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EFFECTS OF DIFFERENT FERTILIZERS FORMULAS ON THE GROWTH AND DEVELOPMENT OF LEAF MUSTARD, *Brassica juncea*

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Abstract

Fertilizers are the most important and complex nutrients for crop plants in particular for grain yield and quality. The composition of the fertilizer as well as the essential elements that influence the growth of the crop need to be clearly identified. Due to that, this study was carried out to investigate the effect of different fertilizer formulation on the leaf mustard (*Brassica juncea*) growth. High nitrogen, phosphorus and potassium fertilizers were used to investigate their effects on the morphometric size of the leaves, plant height and the leaf area index of the leaf mustard. Results showed that the application of different formulation of fertilizer improves the growth of leaf mustard compared to control. Leaf mustard with the high phosphorus treatment recorded an increase in plant height and the leaf area index (LAI). Lamina length (LL) range is shown between phosphorus and control (1.11 cm), while the range of lamina width (LW), left width (WL) and right width (WR) are between potassium and control about 0.57 cm, 0.28 cm and 0.28 cm, respectively. Overall, there is a significant difference between the leaf mustard leaves in different high element fertilizers compared with all of the variable, $F_{(15,1024)} = 29.26$, $p<0.05$. However, the highest mean (in cm) in height was obtained in high phosphorus (16.64) followed by high potassium (16.50), control (16.41) and high nitrogen (16.35) fertilizers with a mean range of 0.29 cm ($F_{(3,176)} = 0.47$; $p>0.05$, no significant difference). The highest mean in LAI was obtained when treated with a high phosphorus fertilizer (0.47 m^2). The mean difference of LAI of high phosphorus compared to high potassium, high nitrogen and control is 0.02 m^2, 0.08 m^2 and 0.12 m^2. There is no significant differences between the LAI in different high element fertilizers with $F_{(3,176)} = 0.15$; $p>0.05$. Further study should be conducted to determine the effects of different fertilizers on the growth of other vegetables and fruit quality.

Keywords: leaf mustard, fertilizers, growth, leaf area index, morphometric measurement

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Introduction

There are about 51 genera in the family Brassicaceae which is also belong to the crucifer family including the genus Brassica (Rakow, 2004). The name crucifer is originally come from the flowers' shape of *Brassica juncea* which have four diagonally opposed petals in the form of a cross (Toosi, 2010). Brassica species also provided with edible leaves, seed, roots and flowers (Rakow, 2004). Mustard is a large and diverse group of plant species that are very important economically around the world. The primary center origin of *B. juncea* is central Asia which is northwest India and the secondary center of origin is in central and western China, from Iran to the Near East and the eastern of India. While, the growing origin of *B. juncea* are Central Africa, Japan, China, India, Bangladesh, Pakistan and also the southern Russia north of the Caspian Sea (Kumar *et al*., 2011).

There are a few species of *Brassica* which are *B. juncea* (leaf mustard), *B. elongata* (elongated mustard), *B. nigra* (black mustard), *B. rupestris* (brown mustard) and *B. tournefortii* (Asian mustard). Besides leaf mustard, cabbage, broccoli and cauliflower are also included in Brassica family (Bischoff, 2016). The *B. juncea* was classified based on their morphological characteristics such as consists of a few hairs on young leaves and leaf blades that terminate well up the petiole and has pale green foliage. *Brassica juncea* or leaf mustard have crumpled, broad or flat textured leaves and have either toothed or lacey edges. However, the typical leaf shapes is thinner towards the end of the leaves and becoming broader towards the large terminal lobe of the leaves (Toosi, 2010).

The major component in production of crop are the soil and the abiotic factors. Nutritious soil and abiotic factor such as fertilizer, wind and water are needed for better production of vegetable (Heggie and Halliday, 2004; Prodhan *et al.*, 2018). Different type of soils also will affect the growth and development of leaf mustard. Soils have greatly different in texture, chemical composition and color depends on the particles size of mineral component and the amount of organic matters. Leaf mustards are the plants that easy to grow and require less attention. However, temperature also important in growing this plant as temperature above 80°F will reduce the germination of seed. Mustard favors a sunny location with temperature about 27°C and fertile soils (Toosi, 2010). Other than that, rapid germination of leaf mustards' seeds occurs when there is favorable seedbed and nutritious soil available. However, if the seedbed conditions do not allow the germination immediately after sowing, the seeds are only capable to survive until the conditions was improved (Ellis, 1992).

