Fertilizer effectiveness based on nutrient requirement from yield of green mustard (Brassica juncea L.)

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Abstract. Green mustard (Brassica juncea L.) is a vegetable that has a high economic value. The application of fertilizer was important to increase crop production. This study aims to calculate the nutrient requirement to get the optimal yield production. The method used survey methods (qualitative research) on June-July 2020. The conventional planting experiment design was 20 × 20 cm spacing/plant in 1 hectare. The percentage of N used the Kjeldahl method, whereas the P, K, and Mg using Spectrophotometry, and the data were analysed by Microsoft Excel, 2013. The variable observed i.e. wet weight (g), dry weight (g), Md dry basis (%), the percentage of N, P, K, and Mg, and total fertilizer needed for 10 ton/ha; 20 ton/ha; 30 ton/ha, and 40 ton/ha. The results were N 3.857 %; P 0.721 %; K 3.827 %; and Mg 0.366 %. Wherein, the average weight of wet green mustard was shown 91.014 g wherein the dry weight of 6.718 g. The Md (dry basis) was 12.54. The fertilizer complex recommendation to green mustard for optimal yield up to 40 ton/ha was 5.45 g/pot. In this case, a total of urea 2.46 g/pot, SP-36 0.57 g/pot, KCl 1.83 g/pot, and dolomite 0.58 g/pot.

1. Introduction
The green mustard (Brassica juncea L.) plants have originated within China and entered to Indonesia around the 17th century. One of the types of mustard greens quite popular and in-demand among the community was green mustard. Green mustard is a vegetable that has a high economic value, it can be cultivated in various places in the upland and lowland. Although the green mustard cultivation has been practiced in Indonesia for a long time, failures to obtain maximum yield production are still commonly [1]. According to the Central Bureau of Statistics Indonesia 2018, the green mustard production in Indonesia averages only 10.42 ton/ha with a total production of 635,988 ton/year, in a planted area of 61,047 ha. This case can still be increased up to 20-40 tons/ha by improving the fertilizer measure and maximum land use.

The application of fertilizer was important in providing nutrients to the soil to increase crop production [2]. Soil contains limited amounts of available nutrients and has various nutrients depending on the place. According to the law of Leibig have been reported the nutrients taken by plants can be replaced by offering fertilizers. Based on the theory of "The Law of Minimum", fertilization aims to maintain and increase the influence of substances containing one or more nutrients in the soil which are added to replace the nutrients that have been absorbed from the soil so that plants will continue to grow well and be able to produce optimally [3].
Nitrogen fertilizer was a good source of nutrients for the soil and that implies a positive effect on growth, development, and yield of vegetables when applied at optimal doses. Recently, treatments 150 kg urea/ha and T2 100 kg urea/ha was statistically significant to the results in yield production was 878 kg/ha [4]. While, three nutrient (NPK) application treatment rates of N 60 kg/ha, P 13.1 kg/ha, and K 16.6 kg/ha, the average yield production was 968 kg/ha, this case not satisfactory because it is much below estimation [5,6].

Leibig's minimum law states that plant growth is highly dependent on nutrient content in the soil. The minimum (limited) nutrient content is a determining factor for plant growth. The limiting factors for soil fertility in North Sumatra are N, P, K, and Mg [7]. This can be overcome by supplying nutrients from the soil to the plants with a fertilizer measure that matches the nutrient needs needed by the plant. This study aims to calculate the N, P, K, and Mg compound to nutrients requirements from urea, SP-36, KCl, and dolomite fertilizers for maximum yield of production the green mustard up to 40 tons/ha.

2. Materials and methods

2.1. Material of green mustard
This research was carried out on June - July 2020. The materials used in this study were superior mustard greens (Brassica juncea. L) var Kumala (plant height specification 31 cm, leaf number 9-10 pieces/plant, harvesting 25-28 days after planting, and potential yields 28-30 ton/ha). The green mustard was obtained from the local plantation at Taman Citra, Titi Papan Village, Medan Marelan District, North Sumatera (3°40'54"N 98°39'44"E). The green mustard conventional planting experiment design was 20 × 20 cm spacing/plant in 1 hectare. A total of 10 samples that ripened and fresh were selected for experiments.

2.2. Dry weight preparation
The green mustards (leaves and roots) were washed and air dry in the sun for 2 weeks. The green mustard destructed using a blender to make a dry extract. The dry extract mixed for all samples for analysis.

2.3. Parameter observed
The parameter observed of the green mustard were wet weight (g), dry weight (g), Md dry basis (%), the percentage of the nutrient requirement for N, P, K, and Mg, and total fertilizer needed for the optimum target of yield production from 10 ton/ha; 20 ton/ha; 30 ton/ha, and 40 ton/ha.

