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The Effect Of Nitrogen Source And Dosage On Growth, Result And Quality Of Red Beetroot (Beta Vulgaris L.)

Padhina Pangestika[1] , Nur Edy Suminarti[2] , Nunun Barunawati[3]

[1]Postgraduate Program in Agronomy, Faculty of Agriculture, Brawijaya University, Malang, Indonesia

[2]Department of Agricultural, Faculty of Agriculture, Brawijaya University, Indonesia

[3]Agroecotechnology Study Program,Faculty of Agriculture,Brawijaya University Malang

Abstract

Beet are one of the commodities that are in demand by consumers because they contain nutrients needed by health such as iron, vitamin C, potassium, phosphorus, magnesium, folic acid, fiber and high water content (Ceclu and Nistor, 2020). The increasing demand for beets cannot be fully met due to the yield and quality of beetroots. This is based on the problems faced by farmers, especially in East Java, where some beet farmers choose to cultivate crops other than beetroot commodities. Judging by its growth, red beet plants are quite responsive to nitrogen administration. This is because nitrogen plays a role in plant protein formation through the preparation of amino acids, nucleic acids, nucleotides, coenzymes, phytohormones, cytokinins, and chlorophyll.The materials used were red beet plant seeds of Ayumi variety which were 17 days old. The source of N fertilizer consisted of Urea (46%N), ZA fertilizer (21%N and 24%S), SP-36 fertilizer (36% P2O5), and KCl fertilizer (60% K2O). The study used a Randomized Block Design (RAK) which consisted of two factors, namely two sources of nitrogen fertilizer (N) and a dose of nitrogen fertilizer (P). N1 is the nitrogen source of urea. N2 is the nitrogen source of ZA. P1 is 50% of the recommended dose, P2 is 75% of the recommended dose, P3 is 100% of the recommended dose, P4 is 125% of the recommended dose, P5 is 150% of the recommended dose. Of these two factors, there were 10 combination treatments. This experiment used three replications to obtain an experimental unit of 60 units. A plant can grow and develop properly if all plant needs can be fulfilled optimally. Application of nitrogen fertilizers from different sources and doses is an attempt to increase plant growth and yield. The growth components included number of leaves, leaf area, total chlorophyll, crop growth rate, and net assimilation rate. While the yield components include tuber diameter, fresh weight of tubers planted, fresh weight of tubers per hectare, total dry weight of plants, and betacyanin content in red beet tubers. Based on the influence of the source of N fertilizer at various doses, then the source of fertilization from Urea gave a higher effect on leaf number and leaf area than ZA. At the age of 90 days, the variable number of leaves with a dose of 75% and a dose of 100% resulted in a higher number of leaves 5.48 strands (32%) than the 50% dose. The low number of leaves is a result of the low availability of N for plants.The yield of fresh weight of planted tubers, tuber diameter, and total dry weight of the resulting plant was strongly influenced by the amount of assimilate produced by the plant. The amount of assimilate produced by plants can be described by measuring the total dry weight of the plant. the provision of ZA sources resulted in higher total plant dry weight than urea. This is because crop needs for various nutrients during growth and development are not the same, require different times and are not the same amount.A better crop growth rate was found in the application of 100% N fertilizer for the N source of ZA, while at the N source from urea a better growth rate was found in the 125% N application compared to the 50% and 150% doses. Application of nitrogen fertilizer from ZA sources resulted in better growth and yield than urea. Giving a dose of 100% ZA was able to suppress the need for a dose of urea which was indicated by the higher tuber weight yield than the need for a dose of 125% urea.

Keywords: Beetroot, Nitrogen, Fertilizer, Dosage

Introduction

Beets are one of the most popular commodities because they include essential elements including iron, vitamin C, potassium, phosphorus, magnesium, folic acid, fiber, and a highwatercontent (Ceclu and Nistor, 2020). Flavonoid chemicals, sterols, triterpenes, tannins, and betacyanin, a purple red plant pigment, are all found in beetroot. Betacyanin is an antioxidant and anticancer agent (Clifford, 2015). Beetroot is utilized as a natural food colorant in addition to being a nutritional enhancer. The nitrogen composition of urea fertilizer ((NH2)2CO) is different from that of ZA (NH4)2SO4) fertilizer. Urea fertilizer has the highest nitrogen content (46%) and hence requires a smaller dose than ZA fertilizer, which has a nitrogen content of 21%. Chemical compounds in ZA fertilizer, on the other hand, contain more than one element, particularly S, which tuber plants can use. The availability of nitrogen in the soil is actually relatively high, but in Indonesia, particularly in tropical areas with heavy rainfall and high radiation, leaching and volatilization processes will occur often, resulting in low levels of soil N availability.

Due to the yield and quality of beetroots, the growing demand for beets cannot be adequately addressed. This is based on the difficulties that farmers experience, particularly in East Java, where some beet farmers prefer to grow crops other than beetroot. Red beet crops appear to respond well to nitrogen fertilization based on their growth. This is because nitrogen is involved in the production of amino acids, nucleic acids, nucleotides, coenzymes, phytohormones, cytokinins, and chlorophyll, all of which are essential for plant protein creation. Chlorophyll is a crucial component in the synthesis of carbohydrates, as well as in the absorption of light for photosynthetic activities. Chlorophyll a ($C_{55}H_{72}O_5N_4Mg$) functions as a solar energy converter and chlorophyll b ($C_{55}H_{70}O_6N_4Mg$) functions as a photosynthetic antenna (Suminarti, 2011; Dzida et al., 2012).

Different nitrogen concentration with ZA ($(NH_4)_2SO_4$) fertilizer, which is generated from urea fertilizer ($(NH_2)_2CO$). Urea fertilizer has the highest nitrogen content (46%) and hence requires a smaller dose than ZA fertilizer, which has a nitrogen content of 21%. Chemical compounds in ZA fertilizer, on the other hand, contain more than one element, particularly S, which tuber crops can use. The availability of nitrogen in the soil is actually relatively high, but in Indonesia, particularly in tropical areas with heavy rainfall and high radiation, leaching and volatilization processes will occur often, resulting in low levels of soil N availability.

