Effect of Foliar Aqueous Garlic Extracts on The Growth and Yield of Indian Mustard (*Brassica juncea* (L.) Czernjaew)

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A Thesis submitted in fulfillment of the requirement for Bachelor of Applied Science (Agrotechnology) with Honor

Faculty of Agro Based Industry

Universiti Malaysia Kelantan

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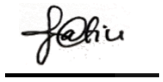
DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institution.



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Effect of Foliar Aqueous Garlic Extracts on The Growth and Yield of Indian Mustard (*Brassica juncea* (L.) Czernjaew)

ABSTRACT

The extensive use of chemical fertilizers possess serious treats to environment, increase pest resistance development, and decline the food safety. Applying plant natural extract to partially replace the chemical fertilizer is a promising approach towards achieving sustainable agriculture development. Therefore, an experiment was conducted at University Malaysia Kelantan (UMK) Jeli Campus, Kelantan, Malaysia to evaluate the efficacy of aqueous garlic extracts on the growth and yield of Indian mustard (*Brassica juncea* (L.) Czernjaew). In this study, Indian mustard plants were treated with foliar application of aqueous garlic extract under shelter house. The aqueous garlic extract was applied at 15 and 25 days after seed sowing with three application rates: 0 (control) (**T0**), 50 µg mL^{-1} (**T1**), 100 µg mL^{-1} (**T2**), and 200 µg mL^{-1} (**T3**). The result from this study showed that there was significant stimulating effect on the growth and yield of Indian mustard at an application rate of 100 µg mL^{-1} (**T2**) for all plant growth parameters, except chlorophyll content. It was found that **T2** showed significant increment ($P \leq 0.05$) in term of plant height (60.58%), fresh weight (67.29%), dry weight (63.74%) and leaf diameter (27.09%) as compared to control. However, the chlorophyll content of Indian mustard at **T2** was likely similar to control and **T3**. Thus, this study proved that the optimum growth and yield of Indian mustard was successfully achieved when the plant treated with 100 µg mL^{-1} foliar application of aqueous garlic extract.

Key words: Aqueous garlic extract, foliar spray, plant growth, Indian mustard (*Brassica juncea* (L.) Czernjaew)

Kesan Foliar Ekstrak Akueus Bawang Putih Terhadap Pertumbuhan dan Hasil Sawi India (*Brassica juncea* (L.) Czernjaew)

ABSTRACT

Penggunaan baja kimia yang ekstensif menimbulkan ancaman yang serius terhadap alam sekitar, meningkatkan pembangunan kerintangan perosak, dan menurunkan keselamatan makanan. Penggunaan ekstrak semula jadi tumbuhan yang menggantikan sebahagian baja kimia adalah pendekatan yang berpotensi ke arah pencapaian pembangunan pertanian yang mampan. Oleh itu, satu kajian telah dijalankan di Universiti Malaysia Kelantan (UMK) Kampus Jeli, Kelantan, Malaysia untuk menilai keberkesanan ekstrak akueus bawang putih terhadap pertumbuhan dan hasil sawi India (*Brassica juncea* (L.) Czernjaew). Dalam kajian ini, pokok sawi India telah dirawat dengan aplikasi foliar ekstrak akueus bawang putih dibawah rumah lindungan. Ekstrak akueus bawang putih digunakan pada hari ke-15 dan 25 selepas penyemaian benih dengan tiga kadar aplikasi: 0 (kawalan) (**T0**), 50 µg mL^{-1} (**T1**), 100 µg mL^{-1} (**T2**), dan 200 µg mL^{-1} (**T3**). Hasil daripada kajian ini menunjukkan bahawa terdapat kesan rangsangan yang signifikan terhadap pertumbuhan dan hasil sawi India pada kadar aplikasi 100 µg mL^{-1} (**T2**) untuk semua parameter tumbuhan, kecuali kandungan klorofil. Didapati bahawa **T2** menunjukkan kenaikan yang signifikan ($P \leq 0.05$) dari segi ketinggian tumbuhan (60.58%), berat segar (67.29%), berat kering (63.74%) dan diameter daun (27.09%) berbanding kawalan. Walau bagaimanapun, kandungan klorofil sawi India pada **T2** seakan sama dengan kawalan dan **T3.** Oleh itu, kajian ini membuktikan bahawa pertumbuhan optimum dan hasil sawi India berjaya dicapai apabila tumbuhan dirawat dengan 100 µg mL^{-1} foliar ekstrak akueus bawang putih.

Key words: Ekstrak akueus bawang putih, foliar, pertumbuhan pokok, sawi India (*Brassica juncea* (L.) Czernjaew)

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LIST OF SYMBOL AND ABBREVIATIONS

℃	Degree Celsius
%	Percent
cm	Centimeter
g	Gram
mm	Millimeter
$\mu g\ mL^{-1}$	Micrograms per milliliter
N	Nitrogen
P	Phosphorus
K	Potassium
ha	Hectare
:	Ratio
ANOVA	Analysis of Variance

CHAPTER 1

INTRODUCTION

1.1 Research background

Brassica juncea (L.) Czernjaew, also known as Indian mustard, is also simply known as 'sawi pahit.' It is a member of the Brassicaceae family and is thought to have originated in Central Asia. Oilseed and vegetable mustards are the two types of mustards that have evolved. Leaf mustard is widely grown in South-East Asia. In our local market, leaf mustard is a popular leafy vegetable. This vegetable is eaten in a variety of ways, including raw, stir-fried, pickled, or brined. It has a strong flavour as well as a strong odour (DOA,2021).

