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The Effect of Sulfur (S) – Silicate (Si) Fertilizer Application on The Growth, Yield, and Physiochemical Properties of Two Soybean Varieties

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ABSTRACT

Soybeans are a food ingredient with a high level of consumption in Indonesia. Low soybean production needs to be increased in productivity and quality by managing soil fertility through fertilization. This research aims to determine the effect of applying Sulfur-Silicate fertilizer to two soybean cultivars, Devon and Dena, and their interaction on soybean productivity and quality. The method used in this research was a randomized block design with 2 treatment factors, namely soybean variety and Si-S fertilizer concentration. The level of treatment for the soybean varieties used are the Devon and Dena1 varieties. The Si-S fertilizer concentration levels tested were without fertilizer, Si-S 110mg/L-23 mg/L; 133 mg/L-30.7 mg/L; 200 mg/L-46 mg/L. Data were analyzed statistically and processed using Duncan's multiple range test. Treatment of Si-S 200 mg/L - 46 mg/L on Devon soybeans increased the average Plant Height to 91.00 cm, Plant Diameter to 0.90 cm, Number of Leaves to 72.0, Number of Branches to 5.33, and the chlorophyll content becomes 35.50. , while Dena1 soybeans were 85.0 cm, 0.90 cm, 80.6 cm, 5.6 and 36.50 respectively. Treatment using 110mg/L-23 mg/L Si-S fertilizer increased seed weight, number of pods per plant and weight of 100 seeds. The results of the research show that applying Si-S fertilizer to Dena1 variety soybean plants can increase productivity in terms of the number of pods and seed weight. It is hoped that these results will provide education to farmers regarding the application of Si-S fertilizer and soybean varieties to increase soybean yield and quality.

Keywords: globulin; pods; protein; silicate; sulfur.

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INTRODUCTION

One of the most often consumed legumes worldwide is the soy bean. Soybean seeds contain 21% oil and 41% stored protein by dry weight (Yang et al., 2011). Conglycinin (7S) and glycinin (11S), the two primary components of soy protein, account for roughly 40% and 30% of the total protein, respectively Utsumi et.al., 1997). Because of their favorable digestibility and functions, soy globulins such as 7S and 11S have recently taken over as the primary source of plant proteins.

Besides, several S-containing components are biologically active and, thus, a source for use as medicinal value. In addition, some of the S-containing components are biologically active and, as such, are sources for use as medicinal values.

Sulfur is an essential plant element that is often classified as a “secondary” nutrient because plants require less than the primary nutrient. Sulfur is a building block of two major amino acids, cysteine and methionine, essential for protein formation and has many functions for plants, including chlorophyll production, cell growth and development, carbon and nitrogen metabolism, and energy production. Several different sulfur fertilizers are suitable for use on crops. These fertilizers can be divided into two categories: fertilizers containing elemental sulfur (S0) and fertilizers containing sulfate ($SO_4$2-).

High-protein soybean cultivars are notable for more protein-content production in soybean curd than low-protein cultivars. Moreover, the present evidence shows dissimilarity in the genotypic of soymilk and soybean curd characteristics. Using fertilizers or isolated nutrients (source only) instead of compounds can provide farmers with better products. Thus, the use of sulfur as an isolated crop nutrient is a new research approach, although recent studies have analyzed different sources and doses of S (Adao et.al., 2018; Rheinheimer et al., 2005; Chien et al., 2011, Karimizarchi et al., 2014). In addition, it is important to emphasize that S directly affects essential amino acids, and its absence slows down plant growth and protein synthesis in seeds (Broch et al., 2011).

To be absorbed by plants, Si needs to be in the form of mono-silicic acid (H4SiO4). However, the natural release of H4SiO4 from SiO2 is a very slow process (Raven, 1983). The Si element plays an important role in the production of soybean protein. The main source of vegetable protein for humans is soy, where about 90% of the protein dissolved in the seeds is in the form of globulin. while 70% of the dissolved protein is glycinin (G) (globulin) and β-conglycinin (βc) (7S globulin). Glycinin is relatively rich (3% - 4.5%) in s-containing amino acids (methionine and cysteine), which are mainly conserved in cotyledons and deposited in protein bodies (Nielsen, 1989; Kaviani & Kharabian, 2008). The aim of the study was to determine the effect of Si-S fertilizer which was made easily soluble and absorbed by plants, on soybean growth, yield, physiochemical components, and proteins 11S and 7S.

