The effect of lime of dolomite and NPK fertilizers on the response of growth, yield and protein content on black soybean (*Glycine soja* L.Merr) in acid soils

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Abstract. The development of cultivation from plant black soybeans (*Glycine soja* (L.) Merr.) in the acid soils can be an alternative to increase the yield of black soybean plants. However, the utilization of acid soils is plagued by soil pH value, high content of Al, Mn, and Fe as well as low availability of macro elements N (nitrogen), P (phosphor), K (potassium), Ca (calcium), and Mg (magnesium). This study aims to determine the effect of dose of lime dolomite and NPK fertilizers on the response of growth, yield, and protein content of plant black soybeans on acid soils. This research used Complete Random Design (CRD) consist of 2 factors, each factor consists of 4 levels. The dose of lime dolomite 4.5 tons/ha was able to produce the highest total dissolved protein content amounted 4.30%, while giving the lime of dolomite and NPK fertilizers showed significant results in plant’s height, weight of fresh pods, weight of seeds/plant, number of seeds/plant, weight of 100 seeds, dry weight of stover, and dry weight of roots.

1. Introduction
The diminishing land area on black soybeans cultivation causes a decrease in the national production of black soybeans itself. In contrast, there has been significant results on the national consumption of black soybeans amounted to 2.98 million tons in 2016 but also it only covered 29% by the production[1]. Therefore one of the strategies to fulfill the needs of black soybeans by doing expansion into acid soils indeed it spread widely in Indonesia, especially in Borneo Island[2]. To reduce the constraints of acid soils we would using lime of dolomite and NPK fertilizers to make a suitable condition for the growth of black soybeans. Also, as a food source of protein, we measured total dissolved protein content from the seeds after cultivation so it might encourage our farmers and stakeholders for using black soybeans as a raw material of its manufacture. The hypothesis tested in this study there is a significant result of lime dolomite and NPK fertilizers on the response of growth, yield, and protein content on black soybeans in acid soils. The treatment of D2K2 is given the best results for total dissolved protein content with 4.30% is higher than others.
2. Material and Methods

2.1. Material

Black soybeans seeds var. Detam 1, lime of dolomite using “Procal” consists of 21% Calcium and 8.03% Magnesium, NPK Fertilizers (Urea consist of 46% Nitrogen, SP36 consist of 36% Phosphor, and KCl consist of 60% Potassium), Acid soil which taken from Sucopangepok village, District of Jelbuk, Jember Regency and polybag size 40 x 40 cm.

2.2. Methods

2.2.1 General

Soil samples were collected from Sucopangepok Village, District of Jelbuk, Jember Regency to analyze the pH value and the status of its fertility so that researchers can determine the dosage of lime dolomite and NPK fertilizer according to soil samples. The soil samples from Sucopangepok Village is a former of cocoa plantation that have been abandoned and have experienced nutrient leaching due to high rainfall. Furthermore, this study continued with the application of lime dolomite two weeks before planting the seeds of black soybean. Fertilizing are done 3 times, namely when the plants were 10 days, 30 days, and 50 days. Harvesting is carried out when the crop was 90 days after the pods are brown and dry. The observations of total dissolved protein content was done after the harvesting using Bradford’s method. Hence for the growth parameters in this study is conducted with the F test on ANOVA table and if there is a significant effect followed by a test DMRT (Duncan Multiple Range Test) at a level of 95%.

2.2.2 Statistic

Identification of collected data were analyzed using Complete Random Design (CRD) consisting of two factors then each factor consists of four levels. The first factor symbolized with the letter D is the dose of lime dolomite then the second factor symbolized with the letter K is the dose of NPK fertilizer. There are 16 treatment combinations. Then the combination treatment will be repeated 3 times so that there are 48 units of the experiment. Each polybag will be arranged with 25 cm distance from each other for easy maintenance and observation.

First factor is lime of dolomite (D):
D0: 0 tons/ha equals to 0 g/polybag
D1: 3.5 tons/ha equals to 14 g/polybag
D2: 4.5 tons/ha equals to 18 g/polybag
D3: 5.5 tons/ha equals to 22 g/polybag

Second factor is NPK fertilizers (K):
K0: Urea 0 g/polybag, SP36 0 g/polybag , KCl 0 g/polybag equals to Urea 0 kg/ha, SP36 0 kg/ha, KCl 0 kg/ha
K1: Urea 0.2 g/polybag, SP36 0.4 g/polybag, KCl 0.3 g/polybag equals to Urea 50 kg/ha, SP36 100 kg/ha, KCl 75 kg/ha
K2: Urea 0.3 g/polybag, SP36 0.5 g/polybag, KCl 0.4 g/polybag equals to Urea 75 kg/ha, SP36 125 kg/ha, KCl 100 kg/ha
K3: Urea 0.4 g/polybag, SP36 0.6 g/polybag, KCl 0.5 g/polybag equals to Urea 100 kg/ha, SP36 150 kg/ha, KCl 125 kg/ha

