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8

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4

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Testing of lollo rossa lettuce varieties (*Lactuca sativa* var. *crispa*) on different ammonium-nitrate ratio in the hydroponic nutrient solution

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Abstract. The study aims to determine the variety of lollo rossa lettuce that has high growth and production, to find out the ratio of ammonium and nitrate which gives the best effect on the growth and production of lollo rossa lettuce and to determine the parameters that have high heritability values. The study was conducted at the Unhas Lecturer Housing screen house, Jalan Al Ghazaly, Block BG number 91, Tamalanrea, Makassar, which took place from October to December 2018. The study used a factorial experimental design in the nested pattern, namely: 8 varieties of Lollo Rossa lettuce (Olga Red, Arista, Concorde Rz, Amandine Rz, Rosano, Mr. Fothergills, Sais, and Century) nested in each ratio of ammonium and nitrate consisting of 4 levels, namely: AB Mix, 1 ammonium: 4 nitrate, 1 ammonium: 6 nitrate, and 1 ammonium: 8 nitrates. The results showed that the lollo rossa lettuce varieties which had high growth and production were Mr. Fothergills variety (140.75 g) and Concorde Rz varieties (129.96 g). Nutrients that provided growth and high production in the lollo rossa lettuce was a ratio of 1 ammonium: 4 nitrate (115.25 g). All observational parameters had high heritability values in the lollo lettuce (parameters of plant height, number of leaves, shoot root ratio, chlorophyll index, and production).

1. Introduction

Lettuce is one of the many horticultural vegetable commodities consumed by the public. Lettuce was chosen by many people because of the texture and color that makes food appear attractive so it can increase appetite [1]. Based on data from the Central Statistics Agency [2], production of lettuce in Indonesia from 2015 to 2017 amounted to 600,200 tons, 600,120 and 627,611 tons. In general, national production of lettuce is still low when compared to a large amount of domestic demand. In addition, demand for lettuce exports also continues to increase. Efforts to increase production still meet several obstacles including the small number of farmers planting lettuce and inefficient use of fertilizers in lettuce planting so that the production of lettuce is relatively low [3]. To increase the production of lettuce, several efforts are needed, among others by the use of suitable varieties, improvement of farming techniques, intensive crop maintenance and efforts to improve the level of plant fertility [4].

One type of lettuce is Lollo Rossa (*Lactuca sativa* var. *Crispa*) lettuce. Lollo Rossa lettuce belongs to the leaf lettuce cultivar group. This type of lettuce leaves loose leaves and wavy or jagged edges and red. Another characteristic is not forming a crop. Lollo Rossa Lettuce has several advantages, such



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5 as faster harvest time (45 days after planting) and the ability to grow in the lowlands to the highlands [5].

One alternative effort that can be done to overcome the problem of inefficient use of fertilizers is to cultivate hydroponically. Hydroponic systems have begun to be chosen because they have various advantages. These advantages include the products produced in this system are cleaner. In addition, nutrient solutions given to plants are more scalable and always available [6]. The success of cultivation using the hydroponic system is not only determined by the media used, but also determined by the nutrient solution given, because plants do not get nutrients from the growing medium. Therefore hydroponic lettuce cultivation must obtain nutrients through a nutrient solution provided [3].

The N element is absorbed by plants almost entirely in the form of nitrates or in the form of ammonium. N absorbed by plants depends on plant species and also environmental factors. Nitrogen uptake by plants in the form of ammonium is almost 100% will increase the availability of protein. Ammonium is more efficient than nitrate in increasing the greenness of leafy vegetables, but its negative impact can cause plants to gradually experience deterioration and a sharp decrease in dry weight due to damage to the root system [7], but if absorption is almost 100% in the form of nitrates, the effect is that only part of the nitrate is assimilated in the root and part of the nitrate is transported to the stem. The presence of nitrates increases the concentration of K, Ca, Mg, and P in the roots and also makes the plant have a higher carbohydrate content and carboxylic content than ammonium. The negative impact is the accumulation of excess nitrate in the stem which is toxic to plants and sensitive to ammonium poisoning [7]. Based on Muharja's opinion [8], that for leaf vegetables the nitrate and ammonium ratio ($\text{NO}_3^- : \text{NH}_4^+$) is 6 which means that 6 (six) nitrates, and 1 (one) ammonium, while the total N is 250 ppm.

Based on the description above, it is necessary to conduct a research to study the effect of ammonium nitrate ratio on the Lollo Rossa lettuce variety as an effort in increasing the production of the plant. The study also aimed to determine the best ratio of ammonium and nitrate added in the nutrient solution for hydroponically grown lettuce variety Lollo Rossa.