MATERIAL AND METHODS

Field Experiment

A field study utilizing a randomized block design was used to study interaction impact of S-Si and soybean V1: Devon 1 and V2: Dena1 on growth characteristics, seed yield, and protein content. The treatments consisted of 8 combinations of four levels of S-Si (P0 : (0 Control), P1: S-Si 23 mg/L-100 mg/L Sulfur-Silicate formula fertilizer (Product of Kosifarm South Korea) diluted with water to 1000 ml Sulfur-silica, P2: 1 ml Sulfur – silicate formula fertilizer diluted with water to 750 ml Sulfur – Silicate content (30,7 mg/L- 133 mg/L), P3: 1 ml Sulfur – silicate formula fertilizer diluted with water to reach 500 ml Sulfur – Silicate content (46 mg/L - 200 mg/L). S-Si were given in split applications (first dose at the time of sowing and the second dose 35 days after sowing). Each treatment had three replications. The beds were made with a length of 1 by 1.5 meters, with a height of 20 cm, and the distance between the beds was 40 cm. Seeds were planted in beds with a size of 20 cm x 40 cm. The basic fertilizer was in the form of 30 tons/ha cow manure and fertilizers N, P, and K containing a dose of 50 kg urea/ha, KCl 100 kg/ha, and SP-36 100 kg/ha. Silica-sulfur fertilizer as a treatment fertilizer was given with a foliar spray technique and spraying was carried out at 15, 30, 45, 60, and 70 DAP (days after planting). Harvesting was done by determining the accuracy of the age in the description of the varieties planted and was carried out when the plants reached physiological maturity at 80 DAP marked by most of the leaves having turned yellow, the fruit changing color from green to brownish yellow, and changes in cracks or pod colors and old appearance.

Plant Height Measurement

Plant height was observed at the age of 26 DAP (day after planting). Measurements were observed from the base of the stem to the highest point. The number of leaves was counted on 26 DAP. The calculation was done by counting all the leaves from the bottom to the top. The stem diameter was measured at 27 DAP using a shearing ruler in cm. The number of branches was manually calculated at 27 DAP.

Leaf chlorophyll content Measurement

The chlorophyll content of the leaves was observed at 28 DAP on dry leaves using the Chlorophyll Meter MC-100. The number of flowers was calculated manually by counting the number in each plant. Calculations are made when all flowering plants account for 70% of all plants

Determination of the Number of Pods

The number of pods was counted after harvesting at 80 DAP. Calculations were carried out by planting until the total pods and pods contained 1, 2, and 3. The weight of 100 seeds was calculated after harvesting for each treatment by selecting 100 seeds randomly, then tumbling them using an analytical balance. Seed weight per plant was calculated after harvesting by taking all the plants in one experimental plot and weighing them after they were dried. Then, the results were converted to grams.

Determination of Globulin Content

From soybean seeds, 7S and 11S globulins were extracted using the method of Thanh and Shibasaki (1976). Fraction yields were expressed as a percentage of the weight of the isolated dry fraction relative to the weight of defatted soy flour. Protein concentrations in the samples were determined using the method proposed by Bradford (1976) using BSA as a standard. The determination of the dissolved protein content in the sample also used the method proposed by Bradford (1976) with the following modifications: 5 μl of the sample was added with 45 μl of distilled water and 950 μl of Bradford's reagent, then incubated for 15 minutes. The absorbance value was measured using a spectrophotometer at a wavelength of 595 nm. Bovine Serum Albumin (BSA) is used as a standard to determine dissolved protein with units of mg BSA/gr sample. Reducing Sugar

The 50 ml sample (supernatant) was added with 0.1 N phosphate buffer with pH = 7.2 of 450 l, incubated at 37ºC – 40ºC for 30 minutes, then added with 500l of DNS, incubated in boiling water for 5 minutes, then cooled down until it reached room temperature. chamber and add 330 l of potassium sodium tartrate tetrahydrate, and measure the absorbance on a spectrophotometer at a wavelength of 575 nm. Calculate the reducing sugar content in the standard glucose equation, and the absorbance as the x value.

Determination of Total Phenolic Compound

According to the method outlined by Taga et al. (1984), the amount of phenolic compounds was measured with gallic acid as the standard for measuring phenolic compounds. A 50 μl of the sample was dissolved in 2 ml of 2% Sodium Carbonate solution, followed by the addition of 100 μl of FCR 50 as a reaction and incubated for 30 minutes. Then, at a wavelength of 750 nm, the absorbance rate was determined.

Determination of Flavonoid Compound

Flavonoid Compound Test The Determination of flavonoid content used the AlCl3 method (Lamaison and Carnet, 1990), where 50 μl of each extract was dissolved in 500 ul of distilled water. An amount of 30 μl of 2% NaNO2 was added, set aside for 5 minutes, then added with 30 μl of 10% ALCl3 and left for 6 minutes. After six minutes, 200 μl of 1 N NaOH was added, followed by the addition of 240 μl of distilled water. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 415 m.