The wet weight of green mustard in grams (g) was weighed at harvest time by weighing all parts of the plant including roots, stems, and leaves using digital scales. The dry weight of mustard greens was obtained by weighing all parts of the plant including roots stems, and leaves, done a week after harvest, and through the drying process, after drying weighed by digital scales. Therefore, different absorb the nutrient requirements (the content of N, P, K, and Mg compounds) from soil to green mustard of moisture dry basis plants have been followed by AOAC (Association of Official Analytical Chemists) standards. The dry basis (Md) to calculate the nutrient-based on the requirement from the soil to plants by the formula:

\[ Md \text{ (dry basis)} = \frac{W-D}{D} \times 100 \]  

To calculate the nutrient requirement, using the formula:

\[ NR = \frac{\text{Production Target (PT)}}{Md \text{ (dry basis)}} \times \text{nutrient (\%)} \times \frac{\text{Fertilizer Compound Total of plants}}{\text{Total of plants}} \]  

2.4. Management of crop
The green mustards plants maintenance in this research includes:

1. Embroidering has been done to replace dead seedlings up to a maximum of 1 week after planting. Embroidering was has done on green mustard plants that have died
2. Watering was carried out with a hose from the pump that delivers water to experiment samples
3. Pest and disease control were carried out by manual control

2.5. Data analyzes
The method used in this study was survey methods (qualitative research) to collected primary data for the target population of green mustard. Furthermore, the data were analyzed in the Laboratory. Dry basis content of green mustard used to calculate the total percentage of N was determined using the Kjeldahl method, the available percentage of P, K, and Mg were determined by a Spectrophotometry ep 384, New York, USA. Furthermore, the data were analyzed using Microsoft Excel, 2013 [8,9].

3. Results and discussion

3.1. The green mustard yield production
Less optimal crop green mustard production is caused by factors of different soil fertility levels due to the varied (complex) soil properties. There are 3 (three) characteristics of the soil, namely being able to fix or bind nutrients in the soil, to give or add nutrients, or not to provide nutrients at all. Research on the effectiveness of the amount of complete fertilizer in green mustard attractive things to measurement.

| Sample | Wet weight (g) | Dry weight (g) |
|--------|---------------|---------------|
| 1      | 137.36        | 8.81          |
| 2      | 58.70         | 4.59          |
| 3      | 65.20         | 4.22          |
| 4      | 61.09         | 4.54          |
| 5      | 65.62         | 8.13          |
| 6      | 96.26         | 5.63          |
| 7      | 112.02        | 8.18          |
| 8      | 99.72         | 7.74          |
| 9      | 95.16         | 4.91          |
| 10     | 119.01        | 10.43         |
| Mean   | 91.014        | 6.718         |

The application of N, P, K, and Mg fertilizers aims to satisfy the requirement of green mustard plants during the vegetative period. Furthermore, to refer to the green mustard plant nutrient insufficient condition or not, measured using calculated the mustard nutrient requirement based on the Leibig minimum law to achieve the trick of fertilization. The minimum total production calculated from the ten wet weights of green mustard is shown in Table 1. The treatment in the green mustard compound, N 3.857 %; P 0.721 %; K 3.827 %; and Mg 0.366 % (Table 2).

| N-Kjehldahl (%) | P-Total (%) | K-Total (%) | Mg-Total (%) |
|-----------------|-------------|-------------|--------------|
| 3.857           | 0.721       | 3.827       | 0.366        |

3.2. The production target based on nutrient requirement
The average weight of wet the green mustard was shown 91.014 g wherein the dry weight of 6.718 g. Thus, a moisture content of dry basis, it can be calculated M_d (dry basis) was 12.54. For a production target of 10 ton/ha:

\[
N = 797.448 \times 0.03857 \times \frac{100}{45} \text{ (urea)} \times \frac{1}{111,111} = 0.62 \text{ g/pot} \tag{3}
\]
\[ P = 797.448 \times 0.00721 \times \frac{100}{36} (\text{SP} - 36) \times \frac{1}{111,111} = 0.14 \text{ g/pot} \quad (4) \]

\[ K = 797.448 \times 0.03827 \times \frac{100}{60} (\text{KCl}) \times \frac{1}{111,111} = 0.46 \text{ g/pot} \quad (5) \]

\[ Mg = 797.448 \times 0.00366 \times \frac{100}{18} (\text{dolomite}) \times \frac{1}{111,111} = 0.15 \text{ g/pot} \quad (6) \]