Garlic (*Allium sativum*) is a nutrient-dense extract that contains over 200 biochemical compounds such as antioxidants and vitamins (Mohamed, 2014). It's rich in volatile and Sulphur compounds like allicin, allyl propyl, among others (El-Saadony *et al.*,2017). Garlic includes useful chemical components such as enzymes, vitamins, flavonoids, and organosulfur compounds such as allicin, diallyl-disulfide, and thiosulfates (Block, 1985) (Bhuiyan *et al.,* 2015; Borlinghaus *et al.,* 2014).

Garlic (*Allium sativum*), one of many helpful plant species, has been used as a medicinal treatment from the beginning of development (Bayan *et al.,* 2014). It possesses effective antibacterial properties against a wide range of bacteria, fungi, and viruses (Ayazi *et al.,* 2011; Aala *et al.,* 2014; Afzal *et al.,* 2000). Furthermore, Chan and Miron (2013) stated that garlic's antioxidant capacity has been proven to be useful in a variety of cardiovascular complications and to exhibit anticancer characteristics. According to research, garlic plantations play an important allelopathic effect in cropping systems, enhancing the development of nearby crops. Nonetheless, its allelopathy was already proposed to implement cropping system ecology, like improving the soil, which in turn improves receiver plant development (Han *et al.,* 2012; Ahmad *et al.,* 2013).

According to Kerin and Berova (2003) foliar sprays have gained popularity due to the numerous benefits of foliar nutrient administration methods, such as quick and adequate responsiveness to plant demands independent of soil conditions. Additional foliar treatment during crop growth and development can enhance nutrient balance, potentially leading to increased yield and quality (Kolota E, *et al.,* 2001). According to a recent assessment (Fernández V, *et al.,* 2009), foliar sprays is an agricultural method that is becoming more important in practice. Theoretically, nutrient spray application may be an environmentally beneficial fertilizing strategy since nutrients are provided straight to the crops in controlled volume, thus it is aid in lessen the environmental effect accompanied with soil fertilization.

1.2 Problem Statement

Plants absorb nutrients through the roots and through the foliage. Many plant nutrients are needed in such great quantities that it is impractical to supply them through the foliage. However, when soil conditions are unfavorable or micronutrients are needed, it desirable to make foliar applications of the plant nutrients. According to Calvo (2014) bio stimulants foliar spray is a substances or materials apart from nutrients that can be used to regulate physiological processes in plants to stimulate growth. Previous studied conducted by Cheng (2011), garlic has a strong biological and positive influence on plant growth and yield. The application of aqueous garlic extract to the leaves promotes plant growth by stimulating photosynthetic pigments (Hanafy *et al.* 2012). However, little known about the efficacy aqueous garlic extract as a biostimulator in plants and there has been no previous research on the growth and yield of Indian mustard using bio stimulants foliar aqueous garlic extract. Therefore, this study was carried out to investigate the effect of foliar aqueous garlic extracts on the vegetative growth of Indian mustard *(Brassica juncea* L. Czernjaew).

1.3 Objective

1) To determine the effect of different rates of foliar aqueous garlic extract on the growth and yield of Indian mustard (*Brassica juncea* L. Czernjaew).

1.4 Hypothesis

The Hypothesis of this study is that

a) H0: There was no significant increase of foliar aqueous garlic extract on the growth and yield of Indian mustard (*Brassica juncea* L. Czernjaew).

b) H1: There was a significant increase of foliar aqueous garlic extract on the growth and yield of Indian mustard (*Brassica juncea* L. Czernjaew).

1.5 Scope of Study

This study was focusses on the effect of foliar aqueous garlic extract on Indian mustard in term of growth (plant height, root length, number of leaves, leaf diameter, chlorophyll content) and yield parameters, (fresh and dry weight).

1.6 Significance of Study

The purpose of this study is to determine the effect of foliar aqueous garlic extract on the growth of Indian mustard. Due to their natural origin, they are excellent candidates to replace synthetic compounds, which are generally considered to have toxicological and carcinogenic effects and can directly have beneficial effects on humans and the

environment. Hence, this research will help farmers improve the growth and yield of Indian mustard (*Brassica juncea* L. Czernjaew).

Foliar application allows for the rapid correction of plant nutrient deficiencies when they are identified on the plant. It frequently provides a convenient method of applying fertilizer materials, particularly those that must be applied in very small amounts and those that are highly soluble. Besides nutrients applied to foliage are generally absorbed faster than nutrients applied to soil. According to Hussein (2014) garlic extracts or garlic-derived chemicals compound could promote the biology and psychology of the receiving plant.