Determination of Antioxidant Activity

Determination of Antioxidant Activity (DPPH) 1,1-diphenyl-2-picrylhydrazil

Test the antioxidant activity of the sample was extracted using the method proposed by Galvez et al (2005). A solution of 0.5 mM DPPH was dissolved in methanol. The supernatant from the sample extract was taken as much as 100 µl then added 100 µl of methanol, and 800 µl (DPPH 50 mM). The solution was incubated for 20 minutes and the absorbance was measured at a wavelength of 517 nm.

RESULTS AND DISCUSSION

Plant height in soybeans is an important piece of data because it is an indicator of plant growth where plants can grow judged from the height of the plant to the emergence of productive branches and the opportunity for more flowers to emerge.

Table 1 shows the effects of the different concentrations of Si-S on agronomy, character, plant height, plant diameter, number of leaves, number of branches, and chlorophyll content. The treatment of sulfur silica P3 had an average plant height value of 87.9 cm, and the lowest average value was found in the P0 treatment with a value of 79 cm. Therefore, it was suspected that the highest dose of silica fertilizer treatment triggers plant height growth more when compared to that without silica fertilizer (control). Plant height was an indicator of growth as well as a parameter to measure and find out the effect of the applied treatment and indicators to examine any environmental influence. The gain in plant height was a form of an increase in the addition of cells due to the presence of increased asymmetry late (Nurmala et al., 2016).

In soybean plants, the longer the plant, the larger the diameter of the plant stem. This is because plant height is quantically related to the level of Si applied to the treatment, so the size of the stem diameter simultaneously increases. P3 treatment in the Dena1 variety showed the highest average value compared to other treatments and other varieties, which was 0.9 cm, and the lowest average value was found in the P0 treatment in the Devon variety with a value of 0.5 cm. Silica elements can strengthen the stems so that plants are resistant to falling. Si can reduce transpiration and abiotic stresses, such as temperature, radiation, light, wind, water, and drought, as well as increase plant resistance to biotic stresses to strengthen plant tissues and become more resistant to pests and diseases (Hussain et al., 2021).

Silica fertilization with the foliar technique can increase soybean growth and production through the number of leaves but does not affect the chlorophyll content in the leaves. The increase in the number of leaves is due to the role of silica which can help plants improve their physical properties to increase the activity of the photosynthesis process (Timotiwu et al., 2018). In soybean crops, the number of leaves greatly affects production since the crop production process requires sufficient energy and food. A very important source of energy is the process of photosynthesis. The P3 treatment on the Dena1 variety showed the highest average value compared to other treatments and varieties with an average value of the number of leaves being 80,67 which means that it was affected by the application of silica sulfur fertilizer. Moreover, the lowest value was found in the P0 treatment with an average value of 50,67. This is due to the influence of the growth of the number of leaves on the surrounding environment and the temperature of the light which plants absorb more optimally. Light absorbed by plants through the leaves is used to carry out the photosynthesis process and get the energy needed by plants as young leaves are growing (Panalosa et al. 2015).

Silica can increase the movement of water and nutrients to cells that can produce maximum growth and development. Silica can induce cytokinin biosynthesis in branches, resulting in more branches in soybean plants (Alikhani et al., 2020). The highest treatment result was found in the P3 treatment with an average value of 5.67 and the lowest value was found in the P0 treatment which resulted in an average value of 3.33 branches.

Table 1. The effects of the different concentrations of Si-s on agronomy, character, plant height, plant diameter, number of leaves, number of branches, and chlorophyll content.

Treatment	Plant Height	Plant Diameter	Number of Leaves	Number of Branches	Chlorophyll Content
Variety 1/Devon 1					
P0	82.00 bc	0.40 a	52.67 a	3.33 a	30,07
P1	83.67 bc	0.70 bc	60.67 ab	4.67 bc	32,80
P2	86.67 cd	0.90 d	69.00 ab	4.67 bc	34,07
P3	91.00 d	0.90 d	72.00 ab	5.33 cd	35,50
Variety 2/Dena1					
P0	76.33 a	0.60 b	50.67 a	4.00 ab	33,33
P1	80.00 ab	0.70 bc	54.00 a	5.00 cd	33,27
P2	82.67 bc	0.80 cd	66.00 ab	5.67 d	34,30
P3	85.00 c	0.90 d	80.67 b	5.67 d	36,50
LSD (0.05)					
Variety (V)	2,47	0,07	10,79	0,47	4,14
Fertilizer Si-S (P)	3,49	0,11	15,27	0,66	5,86
Interaction (V x P)	4,93	0,15	21,59	0,94	8,28

