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Research Article
(Araştırma Makalesi)

Siti Hajrah ARIF [1*]

Feranita HARING [2]

Muhammad RIADI [3]

[1] Hasanuddin University, Faculty of Agriculture, Agrotechnology Master Program, 90245, Makassar, South Sulawesi, Indonesia

[2] Hasanuddin University, Faculty of Agriculture, Agronomy Department, 90245, Makassar, South Sulawesi, Indonesia

[3] Hasanuddin University, Faculty of Agriculture, Agronomy Department, 90245, Makassar, South Sulawesi, Indonesia

***** Corresponding author (Sorumlu yazar):

sthajrah.arif@gmail.com

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Improving growth and productivity of shallot (*Allium ascalonicum* L.) applied using organic and inorganic fertilizer

Organik ve inorganik gübre uygulaması ile şalot soğanının (*Allium ascalonicum* L.) büyüme ve verimliliğinin arttırılması

* This article has been summarized from the first author master thesis

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ABSTRACT

Objective: This research aims to identify and examine organic and inorganic fertilizer on the growth and productivity of shallots.

Materials and Methods: This study was carried out under field conditions in the research and application fields of Faculty of Agriculture, Hasanuddin University. The main plot is the liquid organic fertilizer (LOF) consisting of control, 10 mL/L, and 20 mL/L. The subplots, namely the zwavelzure ammonium (ZA) fertilizer, consist of control, 50 kg/ha, 100 kg/ha, and 150 kg/ha.

Results: Based on the research conducted, it can be seen that the interaction between the application of LOF (20 mL/L) and ZA fertilizer (150 kg/ha) recorded the highest average fresh bulb weight (145.60 g). Applying LOF (20 mL/L) can increase the average plant height (23.50 cm at 21 days after planting (DAP)), number of leaves (25.60 at 35 DAP), the number of bulbs (10.93), bulb diameter (2.77 cm), production per hectare (21.91 t), and chlorophyll index (20.48) of shallot plants. On the other hand, ZA fertilizer (150 kg/ha) influences plant height (44.03 cm at 42 DAP), number of leaves (26.67), production per hectare (20.96 t), and chlorophyll index (20.64) of shallot plants.

Conclusion: The application of organic and inorganic fertilizers has a significant influence on the growth and production of shallot plants, both in interaction and individually.

ÖZ

Amaç: Bu çalışmanın amacı, şalot soğanının büyüme ve gelişimine organik ve inorganik gübre uygulamalarının etkilerinin araştırılmasıdır.

Materyal ve Yöntem: Bu çalışma, Hasanuddin Üniversitesi Ziraat Fakültesi araştırma ve uygulama alanlarında arazi koşullarında gerçekleştirilmiştir. Ana parsel, kontrol, 10 mL/L ve 20 mL/L'den oluşan sıvı organik gübredir (LOF). Alt parseller, yani amonyum sülfat (ZA) gübresi uygulamaları kontrol, 50 kg/ha, 100 kg/ha ve 150 kg/ha'dan oluşmaktadır.

Araştırma Bulguları: Yapılan araştırmalara göre LOF (20 mL/L) ve ZA gübresi (150 kg/ha) uygulaması ile en yüksek ortalama taze soğan ağırlığı (145,60 g) elde edilmiştir. LOF (20 mL/L) uygulanması ortalama bitki boyunu (Dikimden 21 gün sonra 23,50 cm), yaprak sayısını (Dikimden 35 gün sonra 25,60), soğan sayısını (10,93), soğan çapını (2,77 cm), hektar başına üretimi (21,91 t) ve klorofil indeksini (20,48) artırabilir. Öte yandan, ZA gübresi (150 kg/ha) bitki boyunu (Dikimden 42 gün sonra 44,03 cm), yaprak sayısını (26,67), hektar başına üretimi (20,96 t) ve şalot soğanı bitkilerinin klorofil indeksi (20.64) etkilemiştir.

