Ensheatling the first leaf and the shoot apex in grass seedlings are the coleoptiles. they function to protect the first leaf and shoot apex as it emerges from the soil. Growth of coleoptiles is due to cell division and cell enlargement but upon reaching 5 mm long, their growth is due to cell elongation

The mean length of rice and corn coleoptiles subjected to different treatments is shown Table 4. In rice, the highest mean of the coleoptiles was obtained in coleoptiles treated with auxin of 24.39mm, followed by coleoptiles treated with gibberellin with 19.90mm and coleoptiles treated with *V. volvacea* hot water extract of 17.90mm. Statistically, the effect of *V. volvacea* extracts on rice coleoptiles are comparable to those treated with cytokinin (16.88mm).

For the corn, coleoptiles treated with auxin registered the highest mean of 40.16mm, followed by gibberellin of 36.94mm. Meanwhile, based on statistical analysis the effect of *V. volvacea* crude extract (13.13mm) and hot water extract (13.64mm) on corn coleoptiles are insignificant and are comparable to untreated corn seedlings.

Elongation of decapitated coleoptile

For the length of the decapitated rice and corn coleoptile, auxin and gibberellin recorded the highest mean length of coleoptile both on rice and corn. For the rice, coleoptiles treated with auxin and gibberellin are statistically higher than all the other treatments with 8.28mm and 8.13mm respectively, whereas rice treated with *V. volvacea* crude extract with mean length of 6.01mm is comparable to rice coleoptiles treated with cytokinin of 7.26mm. In corn, the highest mean length of coleoptiles was recorded in gibberellin of 18.11mm followed with 16.67mm of auxin, both are comparable and are statistically higher among all other treatments. While *V. volvacea* crude extracts of 8.43mm is comparable with the decapitated coleoptile treated with cytokinin (8.43mm).

Table 4. Length and percentage increase of rice and corn coleoptile in millimeter (mm) as influenced by different treatments

Treatments	Rice	Corn
<i>V. volvacea</i> crude extract	15.64±1.34 ^d	14.82±2.22 ^{cd}
<i>V. volvacea</i> hot water extract	17.90±1.67 ^c	16.67±1.78 ^{cd}
Auxin	24.39±3.43 ^a	40.16±4.35 ^a
Gibberellin	19.90±1.00 ^b	36.95±2.88 ^a
Cytokinin	16.88±2.13 ^{cd}	26.43±2.12 ^b
Distilled water	13.54±1.99 ^c	9.83±1.44 ^d

Mean±SD with the same letter superscript is not significantly different at 5% significance

Table 5. Length of the decapitated rice and corn coleoptile in millimeter (mm) as influenced by different treatments

Treatments	Rice coleoptile	Corn coleoptile
<i>V. volvacea</i> crude extract	6.01±0.47 ^c	8.43±1.02 ^c
<i>V. volvacea</i> hot water extract	7.32±1.00 ^b	11.05±1.85 ^b
Auxin	8.28±0.99 ^a	16.67±1.45 ^a
Gibberellin	8.13±0.23 ^a	18.11±2.01 ^a
Cytokinin	7.26±0.85 ^b	8.43±0.55 ^c
Distilled water	5.83±0.36 ^c	9.83±1.00 ^{bc}

Mean±SD with the same letter superscript is not significantly different at 5% significance

Biomass of radish cotyledon

Shown in table 6 are the mean and %increase in biomass of radish cotyledon. An observable increase in the biomass was noted when subjected to different treatments. Radish cotyledon treated with gibberellic acid had the

highest mean biomass of 206.20 mg followed by auxin of 164.00 mg. Statistically the effect of cytokinin (152.61 mg) was comparable with those treated with auxin, *V. volvacea* crude and hot water extract of 164.00 mg, 139.00 mg and 153.mg, respectively.

Table 6. Biomass and %increase in biomass of radish coleoptile

Treatments	Radish coleoptile (mg)	% increase in biomass
<i>V. volvacea</i> crude extract	139.00±2.30 ^b	54.53±4.12 ^b
<i>V. volvacea</i> hot water extract	153.00±2.78 ^b	69.17±4.23 ^b
Auxin	164.00±5.23 ^{ab}	81.73±5.02 ^{ab}
Gibberellin	206.20±4.20 ^a	128.57±4.03 ^a
Cytokinin	152.61±2.01 ^b	69.17±5.22 ^b
Distilled water	90.00±2.13 ^c	

Mean±SD with the same letter superscript is not significantly different at 5% significance