Note: P0 = Control; P1 = 9.2 - 40 Si-S (mg/plant); P2 = 12.2 - 53 Si-S (mg/plant); P3 = 18.4 - 80 Si-S (mg/plant); LSD = Least Significant Difference

Table 2. The effects of the different concentrations of Si-S yield components in soybean

Treatment	Number of Flowers	Number of Pods	Seed Weight per Plant	Weight of 100 Seeds
Variety 1/Devon 1				
P0	45.67 bc	45.00 a	12.69 a	14.81 ab
P1	52.67 c	62.00 bc	21.39 bc	15.83 ab
P2	54.00 c	66.67 bc	28.36 cd	18.64 c
P3	53.67 c	70.67 bc	26.75 c	24.50 d
Variety 2/Dena 1				
P0	25.67 a	60.67 b	18.49 ab	13.73 a
P1	30.67 ab	62.00 bc	21.65 bc	16.11 ab
P2	53.00 c	97.67 c	34.22 de	18.58 c
P3	60.00 c	98.67 c	36.63 e	21.39 e
LSD (0.05)				
Variety (V)	7,96	5,55	3,54	1,23
Fertilizer Si-S (P)	11,26	7,85	5,01	1,74
Interaction (V x P)	15,92	11,10	7,08	2,45

Note: P0 = Control; P1 = 9.2 - 40 Si-S (mg/plant); P2 = 12.2 - 53 Si-S (mg/plant); P3 = 18.4 - 80 Si-S (mg/plant); LSD = Least Significant Difference

The application of silica sulfur fertilizer can increase the number of branches because the number and growth of branches were influenced by factors such as genotype and cultivation processes. Sulfur treatment can increase growth in plants in the vegetative phase. It has an impact on increasing the number of nodes so that the number of branches increases. This has an impact on increasing the number of planting pods and the yield of planting seeds (Xu et al., 2021).

Flowers are one of the supporting factors in increasing soybean production. Silica sulfur treatment showed the highest number of flowers found in the Devon variety (Table 2). The difference in the character of the plants owned by these two varieties is caused by the different genetic arrangements that exist in each variety that produce different responses in each environment and growth factor (Ratnasari et al., 2015). The Dena1 variety was faster regarding flower formations. The increase in the number of flowers can be influenced by the number of branches. A high number of branches was found in a large number of P3 treatment flowers with an average value of 60,0 and the lowest value was in the P0 treatment with an average value of 25,67 flowers. Sulfur is an essential nutrient for plant growth. Sulfur plays an important role in plant metabolism (Schnung, 1990). The role of silica can help plants improve their physical properties, the photosynthates produced will be used by plants to form generative organs such as branches and flowers.

The number of pods produced by soybean plants is largely determined by vegetative growth which in this case was the number of branches, the number of flowers, and the supply of assimilation results (Permanasari et al., 2014). The Dena1 variety was higher than the Devon variety. This is because the high-yielding varieties planted were able to absorb maximum nutrients for plants because of their genetic potential. Variety plays an important role in soybean production because achieving high yields is largely determined by genetic potential. According to Kardoni et al. (2014), the treatment of silica has a significant effect on the number of planting pods. Based on the results of the study, it was found that the varieties and treatments had a real effect on the Dena1 variety with an average value of 98.7 and the lowest was in the Devon variety with an average value of 45.00.

The genetic traits of plants play a role in the growth period of the plant to the production period. If there are variations that arise in plant populations grown under the same environmental conditions, the variations or differences are derived from genotypes. The Si-S treatment on the Dena variety showed the best results since it was caused by genetic factors and the environment that support the Dena variety. It was able to produce the highest weight of planting seeds and was supported by sulfur and silica nutrients which played a role in pod filling. The role of sulfur was able to increase photosynthetic yield after flowering photosynthetic results were then translocated in the seed for a filling process (Pandiangan & Aslim, 2017).

Soybean seeds show the size of the soybean seeds produced and the weight of the soybean seeds will affect the yield of soybeans. The size of a seed is measured by the weight of 100 seeds. The heavier the weight of 100 seeds, the larger the size of the soybean seeds. The best treatment was found in the P3 treatment with an average value of 24.5 grams. According to the research of Pandiangan & Asli (2017), the weight of 100 seeds of soybean plants increases because each variety has a different seed size which is influenced by genetic factors. The high availability of sulfur in the soil will increase the absorption of sulfur by plants on seeds (Pagani et al., 2011). In this case, the need for sulfur is also very important to increase nutrient uptake, especially in seeds.