Sonuç: Organik ve inorganik gübrelerin uygulanması arpacık soğanı bitkilerinin büyümesi ve üretimi üzerinde hem ayrı ayrı, hem de birlikte önemli bir etkiye sahiptir.

INTRODUCTION

Shallots (*Allium ascalonicum* L.) are seasonal vegetables with high economic potential for development. This plant can thrive in tropical and subtropical areas, including Indonesia (Sihombing, 2018). Shallots have good health benefits because they contain antioxidant compounds (Sari, 2016). Apart from that, the shallot is also a primary cooking ingredient with a distinctive aroma and has many benefits as a natural medicine, such as medicine for coughs, fevers, shortness of breath, colds, and increasing appetite. Several studies have proven that shallots have many benefits, including a potent antioxidant and sunscreen profile (Rahayu et al., 2017; Rahayu & Arini, 2018; Octaviani et al., 2019).

Shallot production has not increased due to higher plant productivity thus far; rather, it has only increased as a result of expanded planting area. The low productivity of shallots is due to a cultivation system that still needs to be optimized, which causes an imbalance of nutrients in the soil. So far, many farmers have used high doses of inorganic fertilizers without including organic fertilizers. If this is done for years, it will impact soil fertility, which can decrease soil productivity so that high production cannot be achieved. Therefore, in shallot cultivation, inorganic fertilizer is used by adding liquid organic fertilizer (LOF) so that the quantity can be reduced.

The use of fertilizer utilizing balanced fertilization is an alternative to increase crop production. Organic fertilizer consists mainly or entirely of organic material originating from plants or animals that have undergone an engineering process, which can be formed into a solid or liquid form used to supply organic material (Sharma & Chetani, 2017). Meanwhile, inorganic fertilizer is fertilizer made by fertilizer factories by combining chemicals (inorganic) with high nutrient levels.

The combination of organic fertilizer and inorganic fertilizer aims to work together to increase the growth of shallot plants. LOF is made from organic materials; the final result is a finished liquid. The use of LOF can be combined with zwavelzure ammonium (ZA) fertilizer. ZA contains sulfur (S), which can improve shallot bulbs' aroma, size, and taste. Sulfur can be obtained from artificial fertilizers such as kieserite with the main element Mg and an S content of 20.03% (Supriyono et al., 2023). Shallots, unlike other plants, require a lot of sulphate. Sulphate is essential for plant metabolism and is linked to several parameters that determine the nutritional quality of vegetable plants. The sulfur content in shallot bulbs has a large influence on its strong aroma (Elisabeth et al., 2022).

Based on the description above, it is necessary to carry out in-depth research regarding the effect of applying liquid organic fertilizer and ZA fertilizer on the growth and production of shallot plants so that the most optimal treatment combination can be obtained.

MATERIALS and METHODS

Study area and experimental design

This study was carried out under field conditions in the research fields of the Faculty of Agriculture, Hasanuddin University. This research starts from October to December 2022. This study was arranged in a split-plot design with three replications. The main plot is the concentration of LOF consisting of 0 mL/L, 10 mL/L, and 20 mL/L. The subplots, namely the ZA (21% N and 24% S) fertilizer, consist of 0 kg/ha, 50 kg/ha, 100 kg/ha, and 150 kg/ha. Soil characteristics on the research land are described in Table 1.

Table 1. Soil properties

Çizelge 1. Toprak özellikleri

Soil Properties	
Texture	Clay loam
pH (H_2O) (1:10)	6.65
C (Walkey & Black)	5.05%
N (Kjeldahl)	0.41%
C/N	12
P_2O_5 (Olsen)	12.06 ppm
K (NH_4-Acetat 1N. pH7)	0.24 cmol/kg
Ca (NH_4-Acetat 1N. pH7)	6.92 cmol/kg
Mg (NH_4-Acetat 1N. pH7)	1.68 cmol/kg
Na (NH_4-Acetat 1N. pH7)	0.46 cmol/kg
Cation Exchange Capacity (NH_4-Acetat 1N. pH7)	22.56 cmol/kg

