LenteraBio
LenteraBio, 2025; Volume 14, Issue 1: 10-19
p-ISSN: 2252-3979 e-ISSN: 2685-7871
https://journal.unesa.ac.id/index.php/lenterabio/index

Effect of Coconut Shell Liquid Smoke and Water Hyacinth Root Extract on the Growth of Soybean in Mycorrhiza-enriched Saline Soil

Roesita Nur Fitria*, Yuni Sri Rahayu
Study Program of Biology, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya
*e-mail: roesita.20043@mhs.unesa.ac.id

Article History:
Received:
22-July-2024
Revised:
9-December-2024
Available online:
31-December-2024
Published regularly:
31-January-2025

Abstract
Saline soil negatively impacts plant growth, requiring improvements to enhance soybean productivity. This study examined the effects of coconut shell liquid smoke, water hyacinth root extract, and their interaction on soybean growth in saline soil enriched with mycorrhiza. This experimental research using a Randomized Group Design (RGD) with three repetitions, two factors were tested: liquid smoke (0%, 1%, 2%) and water hyacinth root extract (0 ppm, 500 ppm, 1000 ppm). Vegetative parameters included plant height, number of leaves, root length, wet biomass, root nodules, active root nodules, mycorrhizal infection percentage, and phosphorus content. Generative parameters included flowering age, number of pods, and pod biomass. Data were analyzed with Two-Way ANOVA, Duncan test, and descriptive methods. Liquid smoke improved the number of leaves (14.56 strands), root length (37.78 cm), wet biomass (14.44 g), and pod biomass (8.00 g). Water hyacinth root extract enhanced plant height (122.33 cm), number of leaves (14.56 strands), root length (39.44 cm), wet biomass (16.00 g), number of pods (11.78 pods), and pod biomass (9.00 g). The interaction of 2% liquid smoke and 1000 ppm root extract yielded the highest wet biomass (17.67 g) and pod biomass (10.67 g), showing significant synergistic effects for improving soybean growth.

Keywords: *Glycine max* L.; giberellin; growth; plant; salinity
How to Cite: Fitria RN, Rahayu YS, 2025. Effect of Coconut Shell Liquid Smoke and Water Hyacinth Root Extract on the Growth of Soybean in Mycorrhiza-enriched Saline Soil. LenteraBio; Volume(14): 10-19
DOI: https://doi.org/10.26740/lenterabio.v14n1.p10-19

INTRODUCTION

The length of the coastline in Indonesia reaches 106,000 km, and the potential land area is 1,060,000 ha, most of which is marginal land (Sari and Zahrosa, 2022). Marginal land has the potential to be used as agricultural development land, but marginal land needs to be appropriately managed. The main problem in utilizing marginal land is the high salinity level (Ihsan et al., 2016). Saline soil negatively affects plant growth because the high NaCl salt content will reduce plants' water supply and disrupt metabolic processes (Hegazi, 2015). Research by Ding *et al*., 2020, revealed that high soil salinity can reduce the availability of P, N, and K elements in the soil. High Na^+ levels in the soil cause the absorption of similar ions, namely Ca^{2+} and Mg^{2+} ions, to decrease. The decreased absorption of Ca^{2+} and Mg^{2+} ions causes the amount of these ions in the environment to increase, resulting in P elements in the soil being absorbed by Ca^{2+} and Mg^{2+} ions, so plants cannot adequately absorb them. High salinity also causes osmotic pressure to decrease, making it difficult for plant roots to absorb nutrients (Karolinoerita and Yusuf, 2020).

Efforts to reduce salinity in coastal soils are needed to increase productive land in Indonesia. One way to improve saline soil is by applying mycorrhiza. According to Nasution *et al*. (2013), mycorrhizal fungi can help increase height growth, number of stem branches, and number of pods per plant and accelerate the flowering period of soybean plants in saline soils. Mycorrhiza is an association between fungi and plant roots that creates a symbiotic relationship (Hajoeningtijas *et al*., 2018). Arbuscular Mycorrhizal Fungi (AMF) positively influence plant growth in high salinity conditions. Mycorrhiza can increase nutrient uptake of phosphate, calcium, potassium, manganese, sodium, copper, magnesium, and water in the soil. According to the research of Rajmi *et al*. (2018), the application of AMF to P-available levels in the soil showed an increase of two times, namely from 5.83 ppm to 11.10

ppm. This is due to the phosphatase enzyme activity of AMF, which releases P ions from the soil to increase the availability of P for plants (Sutariati *et al*., 2014).

Soil conditions with high salinity cause many plants to not grow well. Certain plants with wide tolerance can survive in soil salinity conditions, including Leguminosae plants. Soybean (*Glycine max* L.) is a food crop that is a staple food raw material in Indonesia. Soybeans contain carbohydrates, fat, phosphorus, calcium, and vitamins A and B (Rohmah and Saputro, 2016). Indonesia needs 1.3 million tons of soybeans, but domestic soybean production only reaches 37,530 tons, and imports from abroad amount to 1.05 million tons (Kementerian Perdagangan, 2021). This data shows that domestic soybean production is still deficient and needs increased.

Improving saline soil can be one form of effort in increasing domestic soybean productivity through land utilization by reducing or minimizing its various limitations. In addition to good planting media, growth regulators are needed to support the growth of soybean plants, one of which is the provision of the hormone gibberellin. Gibberellin is a hormone that stimulates cell elongation and division. Gibberellin causes the cell wall to relax, making it easier for proteins to enter the stem cell wall and work together to increase cell wall elongation, if gibberellin is given to dwarf plants, the plants will grow as tall as typical plants (Salisbury and Ross, 1995). Gibberellins are diterpenes, an isoprenoid compound synthesized from acetate units on acetyl CoA through the mevalonic acid pathway. Gibberellin (GA) can be obtained from roots, leaf buds, and fungi, but GA is produced by plants in an inactive form, so it requires a precursor to activate it (Advinda, 2018), one of the GA precursors is acetic acid which can be sourced from coconut shell liquid smoke (Taiz and Zeiger, 2002).