3. Results and Discussion.

Plant’s growth parameters consists of plant height, weight of pods, number of seeds, weight of seeds, weight of 100 seeds, dry weight of stover and dry weight of roots. Growth parameters were using F test on ANOVA table and followed by DMRT (Duncan Multiple Range Test) at a level of 95%. This results are depends on the amount lime of dolomite and NPK fertilizers given. The value of plant height is increased due to more lime of dolomite were added. The higher dose of lime dolomite were added, the less dose of NPK fertilizers is given to produce high value of plant height because lime dolomite also plays a role as a source of macro nutrient elements calcium and magnesium that aimed
for cell division. Otherwise, addition of NPK fertilizers in black soybeans plants could be suppressed with the presence of symbiosis between plant’s roots with the *Rhizobium*, the fixation of N\textsubscript{2} by *Rhizobium* could save the needs of N fertilizers up to 60\% [10]. From the results of F test on ANOVA and DMRT analysis which is shown in table 1.

**Table 1.** Plant’s height of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency.

|          | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|----------|----------------|------------------|------------------|------------------|
| K0       | 51,00 C a      | 52,67 C a        | 54,00 C a        | 53,67 C a        |
| K1       | 55,00 AB c     | 60,00 B b        | 61,67 B b        | 72,33 A a        |
| K2       | 57,57 A b      | 61,33 B a        | 63,33 B a        | 57,00 C b        |
| K3       | 52,00 BC c     | 68,00 A ab       | 71,33 A a        | 64,67 B b        |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

This study also shows that by giving dosage of dolomite 5.5 tons/ha equals to 22 g/polybag (D3) and NPK fertilizers as much as Urea 50 kg/ha, SP36 100 kg/ha, KCl 75 kg/ha equals to Urea 0.2 g/polybag, SP36 0.4 g/polybag, KCl 0.3 g/polybag (K1) are able to produce highest results on plant’s height 72.33 cm. The addition of a dose of lime dolomite for soil pH value is below 6 required lime dolomite as much as 4.6 tons-5.5 tons to be able to improve the growth of plant height of 2.9\% [3].

It indicates that lime of dolomite and NPK fertilizers were taken a role for vegetative growth of plant black soybeans i.e plant height, roots elongation and cell division. Meanwhile, normal trait without lime of dolomite and NPK fertilizers aren’t able to produce a good plant height which accumulated on 51.00 cm. The fertilizing on 10 days after planting could stimulate vegetative growth especially plant height through increasing availability of nutrient contents nitrogen (N), phosphor (P) and potassium (K) where it was needed by the plants in large amount as former of ATP. Dose of urea fertilizer 50 kg/ha is the optimal dose to provide carbohydrates for the growth of *Rhizobium* bacteria fastening N since the phase of vegetative to grain filled [4].

Furthermore, the vegetative growth of plants greatly given an affect on generative growth especially in pods formations and seeds development. Based on the results of fresh weight of pods showed in Table 2 that the higher dose lime of dolomite given, the higher fresh weight produced. Dose lime of dolomite 5.5 tons/ha is capable for generating fresh weight of pods amounted to 11.97 grams, meanwhile without giving the dose lime of dolomite the plants could only meets fresh weight of pods in 4.70 grams. For better vegetative growth of black soybeans organs that function as a producer of assimilate (source) will increase the growth of the organs as a user (sink) that will give higher results [5].

**Table 2.** Fresh weight of pods of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency

|          | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|----------|----------------|------------------|------------------|------------------|
| K0       | 4.70 B c       | 6.10 C b         | 5.96 AB bc       | 8.93 B a         |
| K1       | 7.19 A ab      | 7.71 B ab        | 6.85 A b         | 8.61 B a         |
| K2       | 8.03 A b       | 11.11 A a        | 5.17 B c         | 8.47 B b         |
| K3       | 7.14 A b       | 8.16 B b         | 6.82 A b         | 11.97 A a        |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

Formation of pods on black soybeans plants is affected by the process of photosynthesis because it plays an important role in the formation of photosynthate which stored as food reserves in seeds. An optimal process of photosynthesis requires the availability of nutrient elements which is quite in
accordance with the needs of the plants. Dose lime of dolomite 5.5 tons/ha equals to 22 g/polybag (D3) and dose NPK fertilizers Urea 100 kg/ha, SP36 150 kg/ha, KCl 125 kg/ha equals to Urea 0.4 g/polybag, SP36 0.6 g/polybag, KCl 0.5 g/polybag (K3) is considered to meet the nutrient needs of black soybeans plants on generative phase. When the black soybeans are in generative phase they need a lot of phosphor due to its function for the formation of flowers, seeds and accelerate fruit ripening. The higher availability of P for plants could increase the transfer energy and metabolism of plants, then charging the seeds would run optimally and produce seeds of black soybeans which is round shaped and large [6]