CHAPTER 2

LITERATURE REVIEW

2.1 Botany life cycle and taxonomy of Indian mustard (*Brassica juncea* L. Czernjaew)

Figure 2.1: Indian Mustard (*Brassica juncea* L. Czernjaew)

Brassica juncea L Czernjaew, often known as leafy mustard which a member of the Brassicaceae family. It is a mustard with lustrous green leaves that grows slowly (Pant *et al.*, 2020). It is a native of Central and Eastern Asia and is eaten as a green leafy vegetable from China to South America. The major growers and suppliers of leafy mustard are Asian nations such as India, China, and Japan. It is grown in tiny patches in backyards, on farmed ground, and in hilly sections of Uttarakhand and certain North-eastern states.

Taxonomy of Indian Mustard:

Domain: Eukaryota

Kingdom: Plantae

Division: Spermatophyta

Class: Magnoliopsida

Order: Capparales

Family: Brassicaceae

Genus: Brassica L. (Mustard)

Species: *Brassica juncea* (L.) Czernjaew

2.1.1 Morphological and Ecological Requirement of Indian mustard

Indian Mustard is a shrub with green leaves that grows vertically to a height of 30-120 cm. Short fibrous roots are the most common form of root. Indian mustard has a terminal raceme inflorescence that are green at first and subsequently yellowish. Mustard seeds can develop up to 10-20 seeds per stem, each measuring 1-1.5 mm in diameter. Leaf mustard is an unbranched, upright annual plant with varied leaf shapes and sizes, either heading or non-heading. It thrives on well-drained loamy soils that are rich and well-drained (DOA, 2021). When the mustard seeds are dry enough, they can germinate in three to five days. Because of its chemical composition, Indian mustard has a harsh flavour when cooked. According to Agro, (2011) broad leaf mustard, dissected leaf mustard, head leaf mustard, tillering mustard, stem mustard, shoot mustard, and root mustard are some of the Indian mustard species produced across the world.

2.2 Nutritional Value of Indian Mustard

The food requirements of a rising population are increasing over time, while available land resources are dwindling due to aridity (Witt & Dunn, 2012). Leafy vegetables, both raw and cooked, are often used as least expensive source of energy to

compensate for malnutrition. Furthermore, leafy vegetables are a source of important nutrients such as carbohydrates, protein, vitamins, calcium, and minerals also considered a part of well-balanced diets (Savage, J *et al.*, 2013). Green vegetables contain high levels of antioxidants, which protect us from free radicals and helps in reduce health risks such as cardiovascular disease and cancer (Aune, D *et al.*, 2017).

Rauniyar and Bhattarai (2017) stated that crispy and peppery leafy mustard has wide and soft leaves with high moisture content and a thick sensitive stem that may be utilised to make saag. Green leaves can be eaten fresh as a salad or cooked. Aside from their peppery flavour, Indian mustard contains a variety of phytonutrients, including vitamins A, B, C, and E. They are also high in iron, calcium, and protein, and have health-promoting and disease-prevention characteristics.

According to Macready (2014), regular intake of Indian mustard as a vegetable in the diet protects consumers against iron deficiency, osteoporosis, and different cardiovascular illnesses, as well as playing essential roles in the treatment of arthritis and asthma. Besides, cooked Indian mustard greens is a good source of nutrients, vitamins, and minerals. Consuming 140 gram of cooked mustard green offers 829.8 µg of Vitamin K, 865 µg of Vitamin A, 35.4 mg of Vitamin C, 0.8 mg of Selenium,0.204 mg of copper, 2.49 mg of Vitamin E, 165 mg of Calcium,1.22 mg of Iron,0.3 µg of Betaine and 0.137 mg of Vitamin B6 (USDA, 2019).

2.3 Production and Economic importance

According to the Department of Agriculture Peninsular Malaysia (DOA,2019), in 2019, mustard recorded the second highest production after round cabbage which is 4.4kilogram per capita consumption (PCC) in a year. Besides, Self-sufficiency ratio (SSR) of mustards shows 97.6 percent, indicating that there wasn't enough supply to fulfil local demand (Department of Statistic Malaysia, 2020). Based on hectarage and production of vegetables in Malaysia, the planted area for mustard is about 11,462 hectares with a total yield of 146,894 metric tons in (DOA,2020). Johor has had the largest mustard field with 2,280 hectares and a yield of 23,565 metric tons, followed by Pahang with 1,075 hectares and 9,207 metric tons and Sarawak with 932 hectares.

2.4 Influence of Foliar Spray Application on the leafy vegetables

According to Fageria (2009), the increased interest in foliar sprays is due to the development of high concentration soluble fertilisers or bio-stimulants, as well as machinery for spraying fungicides, herbicides, and insecticides, as well as operating cost in water management, which facilitates the application of nutrients to crops in the form of sprays. Agriculture advancements include lowering crop production costs, protecting

soil quality, employing adequate nutrients, and the application techniques correlated with these aims. Kannan S (2010) stated that, foliar spray cannot replace soil fertilisation, but it may be used in conjunction with soil treatments in sustainable crop production. Foliar application has a slew of significant advantages. It may be employed throughout the growing season, allowing for spraying with a small volume and composition of nutrient solution adapted to the unique demands of the crop at different phases of development (Fernández V *et al.*, 2009).