In increasing soybean crop production, it is necessary to add organic materials that can be utilized to improve plant growth, one of which is liquid smoke. Liquid smoke is a blackish substance obtained through the pyrolysis process of biomass such as wood, bark, and forestry waste. (Ridhuan, 2019). Based on research by Isa *et al*. (2019), coconut shell liquid smoke contains many compounds, with the most significant compound being acetic acid, as much as 48.75%. Research by Jayanudin and Suhendi (2012) also identified that liquid smoke from burning coconut shells produced the most significant chemical component, acetic acid by 46.56% and phenol by 12.93%. Liquid smoke is a plant growth accelerator (Bili *et al*., 2019) through acetic acid that binds to coenzyme-A and forms acetyl Co-A. Acetyl Co-A acts as a precursor compound for the mevalonic acid pathway and will produce terpenoid compounds. This compound precursor the formation of GA compounds in gibberellin biosynthesis (Taiz and Zeiger, 2002). According to research by Putri *et al*. (2023), coconut shell liquid smoke affects the growth parameters of lettuce plants.

Water hyacinth root extract is another organic material with natural gibberellins that helps increase plant growth. The water hyacinth plant (Eichhornia crassipes) is a weed plant that is easy to grow in rivers or swamps and is not utilized by the community. The roots of water hyacinth plants contain the hormone gibberellin, which can benefit plant growth and development (Lindung, 2014). Ummah and Rahayu (2019) research shows that 0.05 grams of water hyacinth root extract contains exogenous gibberellin ZPT of 2995.50 ppm. According to Andriani and Ajiningrum (2021), exogenous gibberellin affects the growth of chilli plants. Gibberellin spurs the activity of hydrolytic enzymes and also functions in cell division and elongation (Arif *et al*., 2016).

The purpose of this study was to describe the effect of coconut shell liquid smoke, water hyacinth root extract, and a combination of both in increasing the vegetative and generative growth of soybean plants in saline soil enriched with the addition of mycorrhiza.

MATERIALS AND METHODS

This research is an experimental research conducted in January-March 2024 in the greenhouse of the Biology study program of Universitas Negeri Surabaya. This research design uses a Randomized Group Design (RGD) with two factors, including liquid smoke concentration (0%, 1%, and 2%) and water hyacinth root extract concentration (0 ppm, 500 ppm, and 1000 ppm). This study had nine treatment combinations and three repetitions, so there were 27 combinations of treatment units. The materials used were liquid smoke, water hyacinth roots, seawater, regosol soil, sand soil, soybean seeds (*Glycine max* L.), methanol 60%, $NaHCO_3$, ethyl acetate, HCl, mycorrhiza (Glomus sp), distilled water, and lactophenol trypan blue. The tools needed are a pH meter, refractometer, rotary evaporator, hot plate, microscope, measuring cup, scales, ruler, meter, polybag, and stationery.

The first stage is the preparation of saline soil media. The saline soil component consisted of 2.5 kg of regosol soil and 2.5 kg of sandy soil, then watered with a mixture of seawater with a concentration of 0.004 M, as much as 1000 ml at the beginning of watering and 250 ml for the next watering. The soil was watered for one week and then left for five days. Sterilization of saline soil was done by adding 200 ml of 2% formaldehyde and sealed with plastic for five days. The next step was to add 40 mg of urea, 40 mg of KCl, and 20 grams of mycorrhiza to the saline soil.

The second stage is the preparation of water hyacinth root extract. The roots of water hyacinth plants obtained from the Surabaya River coast were cleaned and dried. Grind the dried water hyacinth roots to a simple powder of 300 grams. The powder was macerated with 60% methanol once in a ratio of 1:4. Filtrate simplisia was filtered and then evaporated to produce concentrated water hyacinth root extract. Dilute 6 grams of water hyacinth root extract by adding $NaHCO_3$ until the pH becomes 8, then add 50 ml of ethyl acetate and separate it. Add 1N HCl until the pH becomes 2.5, and perform a separation extraction using 75 ml of ethyl acetate solution.

The last stage is planting soybean plants and administering treatments. Soybean seeds (*Glycine max* L.) were sown for three weeks before transplanting. The treatment of liquid smoke was carried out at the ages of 7, 14, 21, 28, 35, and 45 days after planting (DAP). Coconut shell liquid smoke was diluted with 10 ml of liquid smoke for 1% concentration and 20 ml for 2% concentration diluted with one liter of distilled water each. Water hyacinth root extract was treated at 9, 16, 23, 30, 37, and 44 DAP. Dilution of water hyacinth root extract by diluting 0.5 grams of extract in one liter of water to produce a concentration of 500 ppm and 1 gram to produce a concentration of 1000 ppm. Observation parameters consisted of vegetative growth, including plant height, number of leaves, wet biomass, root length, root nodules, active root nodules, percentage of mycorrhizal infection, and elemental P content. Generative growth includes parameters such as the age of flower emergence, number of pods, and pod biomass. Observations of plant height and number of leaves were made at 15, 30, and 45 DAP, and observations of wet biomass, root length, number of root nodules, number of active root nodules, percentage of mycorrhizal infection, P element content, number of pods, and pod biomass were made at 45 DAP.

The results of soybean growth parameters were analyzed using SPSS 25, a two-way ANOVA test. Suppose there is a significant effect of adding liquid smoke concentration, water hyacinth root extract, and their interaction. In that case, the Duncan test was continued with a significance of 0.05. Research data that are not normal and data that do not show significant results from the Two-Way ANOVA test will be analyzed descriptively and quantitatively.

RESULTS

The value of environmental conditions and nutrient content in saline soil before treatment was obtained. Table 1 shows the test results for Na, N, P, and K nutrient content in saline soil before treatment. The Na content test results amounted to 1.20 cmol+/kg, which is included in the very high criteria. This Na level shows that the soil media is included in the saline soil category indicates that the soil media is included in the saline soil category.

Table 1. Environmental parameters and nutrient levels of saline soil before treatment

Parameters	Measurement Results	Criteria*
pH	7.5	Bases
Soil Moisture (%)	65	Moist
Na ($cmol^+/kg$)	1.20	Very High
K ($cmol^+/kg$)	0.37	Low
N (%)	0.30	Medium
P_2O_5 (ppm)	36	Very High

*) Based on the criteria of Sulaeman *et al*. (2005)

The results of applying liquid smoke and water hyacinth root extract of various concentrations showed that the interaction between the concentration of liquid smoke and the concentration of water hyacinth root extract affected the vegetative growth of soybean plants on the parameters of wet biomass (Figure 1). There was no interaction between the concentration of liquid smoke and the concentration of water hyacinth root extract on plant height, number of leaves, and root length of soybean plants. The addition of liquid smoke concentration of 2% and water hyacinth root extract concentration of 1000 ppm gave the highest results in the wet biomass parameter of 17.67 grams. However, it was not significantly different from the combination of 1% liquid smoke with 1000 ppm water hyacinth root extract and 2% liquid smoke treatment with 500 ppm water hyacinth root extract.