Cultivation process

The cultivation process includes land preparation, seeding, transplanting, applying fertilizer, maintenance (watering, weeding, pest control), harvesting, and post-harvest. The experimental plot measures 150 cm × 150 cm, with a height of 30 cm and a distance between beds of 40 cm. After that, chicken manure was applied at a dose of 2 kg/plot, and carbofuran pesticide was applied at 5 g/plot. Apart from that, fertilization is carried out in NPK (16:16:16) at a dose of 100 kg/ha (22.5 g/plot). Then the application of zwavelzure ammonium fertilizer (21% N and 24% S) is also carried out before planting according to the determined dose, namely 0 kg/ha, 50 kg/ha (11.25 g/plot), 100 kg/ha (22.5 g/plot), and 150 kg/ha (33.75 g/plot).

The seeds used are from tubers of the Super Philips variety. The tuber seeds range from 3 to 5 g, are not damaged, and have been stored for three months. Before transplanting, cut the top 1/3 of the bulb to accelerate shoot growth. In each planting hole, one bulb is planted. During plant growth, liquid organic fertilizer is applied. The organic fertilizer containing N, P_2O_5, K_2O, C, Fe, Mn, Zn, Cr, Ni, and Mo, respectively, namely 0.77%, 0.25%, 1.85%, 17.22%, 230 ppm, 100 ppm, 18.06 ppm, 8.64 ppm, 11.79 ppm, and 5.85 ppm. The application of liquid organic fertilizer is carried out according to the predetermined treatment concentration, namely at the ages of 7, 14, and 21 DAP.

Weeding is done using a physical method, namely pulling directly by hand. Then, pest control is carried out by destroying it directly by hand. Harvesting is carried out after the harvest criteria are visible. Namely, the base of the leaves is thinning, the leaves appear yellow, and the leaves have fallen by around 80%. The bulbs are enlarged, and some have emerged from the soil's surface. The bulb segments appear dense, and the skin color is shiny. After harvesting, it is then dried for two weeks under direct sunlight.

Data colleting and analysis

Parameters observed included plant height (cm), number of leaves, number of bulbs, bulb diameter (cm), fresh weight of bulbs per clump (g), dry weight of bulbs per clump (g), production per hectare (t), and chlorophyll index (CCI). Plant height and number of leaves were observed at ages 14, 21, 28, 35, and 42 days after planting (DAP). Production components and the chlorophyll index at 45 DAP using CCM-200 were observed after harvest. The data that has been obtained is then analyzed for variance, and if there is a significant influence, an LSD test is carried out with $\alpha = 0.5$. If there is an interaction

between the two treatment factors, a two-way test is carried out, namely a main plot test on a different subplot and a subplot test on a different main plot. Data analysis uses R Studio software version 4.2.1.

RESULTS and DISCUSSION

Plant height (cm)

There is no interaction effect between LOF and ZA fertilizer on plant height. However, each treatment of liquid organic fertilizer and ZA fertilizer individually influenced plant height at several observation times. The application of liquid organic fertilizer at 21 DAP influenced plant height (Table 2). Application of LOF with a concentration of 20 mL/L recorded the highest average plant height (23.50 cm). Research conducted by Bahua & Gubali (2020) also found the same impact, namely that the application of liquid organic fertilizer was able to increase plant height, number of tillers, and rice production. In addition, Pangaribuan et al. (2019) show that applying organic fertilizer consistently increases sweet corn's growth, production, and quality.

The application of ZA fertilizer influenced almost the entire observation period, except for 35 DAP. Application of ZA fertilizer at a dose of 150 kg/ha recorded the highest average plant height at the age of 14 DAP (16.83 cm), 21 DAP (23.19 cm), 28 DAP (30.42 cm), and 42 DAP (44.03 cm). Supriyono et al. (2019) also found a similar thing in corn and cassava plants. The application of ZA fertilizer was able to increase the average plant height in both types of plants.