Cucumber cotyledon greening assay

The effects of different treatments for the greening of cucumber plants, cucumber cotyledon subjected to different treatments are presented in Table 7. Cotyledons treated with gibberellin and cytokinin had the highest chlorophyll a, chlorophyll b and total chlorophyll contents. Followed by *V. volvacea* hot water extracts of 15.21. meanwhile the least chlorophyll content of 8.87 was recorded in cotyledons subjected in distilled water. Percentage increase in total chlorophyll content ranged from 65.12% to 192.67%. Statistical analysis significant increased in chlorophyll a, chlorophyll b and total chlorophyll content when treated with commercial hormones and *V. volvacea* extracts. The in addition the effect of auxin is comparable to those treated with *V. volvacea* crude and hot water extracts both in chlorophyll a and chlorophyll b.

Table 7. Total chlorophyll contents of cucumber cotyledons (mg/g)

Treatments	Chlorophyll A	Chlorophyll B	Total Chlorophyll	% Increase in Total Chlorophyll
<i>V. volvacea</i> crude extract	4.55±3.64 ^b	10.10±7.95 ^{bc}	14.65±9.59 ^c	65.16
<i>V. volvacea</i> hot water extract	3.24±0.29 ^b	13.97±0.92 ^b	17.21±0.64 ^b	94.02
Auxin	3.93±0.18 ^b	12.20±1.23 ^b	16.13±1.07 ^b	81.84
Gibberellin	6.23±0.81 ^a	19.73±1.47 ^a	25.96±1.67 ^a	192.67
Cytokinin	5.43±0.22 ^{ab}	20.24±0.91 ^a	25.67±0.69 ^a	189.4
Distilled water	1.36±0.53 ^c	7.51±1.07 ^d	8.87±1.37 ^d	

Mean±SD with the same letter superscript is not significantly different at 5% significance

Discussion

Basidiomycetes are known as source of food and for its pharmaceutical, biotechnological and agricultural potentials (Chang and Shao, 2002; Chang and Wasser, 2017; Hyde *et al.*, 2019). Meanwhile, in ecological perspective, they are known to form link in the ecosystem forming mycorrhizal mat in the soil where they dominate affecting microevolution of organisms (Bahram and Netherway, 2022). Fungi can produce substances that could affect plant physiological processes and metabolism (Rangel- Castro *et al.*, 2002; Fonseca *et al.*, 2018; Akhtar *et al.*, 2019). Among these groups of fungi are the ectomycorrhizal fungi such as basidiomycetes and ascomycetes by regulating hormone secretion (Srivastava, 2002; Yang *et al.*, 2009; Quiroz-Castaneda *et al.*, 2011; Raudaskoski and Kothe, 2015; Xia *et al.*, 2023). According to Fernandez-Suarez *et al.*, 2015, these phytohormones helps in plant-fungal interaction. They are involved in the promoting higher biomass and plant growth rates (Vadassery *et al.*, 2008; Hamayun *et al.*, 2017; Khan *et al.*, 2020; Pons *et al.*, 2020; Gomes and Scortecci, 2021).

Previous studies revealed the presence of cytokinin in the forms of zeatin and zeatin ribosides in basidiomycetes (Janitor and Vizarova, 1994; Morrison *et al.*, 2015). According to Vedenicheva *et al.* (2015) and Morrison *et al.* (2015), basidiomycetes could synthesize cytokinins which may vary on specific species of microfungi and the qualitative and quantitative number of produced hormones. Aside from cytokinins, auxin in the form of indole acetic acid (active form of auxin in fungal species) were also detected in fungal species belonging to ascomycota, basidiomycota and muromycota (Waqas *et al.*, 2012). Auxin is involved in apical dominance, cell division and cell enlargement (Peret *et al.*, 2009; Gomes and Scortecci, 2021). Lastly, gibberellic acid was first isolated in fungal pathogen *Gibeberella fujikuroi*. In a study of Hedden and Sponsel (2015), fungal derived auxin had enhanced the biomass and chlorophyll content of the rice plants.

In addition, due to multitude nutritional components of basidiomycetes, they can act as biofertilizers which can increase in the nutritional uptake of the plants, production of secondary metabolites, and induces plant growth regulation and stimulation (Chi *et al.*, 2010; Abdel-Fattah *et al.*, 2013; Pal *et al.*, 2015). Accordingly, they aid in the mobilization and solubilization of the unavailable essential nutrients for plants. Increase in production of various compounds also triggers upregulation of genes for plant defense and development (Vassilev *et al.*, 2015). Rather their observed actions can be attributed to actions of extracellular enzymes it secretes such as amylase, cellulase, lignase and laccase, which were reported to possess different biological activities in relation to plant physiological