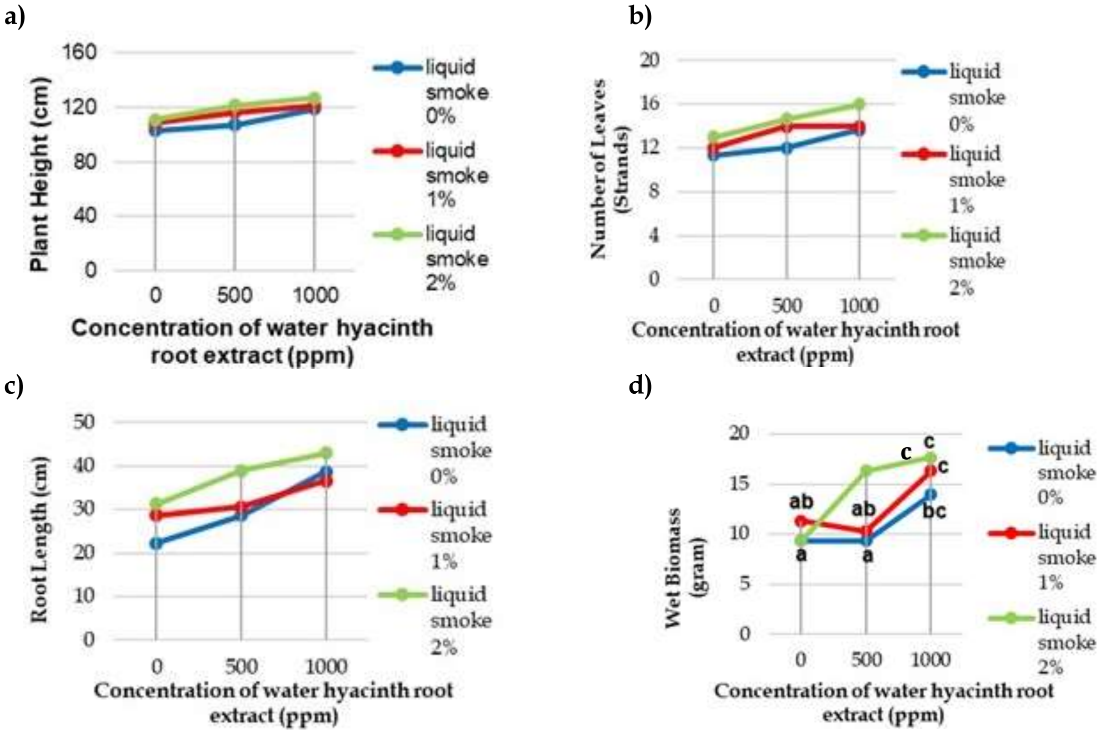

Figure 1. The effect of the combination of liquid smoke and water hyacinth root extract on a) plant height, b) number of leaves, c) root length, and d) wet biomass (Different letters on the graph indicate a significant effect based on Duncan's test at the 0.05 level).

The results of the application of liquid smoke and water hyacinth root extract of various concentrations showed that there was no interaction between the concentration of liquid smoke and the concentration of water hyacinth root extract on vegetative growth in the parameters of the number of root nodules, the number of active root nodules, and the percentage of mycorrhizal infection, and the P content in the leaves of soybean plants.

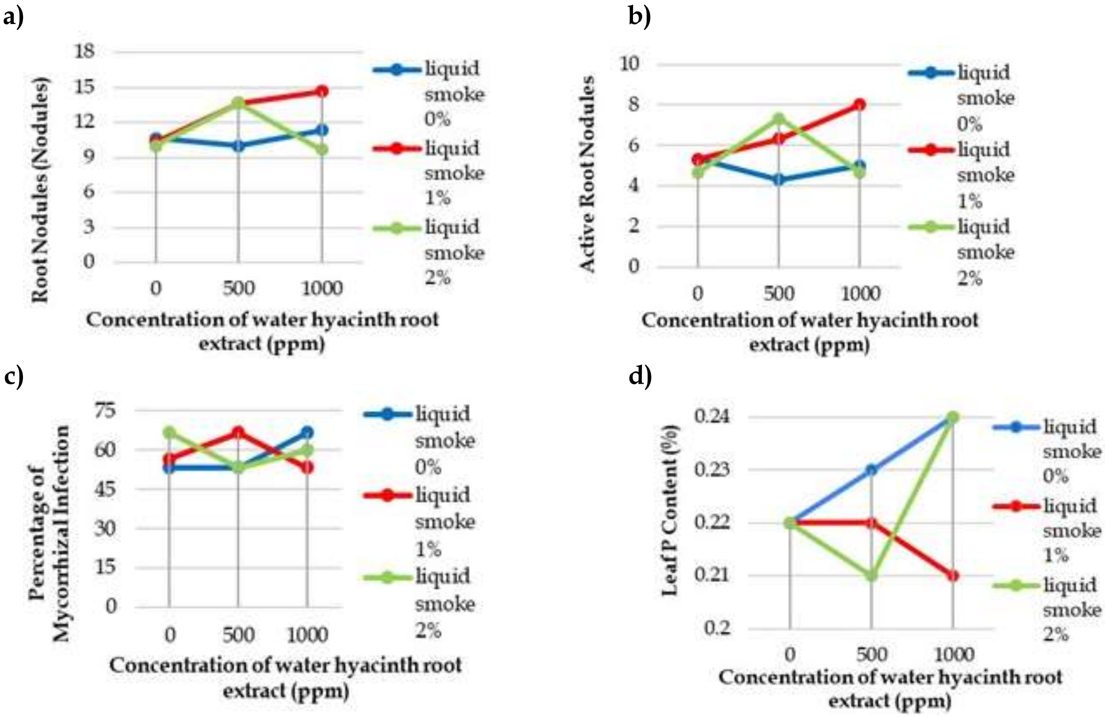

Figure 2. Effect of combination of liquid smoke and water hyacinth root extract on a) number of root nodules, b) number of active root nodules, c) percentage of mycorrhizal infection, d) P content in soybean leaves.