2.5 Aqueous Garlic Extract

To this point, various medicinal plants have been studied for their bioactive components and effects on the bioactivities of both the receiver plants and the surrounding environment (Perelló *et al.*, 2013; Sheren *et al.*, 2015). Garlic is one of these medicinal plants with a fantastic reputation for having good antimicrobial properties. Advances have been made in evaluating and understanding the allelopathic ability of garlic on neighboring crops over the last decade (Wang *et al.*, 2015). Furthermore, numerous scientific research has demonstrated the antioxidant properties of garlic-derived compounds, illustrating their active function as an anticancer agent and a treatment for a variety of cardiological issues in human health (Pan and Wu, 2014).

However, few studies have been performed in the field of plant processing, and the use of garlic-based botanicals as growth promoters and the specific responses of receiver plants to understand the bioactive mechanism are less well known. Previous research has shown that aqueous garlic extracts can play an active role in the activation of antioxidant enzymes in cucumber plants, with varying effects on the plant's growth depending on the extract concentration (Hayat *et al.,* 2016). Garlic is a bio stimulant that has been studied for its direct action against pathogens as well as its role in the physiological responses of receiver plants.

Previous research on garlic effects on other plants has mostly been conducted in the field or in pots (Wang *et al.,* 2014, 2015). The effect of concentration is critical for the application of garlic extract to agricultural production among these factors. Similarly, several factors influence the aqueous garlic extract, including the form and variety of receptor plant, extract concentration, and environmental conditions (Xiao *et al.,* 2013).

CHAPTER 3

METHODOLOGY

3.1 Study site

This study was conducted at University Malaysia Kelantan (UMK) Jeli Campus, Kelantan, Malaysia with the temperature ranging from 25℃ to 35℃ and 80-90% relative humidity. The project was conducted in a shelter house which is at the Agro-Techno Park.

3.2 Plant Materials

Seed of bioassay species, Indian mustard was purchased from Eco shop in Kota Bharu. Meanwhile garlic powder (*Allium sativum*) was purchased from A&T ingredients shop in Shopee.

3.2.1 Apparatus/Equipment

Below are the list of apparatus and equipment that was used in this study:

Table 3.1: The Apparatus/Equipment that used in these studies

Activity	Apparatus/ Equipment
1. Garlic Extract Preparation	- Garlic powder - Filter paper - Beaker - Measuring cylinder - Weighing scale - Media bottle - Spatula
2. Plant growth experiment	- Polybag 15x14 - Seedling tray - Watering can - Topsoil - Cocopeat - NPK Fertilizer - Chicken Manure
3. Data collection	- Ruler/Measuring tape (plant height) - Calipers (leaf diameter) - SPAD meter (chlorophyll content) - Digital scale (fresh weight) - Dry oven (dry weight) - No of leaves
4. Data analysis	- SPSS Software

3.3 Methods

3.3.1 Garlic Extract Preparation

The garlic extract was prepared by dissolving 10g of garlic powder extract in 100ml of distilled water. This mixing then was agitated vigorously by using an orbital shaker at 25˚C at 100 revolutions per minute (rpm) for at least 1 day (24 hours) (Norhafizah, Yew, Ismail & Chuah, 2013). The prepared aqueous extract was filtered through Whatman No. 1 filter paper. To get final concentrations, serial dilutions with distilled water were performed. The total treatments that were applied on the bioassay species as follows in Table 3.2.

Table 3.2: Treatments that were conducted in this study

Treatment	Application Rate
T0 (control)	Soil + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T1	Soil + 50 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T2	Soil + 100 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T3	Soil + 200 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)

3.3.2 Plant Growth Experiment

Indian mustard seed were sowing in seedling tray holes for germination at the nursery located in Agro-Techno Park, UMK Jeli. By using peatmoss as a media, the seed were sown at the depth of 3-5 cm around 1-2 seeds in one hole. The seeds were watered twice daily which is in early morning and late evening to keep the moisture of the media and helps to soften the seed coating. For germination rate, Indian mustard seeds take seven to twelve days to germinate.

Preparation of media for transplanting was done one week before. The topsoil was taken from Agro-Techno Park, UMK and the area has not yet been cultivated. The topsoil and cocopeat are mixed with ratio 3:2. The mixed soil was weighted by using weight scale before placed into polybag. Each polybag contains 1kg of mixed soil. During transplanting, a hole was formed in the middle of each polybag to allow the seedling to be transplanted. The plant was transplanted in the early morning and was watered twice daily which in the early morning and late evening. Weeding was also done on a regular basis to care for the bio-assay plant.