There are a few nutrients that are necessary in growing of plants including nitrogen (N), phosphorus (P) and potassium (K). Potassium is very important as a source of nutrient to the leaf mustards as they help in increasing the height and weight of the plants. Besides that, the role of nitrogen is acceptable among the major essential nutrients required by plants for normal plant growth, development and yield, as it is a necessary components of protein, nucleic acid, chlorophyll and certain important enzymes (Pervez *et al.,* 2004). A sufficient phosphorus (P) nutrition level is essential not only for normal plant growth and development, but also for the synthesis of several metabolic intermediates (Oke *et al.,* 2005). Although phosphorus is important for plants, the response of crops to phosphorus fertilizers depends on phosphorus availability in the soil as well as crop species. In soil deficient in available phosphorus, crops typically respond well to their application (Wang and Li, 2004).

This study was carried out to determine and to compare the growth and development of leaves of leaf mustard following different types of fertilizers treatment. Effects of different fertilizers with different nutrients might give a better option and more accessible to improve the growth and development of the planted vegetables in the garden.

Methods

Soil Preparation

Garden soil was prepared and filled into different polybags. The soil was bought from supplier in Kuala Pilah. The position of polybags was organized by using Randomized Complete Block Design technique (Rashid *et al.,* 2010).

Seeds Germination

About 15 individuals of the leaf mustard seed were germinated in the small container filled with garden soils and high nitrogen fertilizer. Then, the container was placed in the open garage to reduce the evaporation process which can dried out the soil. The seeds were watered by 10 ml each time twice a day. The seeds take about 3-7 days to germinate. Later, each germinated seed was transferred into different polybags filled with garden soil. Each polybag was planted with a single germinated leaf mustard to reduce nutrient competition. Then, about 10 grams of nitrogen fertilizer was added once a week. Then, each leaf mustard in the polybag was watered by 500 ml twice a day. The polybags were

placed on the ground in the open area and were covered by a layer of black net. Similar procedures were prepared for the other germinated leaf mustard seed samples in high potassium fertilizer and high phosphorus fertilizer. By following the same procedure above, similar number of polybags filled with garden soil and seed were prepared without any fertilizer added which act as control.

Morphometric Measurement on Leaf Mustard Growth and Development

The growth of leaf mustard in control and high different elements of fertilizers were measured by using ruler and measuring tapes. Similar procedure was conducted for each sample of leaf mustard including control and high element of phosphorus, nitrogen and potassium. The morphometric study was conducted by measuring their morphological parts including length and width, plant height, and growth parameters of leaf area index of leaf mustard's leaves.

i. Length and Width of Leaves

The leaves' samples of randomly selected leaf mustard in different types of fertilizers were picked every five days starting from the first five days after the emergence of plumule. Then, the morphometric measurement and area of the leaves were recorded and measured as depicted in Figure 1.

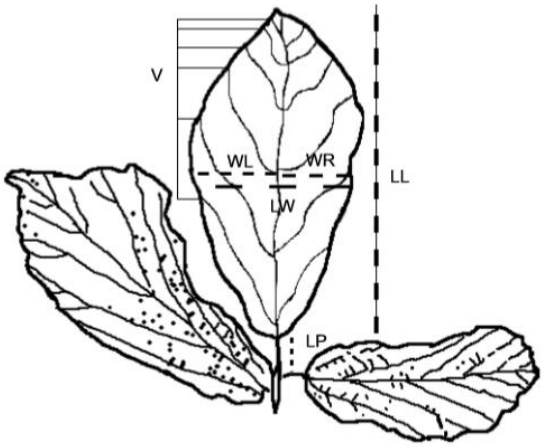

Figure 1. Morphological measurement of assessed leaf mustard with variables: lamina length (LL), lamina width (LW), width in left (WL), width in right (WR), petiole length (PL), number of veins (V) (Sattarian *et al*., 2011)

ii. Plant Height

Height of five randomly selected samples plant were measured every five days from day 20 until day 60 by using ruler. The height of plant was measured from the ground level to the tip of the top most level of the plant. The height of the plant was recorded in centimeters (Rashid *et al.,* 2010). The plant height was recorded.

iii. Growth Parameters

The values for different growth parameters of leaf area index (LAI) was determined on the basis of accumulation of dry matter and leaf area using the following equation (Radford, 1967).

$$LAI = \frac{\text{Area of leaf } (m^2)}{\text{Ground area from which leaves were collected } (m^2)} \times \text{Correction factor}$$

Statistical Analysis

The data were recorded in Excel 2013 and Word 2013. Minitab 17 was used to analyze significant difference of the leaves growth from different fertilizers treatment (confidence level=95%).