The results of the application of liquid smoke and water hyacinth root extract of various concentrations showed that the interaction between the concentration of liquid smoke and the concentration of water hyacinth root extract affected the generative growth of soybean plants in the parameter of soybean pod biomass (Figure 3). There was no interaction between the concentration of liquid smoke and the concentration of water hyacinth root extract on the parameters of the age of flower emergence and the number of soybean pods. The interaction treatment of liquid smoke concentration of 2% and 1000 ppm water hyacinth root extract produced the highest soybean pod biomass of 10.67 grams. This treatment was not significantly different from the treatment of 1% liquid smoke with 1000 ppm water hyacinth root extract and 2% liquid smoke with 500 ppm water hyacinth root extract.

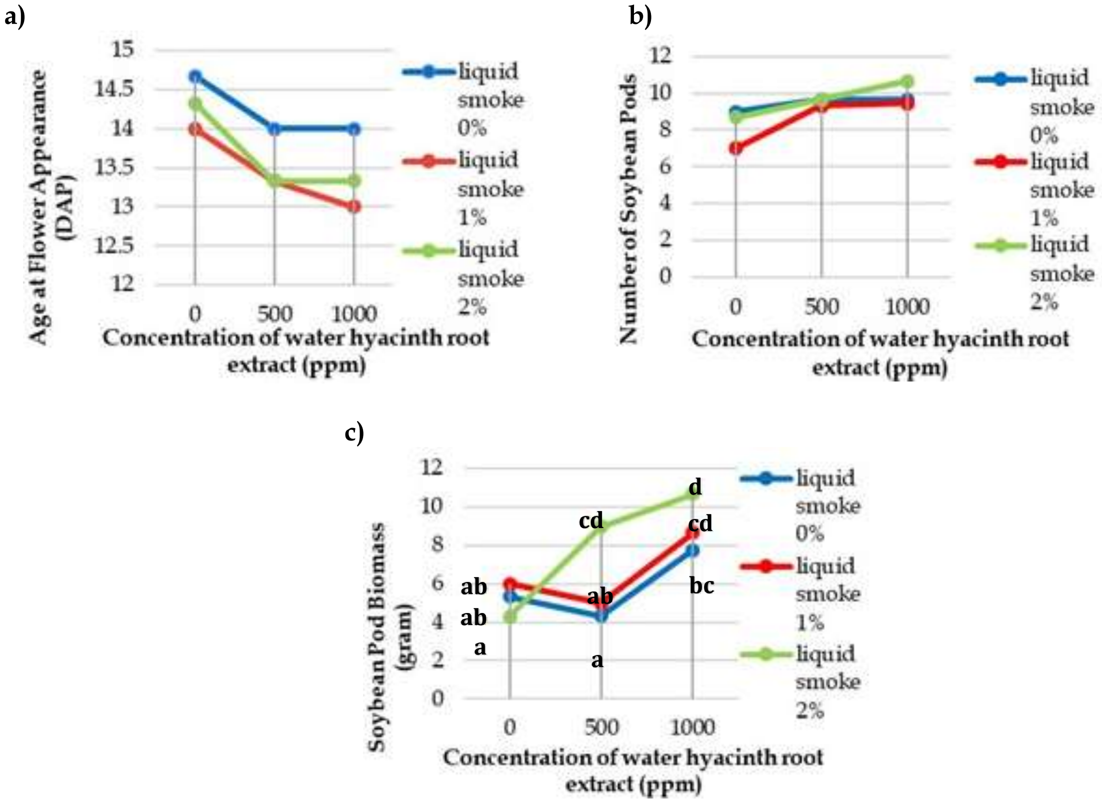

Figure 3. Effect of the combination of liquid smoke and water hyacinth root extract on a) age of flower emergence, b) number of pods, and c) pod biomass (Different letters on the graph indicate a significant effect based on Duncan's test at the 0.05 level).

DISCUSSION

Based on the results of laboratory testing on saline soil media before treatment (Table 1.), the results obtained sodium (Na) nutrient content in saline soil amounted to 1.20 cmol + / kg, which, according to Sulaeman *et al*. (2005) is classified as very high. The very high Na content indicates that the soil media used is soil with high salinity. Saline soils contain high concentrations of dissolved salts such as NaCl (Bhattarai *et al*., 2020). High Na^+ and Cl^- levels in saline soils can hinder nutrient absorption, dehydrate plants, and imbalance ions that will interfere with plant metabolism. Salinity affects many plant physiological processes, including water absorption, respiration, photosynthesis, and plant growth (Putri *et al*., 2017). According to Wahyuningsih *et al*. (2017), an increase in soil salinity causes a decrease in the development and yield of mung bean plants.

Based on the test results of nutrient content in saline soil before treatment (Table 1.), the measurement results of potassium (K) nutrient levels in saline soil amounted to 1.20 cmol +/kg with low criteria, nitrogen (N) element in saline soil amounted to 0.30% with moderate criteria, and phosphate (P_2O_5) nutrient levels amounted to 36 ppm with very high criteria. Phosphate pentoxide (P_2O_5) refers to the crystalline form of phosphorus in soil that binds to oxygen. The amount of P_2O_5 test results does not determine how much phosphorus is available in the soil. Phosphorus is absorbed by plants in the form of phosphate compounds such as orthophosphorus ($H_2PO_4^-$) and secondary orthophosphorus ions (HPO_4^{2-}) (Irawan *et al*., 2021). Soil salinity can also cause the availability of P in the soil to decrease. This decrease in P availability is caused by high levels of Na+ in the soil, which causes the absorption of Ca^{2+} and Mg^{2+} ions to decrease so that the amount of these ions in the environment increases. The increase of Ca^{2+} and Mg^{2+} ions causes phosphorus (P) to bind or be trapped by them, so plants cannot absorb it properly. According to research by Ding *et al*., 2020, high soil salinity can reduce the availability of P, N, and K elements in the soil.