As a result, delivering enough nitrogen to plants, particularly red beet crops, is critical. Excessive nitrogen fertilization can lower production quality, interfere with plant tolerance to weather and viruses, reduce consumption value, and limit post-harvest storage duration. Plants that lack nitrogen will grow slowly, which will result in the formation of red beet tubers (Dzida et al., 2012). The activity of red beet cultivation can be maximized by choosing the proper source and dose, which is why this study was conducted.

Materials

The tools used are hoe, watering can, shovel, ruler, analytical scale, meter, impraboard, LAM (Leaf Area Meter), oven and spectrophotometer. The materials used were red beet plant seeds of Ayumi variety which were 17 days old. The source of N fertilizer consisted of Urea (46%N), ZA fertilizer (21%N and 24%S), SP-36 fertilizer (36% P_2O_5), and KCl fertilizer (60% K_2O).

Method

The research was carried out from April 2021 to July 2021 on agricultural land in Cemorokandang Village, Kedungkandang District, Malang City. The research location is located at an altitude of ±506m above sea level, the average daily temperature ranges from 24-28oC with rainfall of around 297 mm/month - 319 mm/month and an average humidity of 75-80% (BPS, 2019).

The study used a Randomized Block Design (RBD) which consisted of two factors, namely two sources of nitrogen fertilizer (N) and a dose of nitrogen fertilizer (P). N1 is the nitrogen source of urea. N2 is the nitrogen source of ZA. P1 is 50% of the recommended dose, P2 is 75% of the recommended dose, P3 is 100% of the recommended dose, P4 is 125% of the recommended dose, P5 is 150% of the recommended dose. Of these two factors, there were 10 combination treatments. This experiment used three replications to obtain an experimental unit of 60 units.

The land area used is around 321.63 m^2 with details 7.10m length and 45.30m wide. The initial activity carried out was land sanitation by removing litter from previous crops, as well as weeds that grew around the land. Next is the first tillage withusing a hoe which aims to turn over and dismantle lumps of soil and cut off the growth of weeds. Then the second tillage is carried out to destroy the remaining plant debris while forming mounds or beds andget a loose soil texture.Each replication consisted of 10 treatment plots and each treatment plot measuring 4.20m length and 1.70m wide, consisting of 119 planting holes. The spacing used was 25cm X 25cm with the distance between replicates and between treatment plots was 50cm. Initial soil analysis was carried out before planting which aims to determine the status of nutrients in the soil, including the content of N, P and K elements in the soil. Soil analysis was carried out at the BALITKABI Soil Chemistry Laboratory, Malang.

The beet seed used is the Ayumi variety which has been certified No: 100/Kpts/SR.120/D.2.7/10/2017. Seeds are sown in the seedling tray which has been filled with soil:sand (1:1). After the leaves appear, transplanting is carried out. The seeds are watered until the planting medium is moist enough and is done every morning. Transplanting is carried out when the plant is 17 days after sowing, with the characteristics of having two perfect leaves appear. The criteria for the selected seeds are uniform and not infected with pests and diseases.

The fertilizers used are inorganic fertilizers, namely N fertilizer (Urea 46% N and ZA 21%N) and K fertilizer (KCL: 60% K2O). P fertilizer is given at the time of final tillage. N and K fertilizers are given when the plant is 7 days old as much as 1/3 part of the entire dose which is useful for stimulating early plant growth. The remaining 2/3 part is applied when the plant is 21 days after planting which is useful for spurring the generative growth of plants. Fertilizer is given by ditugal and covered again with soil. The dose of fertilizer applied was adjusted to the treatment. Watering was carried out one day before planting, after the first fertilization and second fertilization, and adjusted to field conditions. If it rains then no watering. Harvesting when the plants have harvest criteria.

Results and Discussion

1. Number of Leaves

Table 1. The average number of leaves of red beet crops at different sources and dosage of nitrogen fertilizer at the five ages of observation

Treatment	Number of leaves (crop^{-1}) at the age of observation (DAP)				
	30	45	60	75	90
Source of N Fertilizer:					
Urea	5.49	7.99	11.17 b	15.43 b	8:37
ZA	5.84	7.80	9.96 a	13.78 a	19.03 a
HSD 5%	ns	ns	0.42	1.03	1.29
CV %	6.39	8.71	5.20	9.19	8.50
N Fertilizer Dosage (%Recommendation):					
50%	5.48	7.42	10.12	13.08 a	17.12 a
75%	5.78	7.96	10.59	14.10 ab	20.63 cd
100%	5.88	8.67	11.15	16.26 c	22.60 d
125%	5.72	7.79	10.48	15.39 bc	19.86 bc
150%	5.45	7.64	10.48	14.20 ab	18.31 ab
HSD 5%	ns	ns	ns	1.63	2.03
CV %	6.39	8.71	5.20	9.19	8.50

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 2 at 60, 75 and 90 DAP following planting, the nitrogen source treatment had a significant effect on the number of leaves. Showed that providing nitrogen supplies from urea resulted in the maximum number of leaves as compared to ZA, as seen by the number of leaves seen at 60, 75, and 90 DAP. The 50%dose did not change much from the 150%dose at 90dayafter planting.Delivering a 150%dose, on the other hand, produced the same results as giving a 125%dose. 75%and 100%doses had the same impact as the same number of leaves. When compared to doses of 50%and 150%, 75%and 100%increased the number of leaves by 5.48 leaves (32%) and 3.51 leaves (21%), respectively. The number of leaves reduced by 2.74 strands (14%) and 4.21 leaves when the fertilizer dose was increased from 100%to 125%and 150%(23%). The 75%dose treatment raised the number of leaves by 3.51 strands (21%) compared to the 50%dose, however there was a drop of 2, according to this study.

Crop growth is the process of a plant's size increasing, which may be assessed by the size and height of the plant's organs (Hapsari et al., 2018). A plant can grow and develop properly if all of its demands are met to their full potential. The use of nitrogen fertilizers from various sources and in various amounts is an attempt to boost plant growth and output. The findings revealed a substantial relationship between nitrogen fertilizer and dose on red beet growth and production. The number of leaves, leaf area, total chlorophyll, crop growth rate, and net assimilation rate were all considered growth factors. Tuber diameter, fresh weight of tubers planted, fresh weight of tubers per hectare, total dry weight of crop, and betacyanin content in red beet tubers are among the yield components.