Result and Discussion

Development of Lamina

The mean of lamina length (LL) of leaf mustard that had been treated with high phosphorus fertilizers (6.12 cm) was higher than leaf mustard that were treated with high potassium (5.84 cm) and high nitrogen (5.46 cm) fertilizer. However, the mean of lamina width (LW), width in left (WL) and width in right (WR) of the leaf mustard in potassium fertilizers with 4.30 cm, 2.15 cm and 2.15 cm were higher than phosphorus fertilizers (LW = 4.21 cm, WL = 2.11 cm and WR = 2.11 cm). While, the mean of LL, LW, WL and WR of untreated leaf mustard (control) shows the lowest mean among the other leaf mustard that had been treated with different types of fertilizers with 5.01 cm, 3.73 cm, 1.87 cm and 1.87 cm, respectively. Other than that, the results shows that there is no significant difference between the growth of leaf mustard in different fertilizers compared by each of the variable, LL ($F_{(3,256)} = 1.16$; $p>0.05$), LW ($F_{(3,256)} = 0.62$; $p>0.05$), WL ($F_{(3,256)} = 0.66$; $p>0.05$) and WR ($F_{(3,256)} = 0.67$; $p>0.05$). However, there is a significance difference between the growth of leaf mustard in different high nitrogen, phosphorus and potassium fertilizers compared by all of the variable, $F_{(15,1024)} = 29.26$, $p<0.05$, shown in Figure 2.

There is a significant or no significant difference among variables from different element of fertilizers were shown based on grouping (A, B, C and D). In figure below, the letter shows that either the mean of all characteristics of leaf mustard are statistically significant or not. The differences between means that share a letter are not statistically significant (Minitab.com, 2019). WL and WR in high nitrogen fertilizer show no significant difference with the same variables in high phosphorus fertilizer, high potassium fertilizer and control (group D). However, there is a significant difference between both WL and WR with LL and LW from all element of fertilizers and control which indicated by different groups A, C, BC and ABC. While LL (group A) and LW (group C) shows no significant difference in every high element of fertilizer.

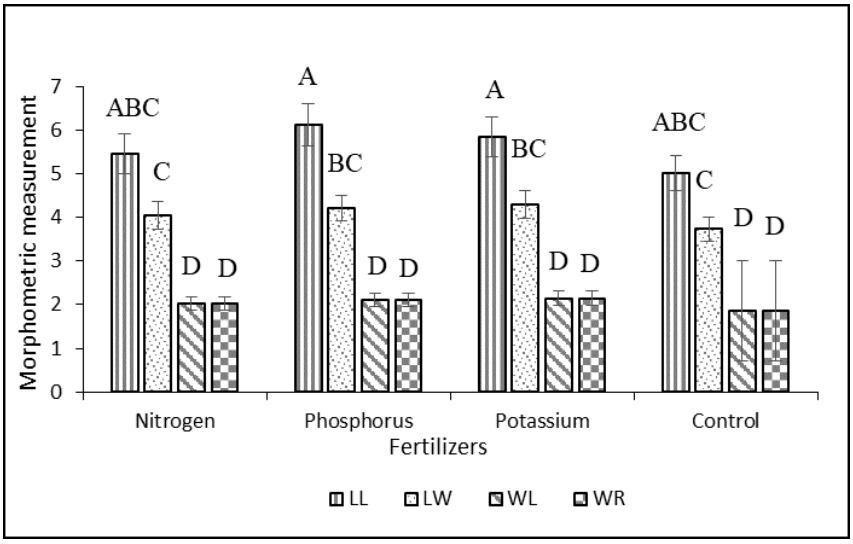

Figure 2. The mean of morphometric measurement of leaf mustard in high nitrogen, phosphorus and potassium fertilizer: LL = lamina length, LW = lamina width, WL = width in left, WR = width in right (4 groups including A, B, C and D)

The results show that control leaf mustard has the lowest mean, it proved that fertilizers plays crucial role in growth of plants. This results also showed that only mean of LL of leaf mustard treated with phosphorus fertilizers was higher than treated with potassium but lower in the LW, WL and WR. The data obtained from this observation was supported by Lin and Yeh (2008) as potassium plays role in cell elongation of plants and also known as dominant osmoticum and leads to the growth of leaves. Additionally, potassium is well known as a nutrient that serves as an important role for osmoregulation

cell, turgor maintenance, cell expansion and stomatal role in plants (Shabala, 2003). The width increase of fully grown leaves is correlated to the potassium concentration available, which is the higher potassium concentration used, the wider the leaves. Besides that, the data obtained has shown that untreated leaf mustard has the lowest mean compared to leaf mustard that treated with nitrogen fertilizers and this result had been supported by Maereka *et al.* (2007) that shows the uses of nitrogen fertilizers in mustard rape increased the size of the leaves.