The nutrient content in saline soil media based on laboratory test results (Table 1) is low. Therefore, efforts were made to increase the nutrient content in the soil due to salinity by providing mycorrhiza. Mycorrhiza can improve the soil's phosphate, calcium, potassium, manganese, sodium, copper, magnesium, and water uptake. According to the research of Rajmi *et al*. (2018), the application of AMF to P-available levels in the soil showed an increase of two times, namely from 5.83 ppm to 11.10 ppm. This is due to the phosphatase enzyme activity of AMF, which releases P ions from the soil to increase the availability of P for plants (Sutariati *et al*., 2014).

Based on the results of the research that has been carried out, it is known that the application of liquid smoke and water hyacinth root extract as a source of gibberellin affects the growth (Figure 1., Figure 2., and Figure 3.) of soybean plants in saline soil enriched by mycorrhiza. The parameters of this study include vegetative growth parameters (plant height, number of leaves, root length, wet biomass, number of root nodules, number of active root nodules, percentage of mycorrhizal infection, P content in leaves) and generative growth parameters (age of flower emergence, number of pods, pod biomass).

The research data showed that in the parameter of plant height (Figure 1), the results showed no significant effect on the interaction treatment of liquid smoke and water hyacinth root extract. However, water hyacinth root extract concentration treatment has a significant impact. In the parameter of the number of leaves (Figure 1.), the results showed no significant effect on the interaction treatment of liquid smoke and water hyacinth root extract. However, the treatment of liquid smoke concentration and concentration of water hyacinth root extract had a significant impact. In the root length parameter (Figure 1.), the results showed no significant effect on the interaction treatment of liquid smoke and water hyacinth root extract. However, water hyacinth root extract concentration treatment had a significant impact. The results of the wet biomass parameter (Figure 1.) significantly impact the interaction of liquid smoke and water hyacinth root extract. The combination of liquid smoke concentration of 2% and 1000 ppm water hyacinth root extract produced the highest average value of 17.67 grams.

Coconut shell liquid smoke contains various chemical components, including acetic acid, which is as much as 46.56%. Acetic acid is one of the compounds involved in the citric acid pathway (Krebs cycle). In secondary metabolites, pyruvate is decarboxylated in oxidation reactions by the enzyme pyruvate dehydrogenase to produce products; one is acetic acid, which binds to coenzyme-A to form acetyl -CoA. Acetyl-CoA is a precursor compound for the mevalonic acid pathway in gibberellin synthesis (Taiz and Zeiger, 2002). Plant gibberellins are mostly inactive, so activating them requires precursors (Asra *et al*., 2020). According to research by Putri *et al*. (2023), the application of coconut shell liquid smoke significantly affects the growth parameters of lettuce plants.

Liquid smoke acts as a precursor to gibberellin biosynthesis in plants, so when applied to plants, it still takes time from starting biosynthesis to producing endogenous gibberellin hormones that can affect plant growth. Therefore, exogenous gibberellin hormone is needed to support plant growth (Asra *et al*., 2020). Exogenous gibberellin hormone increases stem and leaf growth in plants, thus spurring the photosynthesis process, which results in increased growth in all plant organs (Sundahri *et al*., 2016). Water hyacinth root extract has been known to contain growth regulators, namely exogenous gibberellins. Umah and Rahayu (2019) showed that in 0.05 grams of water, hyacinth root extract contains exogenous gibberellin of 2995.50 ppm. Exogenous gibberellin hormone administration is optimal with the appropriate concentration setting (Sundahri *et al*., 2016). Research by Rima *et al*. (2024) showed that providing gibberellin with a concentration of 200 ppm had the best effect on cucumber plant growth.

Gibberellin hormone is an isoprenoid group compound with several properties, namely its crystalline form dissolves easily in acetone, ethanol, and methanol and dissolves with water in small amounts (Asra *et al*., 2020). Plants given gibberellin hormone will provide the primary response in stem length increase because gibberellin can increase the activity of cell division and enlargement. This increase in cell division and enlargement rate can encourage the formation of plant tissues and organs such as stems, leaves, and roots (Ichwan *et al*., 2020). Gibberellin promotes the production of cell wall softening enzymes, especially proteolytic enzymes responsible for releasing auxin precursors (amino acid tryptophan) so that auxin production increases (Asra *et al*., 2020). This auxin hormone can trigger cell elongation in the stem to encourage increased stem length (Asra *et al*., 2020).

Gibberellin hormone affects the stem elongation process through three stages, in stage one, cell division occurs at the end of the plant stem. In stage two, gibberellin will generate hydrolysis of starch, sucrose, and fructose into glucose and fructose to increase growth in plants in the respiration process so that energy is formed. In stage three, gibberellin can increase cell wall plasticity (Asra *et al*., 2020). Gibberellin will encourage the enzyme a-amylase, which will break amylum so that the sugar content in the cell increases, causing water to enter the cell and elongate. During respiration, mitochondria will take amylum from the breakdown and produce ATP, which will be used in cell development, growth, and expansion (Salisbury and Ross, 1995).

Research by Atika *et al*. (2018) reported that gibberellin application significantly affected the plant height of several varieties of mung beans (*Vigna radiate* L.) on saline soil. Sharfina and Yuliani (2023) also revealed that adding gibberellin hormone effectively increased the height of *Cosmos* sp. Research by Pertiwi *et al*. (2014) also showed that adding gibberellin hormone type GA3 affected the height of soybean plants (*Glycine max*). Nurita and Yuliani (2023) suggested that the provision of auxin hormones and gibberellin hormones significantly increased the number of leaves of eggplant plants (*Solanum melongena* var. Gelatik).

Wet biomass is an accumulation of plant height, number of leaves, and root length of soybean plants, so the higher the increase in plant growth, the higher the biomass of soybean plants (Figure 1.) The combination of liquid smoke treatment with a concentration of 2% and water hyacinth root extract concentration of 1000 ppm is the treatment with the highest plant height, number of leaves, and root length so that it affects the wet weight of soybean plants.

The treatment of liquid smoke concentration, water hyacinth root extract concentration, and their combination did not significantly affect the parameters of the number of root nodules and the number of active root nodules of soybean plants (Figure 2). The formation of root nodules is directly related to the amount of nitrogen fixation in the growing medium. A pink color characterizes active root nodules due to leghemoglobin in the inner part of the nodule. Active root nodules indicate the activity of free N2 inhibition by rhizobium. Gardner *et al*. (1991) revealed that the low rhizobium population influences the small size of rhizobium colonies in the roots. As a result, these colonies cannot enter the root reed and form root nodules.