Aqueous garlic extract at different levels of concentrations which is 50 µg mL^{-1} 100 µg mL^{-1} and 200 µg mL^{-1} was applied as foliar spray with a spraying volume of 160L/ha (equivalent to 45 ml per plant). The plant was sprayed directly to the plant's leaves until the mixture dripping from the leaves. The Indian mustard was treated at day

15 and day 25 of planting. All treatments are in three replications. Non-treated Indian mustard was served as control treatment. The Indian mustard was harvested after 30 days of planting.

3.3.3 Growth Parameter

3.3.3.1 Plant Height

Plant height of Indian mustard was measured at the end of experiment using measuring tape. The height of Indian mustard was measured excluding roots after 30 days of planting.

3.3.3.2 Fresh Weight and Dry Weight

The fresh weight was measured at maturity stage by using digital balance. Roots was removed, and Indian mustard plants was put on the digital balance after being clean under tap water. The dry weight of Indian mustard was measured after been placed in the oven for 24 hours at 70℃.

3.3.3.3 Chlorophyll content

Chlorophyll contents of plants was measured using SPAD meter (Spectrum SPAD-502 Plus). The SPAD-502 meter generates a value that is proportionate to the quantity of chlorophyll concentration. Chlorophyll content readings was taken at three places of the same leaves and mean was calculated.

3.3.3.4 Leaf Diameter

Leaf diameter of the Indian mustard was measured at the end of experiment by using vernier calipers. For leaf diameter, the length of each plant's longest leaf was measured.

3.3.4 Statistical Analysis

Experiment will be arranged in a completely randomized design (CRD) with three replications. All data will be subjected to one-way ANOVA analysis. The Tukey HSD will be used to compare mean among the treatments. Differences regarded as a significant when the p-values were less that 0.05 ($p < 0.05$).

CHAPTER 4

RESULT AND DISCUSSION

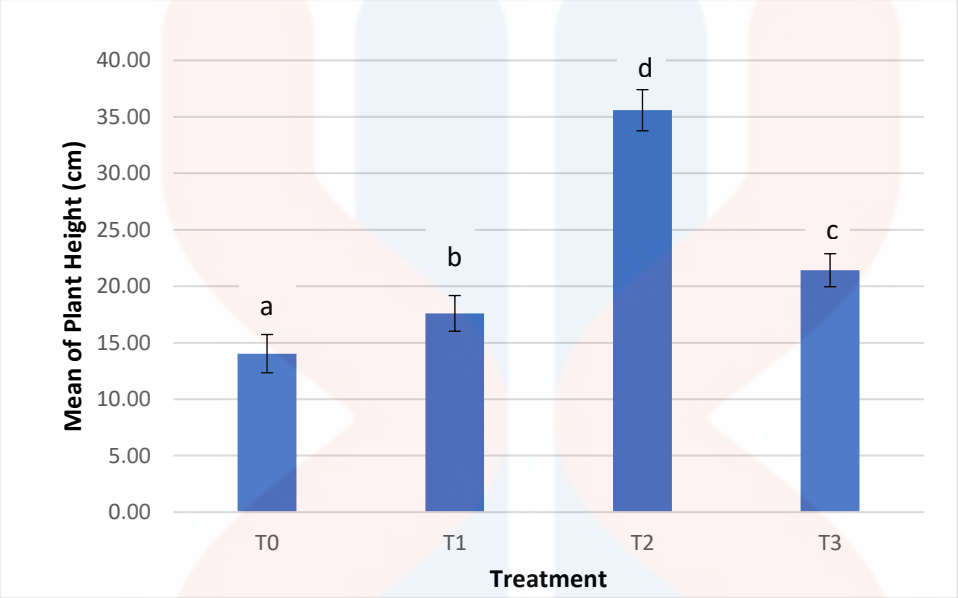
4.1 Effect of aqueous garlic extract on the plant height of Indian mustard

Morphological data variations demonstrated significant effect on Indian mustard's growth when treated with different concentrations of aqueous garlic extract (Appendix A.1). Based on Figure 4.1, it shows that **T2** with the concentration of 100 µg mL^{-1} aqueous garlic extract significantly increase the plant height by 38.2 cm (60.58%) followed by **T3** (200 µg mL^{-1}) with 23.2 cm, and **T1** (50 µg mL^{-1}) with 16.4 cm.

Previous research by Martina (2016) discovered that foliar spraying of aqueous garlic extracts to cowpea (*Vigna unguiculata*) and groundnut (*Arachis hypogaea*) plants at 200 µg mL^{-1}, 400 µg mL^{-1}, 600 µg mL^{-1} and 800 µg mL^{-1} demonstrates that the higher the treatment concentration, the slower the plant's growth. The plants with the lowest concentration at 200 µg mL^{-1} reached their plant height by 22 cm, while the plants with the highest concentration at 800 µg mL^{-1} reached their plant height by 15 cm.

The result obtained from this study was supported by Hayat (2018), which showed the concentration aqueous garlic extract at 100 µg mL^{-1} and the chemical reactions

induction on cellular levels may be responsible for the plant height in the treated tomato (*Solanum lycopersicum* L.) seedlings. Similar in this current study, it was found that aqueous garlic extract at 100 µg mL^{-1} concentration had resulted into a significant height of Indian mustard.