Si application significantly increased the accumulation of protein, reducing sugar and DPPH content (Figure 1). Si application significantly increased the yield by increasing the number of effective pods per plant, the number of beans per plant, and the weight of beans per plant. The combination treatment of the Dena1 variety and Si-S fertilizer of 46 ppm 200 ppm resulted in the highest seed protein content of 44,9%

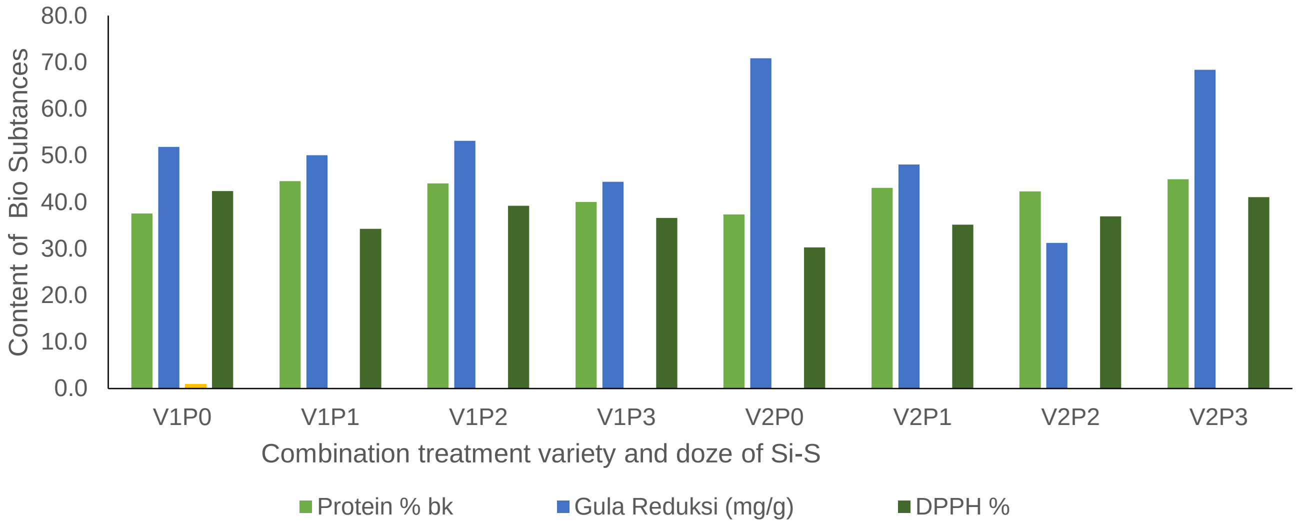

Figure 1. Content of some physiochemical Protein, Reducing Sugar and DPPH of soybean treated with some concentration of Si-S

while without Si-S fertilizer, the lowest protein content produced was 37.4%.

The Devon variety produced the highest protein content (44.5%) in the 23 mg/L-100mg/L Si-S fertilizer treatment, while the lowest protein value was produced without Si-S fertilizer treatment (37.6%). The Dena1 variety produced the highest soluble protein compared to the Devon variety (Figure 3). Sulfur and Silica fertilizer treatment can increase the protein content of soybean seeds. Burkitbayev et al. (2021) reported that the use of fertilizers containing sulfur increases all protein fractions in soybeans. The results showed that fertilization using agricultural chemicals containing sulfur in both powder and solute form was needed to increase soybean yields and increase protein supply in grains.

Furthermore, it was mentioned that the availability of sulfur for soybean plants is an important factor. Fertilizers containing sulfur can promote higher grain yields and higher soy protein content. Hussain et al. (2021) state that the use of Si in soybean plants significantly increases the accumulation of some carbohydrates such as soluble sugars and sucrose in the stems and leaves, leading to better stem strength. Si application significantly increases yield by increasing the number of effective pods per plant, number of seeds per plant, and seed weight per plant. Ibanez et al. (2019) in a study on Sulfur modulating yield and storage proteins in soybean grains state that albumin and glutelin fractions have a positive quadratic response to all S sources, the maximum values were observed at levels 133 and 100 mg kg–1 ESPA (S pastilles -90% S), (297% and 4% increase over control, respectively), 129 and 95mg kg–1 for the GY-gypsum (326% and 7% increase over control, respectively), 125 and 85 mg kg–1 for the GI-gypsite (49% and 28% increase over control, respectively), and 116 and 73 mg kg–1 for the ESPO-elemental S powder (113% and 9% the increase over control, respectively).