The treatment of liquid smoke concentration, water hyacinth root extract concentration, and the combination of both did not significantly affect the percentage parameter of mycorrhizal infection of soybean plants. Mycorrhizal infection starts from the appressorium on the root surface, forming and entering into the epidermal cells of the root. Afterwards, hyphae will grow inside the cortex on some hosts, and hyphal coils outside the cortex will also form. Applying gibberellin hormone sourced from liquid smoke and water hyacinth root extract did not give a significantly different effect. Although gibberellin is essential in plant roots' growth and development, it also indirectly affects mycorrhizal development. Foo *et al*. (2013) suggested that applying exogenous gibberellins can inhibit arbuscular formation in pea plants. Gibberellins tend to affect the final stage of mycorrhizal colonization, especially in regulating arbuscular formation.

Based on the results of data analysis on the parameter of P nutrient levels in the tops of soybean plant leaves, the treatment of liquid smoke concentration, water hyacinth root extract concentration, and their interaction did not give a significantly different effect. The element phosphorus (P) plays a role in various metabolic mechanisms of carbohydrate compounds and photosynthetic reactions by forming cell nuclei and spreading the results of photosynthetic compounds to all parts of the plant, including reproductive organs (Saputra *et al*., 2018). In photosynthesis, phosphorus plays a role in the formation of ATP (Adenosine triphosphate), which plays a role in translocating photosynthate to plant organs in need (Wasilah *et al*., 2019). Phosphate elements also function to transfer and store energy, build roots, form fruit, divide cells, and form nucleoproteins that makeup DNA and RNA (Murtafaqoh and Winarsih, 2022). According to Nuryani *et al*. (2019), phosphorus is essential in cell elongation, division, and development by activating various enzymatic reactions. According to Taufiqurrohman and Dewi (2024), element P is one of the enzyme activators and regulates enzymatic reactions, such as in the process of amylose synthesis through the function of the enzyme phosphorylase glucosan.

Sodium levels strongly influence the availability of P elements that plants can absorb in saline soils. High sodium levels cause element P to bind or be trapped by similar ions, such as Al, Fe, Ca, and Mg, so its availability in the soil is small (Lele, 2023). Efforts to increase the availability of P elements in saline soils are carried out by applying mycorrhiza. Mycorrhizal fungi that are symbiotic with roots can help plant growth by expanding the absorption area and increasing the absorption of nutrients by the roots. Mycorrhiza can also increase the availability of P elements in the soil, this is due to the phosphatase enzyme produced by mycorrhiza, which works by releasing P ion bonds from organic complexes so that P availability increases and can be absorbed by plants (Sutariati *et al*., 2014).

Soybean plants reach the maximum vegetative period at 45 DAP (Lagiman *et al*., 2022), but in the research observations, soybean plants appear to flower before the maximum vegetative period ends. In the observation of the age of flowering of soybean plants, it can be seen that there is no significant effect on the concentration of liquid smoke, the concentration of water hyacinth root extract, and the interaction between the two on the age of flowering. In observing the number of pods (Figure 3.), the results showed no significant effect on the interaction treatment of liquid smoke and water hyacinth root extract. However, water hyacinth root extract concentration treatment has a significant impact. In the pod biomass parameter, liquid smoke concentration, water hyacinth root extract concentration, and the interaction between the two significantly affected the best pod biomass. The treatment of liquid smoke concentration of 2% and 1000 ppm water hyacinth root extract was the best treatment, with an average pod biomass of 10.67 grams.

The application of gibberellin hormones sourced from liquid smoke and water hyacinth root extract did not significantly affect the flowering age of soybean plants. In various cases, plants with high gibberellin can inhibit flowering, while plants with low gibberellin content will be induced to flower (Wiraatmaja, 2017). Husnul (2013) suggested that the gibberellin hormone activates floral meristem genes by producing proteins that can stimulate the expression of genes that form flower organs in plants. Gibberellin hormone can generate hydrolysis of starch, sucrose, and fructose into glucose and fructose needed in respiration so that energy formation occurs (Asra *et al*., 2020). The energy produced from the hydrolysis process of amylum, sucrose, and fructose due to applying gibberellin hormone to plants can stimulate the flowering process of plants so that flowers appear faster.

External factors such as environmental conditions also affect flowering in soybean plants. Soybean plants grow optimally at a temperature of 23 - 27 ° C, 12 hours of sunlight per day, and the most optimum rainfall between 100-200 mm/month. When soybean planting occurs, the surrounding weather conditions are often rainy and cloudy, so soybean plants do not get 12 hours of sunlight. Soybeans are included in short-day plants, and if the irradiation is less than 12 hours, it will accelerate the flowering process (Jayasumarta, 2012). Safitri and Islami (2018) revealed that soybean plants produce many flowers at the beginning of the generative period, but the possibility of flower miscarriage is 40-80%. Gibberellin application during the generative period can increase the resistance of soybean flowers and pods because GA3 gibberellin can prevent flower abscission by indirectly increasing auxin content (Sahur, 2021). The more flowers that become pods, the more pods there are, and so is the biomass of soybean pods.

CONCLUSION

This study explains that the application of liquid smoke from coconut shells affects the vegetative and generative growth of soybean plants in saline soil enriched with mycorrhiza on the parameters of the number of leaves, root length, wet biomass, and pod biomass. Applying water hyacinth root extract affects soybean plants' vegetative and generative growth in saline soil enriched with mycorrhiza in the parameters of plant height, number of leaves, root length, wet biomass, number of pods, and pod biomass. The interaction of coconut shell liquid smoke and water hyacinth root extract affected soybean plants' vegetative and generative growth in mycorrhiza-enriched saline soil on wet biomass and pod biomass parameters. The combination of liquid smoke treatment at 2% concentration and water hyacinth root extract at 1000 ppm concentration had the best effect on soybean plant growth.

ACKNOWLEDGEMENTS

The authors would like to thank Balai Besar Pelatihan Pertanian (BBPP) Ketindan for providing research materials and Badan Standarisai Instrumen Pertanian (BSIP) Aneka Kacang for their assistance during data collection.