Table 2. Effect of liquid organic fertilizer (LOF) and ZA fertilizer on plant height (cm)

Çizelge 2. *Sıvı organik gübre (LOF) ve amonyum süfat (ZA) gübresinin bitki boyu (cm) üzerine etkisi*

Liquid Organic Fertilizer (mL/L)	Plant Height (cm)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
0	15.84±0.41	20.75±0.48^{q}	27.50±0.87	20.23±0.53	40.04±1.15
10	15.69±0.36	22.00±0.49^{pq}	28.53±0.84	30.23±1.75	43.59±0.54
20	16.35±0.41	23.50±0.65^{p}	28.89±0.78	29.79±0.90	43.23±0.71
LSD 5%	Ns	2.04	Ns	Ns	Ns
ZA (kg/ha)					
0	14.99±0.11^{c}	20.71±0.63^{c}	26.53±0.30^{b}	27.37±0.58	40.57±1.32^{c}
50	15.80±0.28^{bc}	21.80±0.85^{bc}	27.67±0.70^{ab}	28.50±0.22	41.42±1.62^{bc}
100	16.22±0.31^{ab}	22.64±0.87^{ab}	28.60±0.35^{a}	29.56±0.80	41.12±0.84^{ab}
150	16.83±0.18^{a}	23.19±0.85^{a}	30.42±0.33^{a}	32.4±1.50	44.03±0.73^{a}
LSD 5%	0.81	1.13	0.81	ns	1.99

* Means next to the identical letter are not considerably distinct according to LSD Test.

Number of leaves

There is no interaction effect between liquid organic fertilizer and ZA fertilizer on the number of leaves. However, each treatment of LOF and ZA fertilizer individually influenced the number of leaves at several observation times. Application of LOF did not affect the number of leaves at 14, 21, and 42 DAP (Table 3). Application of LOF with a concentration of 20 mL/L recorded the highest average number of leaves at the age of 28 DAP (22.14) and 35 DAP (25.60). Research conducted by Martinez-Alcantara et al. (2016) also found that using liquid organic fertilizer increased plant growth, as indicated by significant leaf and root growth in citrus plants. Apart from that, applying LOF can increase the application of macro and micronutrients, directly influencing plants' carbohydrate content.

Table 3. Effect of liquid organic fertilizer (LOF) and ZA fertilizer on number of leaves

Çizelge 3. *Sıvı organik gübre (LOF) ve amonyum süfat (ZA) gübresinin yaprak sayısına üzerine etkisi*

Liquid Organic Fertilizer (mL/L)	Number of Leaves				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
0	6.26±0.10	10.8±0.16	17.53±0.50^{c}	21.53±0.53^{b}	24.10±0.66
10	6.64±0.24	11.12±0.19	20.00±0.70^{b}	23.99±0.52^{b}	25.58±0.23
20	7.01±0.24	11.29±0.14	22.14±0.17^{a}	25.60±0.41^{a}	27.06±0.68
LSD 0.05	Ns	Ns	1.59	2.30	Ns
ZA (kg/ha)					
0	6.11±0.13	10.60±0.09	18.98±1.86^{c}	22.20±1.27^{c}	24.09±0.95^{c}
50	6.49±0.26	11.08±0.12	19.45±1.32^{bc}	23.68±1.16^{bc}	25.41±1.07^{b}
100	6.89±0.29	11.25±0.05	20.37±1.13^{ab}	24.05±1.14^{ab}	26.15±0.85^{a}
150	7.06±0.20	11.59±0.09	20.78±1.14^{a}	24.89±1.16^{a}	26.67±0.68^{a}
LSD 0.05	ns	ns	1.02	ns	0.73

* Means next to the identical letter are not considerably distinct according to LSD Test.