The application of different Si-S fertilizers on soybean varieties of Devon and Dena showed various reducing sugar values. The Dena1 soybean variety treated without Si-S fertilizer produced the highest reducing sugar (70.9 mg g-1), while that with Si-S fertilizer 30.7 mg/L-133mg/L produced the lowest reducing sugar (31.3 mg g-1). The Devon variety with Si-S fertilizer 30.7 mg/L-133mg/L produced the highest reducing sugar value (53.1 mg g-1) compared to that without fertilizer Si-S (51.8 mg g-1) and fertilizer Si-S 23 mg/L-100mg/L and 46 mg/L-200 mg/L (50.0 mg g-1/44.3 mg g-1) (Figure 5). The average reducing sugar in Devon was lower (41.5 mg g-1) when compared to Dena1 (41.9 mg g-1).

Moretti et al. (2021) state that by reducing sugars and sucrose, the yield of soybean increases along with the treatment of Silica rates. The results of their study suggest that soybean supplementation is helpful to control blood glucose and serum lipid in diabetic patients. Other than that, soybean shows an antioxidant activity that may contribute to enhancing the effect of antioxidant defense. This activity contributes to protection against oxidative damage in type 2 DM patients. Soybean may have potential use in treating patients with DM.

Phenolic compounds are compounds produced by plants as a response to environmental stress. Phenolic compounds function as protection against UV-B rays and cell death to protect DNA from dimerization and damage (Lai & Lim, 2011). The components in this compound are known to have an important role as agents of prevention and treatment of several disease disorders such as arteriosclerosis, brain dysfunction, diabetes, and cancer (Garg et al., 2016).

Meanwhile, the calculation of phenolic levels in (Figure 2) shows that the number of flavonoid compounds is always directly proportional to the total content of phenolic compounds in a sample. The largest group of phenolic compounds is flavonoids. Each plant generally contains one or more flavonoid group compounds and has a unique composition of flavonoid content (Indrawati & Razimin, 2013). Flavonoids are found in almost all parts of plants, such as leaves, roots, skin, pollen, nectar, flowers, fruits, and seeds (Neldawati et al., 2013). The application of different Si-S on soybean varieties Devon and Dena showed various phenolic and flavonoid values. The Devon variety treated with 23 mg/L-100 mg/L of Si-S fertilizer produced the highest phenolic content (33 mg/g) as well as the Dena1 variety

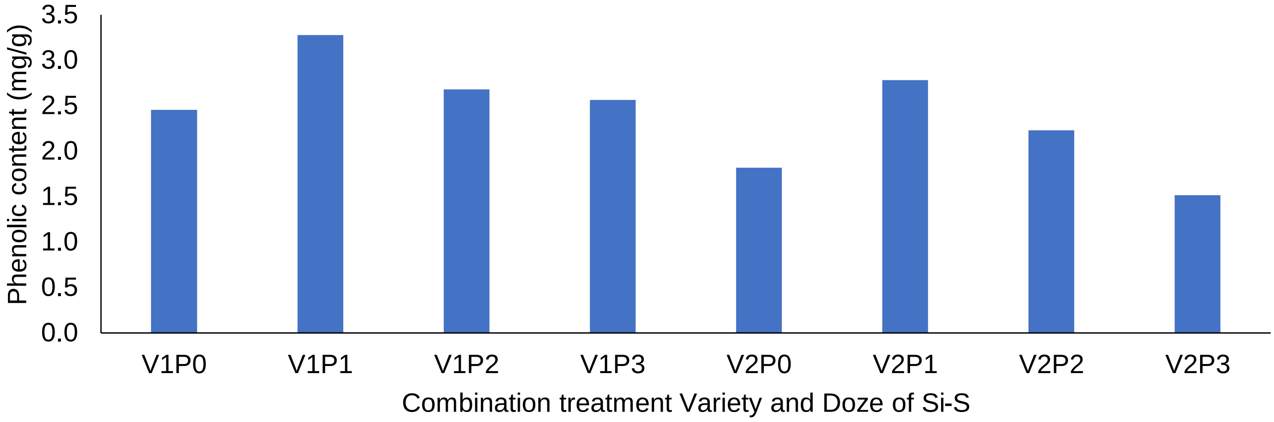

Figure 2. Phenolic content of two soybean varieties treated with various concentrations of Si-S

(2.8 mg/g).

The Devon variety with the highest flavonoid content (4.6 mg/g) was obtained through treatment with 46 mg/L-200 mg/L of Si-S and the Dena variety using 30.7 mg/L -133 mg/L of Si-S fertilizer. (TTT image). Meanwhile, the result of the lowest flavonoid content was (2.5 mg/g) in the treatment without Si-S fertilizer. The Dena1 variety was different from the Devon variety, the lowest yield of Phenolic was 46 mg/L-200 mg/L Si-S treatment. In general, the Si-S fertilizer treatment affects the 7S and 11S content. The protein content values of 7S and 11S are presented in Table 3.