CONFLICT OF INTEREST

There is no conflict of interest.

REFERENCES

Advinda L, 2018. *Dasar–dasar fisiologi tumbuhan*. Yogyakarata: Deepublish.

Andriani V and Ajiningrum PS, 2021. Pertumbuhan, produksi dan kandungan biokimia tanaman cabai rawit (*capsicum frutescens* l.) pada perlakuan kombinasi ekstrak kulit singkong dan akar eceng gondok. *Teknosains: Media Informasi Sains dan Teknologi*, 15(2): 161-169.

Arif M, Murniati M and Ardian A, 2016. Uji beberapa zat pengatur tumbuh alami terhadap pertumbuhan bibit karet (*Hevea brasiliensis* Muell Arg) stum mata tidur. *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau*, 3(1) : 1-10.

Asra R, Samarlina RA and Silalahi M, 2020. *Hormon Tumbuhan*. Jakarta: UKI Press.

Atika R, Bayu ES and Kardhinata EH, 2018. Respons pertumbuhan dan produksi beberapa varietas kacang hijau (*Vigna radiata* L.) dengan pemberian giberelin di lahan salin. *Jurnal Pertanian Tropik*, 5(3): 384-390.

Bhattarai S, Biswas D, Fu YB and Biligetu B, 2020. Morphological, physiological, and genetic responses to salt stress in alfalfa: A review. *Agronomy,* 10(4): 577.

Bili HY, Yuniwati ED and Rahayu YS, 2019. Efektivitas Penggunaan Asap Cair dan Biochar Pada Budidaya Tanaman Cabe Rawit (*Capsicum frutescens*). *Primordia,* 15(1): 1-8.

Ding Z, Kheir AM, Ali MG, Ali OA, Abdelaal AI, Lin XE, Zhou Z, Wang B, Liu B, and He Z, 2020. The integrated effect of salinity, organic amendments, phosphorus fertilizers, and deficit irrigation on soil properties, phosphorus fractionation, and wheat productivity. *Scientific Reports,* 10(1): 2736.

Foo E, Ross JJ, Jones WT and Reid JB, 2013. Plant hormones in arbuscular mycorrhizal symbioses: an emerging role for gibberellins. *Annals of botany,* 111(5): 769-779.

Gardner FP, Pearce R and Mitchell RL, 1991. *Fisiologi Tanaman Budidaya*. Jakarta. UI-Press.

Hajoeningtijas OD, Suyadi A and Ardiana US, 2018. Produksi Inokulan Fungi Mikoriza Arbuskula Pada Media Perbanyakan dan Spesies yang Berbeda. *In Seminar Nasional Pertanian Peternakan Terpadu,* 1(02): 20-38

Hegazi AM, El-Shraiy AM and Ghoname AA, 2015. Alleviation of salt stress adverse effect and enhancing phenolic anti-oxidant content of eggplant by seaweed extract. *Gesunde Pflanzen,* 67(1): 21-31.

Husnul AH, 2013. Pengaruh Hormon Giberelin dan Auksin terhadap Umur Pembungaan dan Persentase Bunga menjadi Buah pada Tanaman Tomat (*Lycopersicum esculentum* Mill.). *Jurnal hort,* 11(1): 66-72.

Ichwan, Syakur W, and Lasmini SA, 2020. Pengaruh Pemberian Berbagai Macam Pupuk Kandang Terhadap Pertumbuhan Stek Tanaman Anggur (*Vitis vinifera* L.). *Jurnal Agrotekbisnis,* 8(3): 588-596.

Ihsan GT, Arisanty D and Normelani E, 2016. Upaya Petani Meningkatkan Produksi Padi di Desa Tabihi Kecamatan Padang Batung Hulu Sungai Selatan. *Jurnal Pendidikan Geografi,* 3(2): 11-20.

Irawan S, Tampubolon K, Elazhari E and Julian J, 2021. Pelatihan pembuatan pupuk cair organik dari air kelapa dan molase, nasi basi, kotoran kambing serta activator jenis produk EM4. *Journal Liaison Academia and Society,* 1(3): 1-18.

Jayanudin and Suhendi E, 2012. Identifikasi Komponen Kimia Asap Cair Tempurung Kelapa Dari Wilayah Anyer Banten. *Jurnal Agroekoteknologi,* 4(1): 39-46.

Jayasumarta D, 2012. Pengaruh sistem olah tanah dan pupuk P terhadap pertumbuhan dan produksi tanaman kedelai (*Glycine max* L. Merril). *AGRIUM: Jurnal Ilmu Pertanian,* 17(3): 1-7

Karolinoerita V, Annisa W, 2020. Salinisasi lahan dan permasalahannya di Indonesia. *Jurnal Sumberdaya Lahan,* 14 (2): 91-99.

Kementerian Perdagangan RI, 2021. Analisis perkembangan harga bahan Pangan pokok di pasar domestik dan internasional. Jakarta: *Pusat Pengkajian Perdagangan Dalam Negeri, Badan Pengkajian dan Pengmbangan Perdagangan, Kementerian Perdagangan Republik Indonesia.* p, 134.

Lagiman L, Suryawati A and Widayanto B, 2022. *Budidaya Tanaman Kedelai Di Lahan Pasir Pantai*.

Lele OK, 2023. Peran Endomikoriza and Tingkat Ketersediaan Air pada Tanah Vertisol terhadap Peningkatan Serapan Fosfor dan Hasil Paprika. *Savana Cendana,* 8(1): 1-5.

Lindun, 2014. *Teknologi Aplikasi Zat Pengatur Tumbuh.* Jambi: Balai Latihan Pertanian.

Murtafaqoh VN and Winarsih W, 2022. The Influence of Giving Vegetable Waste Leachate as Liquid Organic Fertilizer on the Growth of Mustard Plants (*Brassica juncea* L.). *LenteraBio : Berkala Ilmiah Biologi,* 11(3): 449–456.

Nasution TH, Rosmayati R and Husni Y, 2013. Respons Pertumbuhan Dan Produksi Kedelai (*Glycine max* (L.) Merrill) Yang Diberi Fungi Mikoriza Arbuskular (Fma) Pada Tanah Salin. *Jurnal Agroekoteknologi Universitas Sumatera Utara,* 2(1): 97572.