Legend:

T0 (control)	Soil + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T1	Soil + 50 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T2	Soil + 100 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T3	Soil + 200 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)

Figure 4.1: Plant height of Indian mustard with different concentration of aqueous garlic extract. Vertical bars represent standard deviation (SD) of mean.

4.2 Effect of aqueous garlic extract on the fresh weight and dry weight

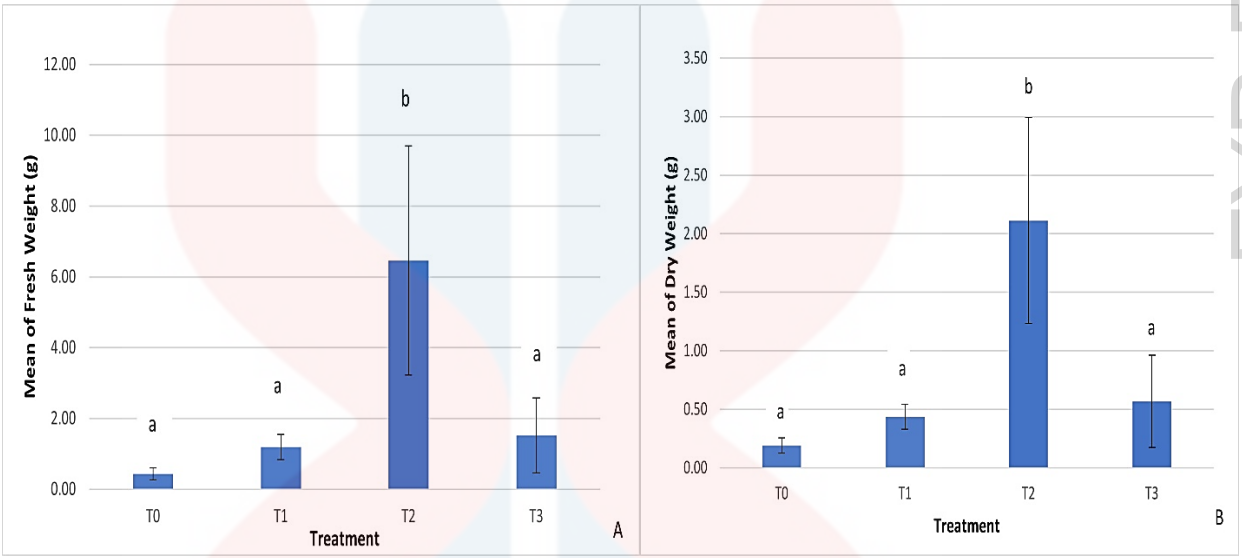
Figure 4.2 illustrate the effect of aqueous garlic extract on the fresh weight and dry weight of Indian mustard. The fresh weight of Indian mustard in **T2** exhibited a significant increased as compared to all treatment (Appendix A.2). Based on Figure 4.2A, the highest percentage of fresh weight with the application of foliar aqueous garlic extract was obtained at **T2** 100 µg mL^{-1} with 67.29% (9.2 g) as compared to control, **T0** with 4.48% (7 g). However, the highest concentration of aqueous garlic extract in **T3** (200 µg mL^{-1}) shows lower fresh weight with 15.83% as compared to **T2** (100 µg mL^{-1}) with 67.29%, indicating that foliar aqueous garlic extract opposition at higher concentration.

Figure 4.2B depicts the effect of foliar aqueous garlic extract on dry weight. It was observed that **T2** show significant increase in plant dry weight as compared to control (Appendix A.3). Plant treated with **T2** resulted in the highest percentage (63.74%) as compared to **T0** with 5.74%, followed by **T3** and **T1** with the percentage increases of 17.22% and 13.29% which is higher than control, respectively. **T2** was shown to be significantly different ($p<0.05$) from **T0**, **T1**, and **T3**.

According to a previous study conducted by Hayat (2018), the application of aqueous garlic extract with a concentration of 100 µg mL^{-1} and acetyl salicylic acid has incrementing effects on the fresh weight of the pepper (*Piper nigrum*) plants. Fresh weight was significantly increase by 3.5 g for seedlings treated with a foliar spray of aqueous garlic extract, with statistical significance. Besides, Nailul (2018) stated that the

fresh weight was significantly influenced by crude and purified extracts of fern (*Gleichenia linearis)* leaves. It was found that the application of crude extract at 100 µg mL^{-1} yielded the highest fresh weight of 77.7 g.

El-Rokiek (2019) stated that spraying garlic clove extract and eucalyptus leaf extract at 50000 µg mL^{-1} concentrations showed significant increases in dry weight of quinoa (*Chenopodium quinoa*) plant with 1.85 g, whereas at 150000 µg mL^{-1} showed reduction in dry weight with 1.65 g. Similar result were obtained in the current study as the increase application concentration of foliar aqueous garlic extract shows significant increase in a dry weight of **T2** (100 µg mL^{-1}) with 2.68 g over **T0** (control) with 0.32 g. However, the highest concentration in **T3** (200 µg mL^{-1}) showed a lower value (0.96 g) than **T2**. Reduction in weight of Indian mustard might be because of the allelopathic threshold level of aqueous garlic extract (Han *et al.*, 2013).