The protein quality in soybean seeds is strongly influenced by nutritional conditions. Glycinin (11S globulin) and β-conglycinin (7S globulin) are the 2 main proteins in soybean seeds. The protein quality of glycinin (11S) is higher than that of β-conglycinin (7S), due to the presence of higher amounts of s-containing amino acids (methionine and cysteine) in glycinin than β-conglycinin.

Based on the results of observations, it can be seen the levels of protein fractions of 7S globulin, 11S globulin, and 7S/11S ratio of two soybean varieties due to Si-S fertilizer treatment. The composition of the 7S globulin protein fraction, 11S globulin, and the 7S/11S ratio can be seen in Table 3.

The results of the analysis show that there were differences in the composition of the 7S and 11S fractions between soybean varieties with the application of Si-S fertilizer. Table 4 shows the 7S globulin levels of the Devon soybean variety ranging from 103.6 mg/g to 105.3 mg/g, while those in the Dena1 variety ranged from 103.6 mg/g to 105.1 mg/g. The highest level of 7S protein content (105.3) was found in the Devon variety with Si-S fertilizer application of 30.7 mg/L-133 mg/L, while the lowest 7S globulin content (103.1 mg/g) was found in the Dena1 variety without Si-S fertilizer treatment.

In addition to 7S globulin levels, the levels of 11S globulin protein fraction of the two soybean varieties varied widely, ranging from 108.0 mg/g (Devon variety without Si-S fertilizer treatment) to 109.7 mg/g (Devon variety with S fertilizer treatment). The highest 11S fraction was found in the Devon variety with a value of 110.0 mg/g and the lowest was found in that without Si-S fertilizer treatment (89.0 mg/g).

Treatments of Si-S fertilizer on two soybean varieties with several doses showed that treatment affected the level of 11S globulin. This indicates that Si-S fertilizer can affect the globulin 11 content of soybean seeds. These two globulin protein fractions play a very important role in determining the textural properties of the gel formed. The results of the isolation of protein fractions 7S and 11S were in line with the results of the isolation carried out by Liu et al. (2006).

Based on table 4, the 7S/11S ratio of each soybean variety varies. The largest ratio was owned by the Devon variety with no Si-S fertilizer treatment (1.00) and the lowest was owned by the Devon variety with the Si-S fertilizer treatment 23 mg/L-100 ppm/L (0.94). The higher the 7S/11S globulin ratio, the lower the 11S globulin content contained. The content of 7S and 11S globulins in Devon soybean showed the lowest 88.9 and 89.0 with a 7S/11S ratio of 1.00. This shows that the globulin content in the metabolic process of its formation is influenced by the presence of Si-S elements.

Meanwhile, two major fractions of β-conglycinin (7S) and glycinin (11S) accounting for more than 70% of the total proteins were dominating the protein storage in soybean seed (Tsukada et al., 1986). Several studies have shown that globulins 7S and 11 have benefits in digestion and human health. Zheng et al. (2021) state in their study on 7S and 11S globulins on anthocyanins suggest that it may be helpful to use soybean 7S and 11S globulins as carriers to improve the stability and antioxidant activity of ACNs.

Several studies have shown that the manipulation of BETAc subunit according to several studies is very difficult to manipulate. Furthermore, the procedure is complicated, even when using the N and S levels. Paek et al. show that under conditions of sulfur deficiency, 7S protein is not formed much, thus it will affect the 7S/11S ratio.

Amino acids are the building blocks of all proteins, including the 7S and 11S globulins. Cysteine and methionine are found more in Globulin 11S than the total protein in soybean seeds and Globulin 7S. Marcone (1999) states that compared to globulin 7S, globulin 11S contains high levels of essential amino acids such as tryptophan, methionine, lysine, histidine, phenylalanine, valine, and isoleucine.

Table 3. Protein content of the 7S and 11S in two soybean varieties Devon and Dena1 in various treatments using S-Si fertilizer

Treatment variety	Globulin 7S (mg/g)	Globulin 11 S (mg/g)	Ratio 11S/7S
D1P0	88,6	89,0	1,00
D1P1	103,7	110,0	1,06
D1P2	105,3	109,6	1,04
D1P3	104,9	109,7	1,23
D2P0	103,1	108,8	1,06
D2P1	105,1	109,1	1,04
D2P2	104,8	108,5	1,04
D2P3	104,7	108,2	1,03

The SDS-PAGE profiles of the 7S and 11S proteins are shown in Figure GG44. The results of the study indicate that between various types of soybean, the composition of the 7S and 11S subunits is different and this affects the level of gelling ability. The results of the SDS-PAGE globulin 7S and 11S profile results are inconsistent and may differ from other studies. However, according to Liu et al. (2007), this is still possible because there are several methods of isolation of 7S and 11S globulins.