The total of fertilizer was 1.34 grams/pot, within the urea using in the target of production 10 ton/ha was 0.62 grams/pot. The different research has been reported, the combination of fertilizer application with a fertilizer of urea 0.5 grams/pot, SP-36 0.375 grams/pot, and compost 50 grams/pot, fresh weight average of green mustard plants 67.50 grams/plant [10]. For a production target of 20 ton/ha:

\[ N = 1,594.896 \times 0.03857 \times \frac{100}{45} (\text{urea}) \times \frac{1}{111,111} = 1.23 \text{ g/pot} \quad (7) \]

\[ P = 1,594.896 \times 0.00721 \times \frac{100}{36} (\text{SP} - 36) \times \frac{1}{111,111} = 0.29 \text{ g/pot} \quad (8) \]

\[ K = 1,594.896 \times 0.03827 \times \frac{100}{60} (\text{KCl}) \times \frac{1}{111,111} = 0.92 \text{ g/pot} \quad (9) \]

\[ Mg = 1,594.896 \times 0.00366 \times \frac{100}{18} (\text{dolomite}) \times \frac{1}{111,111} = 0.29 \text{ g/pot} \quad (10) \]

A total of fertilizer was 2.73 grams/pot, within the KCl using in target of production 10 ton/ha was 0.92 g/pot. Other case have been reported, the total of K 14.5 mg/kg in the equilibrium solution is sufficient to get the highest yield from plants that need K. The function of kalium (K) for plants is to affect the composition and circulate carbohydrates in plants and accelerate nitrogen (N) metabolism [11]. For a production target of 30 ton/ha:

\[ N = 2,392.344 \times 0.03857 \times \frac{100}{45} (\text{urea}) \times \frac{1}{111,111} = 1.85 \text{ g/pot} \quad (11) \]

\[ P = 2,392.344 \times 0.00721 \times \frac{100}{36} (\text{SP} - 36) \times \frac{1}{111,111} = 0.43 \text{ g/pot} \quad (12) \]

\[ K = 2,392.344 \times 0.03827 \times \frac{100}{60} (\text{KCl}) \times \frac{1}{111,111} = 1.37 \text{ g/pot} \quad (13) \]

\[ Mg = 2,392.344 \times 0.00366 \times \frac{100}{18} (\text{dolomite}) \times \frac{1}{111,111} = 0.44 \text{ g/pot} \quad (14) \]

To expecting a yield of 30 ton, the fertilizers complex remained recommended was 4.09 g/pot, include P 0.43 g/pot. Natural phosphate is apatite rock that contains high enough phosphate, so it can be used as fertilizer. Phosphate rock is very insoluble, so the P number is low for plant growth [12]. For a production target of 40 ton/ha:

\[ N = 3,189.792 \times 0.03857 \times \frac{100}{45} (\text{urea}) \times \frac{1}{111,111} = 2.46 \text{ g/pot} \quad (15) \]

\[ P = 3,189.792 \times 0.00721 \times \frac{100}{36} (\text{SP} - 36) \times \frac{1}{111,111} = 0.57 \text{ g/pot} \quad (16) \]

\[ K = 3,189.792 \times 0.03827 \times \frac{100}{60} (\text{KCl}) \times \frac{1}{111,111} = 1.83 \text{ g/pot} \quad (17) \]
\[
Mg = 3.189.792 \times 0.00366 \times \frac{100}{18} \times \frac{1}{111,111} = 0.58 \text{ g/pot}
\] (18)

The data presented clearly indicated that the measured for maximum production of green mustard (5.45 g/pot). Urea fertilizer is a chemical fertilizer that contains sources of Nitrogen (N). In a plant P and K, nutrients were interdependent. Kalium roles as a transportation medium that carry out the nutrient K from the roots including leaves to leaves and translocates assimilates from leaf to all plant tissue. For the green mustard production up to 40 ton/ha needed Mg 0.58 g/pot. Similarly, other case, the total uptake of Mg 0.59 g/pot has been reported in nutrients which might be due to higher initial Mg content in the soil understudy to crop response [13].

4. Conclusions
Fertilization aims to maintain and increase the influence of substances containing one or more nutrients from the soil that are introduced to replace the nutrients that have been absorbed from the soil so that plants will continue to grow well and be able to produce optimally. Four sources of fertilizer complex recommendation to mustard for optimal yield up to 40 ton/ha was 5.45 g/pot. Wherein a total of urea 2.46 g/pot, Sp-36 0.57 g/pot, KCl 1.83 g/pot, and dolomite 0.58 g/pot.

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