2. Methodology

The study was conducted at a screen house in the Lecturer Unhas Housing, Al Ghazaly Street, Block BG number 91, Tamalanrea District, Makassar City. The study used a factorial experimental design in a nested pattern, the Lollo Rossa lettuce variety nested in each ratio of ammonium and nitrate. Ammonium and nitrate comparison factors consist of four levels: AB Mix (n1), 1 ammonium: 4 nitrate (n2), 1 ammonium: 6 nitrate (n3) and 1 ammonium: 8 nitrate (n4). While the Lollo Rossa lettuce variety factor consists of eight varieties, namely: Olga Red (v1), Arista (v2), Concorde RZ (v3), Amandine RZ (v4), Rosano (v5), Mr. Fothergills (v6), Sais (v7), and Century (v8). The observation consisted of plant height, root length, root volume, number of leaves, total leaf length, total leaf width, total leaf thickness, crown weight, shoot and root weight ratio, chlorophyll index, and production.

Observation data were analyzed using analysis of variance (ANOVA). If the treatment shows significant effect, a further test was conducted using Tukey's Honestly Significant Difference (HSD) test at the 0.05 level.

3. Results and discussion

Based on the results of the study shown in table 1, the highest plant height (39.85 cm), the highest number of leaves (20.15 strands), the highest shoot and root weight ratio (5.46), and the highest production (115.25 g) were obtained in the treatment of 1 ammonium: 4 nitrate ratio. On the other hand, highest chlorophyll index was shown by the use of 1 ammonium: 8 nitrate ratio in the nutrient solution. This shows that nutrition is one of the important factors in the success of hydroponic cultivation. This is in line with the opinion of Azis and Kumia [9], that nitrogen can be absorbed by plants in the form of NH_4^+ and NO_3^- . Adequate nitrogen supply in plants can accelerate vegetative growth of plants, either in the stems, branches, or the leaves. Nitrogen also important in the synthesis

of chlorophyll, an important pigment that determines the photosynthesis process. Higher nitrate dose than ammonium seems to improve chlorophyll synthesis in this study.

Table 1. Average plant height (cm), number of leaves (strands), the weight ratio of shoots and roots, chlorophyll index, and production (g) for various ammonium:nitrate ratio treatments.

Nutrition	Plant Height (cm)	Number of Leaves (leaves)	Shoot Root Ratio	Chlorophyll Index	Production (g)
n1 (AB Mix)	35.52 b	16.13 c	4.06 c	91.57 b	75.25 c
n2 (1:4)	39.85 a	20.15 a	5.46 a	93.33 b	115.25 a
n3 (1:6)	36.79 ab	18.23 ab	4.73 b	96.54 a	99.88 b
n4 (1:8)	35.88 b	16.67 bc	4.78 b	96.84 a	81.06 c
HSD _{0.05}	3.61	2.02	0.60	2.90	11.84

The numbers followed by the same letters in columns (a, b and c) mean that they are not significantly different in the HSD test level $\alpha = 0.05$.

Ratio of 1 ammonium: 4 nitrate in the nutrient solution gave better results when compared to the ratio of ammonium and nitrate which has a higher nitrate content of 1: 6 and 1: 8. According to Damayanti et al. [10], the nitrogen content of the AB Mix nutrient itself was 27.7% (3.7 NH_4^+ and 24% NO_3^-) or 1 ammonium: 6.49 nitrate. This is in accordance with the opinion of Hasiholan et al. [7] which states that high nitrate content causes nitrate reduction in plants to run slowly so that amino acids for protein synthesis are not available as a result of slow protein synthesis and cell division in leaves is also slow. In addition, nitrate accumulation in leaves transported from the roots may be toxic to plants, so cell division is interrupted.

1 ammonium: 4 nitrate ratio containing 50 ppm of ammonium, 1 ammonium: 6 nitrate ratio of 35.7 ppm of ammonium, 1 ammonium: 8 nitrate ratio of 27.8 ppm of ammonium, and AB mix containing 38.52 ppm of ammonium. 1 ammonium: 4 nitrate ratio has more ammonium content compared to other nutrients so that the production at 1: 4 ratio is greater. This is consistent with the opinion of Muharja [8] which stated that the use of a relatively larger ammonium ratio will make giant cells so that plants will grow faster and have large size. The leaves formed are large in size and have large evapotranspiration so that water and nutrient absorption capacity increases as only large leaves will be sensitive to evaporation and vegetables wither easily. The stimulated vegetative growth will produce many leaves with a wider size so that the appearance of leafy vegetables will be attractive.