Results from this study suggest that the treatment of fertilizer Si-S on two soybean varieties shows a beneficial effect on plant growth, yield, and chemical physiology. Si and S fertilizers are needed to increase the agronomic character and yield of soybeans. The content of 7S and 11S globulins vary between Si-S fertilizer treatments in the two soybean varieties Devon and Dena1.

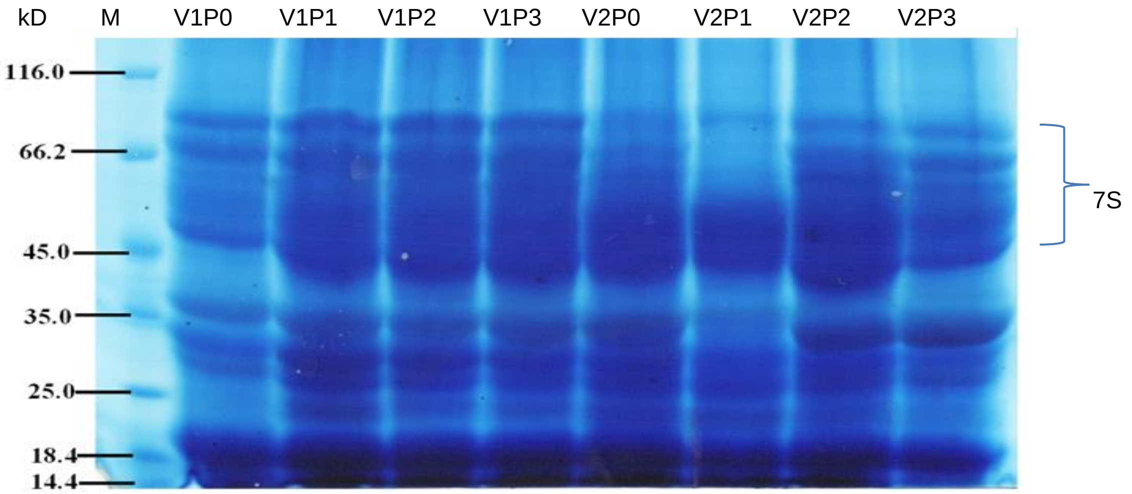

Figure 3. Profile of Globulin 7S of the Devon and Dena1 varieties when treated with Si-S fertilizer.

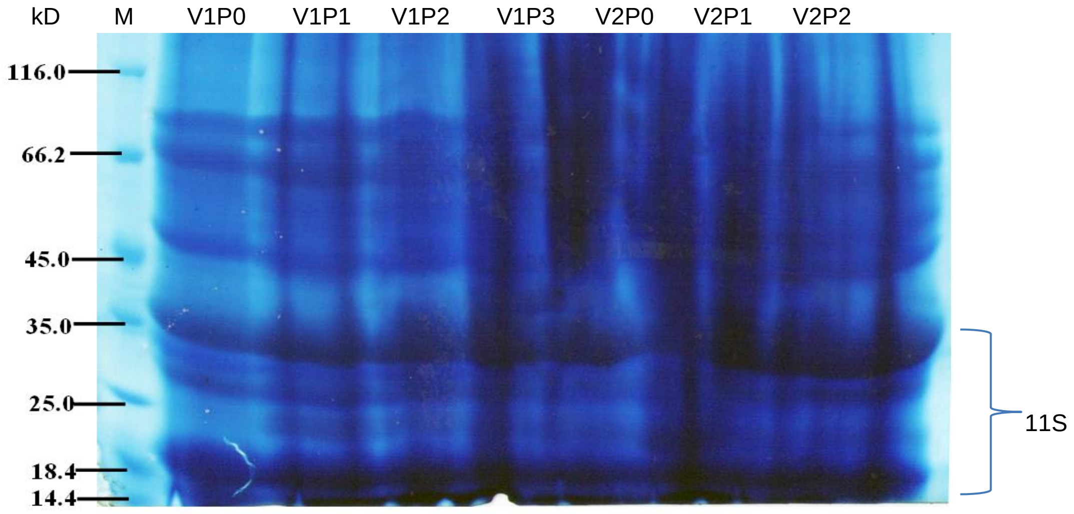

Figure 4. Profile of Globulin 11S of the Devon and Dena1 varieties when treated with Si-S fertilizer.

CONCLUSION

The results from this study strongly suggest that the treatment of fertilizer sulfur-silicate on two soybean varieties shows a beneficial effect on plant growth, yield, and chemical physiology. Sulfur and silicate fertilizers are needed to increase soybeans' agronomic character and yield. The 7S and 11S globulins' content varies between Si-S fertilizer treatments in the soybean varieties Devon and Dena1.

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