Based on the effect of different N fertilizer sources at different doses, Urea had a greater effect on leaf number and leaf area than ZA. The variable number of leaves with a dose of 75%and a dose of 100%resulted in a higher number of leaves 5.48 cm^2 (32%), compared to the 50%dose, at the age of 90 days. The lack of leaves is due to the lack of nitrogen available to plants. Meanwhile, increasing the fertilizer dose to 125%and 150%reduced the number of leaves produced. This is due to the enormous amount of nitrogen that plants absorb, resulting in succulent plants (excess N). Excessive usage of N fertilizers, according to Pahlevi et al. (2016), can reduce fertilization efficacy and increase plant damage owing to insect and disease attacks, therefore the 125%and 150%doses did not generate a sufficient number of leaves and leaf area

Table 2. Average leaf area of red beet crops on different sources and dosages of nitrogen fertilizer at five ages of observation

Treatment	Leaf Area (cm2 crop^{-1}) at Observation Age (DAP)				
	30	45	60	75	90
Source of N Fertilizer:					
Urea	33.41	157.26 b	567.69 b	783.55 b	1203.86 b
ZA	34.01	143.75 a	508.48 a	705.93 a	1047.17 a
HSD 5%	ns	7.53	57.08	63.21	99.34
CV %	6.25	6.53	13.83	11.06	11.51
N Fertilizer Dosage (%Recommendation):					
50% dose	32.45	137.81 a	423.29 a	685.12 a	974.93 a
75% dose	33.48	150.61 bc	480.23 a	699.55 ab	1041.28 ab
100% dose	34.63	168.48 d	725.29 c	906.24 c	1273.64 c
Dosage 125%	34.37	156.55 c	615.98 b	734.87 b	1197.94 bc
150% Dosage	33.62	139.07 ab	445.52 a	637.91 a	1139.79 bc
HSD 5%	ns	11.91	90.25	99.95	157.08
CV %	6.25	6.53	13.83	11.06	11.51

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

At 45, 60, 75, and 90 days after planting, nitrogen source treatment had a very substantial effect on leaf area metrics, as shown in Table 3. In comparison to ZA, providing nitrogen from urea resulted in the same increase in leaf area at four observation ages: 45, 60, 75, and 90 days after planting. Treatment with N source urea was significantly greater than ZA, with 13.51 cm^2 (9%), 59.21 cm^2 (12%), 77.62 cm^2 (11%), and 156.69 cm^2 (15%), respectively.

At 90 days following planting, leaf area showed that a 100%nitrogen dose had the same response as 125%and 150%nitrogen doses, but was much wider than 50%and 75%nitrogen doses. A 75%dose had the same effect on leaf area as 50%, 125%, and 150%doses. The effect of the 50%dose was less than the 125%dose of 223.01 cm^2 (23%), and the 150%dose of 164.86 cm^2 (17%). When compared to doses of 50%and 75%, the area of 298.71 cm^2 (31%) and 232.36 cm^2 (22%) grew significantly at 100%.

Because of its role as a factor of the size of the rate of photosynthesis produced, leaf area is one measure of growth. Meanwhile, the observed leaf area with a dose of 100% was larger than that with a dose of 50%, and the same result was seen with doses of 125% and 150%. However, increasing the dose resulted in a leaf area effect that was similar to the 75%dose.

The dose and type of nitrogen, which stimulates rapid cell division and elongation in plant meristem tissue, affects the number of leaves planted and the area of the leaves, affecting vegetative development (Sapkota et al., 2021). Because it is a component of chlorophyll, nucleotides, amino acids, proteins, and secondary metabolic products, nitrogen is a crucial component for plants (Taiz and Zeiger, 2013). According to the findings of Najm et al (2013), leaf area rose in tandem with the amount of N fertilizer applied, but only up to the maximum limit of plant nutrient absorption. Because the amount of nitrogen in urea differed from that in ZA, urea produced more leaf area. Urea has a single nitrogen content of 46%, whereas ZA has a nitrogen content of 21%and a sulfur content of 24%. During growth and development, the needs of plants for various nutrients are not the same, require different times, and require different amounts. Because of its role as a factor of the size of the rate of photosynthesis produced, leaf area is one measure of growth.

Giving the plant the right amount of nitrogen promotes an increase in leaf area, which results in more solar energy being intercepted by the leaf canopy (Singh et al., 2015). Chlorosis, or yellowing of the leaves due to reduced chlorophyll content, can occur when plants are lacking in nitrogen due to inadequate availability or absorption (Suminarti et al., 2019). A 125%dose of urea contains the same amount of chlorophyll as a dose of 100%or 150%. Meanwhile, the chlorophyll levels in the 7%and 125%ZA dosages were the same. When the chlorophyll content was increased to 150%, the effect was the same as when the dose was 50%.

2. Crop Growth Rate (CGR)

Table 3. Average crop growth rate of red beet crops on different sources and dosage of nitrogen fertilizer at age phase30-45DAP, 45-60DAP, 60-75DAP.

Treatment	Crop Growth Rate (mg $cm^{-2}day^{-1}$) at Observation Age (DAP)		
	30-45	45-60	60-75
Source of N Fertilizer:			
Urea	0.0410 b	0.1202 a	0.1330 a
ZA	0.0303 a	0.1481 b	0.1724 b
HSD 5%	0.0068	0.0148	0.0251
CV %	4.00	6.93	4.65
N Fertilizer Dosage (%Recommendation):			
50%	0.0278 a	0.1249 a	0.1302 a
75%	0.0315 a	0.1352 ab	0.1576 ab
100%	0.0520 b	0.1531 b	0.1950 b
125%	0.0349 a	0.1378 b	0.1509 a
150%	0.0322 a	0.1197 a	0.1299 a

HSD 5%	0.0108	0.0234	0.0397
CV %	4.00	6.93	4.65

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 4 reveals that differing nitrogen fertilizer sources and doses had a substantial impact on all phases. The addition of nitrogen source from urea fertilizer offered the best yield compared to ZA of 0.0107mg $cm^{-2}day^{-1}$ in the 30-45 DAP phase (35%). A dose of 100% gave a high growth rate effect of 49%, 29%, and 50%in the 60-75 DAP compared to doses of 50%, 125%, and 150%, but it was not substantially different when given a dose of 75%. A dose of 75%did not differ significantly from doses of 50%, 125%, or 150%.