The more nitrate content in nutrient media, N will be more difficult to be absorbed by plants because it is submerged in water or anaerobically. This is consistent with the opinion of Nasaruddin and Musa [11] which stated that agricultural crops mainly use nitrogen in the form of nitrate, but under certain conditions, especially in acid soils and anaerobic conditions, plants will utilize nitrogen in the form of ammonium ions. If plants use ammonium ions directly as a source of nitrogen, they will automatically turn into NH_3 when they react with water.

Table 2 shows that the highest plant height (62.38 cm) and highest production (140.75 g) were found in the treatment of Mr. Fothergills variety. The HSD test showed that the treatment of Arista variety on the number of leaf parameters had the highest number of leaves (21.96 strands) but was not significantly different from the Olga Red, Concorde Rz, Mr. Fothergills, and Sais. Whereas the weight and root ratio parameters showed the highest average found in Concorde Rz varieties and not significantly different from Amandine Rz and Mr. Fothergills varieties. Highest chlorophyll index shown by Century variety (97.46) that was not significantly different to all varieties tested except for Olga Red and Concorde Rz. The lowest chlorophyll index shown by the Olga Red variety (89.90). Mangoendidjojo [12] stated that variations that occur in each class of plants can be found based on genetic factors.

Table 2. Average plant height (cm), number of leaves (strands), the weight ratio of shoots and roots, chlorophyll index, and production (g) of various Lollo Rossa lettuce varieties treatment.

Varieties	Plant Height (cm)	Number of Leaves (leaves)	Shoot Root Ratio	Chlorophyll Index	Production (g)
v1 (Olga Red)	47.33 b	21.75 a	4.72 b	89.90 c	102.54 b
v2 (Arista)	48.08 b	21.96 a	4.94 b	95.54 ab	106.67 b
v3 (Concorde Rz)	29.46 c	19.21 a	6.09 a	92.23 bc	129.96 a
v4 (Amandine Rz)	27.00 c	12.04 b	5.16 ab	93.98 abc	64.67 c
V5 (Rosano)	18.71 d	11.88 b	3.67 c	95.28 ab	52.67 c
V6 (Mr. Fothergills)	62.38 a	20.08 a	5.35 ab	96.64 ab	140.75 a
V7 (Sais)	51.42 b	21.92 a	4.77 b	95.55 ab	98.00 b
V8 (Century)	11.71 e	13.50 b	3.38 c	97.46 a	47.63 c
HSD _{0.05}	6.07	3.40	1.01	4.86	19.89

The numbers followed by the same letters in columns (a, b and c) mean that they are not significantly different in the HSD test level $\alpha = 0.05$.

Table 3. Heritability Values

No	Parameter	h^2 (%)	Category
1	Plant Height (cm)	93.45	High
2	Number of Leaves (leaves)	78.93	High
3	Shoot Root Ratio	61.62	High
4	Chlorophyll index	54.47	High
5	Production	88.71	High

0 < h^2 < 20 (Low), 20 \leq h^2 \leq 50 (Medium), 50 < h^2 < 100 (High).

Heritability analysis is a quantitative benchmark to determine whether the differences in the phenotype of a character are caused by genetic or environmental factors so that it can give an idea whether the characters observed are more influenced by genetic or environmental factors. Table 3 shows the heritability values in the lollo lettuce. The parameters of plant height (93.45%), number of leaves (78.93%), the weight ratio of shoots and roots (61.62%), chlorophyll index (54.47%), and production (88.71%) had high heritability values. According to Fachri [13], characters that have high heritability will increase the effectiveness of selection in endurance testing because the observed characters are a reflection of the influence of genetic factors compared to environmental influences. Quantitative characters that have high heritability will produce progress of selection for desirable traits, whereas if low heritability is less effective to be used as selection material. Development of new varieties of Lollo Rossa lettuce can emphasize on these parameters of plant height, production, number of leaves, and shoot root ratio. As lettuce is a leafy vegetables, the mentioned parameters are important traits to be considered for new varieties.

4. Conclusions

The Lollo lettuce varieties which have high growth and production were Mr. Fothergills (140.75 g) and Concorde Rz varieties (129.96 g). Nutrients that provide growth and high production in the lollo rossa lettuce are a ratio of 1 ammonium: 4 nitrate (115.25 g). All observational parameters had high heritability values in the lollo lettuce (parameters of plant height, number of leaves, shoot and root weight ratio, chlorophyll index, and production).

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