Nurita FD and Yuliani Y, 2023. The Effect of Auxin and Gibberellin Combination on the Growth and Parthenocarpy of Eggplant (*Solanum melongena* var. Gelatik). *LenteraBio : Berkala Ilmiah Biologi,* 12 (3): 457–465.

Nuryani E, Haryono G and Historiawati H, 2019. Pengaruh Dosis dan Saat Pemberian Pupuk P terhadap Hasil Tanaman Buncis (*Phaseolus vulgaris,* L.) Tipe Tegak. *VIGOR: Jurnal Ilmu Pertanian Tropika dan Subtropika*, 4(1): 14-17.

Pertiwi PD, Agustiansyah A and Nurmiaty Y, 2014. Pengaruh giberelin (ga3) terhadap pertumbuhan dan produksi tanaman kedelai (*Glycine max* (L.) Merrill.). *Jurnal Agrotek Tropika,* 2(2): 276-281.

Putri NH, Melani D and Rahayu YS, 2023 Pengaruh Pemberian Asap Cair dari Tempurung Kelapa terhadap Pertumbuhan dan Produktivitas Tanaman Selada (*Lactuca sativa* L.). *Makalah disajikan dalam Seminar Nasional Biologi "Inovasi Penelitian dan Pembelajaran Biologi VII (IP2B VII) 2023.*
Putri PH, Susanto GWA and Taufiq A, 2017. Toleransi genotipe kedelai terhadap salinitas. *Penelitian Pertanian Tanaman Pangan,* 1(3): 233-242.
Rajmi SL, Margaretha M and Refliati R, 2018. peningkatan ketersediaan P ultisol dengan pemberian fungi mikoriza arbuskular. *Jurnal Agroecotania: Publikasi Nasional Ilmu Budidaya Pertanian,* 1(2): 42-48.
Ridhua K, Irawan D and Inthifawzi R, 2019. Proses pembakaran pirolisis dengan jenis biomassa dan karakteristik asap cair yang dihasilkan. *Turbo: Jurnal Program Studi Teknik Mesin,* 8(1): 69-78.
Rima BK, Oktarina O and Murtiyaningsih H, 2024. Efektivitas Konsentrasi Giberelin (Ga3) Dan Waktu Penyiangan Terhadap Pertumbuhan Dan Hasil Tanaman Mentimun (*Cucumis Sativus* L.). *Callus: Journal of Agrotechnology Science,* 2(1): 34-43.
Rohmah EA and Saputro TB, 2016. Analisis Pertumbuhan Tanaman Kedelai (*Glycine max* L.) Varietas Grobogan Pada Perlakuan Cekaman Genangan. J*urnal Sains dan Seni ITS,* 5(2): 29-33
Safitri ND and Islami T, 2018. Pengaruh Tingkat Pemberian Air dan Waktu Aplikasi GA3 pada Pertumbuhan dan Hasil Tanaman Kedelai (*Glycine Max* L. Merrill). *Jurnal Produksi Tanaman,* 6(3): 470-478.
Sahur A, 2021. *Teknologi Mikroba: Actinomycetes dan Rhizobium untuk Perbaikan Pertumbuhan dan Produksi Tanaman Kedelai.* Ficus Press
Salisbury FB and Ross CW, 1995. *Fisiologi Tumbuhan Jilid 3. Edisi Keempat*. Bandung: Penerbit ITB.
Saputra D, Timotiwu PB and Ermawati, 2015. Pengaruh Cekaman Kekeringan terhadap Pertumbuhan dan Produksi Benih Lima Varietas Kedelai. *Jurnal Agrotek Tropika,* 3(1): 7-13.
Sari S and Zahrosa DB, 2022. Lahan Marginal Menyimpan Ragam Potensi. Jember: Polije Press.
Sharfina F and Yuliani Y, 2023. Appropriation of Various Concentrations of Gibberellin on the Growth and Flowering Kenikir Plants (*Cosmos* sp.). *LenteraBio : Berkala Ilmiah Biologi,* 12(3): 396–404.
Suhendi E, 2012. Identifikasi komponen kimia asap cair tempurung kelapa dari wilayah Anyer Banten. *Jurnal Agroekoteknologi,* 4(1): 39-46.
Sulaeman, Suparto and Eviati, 2005. *Analisis Kimia, Tanah, Tanaman, Air, dan Pupuk*. Bogor: Balai Penelitian Tanah.
Sundahri S, Tyas HN and Setiyono S, 2016. Efektivitas pemberian giberelin terhadap pertumbuhan dan produksi tomat. *Agritrop: Jurnal Ilmu-Ilmu Pertanian (Journal of Agricultural Science),* 14(1): 42-47
Sutariati GAK, Khaeruni AR and Muhidin, 2014. *Biofertilizer: Solusi Teknologi Pengembangan Lahan Sub Optimal.* Unhalu Press, Kendari.
Taiz l and Zeiger E, 2002. *Plant Physiology*. sinauer associates
Taufiqurrohman H and Dewi SK, 2024. Effectiveness of Liquid Organic Fertilizer Made from Sugarcane Bagasse and Rice Water on Green Spinach Plants (*Amaranthus hybridus* L.). *LenteraBio : Berkala Ilmiah Biologi,* 13(1), 184–190.
Ummah K and Rahayu YS, 2019. The effect of gibberellin extracted from Eichhornia crassipes root on the viability and duration of hard seed germination. *In Journal of Physics: Conference Series, 1417 (1): 012037. IOP Publishing.*
Wahyuningsih S, Kristiono A and Taufiq A, 2017. Pengaruh ameliorasi tanah salin terhadap pertumbuhan dan hasil kacang hijau. *Buletin Palawija,* 15(2): 69-77.
Wasilah QA, Winarsih and Bashri A, 2019. Pengaruh Pemberian Pupuk Organik Cair Berbahan Baku Limbah Sisa Makanan dengan Penambahan Berbagai Bahan Organi terhadap Pertumbuhan Tanaman Sawi (*Brassica juncea* L.). *LenteraBio,* 8(2): 136-142.
Wiraatmaja IW, 2017. *Zat Pengatur Tumbuh Giberelin dan Sitokinin*. Bali: Universitas Udayana.