Table 5. Average Crop Growth Rate ($mgcm^2day^{-1}$) Red Beet on Different Sources and Dosages of Nitrogen Fertilizer at Age 75-90 DAP.

Source N . fertilizer	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	0.1432 a	0.1690 a	0.2004 a	0.2350 a	0.1358 a
	A	A	A	A	A
ZA	0.0851 a	0.2706 c	0.2618 bc	0.1592 ab	0.2288 bc
	A	A	A	A	A
HSD 5%	0.1087				
CV %	4.21				

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, tn = no significant effect, CV = coefficient of diversity

There was an interaction between the provision of nitrogen fertilizer sources and the dose of fertilizer during the final phase, which occurred 75-90 days after planting. At all dose levels, the treatment of the N source of urea was not significantly different. The number of leaves was not substantially different when the N source of ZA was treated with a dose of 75%compared to 100%and 150%. However, the 50%and 125%dosages resulted in significantly greater growth rates of 0.1855mg cm^{-2} day^{-1} and 0.1114 mg cm^{-2} day^{-1}, respectively. 100%doses produce the same plant growth rate response as 125%and 150%doses, but at a 0.1317 greater cost. against a 50%dosage of mg cm^{-2} day^{-1} The growth rate was much lower at the 50%dose than at the 75%, 100%, and 150%doses. When the effect of various amounts of N fertilizer on the two sources of N fertilizer was examined, it was discovered that the growth rate was the same.

The net absorption rate increased as the amount of N fertilizer applied increased. However, the plant does not always respond well to the excessive amount (Sikuku et al., 2016). According to Liao et al. (2019), all N treatments examined yielded high yields and tuber weights when compared to N1 (Urea). With increasing N application, yield and single tuber weight increased, but the excess N applied did not result in a further increase in production, as projected. Because of the existence of S components, providing a source of N from ZA can boost the rate of net assimilation of plants. Low sulphurcan impair absorption in sugar beet plants, according to Hoffmann (2004)'s research.

According to Taiz and Zeiger (2013), the existence of chlorophyll in plants is critical for their development. When chlorophyll levels are controlled to low levels, cultivar production and growth are directly impacted. Because N is an amino basic component required for the synthesis of chlorophyll, this is related to the availability of N in the soil and N uptake. Skudra et al. (2017) discovered that chlorophyll concentration is influenced by the amount of N and S fertilizers applied. The amount of chlorophyll in the leaves is a useful measure for evaluating N uptake from the soil under various growing circumstances. Furthermore, by supplying nutrients A high level does not always imply that the amount of chlorophyll in the leaves will rise. This is according to Suminarti's (2011) research, which found that when N is administered at a level of 200%, the amount of chlorophyll generated is lower than when N is administered at doses of 100%and 150%. The high N provided not only for chlorophyll production, but also lost due to other processes, suggests this.

3. Chlorophyll Content

Table 7. Average chlorophyll content (μgg^{-1}) red beet crop at different sources and dosages of nitrogen fertilizer at five observation ages

Nitrogen Source	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	2,876 a	1.255 a	4.431 ab	5,285 b	4,142 ab
	A	A	A	A	A
ZA	1.915 a	1.949 ab	4.225 b	3,016 ab	1,768 a
	A	A	A	B	B
HSD 5%	1.64				
CV %	19.97				

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

There is a connection between the nitrogen fertilizer source and the fertilizer dose when it comes to total chlorophyll content. The treatment of N source of urea at a dose of 125%was not substantially different from doses of 100 and 150%, but it was significantly higher than doses of 50 and 75%, 2.409 (87%) and 22.030 (75%), respectively (62%). The total chlorophyll amount was not substantially different in the treatment of N source of ZA with a dose of 100%compared to doses of 75%and 125%, but was significantly greater at 2.34 and 2.457 compared to doses of 50%and 150%. When the effect of various doses of N fertilizer on the two sources of N fertilizer was examined, it was discovered that the differences in N dosages of 50%, 75%, and 100% of total chlorophyll produced were not statistically different between the two N sources from urea and ZA. In the N source of ZA, however, increased total chlorophyll was achieved when N fertilizer doses of 125%and 150%were administered.

The provision of N from urea and ZA had an interaction, with ZA administration increasing the chlorophyll content. Nitrogen is a key component of proteins and biomolecules in plants, such as chlorophyll (Yuming et al., 2017). While chlorophyll is a molecule that aids photosynthesis by absorbing light. When there is enough chlorophyll in the plants, photosynthesis functions best (Suminarti, 2011). Chlorophyll a ($C_{55}H_{72}O_5N_4Mg$) is a solar energy converter, and chlorophyll b ($C_{55}H_{70}O_6N_4Mg$) is a photosynthetic antenna. The assimilate is low if the absorbed chlorophyll does not go well. The poor rate of assimilation This inhibits the energy needed in the growth process as well as a portion of what will be stored as food reserves in the form of tubers. Suminarti (2011) claims that the total and leaf area results will have a substantial impact on the fresh weight and total dry weight of the producing plant. The greatest solar radiation that can be captured by plants is determined by the breadth of the leaf area, which affects the photosynthesis process. This is based on the findings of Zhang et al. (2018), who claim that increasing leaf area optimizes light interception, which leads to increased photosynthesis and biomass. Optimal photosynthesis will supply sufficient photosynthate for the correct formation of tubers. However, an increasing number of leaves does not always imply a high photosynthetic value because the higher the leaf density, the lower the photosynthetic value. As a result, sunlight is unable to reach the lower leaves, and the leaves are unable to use sunlight effectively for photosynthesis. Suminarti (2011) findings reveal that when plant density rises, solar radiation intensity decreases. Excessive dosage, on the other hand, had no effect on the broadening of the leaf area. This demonstrates that a big number of leaves does not always imply a large overall leaf area for the plant.