Based on the results below on Table 3, number of seeds need a dose of lime dolomite which is little compared with parameters of plant height and fresh weight of pods. The dose of dolomite 4.5 tons equals to 18 g/polybag (D2) and dose of NPK fertilizers Urea 75 kg/ha, SP36 125 kg/ha, KCl 100 kg/ha equals to Urea 0.3 g/polybag, SP36 0.5 g/polybag, KCl 0.4 g/polybag (K2) were able to produce the highest number of seeds/plants of 107.67. While the other treatments without giving dose of lime dolomite and NPK fertilizers gave a low number of seeds/plants amounted 49.67.

Table 3. Number of seeds/plants of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency

|   | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|---|----------------|------------------|------------------|------------------|
| K0| 49.67 C d      | 66.00 C c        | 74.33 C b        | 79.00 C a        |
| K1| 63.00 A c      | 92.67 B a        | 90.33 B b        | 95.0 B a         |
| K2| 51.67 B c      | 102.33 A b       | 107.67 A a       | 101.00 A b       |
| K3| 65.33 A c      | 94.67 B a        | 93.00 B b        | 98.00 A a        |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

Photosynthate within the leaves will be translocated in seed to form a food reserves. During the translocation process, nitrogen (N), phosphor (P) and potassium (K) will be absorbed in large quantities by the plants. When the phase of grain fill progresses, the translocation of N to seed is done very quickly whereas the fixation of N at the same time already started to decline activities that required the addition of N when the plants are flowering [6]. Second fertilizing in this study is done when the plants are in 30 days or start flowering that aims to meet their needs of the nutrient elements nitrogen (N), phosphor (P) and potassium (K) for seeds formation. When soybean plants are in the phase of R3-R4 (pod formation) and R5-R6 (pod filling) the concentration of the potassium in soybeans plant’s tissue are 0.88% and 0.39% [7].

The dose of dolomite 4.5 tons/ha equals to 18 g/polybag (D2) and dose of NPK fertilizers Urea 75 kg/ha, SP36 125 kg/ha, KCl 100 kg/ha equals to Urea 0.3 g/polybag, SP36 0.5 g/polybag, KCl 0.4 g/polybag (K2) were able to produce the highest results on parameter weight of seeds/plants (Table 4).

Table 4. Weight of seeds/plants of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency

|   | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|---|----------------|------------------|------------------|------------------|
| K0| 656.67 A d     | 718.13 D c       | 746.77 D b       | 853.17 D a       |
| K1| 635.20 B d     | 827.73 C d       | 1156.87 C a      | 1126.20 B b      |
| K2| 618.17 B d     | 909.40 B c       | 1941.13 A a      | 1592.20 A b      |
| K3| 655.29 A d     | 947.03 A c       | 1255.93 B a      | 976.43 C b       |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

Weight of seeds are depends on the results of photosynthate where translocated in seeds during the photosynthesis process. Moreover, seed’s shape and its size are controlling by the genes from the plants [7]. The function of lime dolomite is to enhance the soil pH value become normal within 6.5 –
7.00 in order to support the availability of nutrient elements especially nitrogen (N), phosphorus (P) and potassium (K). Macro nutrients availability in soils could reach an optimum score where the soil pH value amounted at 6.5 – 7.5 [8]. In contrast, based on the results on Table 4, the more lime of dolomite and NPK fertilizers were added, they diminished the results of weight of seeds/plants. It occured by the excessive dose of lime dolomite and NPK fertilizers would ruin metabolism system on black soybean plants.

In this study, we also analyze weight of 100 seeds to support plant growth parameters. It is shown that the dose of lime dolomite 3.5 tons/ha equals to 14 g/polybag (D1) and dose NPK fertilizers Urea 100 kg/ha, SP36 150 kg/ha, KCl 125 kg/ha equals to Urea 0.4 g/polybag, SP36 0.6 g/polybag, KCl 0.5 g/polybag (K3) is able to produce the highest result on weight of 100 seeds 20.20 g, while the treatment of lime dolomite 4.5 ton/ha (D2) and without the dose of NPK fertilizers (K0) are given the lowest results 8.67 g. It is shown on Table 5 below.