Plant Height

The results indicate the mean and standard error in height of the leaf mustard grow in different fertilizers shown in Figure 3. Leaf mustard with phosphorus fertilizer has the highest mean (16.64 cm) followed by leaf mustard with potassium (16.50 cm) and nitrogen fertilizer (16.35 cm). However, the mean of control leaf mustard was slightly higher (16.41 cm) than the leaf mustard that received nitrogen fertilizers.

The results shows higher mean in phosphorus because it is seen as an important nutrient for growth and development of plant (Khan *et al.*, 2014). Phosphorus is an essential factor that affects plant growth from the cellular to the entire plant level including plant height (Hawrylak-Nowak *et al.*, 2018). This finding was supported by Firoz (2009) and it shows that the plant height was increased with higher level of phosphorus content. De Villiers (2007) also shows that the plants height increased after being treated with phosphorus in a few months.

However, the mean of leaf mustard's height treated with nitrogen was lower than the control leaf mustard. It is might due no process of mineralization occur in nitrogen. Mineralization is a conversion process of nitrogen to ammonium before it can be used by plants (Truong, 2017). The similar group was shown in Figure 3 which indicate that the plant height is in the same group with no significant different between high nitrogen, phosphorus and potassium fertilizers. Overall, the results obtained from this observation also shows that there is no significant difference between the plant height in different high nitrogen, phosphorus and potassium fertilizers as well as control with $F_{(3,176)} = 0.47$; $p>0.05$.

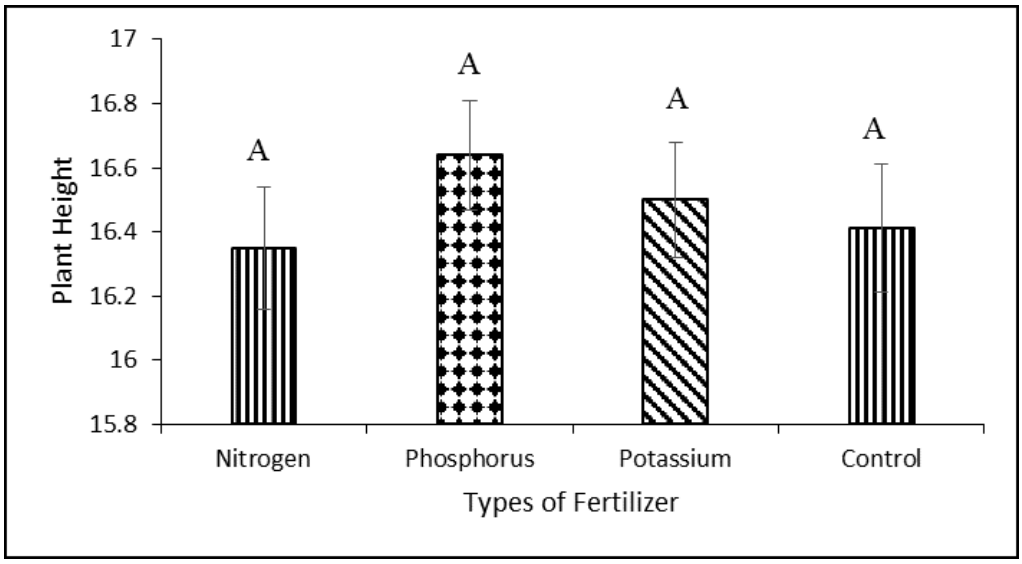

Figure 3. The mean of leaf mustard height in group treated with high nitrogen (Nitrogen), phosphorus (Phosphorus) and potassium (Potassium) fertilizers and control (Control) (A= same group with no significant difference)

Leaf Area Index (LAI)

The result shows in Figure 4 indicate the mean and standard error in leaf area index (LAI) of the leaf mustard growth in different type of fertilizers. LAI of leaf mustard with phosphorus fertilizers (0.47 m^2) has the highest mean followed by leaf mustard with potassium fertilizers (0.45 m^2), nitrogen fertilizers (0.39 m^2) and the control leaf mustard has the lowest mean (0.35 m^2).