5. Bulb Diameter

Table 8. Average Diameter of Red Beet Bulbs at Different Sources and Dosages of Nitrogen Fertilizer

Nitrogen Source	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	75.04 a	86.23 abc	97.83 c	95.78 bc	84.18 ab
	A	A	A	A	A
ZA	78.49 a	93.41 b	120.43 c	101.52 b	91.46 b
	A	A	B	A	A
HSD 5% 11.79					
CV % 5.25					

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 8 shows that the diameter of the red beet tuber is affected by the amount of nitrogen fertilizer used and the amount of fertilizer applied. The treatment of N source of urea at doses of 100%, 75%, and 125%did not differ significantly. It was, however, much higher than the doses of 50% and 150%. The dose of 125%was much higher than the dose of 50%. A 50%dose did not differ much from a 75%and 125%dose.

At 100%urea dose, tuber diameter was comparable to 75%and 125%urea doses, as well as 100%ZA. The limited yield of translocated assimilate was shown by the small tuber diameter produced. The assimilation utilized for tuber development suggests that the more N fertilizer added, the greater the impact on yields such as tuber diameter (Sinta and Garo, 2021). The yield component of a plant is influenced by its growth component. A good growth phase will be followed by a good generative phase, in which the plant's generative organs will grow well and the plant will be capable of producing good results.

Because the element S present in ZA is capable of pursuing the desired tuber formation ability, the influence ofZA as a source of N is greater than that of urea. Sulfur is also found in coenzyme A, as well as the carbohydrate-metabolizing hormones biotin and thiamin (Wihardjaka and Poniman, 2015). In lowland rice, ZA fertilization can replace urea fertilizer and boost grain production by 7.5%. The number of tillers is lowered and rice yields are reduced if S is not present at the start of plant growth (Singh et al. 2012). When nutrient S is scarce, adding nitrogen fertilizer has little effect on plant output or protein content (Zuzhang et al. 2010). Tuber diameter, total dry weight of the plant, and wet tuber weight were all significantly affected by the ZA fertilizer dose treatment. According to the research of Sahar et al., raising S content can change the width of tubers (2013).

9. Fresh Weight of Plant Bulbs

Table 9. Average Fresh Weight of Red Beet Bulbs per Plant at Different Sources and Dosages of Nitrogen Fertilizer at Five Observation Ages

Treatment	Bulb Fresh Weight (g crop-1) at Observation Age			
	30	45	60	75
Source of N Fertilizer:				
Urea	7.76	15.80	94.73 a	161.14 a
ZA	7.71	16.10	121.09 b	187.60 b
HSD 5%	ns	ns	10.53	13.72
CV %	7.58	6.55	12.73	10.26
N Fertilizer Dosage (%Recommendation):				
50%	7.66	15.26	91.26 a	142.64 a
75%	7.63	16.11	104.44 ab	169.36 b
100%	7.74	16.32	123.57 c	210.90 c
125%	7.88	15.96	113.46 bc	178.44 b
150%	7.75	16.12	106.84 ab	170.53 b
HSD 5%	ns	ns	16.66	21.69
CV %	7.58	6.55	12.73	10.26

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 9 shows that the ZA nitrogen source treatment had a very substantial influence on the fresh weight characteristics of tubers at 60 and 75 days after planting when compared to urea at 26.36 g crop-1 (28%) and 26.46 g crop^{-1} (28%) respectively (16%). Tubers by 66.51g crop^{-1} from 60 days after planting to 75 days after ZA fertilizer was applied (55%).

Giving a 100%dose at 75 days after planting considerably improved the fresh weight of the highest tuber harvest compared to other treatments. A dose of 75% produced the same results as doses of 125 and 150%, but it was much greater than the dose of 50%.

Table 10. Average fresh weight of bulbs (g crop^{-1})red beets on different sources and doses of nitrogen fertilizer

Nitrogen Source	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%

Urea	244.14 a	372.70 c	368.76 bc	288.24 abc	252.91 ab
	A	A	A	A	A
ZA	248.01 a	426.30 c	590.03 d	378.50 bc	271.81 ab
	A	A	B	A	A
HSD 5%			116.63		
CV %			13.98		

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

At 90 days after planting (Table 10), urea treatment at a 75%dose was not significantly different from urea treatment at 100%and 125%, but was significantly heavier at 128.56 g crop^{-1} (53%) and 119.79 g crop^{-1} (47%) versus urea treatment at 50%and 150%. The application of the 100%dose resulted in significantly higher fresh weight than the 50%dose of 124.62 g crop-1 (51%), while doses of 75%, 125%, and 150%did not differ significantly. In comparison to dosing of 50%, 75%, 125%, and 150%, providing nitrogen source from ZA with a dose of 100%resulted in the maximum production of fresh weight of tubers of 348.02 g crop^{-1}, 163.73 g crop-1, 211.53 g crop^{-1}, and 318.22 g crop-^{1}. Following that, a nitrogen source ZA was administered at a 75%dose, which had the same response as a 125%dose but was much heavier than the 50%dose of 178.29 g crop^{-1} (72%) and the 150%dose of 154, 49 g crop^{-1} (150%) (57%). A 125%dose produced the same fresh weight of tubers as a 150%dose.

The amount of assimilate produced by the crop had a significant impact on the yield of fresh weight of planted tubers, tuber diameter, and total dry weight of the resultant plant. The total dry weight of a crop can be used to calculate the quantity of assimilate it produces. Table 12 reveals that urea injection resulted in a high dry weight 45 days after the age of observation when compared to ZA. Meanwhile, with the addition of ZA sources, the total dry weight of the crop is larger than urea when the plants reach the age of 60 to 90 days after harvest (harvest). This is due to the fact that plants nutritional requirements during growth and development are not the same, necessitate different periods, and require different amounts. Root weight and plant dry weight rose after receiving ZA containing 24%S. (Awad et al., 2013).

Plants use bulbs as a storage location for their food stores. Bulbs are also defined as a qualitative shift in root system growth from roots to tubers. The source and dose of nitrogen are critical factors that impact tuber development (Sinta and Garo, 2021). Fertilization, which provides nutrients from the soil, can impact the fresh weight of plant tubers. Excessive nitrogen treatment causes excessive leaf growth and prevents red beet tuber formation. A regression analysis was performed to evaluate how far the link between the application of fertilizer N (X) and the fresh weight of the tubers (Y) was related to the dose administered (Figure 3). The N source of ZA fertilizer was determined by regression analysis.