**Table 5. Weight of 100 seeds of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency**

|        | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|--------|----------------|------------------|------------------|------------------|
| K0     | 12.50 AB a     | 10.37 C b        | 8.67 C c         | 9.17 B bc        |
| K1     | 11.50 B b      | 16.83 B a        | 15.00 B a        | 15.40 A a        |
| K2     | 12.60 AB c     | 19.97 A a        | 18.67 A a        | 15.57 A b        |
| K3     | 13.98 A b      | 20.20 A a        | 14.23 B b        | 9.23 B c         |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

By adding dose of lime dolomite as a source of calcium and magnesium is able to increase the content of N and also could increase the yield of black soybeans due to the adequacy of calcium makes cell plants become more selective in absorbing nutrient. Calcium also needs for pods and seeds formation in black soybean plants so it has an optimal content of calcium for it i.e by 0.36% to 2.00% and the content of magnesium of 0.26 – 1.00% in the young leaves perfect openly or young fully matured leaf (YMFL) [9].

Photosynthesis process on plants also plays an important role on weight of stover and roots, where most of the results will accumulate on plant especially on weight of pods, number of pods, weight of fresh stover and weight of dry stover and roots. Nitrogen with Phospor are together will form proteins, carbohydrates, nucleic acids and would be translocated by phosphor so they would increase the dry weight of plants [10]. The dose of lime dolomite 3.5 tons/ha equals to 14 g/polybag and dose NPK fertilizers Urea 100 kg/ha, SP36 150 kg/ha, KCl 125 kg/ha equals to Urea 0.4 g/polybag, SP36 0.6 g/polybag, KCl 0.5 g/polybag (K3) is able to produce the highest results of dry weight of stover (Table 6) and dry weight of roots (Table 7). The low result on dry weight of roots was also influenced by heavy soil structure so development of roots was not optimal. Soil characteristics such as soil texture, structure and its fertility status affect the yield of black soybean plants. The higher value of soil’s volume weight then the root development is inhibited.

**Table 6. Dry weight of stover of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency**

|        | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|--------|----------------|------------------|------------------|------------------|
| K0     | 8.35 B b       | 9.24 B a         | 8.03 B c         | 9.04 A ab        |
| K1     | 7.21 C c       | 9.80 B ab        | 10.48 A a        | 9.51 A b         |
| K2     | 9.52 A b       | 9.22 B b         | 10.59 A a        | 9.56 A b         |
| K3     | 7.64 B c       | 10.99 A a        | 9.92 A b         | 9.46 A b         |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.
Table 7. Dry weight of roots of black soybeans in acid soil from Sucopangepok Village, District of Jelbuk, Jember Regency.

|          | D0 (0 tons/ha) | D1 (3.5 tons/ha) | D2 (4.5 tons/ha) | D3 (5.5 tons/ha) |
|----------|----------------|-------------------|------------------|------------------|
| K0       | 1.82 C c       | 1.93 C c          | 2.95 A a         | 2.49 B b         |
| K1       | 3.05 A b       | 3.58 B a          | 2.66 B b         | 2.96 B b         |
| K2       | 2.33 B c       | 3.27 B a          | 3.19 A b         | 3.11 B b         |
| K3       | 2.94 A c       | 4.49 A a          | 2.75 B c         | 3.82 A b         |

Description: Uppercase (vertical) and lowercase (horizontal). Numbers followed by different letters in the same column indicate significant difference according to the test DMRT at level 95%.

Figure 1. Total dissolved protein content results using Bradford’s Method on black soybean plants

Based on the results on this study, we also known that treatments of D2K2 produced the highest total dissolved protein content up to 4.30% compared to other treatments. Addition of macro elements from lime of dolomite and NPK fertilizers in black soybean plants is to stimulate the growth and yield also intended to enhance the yield quality i.e total dissolved protein content. Each of macro elements have a role in forming of seed and protein metabolism. Nitrogen serves to enlarge the size of their leaves and increase the protein percentage [11]. The role of potassium (K) namely as a catalyst in metabolism processes of plant resulting in the formation of protein could be optimal as well as prevent on damping off due to the excessive addition of nitrogen. High results of total dissolved protein content would encourage our farmers to undertake the cultivation of black soybean plants and develop our food industry for using it as their raw materials.

4. Conclusion
Black soybeans plants (Glycine soja (L.) Merr) which cultivated in Sucopangepok Village, District of Jelbuk, Jember Regency is influenced by the dosage of lime dolomite and NPK Fertilizers. Growth parameters i.e plant height could produce the highest result by the dose of lime dolomite 5.5 tons/ha equals to 22 g/polybag otherwise the dose of lime dolomite 4.5 tons/ha equals to 18 g/polybag is given the highest results on yield parameters and total dissolved protein content. Also, in this study that has been conducted we could assume that administering lime of dolomite and NPK fertilizers in large amount is not suitable because could inhibit the growth of the plants.

5. References
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