processes (Ahlawat *et al.*, 2008). Also, secondary metabolites such as the alkaloids, saponins, phenolics, and terpenoids are also present in *V. volvacea* (Jonathan and Adeoyo, 2011; Roy *et al.*, 2011). Based on reports, the secondary metabolites are potent stimulants or inhibitors of plant growth (Chen *et al.*, 2011; Chaudhary and Rahi, 2023). Whereas the presence of essential minerals also important biochemical function in plants seed germination and establishment. This includes calcium and boron for cell wall establishment and cell elongation, magnesium, selenium, zinc, iron, copper, nickel, molybdenum, manganese for stress related proteins and potassium for osmoregulation and turgor stability (Ahlawat *et al.*, 2008).

Hormonelike activities were exhibited by *V. volvacea* crude and hot water extracts. During root initiation and elongation, auxin function as a root forming hormone which influences the root architecture and trigger lateral root formation (Gomes and Scortecci, 2021;). It also exhibits bi-modal effect on plants which can limit the elongation of the primary root and increases the number of lateral roots. Similarly, gibberellin also induce root elongation and promote cell expansion, differentiation and proliferation (Overvoorde *et al.*, 2010; Vishal and Kumar, 2018). On the other hand, cytokinins has an inhibitory effect on the formation of lateral roots, increasing its concentration reduces the formation of lateral roots. In addition, its function in modulating ethylene biosynthesis is inhibitory to root cell elongation (Chae *et al.*, 2003; Laplaze *et al.*, 2007; Street *et al.*, 2016; Julkowska, 2018).

Cell elongation has been shown to be coordinately regulated by auxins and gibberellins and their effects overlap with respect to cell expansion and tissue differentiation (Stamm and Kumar, 2010; Ross *et al.*, 2011;). In many plants, gibberellic acid is higher in zone of elongation and vigorous growth period in rice and endogenous levels of gibberellins were higher in younger than older leaves (Watanabe *et al.*, 2007; Xu *et al.*, 2006b). Whereas cytokinin control diverse developmental processes including the determination of the final size and function of plant organs such as leaves (Zucher *et al.*, 2013; Kieber and Schaller, 2014).

For the coleoptiles, auxin causes coleoptile elongation by affecting biochemical composition of cell wall, that induces growth by cell expansion and elongation through expression of cell wall remodeling factors (Coenen *et al.*, 2003; Majda and Robert, 2018). Meanwhile, Nanda and Melnyk (2018) mentioned that gibberellins also take part in coleoptile growth, Accordingly, decapitation cause the reduction in gibberellin, auxin triggers the production of gibberellins and in turn it promotes auxin transport.

According to Hedden and Sponsel (2015) and Hyde *et al.* (2019), production of GAs by microorganisms is dependent on the optimized cultural

parameters such as pH, temperature, culture medium, light and days of cultivation. Series of screening, optimization, solid state fermentation, confirmation and identification of GAs is done to isolate and produce specific amount of GA. Furthermore, exposure of fungal isolates to stress such as salinity stress increases the production of GA.

Gibberellins are present in some fungi and bacteria which can be a symbiont or a pathogen. GAs produced by fungi do not influence fungal growth but rather function to suppress the immunity of the host plants and aid in infection. Additionally, they function in several physiological processes such as seed germination, shoot and stem elongation, and flower development. GAs produced by plants and fungi are structurally the same but have differences in the pathways and enzymes involved (Hedden *et al.*, 2001).

Cotyledons are highly sensitive to plant different hormones that could either inhibit or promote growth. Of which cytokinin can cause extensive growth through cell division and altering the size and activity of the meristem (Werner *et al.*, 2001; Kosakivska, 2018). As reported by Srivastava (2002), the rate of endosperm cell division is closely associated with cytokinin level and that exogenous kinetin significantly increases the number of endosperm cells and grain weight.

Results of the study elucidated the hormonelike activities of *V. volvacea* crude and hot water extracts that both enhanced or deterred the development of rice, corn and radish. In terms of number of roots in corn, gibberellin like activity was noted in *V. volvacea* crude extract while auxin and gibberellin like activity for the elongation of the corn roots. In addition, auxin like activity was exhibited by *V. volvacea* crude extracts on the growth of the second leaf of rice and in corn, *V. volvacea* crude and hot water extracts gibberellin like activity. Cytokinin like activity was observed in *V. volvacea* hot water and crude extract in elongation of coleoptiles and biomass of radish. Lastly, *V. volvacea* crude extracts influenced the production of total chlorophyll content of cucumber cotyledon.

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Conflicts of interest

The authors declare no conflict of interest.

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