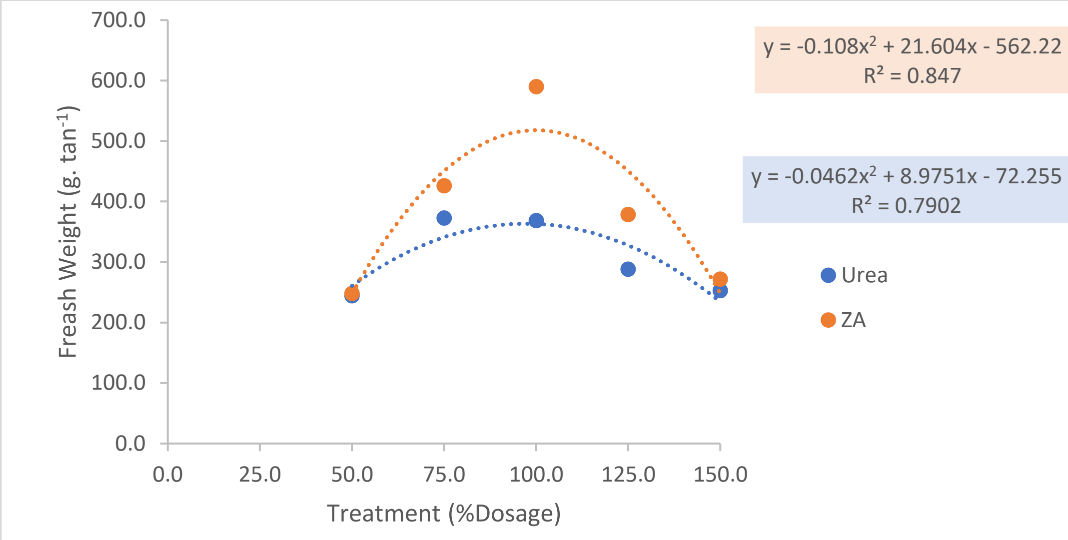

Figure 1. Regression between source and dose of N fertilizer with fresh weight of tubers.

The fresh weight of tubers on the source of N ZA 100% was 590g, while the fresh weight of tubers on the source of 100%urea was 368.8g, according to these formulae. The coefficient of determination at the source of Urea and ZA was 0.79 and 0.84, respectively, indicating that the source and dose of N fertilizer influenced roughly 79%and 84%of the fresh weight of the tubers produced. The ZA source treatment resulted in better yields than the urea treatment. Plants absorb N in little amounts during the tuber formation phase (generative). The presence of element N has an effect on the yield attained at each dose. This is because the presence of element S can promote tuber development. The nutrient S has an essential part in plant metabolism, especially when it comes to the characteristics that affect the quality of red beetroot output. A high sulfur level, on the other hand, might cause the soil to become acidic and bind other nutrients, causing plant growth to be inhibited. According to Muhammad et al.(2003), the more the sulfur treatment to plants, the lower the plant development and yield, because excess S in the soil is a major barrier for plants to create tubers. Sulfur is also required as a component of coenzymes and amino acids such as methionine and cysteine, which are required for the production of protein structures and are linked to the synthesis of chlorophyll, vitamins, proteins, and carbohydrates, hence S deficit can affect protein synthesis (Awad et al., 2013).

6. Fresh Weight of Bulbs Per Hectare

Table 11. Average Fresh Weight of Bulbs Per hectare (ton ha-1) Red Beet on Different Sources and Dosages of Nitrogen Fertilizer

Source Nitrogen	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	12.03 a A	13.30 ab A	20.86 c A	20.10 bc A	15.32 ab A
ZA	18.35 ab A	21.70 ab B	23.10 b A	21.42 ab A	16.49 a A

HSD 5% 5.29
CV %11.95

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 11 demonstrates that the yield of fresh weight of tubers per hectare at a dose of 100%urea was not substantially different from that at a dose of 125%. When compared to doses of 50%, 75%, and 150%, it has a substantial effect on raising the fresh weight of tubers per hectare by 8.83 g crop^{-1} (73%), 7.56 g crop^{-1} (57%), and 5.54 g crop^{-1} (36%). The 125%dose was not statistically different from the 150%dose, but it was significantly higher than the 50%and 75%doses of 8.07 g crop^{-1} (67%) and 6.8 g crop^{-1} (68%), respectively (51%).

Furthermore, a 100%dose of ZA had the same reaction as 50, 75, and 125%doses, but was much higher than the 150%dose of 6.61 g crop^{-1} (40%). The treatment doses of 50%, 75%, and 125%had the same effect as the 150%dose. When comparing the effects of various N fertilizer doses on the two sources of N fertilizer, it was discovered that the differences in N doses of 50%, 100%, 125%, and 150%of the fresh weight of tubers per hectare produced were not significantly different between the two sources of N fertilizer. The fresh weight of the tubers was heavier on the N source than ZA when the dose of N fertilizer applied was 75%.

7. Total Crop Dry Weight

Table 12. Average Dry Weight of Red Beet Crops at Different Sources and Dosages of Nitrogen Fertilizer at Four Observation Ages

Treatment	Total Dry Weight (g crop-1) at Observation Age			
	30	45	60	75
Source of N Fertilizer:				
Urea	0.74	4.58 b	16.15 a	28.62 a
ZA	0.74	3.58 a	17.50 b	33.67 b
HSD 5%	ns	0.64	1.27	2.28
N Fertilizer Dosage (%Recommendation):				
50%	0.70	3.31 a	15.02 a	27.23 a
75%	0.72	3.67 a	16.35 ab	31.12 b
100%	0.72	5.60 b	19.95 c	38.24 c
125%	0.78	4.05 a	17.81 b	31.96 b
150%	0.77	3.78 a	15.01 a	27.19 a
HSD 5%	ns	1.11	2.00	3.61
CV %	11.9	20.51	9.81	9.55

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Giving a dose of 100%at 75 days after planting enhanced the total dry weight of the plant by 11 g crop^{-1} (40%), 7.12 g crop^{-1} (23%), 6.28 g crop-1 (20%), and 11.05 g crop^{-1} (20%). (41%). However, when compared to the 50%and 150%doses, the 75%and 125%doses were significantly higher at 3.89g crop^{-1} (14%) and 4.77 g crop^{-1} (18%). The findings of the analysis of variance at 90 days after planting (Table 12) revealed that the source of nitrogen fertilizer and the dose of fertilizer had a significant interaction on the crops total dry weight variable.