The leaf mustard that treated with phosphorus fertilizers has the highest mean because phosphorus contribute a vital role in the division and enlargement of the cells (Assuero *et al.*, 2004), thus affect the leaf area of the leaf mustard. In addition, the increase of LAI is also due to the role of phosphorus in promoting the plants' growth and root development (Shah *et al.,* 2016). A research conducted by Gutiérrez-Boem (2001) also shows that the phosphorus deficit reduced the individual leaf area substantially, and this effect was consistent across all leaf positions. Other than that, the data obtained from this observation also was supported from a research done by Rodríguez (1998) which shows that the leaf area index of sunflower plants increase with increasing concentration of phosphorus fertilizer. The result shows that there is no significant difference between the leaf area index in different fertilizers, $F_{(3,176)} = 0.15$; $p>0.05$. The similar group was shown in Figure 4 which indicate that the LAI is in the same group with no significant different between high nitrogen, phosphorus and potassium fertilizers.

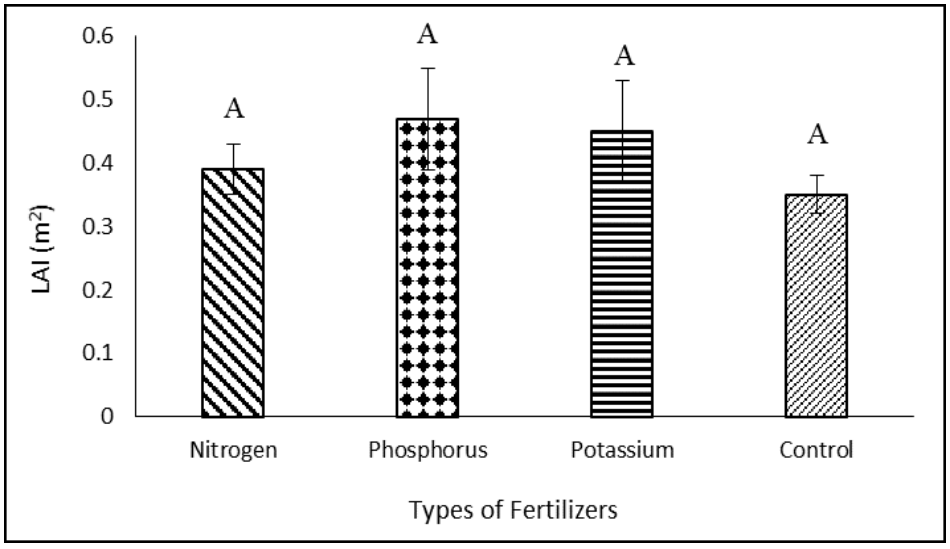

Figure 4. The mean of leaf area index of leaf mustard in control (Control) and different high nitrogen (Nitrogen), phosphorus (Phosphorus) and potassium (Potassium) fertilizers (A= same group with no significant difference)

Conclusion

The use of fertilizer as an alternative to increase the growth rate of plants, especially agricultural crops have been widely used throughout the world. A study on *B. juncea* have been conducted by comparing the effects of its growth after being supplied with several types of elements at high rates including phosphorus, potassium and nitrogen. Overall, there is no significant difference shown in the height and growth rate of *B. juncea* supplied with high phosphorus, potassium and nitrogen fertilizer. However, it shows a slight difference in these two parts where the mean height and growth rate of *B. juncea* are higher in high phosphorus fertilizer compared to the other two high elements of fertilizer and control. While, there are significant differences indicate that the development of *B. juncea* lamina is different when supplied with different high elements of fertilizer especially on high phosphorus fertilizer. It is because phosphorus plays a crucial function in cell enlargement, cell division and development of the

plant. For leafy plants such as *B. juncea*, high phosphorus fertilizer is expected to be very suitable for being used to help the production of plants with larger and wider leaf size. Through monitoring as well, mean height, lamina and growth rate of *B. juncea* is the lowest indicated by the control. It proves that the elements contained in the fertilizer are very important because it can affect the development of the crops including *B. juncea.* Due to that, there is a possibility that the combination of different types of fertilizer with an appropriate ratio is likely to produce crops which larger in size, especially leafy plant. Thus, it is recommended to determine the impact of different quantity of the element in fertilizer on other leafy plants and fruit quality.

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