Legend:

T0 (control)	Soil + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T1	Soil + 50 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T2	Soil + 100 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T3	Soil + 200 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)

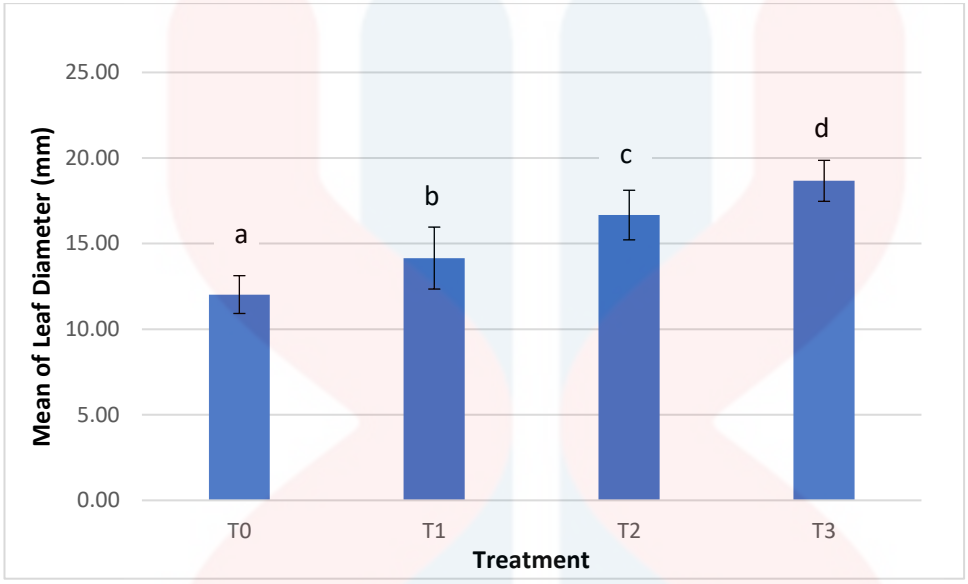
Figure 4.2: Fresh weight (A) and dry weight (B) of Indian mustard with different concentration of aqueous garlic extract. Vertical bars represent standard deviation (SD) of mean.

4.3 Effect of aqueous garlic extract on the leaf diameter

Plants treated with foliar aqueous garlic extract significantly had largest leaf diameters (Appendix A.4). According to Figure 4.4, the **T3** (200 µg mL^{-1}) had the largest leaf diameter (20.5mm) with a percentage increase by 30.35% and significantly different as compared to the **T0** (control). Subsequently, **T2** (100 µg mL^{-1}) and **T1** (50 µg mL^{-1}) were increased by 27.09% and 23.02% respectively.

Previous study that conducted by Al-Ubaidy (2015) found that the increase in leaf diameter (109.96mm) of tomato (*Solanum lycopersicum* L.) seedlings appears to be a result of improved metabolic processes caused by the application of aqueous garlic extract (2500 µg mL^{-1}) which is consistent with previous reports on tomato seedling growth promotion using garlic extracts foliar applications.

Furthermore, according to Hanafy (2012), spraying dwarf umbrella tree (*Schefflera arboricola*) plants with higher concentration of garlic extract at 5% increased leaf diameter (159.9 mm). This outcome showed a similar result to this current study that the application of aqueous garlic extract at higher concentration in **T1** (50 µg mL^{-1}) to **T3** (200 µg mL^{-1}) significantly increased the leaf diameter of Indian mustard.



Legend:

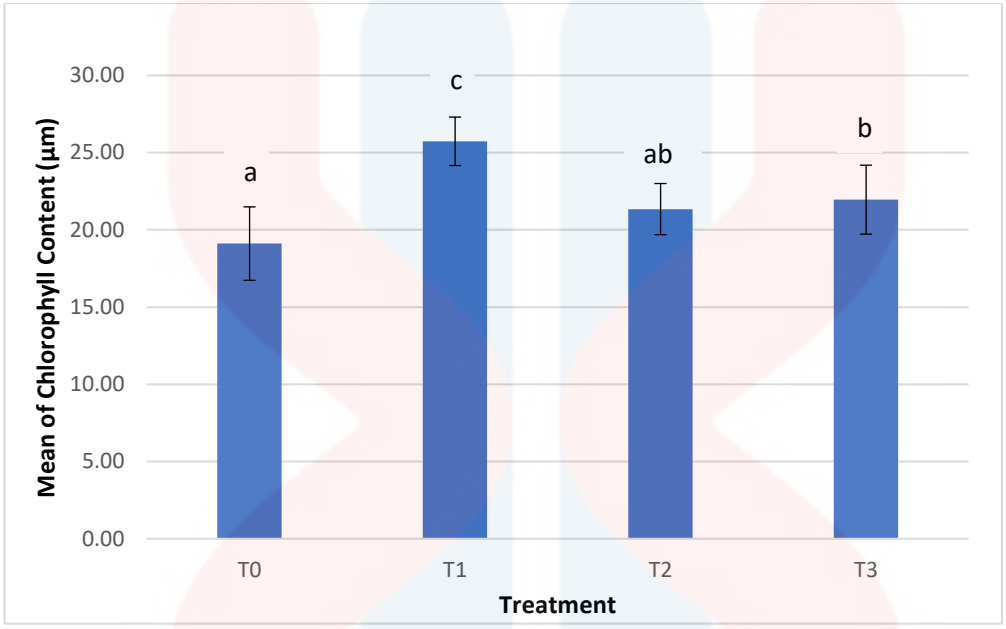
T0 (control)	Soil + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T1	Soil + 50 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T2	Soil + 100 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T3	Soil + 200 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)