Table 12. Average total dry weight (g crop^{-1})red beet crop on different sources and doses of nitrogen fertilizer at 90 DAP.

Nitrogen Source	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	38.80 ab	44.05 ab	55.76 c	49.63 bc	37.69 a
	A	A	A	A	A
ZA	37.07 a	59.41 bc	64.04 c	51.25 b	50.86 b
	A	B	A	A	B
HSD 5% 8.92					
CV %7.80					

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 12 reveals that the 100%urea dose was not substantially different from the 125%dose, but the total dry weight of the resultant plant was 16.96 (44%), 11.71 (27%), and 18.07%higher than the 50%, 75%, and 150%doses, respectively (48%). The effect of the 125%dose was the same as the 50%and 75%doses. Meanwhile, increasing the dose to 150%did not substantially differ from the 50 and 75%doses, but it was significantly lower by 11.94 (32%), compared to the 125%dose.

A dose of 100%ZA produced the same total dry weight as a dose of 75%, but was significantly different from doses of 50%, 125%, and 150%, which produced total dry weights of 26.97 (73%), 12.79 (25%), and 13.18%, respectively (26%). The 75%dose did not differ significantly from the 100%, 125%, and 150%doses. 75%, 125%, and 150%doses, on the other hand, considerably increased plant total dry weight by 22.34 (60%), 14.18 (38%), and 13.79%, respectively (37%).When comparing the effects of various N fertilizer doses on the two sources of N fertilizer, it was discovered that the differences in N dosages of 50%, 100%, and 125%of the total dry weight of the resultant plants were not statistically different between the two sources of N fertilizer. However, the N source outperformed ZA when the N fertilizer dose was 75%and 150%of the total dry weight of the plant.

At 90 days following planting, the application of a 100%dose resulted in the plant's total dry weight being higher than the complete dose treatment. The total dry weight of the plant was reduced by 50% when the dose was reduced by 50% and by 150%when the dose was increased. The low dry weight produced shows that the nutrients available to plants are insufficient or excessive, which inhibits the creation of plant tubers. (b) As a result of the low dry density, the nutrients accessible to plants are poor. Assimilate is energy that will be consumed by plants, and as a result, the creation of plant physiological organs will be hampered. The assimilate is used as energy for plant growth, with some tubers being stored as food reserves. Because the nitrogen application in the treatment has exceeded the optimal point, causing some of the assimilated nitrogen to separate as amides, only increasing plant nitrogen content but reducing carbohydrate synthesis, an excess supply of N does not always result in an increase in yield, but can result in a decrease in growth and yield. This is justified because excessive N fertilizer application delays maturity, and competition between sinks (tubers) and sources (leaves) limits storage organ formation, resulting in decreased tuber yields (Table 10) (Najm et al., 2013). It can affect tuber quality in terms of physical, flavor, and maturity, in addition to lowering yields.Betacyanin Content

Table 13. Average Betacyanin Content of Red Beet on Different Sources and Dosages of Nitrogen Fertilizer

Source N . fertilizer	Dosage of Nitrogen Fertilizer (%Recommendation)				
	50%	75%	100%	125%	150%
Urea	120.38 ab	129.51 abc	152.76 c	150.66 bc	104.69 a
	A	A	A	A	A
ZA	155.57 ab	167.67 b	157.54 ab	146.36 ab	132.62 a
	B	B	A	A	B
HSD 5% 260.56					
CV %10.16					

Note: Numbers accompanied by the same letter in the same column and treatment show no significant difference based on the HSD test at 5% level, DAP = Days After Planting, ns = no significant effect, CV = coefficient of diversity

Table 13 shows that 100%urea administration was not substantially different from 75%and 125%urea administration, but that including betacyanin was greater than the 50% dose of 32.38 (27%) and the 150%dose of 48.07 (46%). The betacyanin level of the 125%dose treatment was the same as the 50%, 75%, and 100%doses, but it was 45.97 (44%) higher than the 150% dose. The administration of ZA at a dose of 75% resulted in a higher betacyanin content of 35.05 (26%), compared to a dose of 150%, but there was no significant difference at doses of 0%, 100%, or 125%.When the effect of various doses of N fertilizer on the two sources of N fertilizer was examined, it was discovered that the difference in N dosages of 100%and 125%of the betacyanin content produced between the N sources of urea and ZA was not significant. The betacyanin concentration of the N source was higher than that of the ZA when doses of N fertilizer were applied at 50, 75, and 150%.

Urea has a high content at doses of 50% and 75% ZA, and up to a dose of 125%ZA. The betacyanin concentration, on the other hand, reduced by 80% when the dose was increased to 150%. Because betacyanin is made up of nitrogen components, nitrogen fertilization has a major impact on beetroot betacyanin level. With increased nitrogen application, the betacyanin concentration decreased (Tanaka et el., 2008). Plants absorb available nitrogen and synthesis it into numerous amino acids, one of which is tyrosine (TyH). Through the shikimate synthesis route, this amino acid serves as a precursor for the formation of betacyanin. With adequate N fertilization, it is believed that a rise in the fresh weight of tubers will result in an increase in the betacyanin content of crops (Sitompul et al., 2020). Sulphur shortage in tubers mimics the symptoms of plant pigment diseases. Because both nutrients are used in protein production, N and S metabolism are intertwined. As the administration of the given dose of N rises, the total protein content can decrease (Maboko et al., 2017). In the case of extra N in the bit, S uptake is increased. The application of N fertilization, which has a function in primary metabolites, has a significant impact on beetroot yield. Strongly stimulates plant growth and development, as well as the adaptation and survival of the red beet plants secondary metabolites.

Conclusion

It is possible to draw the following conclusions based on the findings of the research: For the N source of ZA, a higher plant growth rate was obtained when a 100% dose of N fertilizer was applied, while for the N source of urea, a higher plant growth rate was obtained when a 125% dose of N was applied, compared to doses of 50% and 150%. The use of nitrogen fertilizer derived from ZA sources resulted in higher growth and yield than the use of urea. Giving a dose of 100% ZA was able to reduce the demand for urea, as evidenced by the increased tuber weight output compared to a dose of 125% urea.

Reference

Awad, N. M. M., Gharib, H. S., &Moustafa, S. M. (2013). Response of Sugar beet (beta vulgaris L.) to Potassium and Sulphur Supply in Clayed Soil at North Delta, egypt. Egypt. J. Agron, 35(1), 77-91.

BPS. 2018. Kabupaten Malang dalam Angka-Malang Regency in Figures. Malang. BPS Kabupaten Malang. p20.

Ceclu, L., &Nistor, O. V. (2020). Red Beetroot: Composition and Health Effects—A Review. J. Nutr. Med. Diet Care, 6, 043.

Clifford, T., Howatson, G., West, D. J., & Stevenson, E. J. (2015). The potential benefits of red beetroot supplementation in health and disease. Nutrients, 7(4), 2801-2822.

Dzida, K., Jarosz, Z., &Michałojc, Z. (2012). Effect of nitrogen fertilization on the yield and nutritive value of Beta vulgaris L. Journal of Elementology, 17(1).

Hoffmann, C., Stockfisch, N., & Koch, H. J. (2004). Influence of sulphur supply on yield and quality of sugar beet (Beta vulgaris L.)—determination of a threshold value. European journal of agronomy, 21(1), 69-80.

Liao, L., Dong, T., Qiu, X., Rong, Y., Wang, Z., & Zhu, J. (2019). Nitrogen nutrition is a key modulator of the sugar and organic acid content in citrus fruit. Plos one, 14(10), e0223356.

Maboko, M. M., Du Plooy, C. P., Sithole, M. A., &Mbave, A. (2018). Swiss Chard (Beta vulgaris L.) Water Use Efficiency and Yield under Organic and Inorganic Mulch Application.

Najm, A. A., Hadi, M. R. H. S., Darzi, M. T., &Fazeli, F. (2013). Influence of nitrogen fertilizer and cattle manure on the vegetative growth and tuber production of potato. International Journal of Agriculture and Crop Sciences (IJACS), 5(2), 147-154.

Pahlevi, R. W., Guritno, B., &Suminarti, N. E. (2016). Pengaruhkombinasiproporsipemupukan nitrogen dan kalium pada pertumbuhan, hasil dan kualitastanaman ubi jalar (Ipomea batatas (L.) Lamb) varietasCilembu pada dataranrendah. JurnalProduksiTanaman, 4(1).

Tawfic, S. F., Abdel Aziz, R. M., &Eanar, A. K. (2014). Effect of planting date and sulphur fertilizer on yield and quality of sugar beet under newly reclaimed soils. Journal of Plant Production, 5(9), 1547-1556.

Sapkota, A., Sharma, M. D., Giri, H. N., Shrestha, B., & Panday, D. (2021). Effect of Organic and Inorganic Sources of Nitrogen on Growth, Yield, and Quality of Beetroot Varieties in Nepal. Nitrogen, 2(3), 378-391.

Sikuku, P. A., Kimani, J. M., Kamau, J. W., &Njinju, S. (2016). Influence of nitrogen supply on photosynthesis, chlorophyll content and yield of improved rice varieties under upland conditions in Western Kenya. Journal of Experimental Agriculture International, 1-14.

Singh, A. K., Meena, M. K., & Upadhyaya, A. (2012). Effect of sulphur and zinc on rice performance and nutrient dynamics in plants and soil of Indo Gangetic plains. Journal of Agricultural Science, 4(11), 162.

Sinta, Z. and G. Garo. 2021. Influence of Plant Density and Nitrogen Fertilizer Rates on Yield and Yield Components of Beetroot (Beta vulgaris L.). J. Agr.10 : 1-7.

Sitompul, S. M., Roviq, M., Yudha, A., Khesia, S. A., Avyneysa, N. J., & Yolanda, Y. (2020). Plant Growth of Beetroots (Beta vulgaris L.) with Nitrogen Supply at Suboptimal Elevations in a Tropical Region. AGRIVITA, Journal of Agricultural Science, 42(2), 272-282.

Skudra, I., &Ruza, A. (2017). Effect of nitrogen and sulphur fertilization on chlorophyll content in winter wheat. Rural sustainability research, 37(332), 29-37.

Suminarti, N.E. 2011. Teknik BudidayaTanaman Talas Colocasia esculenta (L.) Schott Var. Antiquorum Pada KondisiKering dan Bawah. Disertasi. Universitas Brawijaya. Malang.

Suminarti, N. E. (2019). DampakPemupukan N Dan Zeolit Pada Pertumbuhan Serta Hasil TanamanSorgum (Sorghum bicolour L.) Var. Super. JurnalAgro, 6, 1.

Taiz, L. and E. Zeiger. 2002. Plant Physiology 3rd Edition. pp 67.

Tanaka, Y., Sasaki, N., &Ohmiya, A. (2008). Biosynthesis of plant pigments: anthocyanins, betalains and carotenoids. The Plant Journal, 54(4), 733-749.

Wihardjaka, A., &Poniman, P. (2015). Kontribusi Hara Sulfur terhadapProduktivitasPadi dan Emisi Gas RumahKaca di Lahan Sawah. IptekTanamanPangan, 10(1).

Fu, Y., Li, H., Yu, J., Liu, H., Cao, Z., Manukovsky, N. S., & Liu, H. (2017). Interaction Effects of Light Intensity and Nitrogen Concentration on Growth, Photosynthetic Characteristics and Quality of Lettuce (Lactuca sativa L. Var. youmaicai). Scientia horticulturae, 214, 51-57.

Zhang, W., Chen, X. X., Liu, Y. M., Liu, D. Y., Du, Y. F., Chen, X. P., & Zou, C. Q. (2018). The role of phosphorus supply in maximizing the leaf area, photosynthetic rate, coordinated to grain yield of summer maize. Field Crops Research, 219, 113-119.

Zuzhang, L., Guangrong, L., Fusheng, Y., Xiangan, T., & Blair, G. (2010, August). Effect of sources of sulphur on yield and disease incidence in crops in Jiangxi Province, China. In Proceeding of World Congress of Soil Science, Soil Solutions for a Changing World (pp. 1-6).