Figure 4.3: Leaf diameter of Indian mustard with different concentration of aqueous garlic extract. Vertical bars represent standard deviation (SD) of mean.

4.4 Effect of aqueous garlic extract on the chlorophyll content

Figure 4.5 presented the mean value of chlorophyll content of Indian mustard plants. It was found that all treatments significantly increased the chlorophyll content, except **T2** (100 µg mL^{-1}) (Appendix A.5). The application of foliar aqueous garlic extracts significantly influenced the chlorophyll content of Indian mustard in **T1** with 29.19% and **T3** with 24.91% over **T0** (control).

Fracheboud (2006) stated that chlorophyll is the main component of pigment protein complexes, which play an important role in photosynthesis. El-Ghinbihi and Hassan (2007) found that under drought stress, spraying the foliage of pepper (*Piper nigrum*) plants with natural extracts i.e., garlic, eucalyptus, and yeast or ascorbic acid increases the number of photosynthetic pigments. In the current study, there are reduction amount of chlorophyll content when foliar aqueous garlic extract was applied at high concentration of **T2** and **T3**. This demonstrates that the inhibitory effect of aqueous garlic extract on the receiver plant exceeds the threshold level. These findings are consistent with the study that *Artemisia judaica* shoot extracts reduced the chlorophyll content of lettuce leaves in a highest amount (60 mg) (Zeng *et al.* 2009).



Legend:

T0 (control)	Soil + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T1	Soil + 50 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T2	Soil + 100 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)
T3	Soil + 200 µg mL^{-1} aqueous garlic extract + chicken manure (5 tan/ha) + NPK (0.6tan/ha)

Figure 4.4: Chlorophyll content of Indian mustard with different concentration of aqueous garlic extract. Vertical bars represent standard deviation (SD) of mean.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This current study shows that the application of aqueous garlic extract had increased the plant growth and development, thereby increase the yield of Indian mustard (*Brassica juncea* (L.) Czernjaew. The growth parameter of Indian mustard such as plant height, leaf diameter and yield were significantly increased ($P \leq 0.05$) while the chlorophyll content shows insignificant result as compared to control. There was significant stimulating effect on the growth and yield of Indian mustard at an application rate of 100 µg mL^{-1} (**T2**) of aqueous garlic extract. It was observed that **T2** showed significant increment ($P \leq 0.05$) in term of plant height (60.58%), fresh weight (67.29%), dry weight (63.74%) and leaf diameter (27.09%) as compared to control. However, the chlorophyll content of Indian mustard at **T2** was likely similar to control and **T3**, thus highlighting its potential as a plant bio stimulant at efficient rate of 100 µg mL^{-1}.

5.2 Recommendation

Aqueous garlic extract has a lot of potentials in terms of growth-stimulating properties towards vegetables plant. Therefore, further study on the fundamentals of the chemical reaction of the stimulating process need to be explored. Isolation and identification of phytochemical that present in aqueous garlic extract could be carry out in order to elucidate the mechanism of the identified allelochemical on selected bioassay species. This, in turn, could help in developing new plant bio stimulant to promote the vegetables or crop growth.

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Appendix A

A.1 Plant Height of Indian mustard after been harvested

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05			
		1	2	3	4
0	9	14.0333			
1	9		17.6000		
3	9			21.4222	
2	9				35.5889
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.000.

A.2 Fresh weight of Indian mustard

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		1	2
0	9	.4333	
1	9	1.1889	
3	9	1.5222	
2	9		6.4556
Sig.		.540	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.000.

A.3 Dry weight of Indian mustard

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	1	2
0	9	.1889	
1	9	.4367	
3	9	.5678	
2	9		2.1111
Sig.		.391	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.000.

A.4 Leaf diameter of Indian mustard

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05			
		1	2	3	4
0	9	12.0222			
1	9		14.1556		
2	9			16.6667	
3	9				18.6667
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.000.

A.5 Chlorophyll content of Indian mustard

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05		
		1	2	3
0	9	19.1111		
2	9	21.3444	21.3444	
3	9		21.9556	
1	9			25.7333
Sig.		.101	.914	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.000.

Appendix B

Figure 1: Indian mustard

Figure 2: Harvesting Indian mustard

TURNITIN

FYP II THESIS

ORIGINALITY REPORT

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