Application of ZA fertilizer had no effect over almost the entire observation period, except at the ages of 28 DAP and 42 DAP. Application of ZA fertilizer at a dose of 150 kg/ha recorded the highest average number of leaves at the age of 28 DAP (20.78) and 42 DAP (26.67). Research conducted by Supriyono et al. (2023) found that applying ZA and phosphate fertilizers increased the average number of leaves of ginger plants**.**

Number of bulbs and bulb diameter

There is no interaction effect between liquid organic fertilizer and ZA fertilizer on the number of bulbs and bulb diameter. However, liquid organic fertilizer treatment alone influenced the number of bulbs and bulb diameter, while the application of ZA fertilizer did not affect these two parameters. The application of LOF did not affect the number of leaves at 14, 21, and 42 DAP (Table 4). Application of LOF with a concentration of 20 mL/L recorded the highest average number of bulbs (10.93) and the widest bulb diameter (2.77 cm). Research conducted by Faried et al. (2021) using various types of biological liquid fertilizers positively impacted the growth of shallot bulbs. Then, Ji et al. (2017) found that the application of organic fertilizer not only increased canopy growth but also the root growth of chrysanthemum plants. Apart from that, applying LOF can also influence the microbial community in the soil.

Table 4. Effect of liquid organic fertilizer (LOF) and ZA fertilizer on number of bulbs and bulb diameter (cm)

Çizelge 4. *Sıvı organik gübre (LOF) ve amonyum süfat (ZA) gübresinin soğan sayısı ve soğan çapı (cm) üzerine etkisi*

Liquid Organic Fertilizer (mL/L)	Number of Bulbs	Bulb Diameter (cm)
0	9.88±0.13^{b}	2.35±0.09^{b}
10	10.64±0.20^{a}	2.52±0.04^{b}
20	10.93±0.15^{a}	2.77±0.09^{a}
LSD 5%	1.08	0.25
ZA (kg/ha)		
0	10.09±0.29	2.41±0.10
50	10.68±0.41	2.53±0.20
100	10.45±0.20	2.51±0.08
150	10.71±0.35	2.73±0.12
LSD 5%	ns	ns

* Means next to the identical letter are not considerably distinct according to LSD Test.

Fresh bulb weight per clump (g)

It was found that LOF and ZA fertilizer applications had a significant effect on the fresh weight of bulbs per clump (Table 5). When the data in terms of shallot weight were evaluated, it was found that the highest mean value (145.60 g) was reached in the combined applications of 20 mL/L LOF and 150 kg/ha ZA doses. The combination of fertilizing through the soil with ZA and through the leaves with LOF can increase the growth of shallot bulbs. Meher et al. (2016) found a linear relationship between increasing doses of S fertilizer and increasing production components in onion plants. Moreover, liquid organic fertilizer can increase organic carbon, soil organic matter, exchangeable potassium, and sodium (Triharyanto et al., 2022).

Table 5. Effect of liquid organic fertilizer (LOF) and ZA fertilizer on fresh bulb weight per clump (g)

Çizelge 5. *Sıvı organik gübre (LOF) ve amonyum süfat (ZA) gübresinin kümelenmiş taze soğan ağırlığına etkisi (g)*

Liquid Organic Fertilizer (mL/L)	ZA (kg/ha)				LSD 0.05
	0	50	100	150	
0	$46.80\pm3.68^{b}_{q}$	$53.43\pm1.49^{b}_{r}$	$58.83\pm8.90^{b}_{r}$	$76.73\pm6.76^{a}_{r}$	
10	$54.47\pm5.79^{d}_{q}$	$71.70\pm6.02^{c}_{q}$	$84.97\pm0.37^{b}_{q}$	$108.87\pm6.25^{a}_{q}$	12.19
20	$111.43\pm13.12^{c}_{p}$	$132.50\pm7.79^{b}_{p}$	$128.23\pm9.38^{b}_{p}$	$145.60\pm4.12^{a}_{p}$	
LSD 5%	11.31				

* Means next to the identical letter in column (p, q, r) and in row (a, b, c) are not considerably distinct according to LSD Test.

Dry bulb weight (g), production per hectare (t) and chlorophyll index (CCI)

There is no interaction effect between LOF and ZA fertilizers on bulb dry weight, production per hectare, and chlorophyll index. However, LOF and ZA fertilizers individually influenced all of these parameters (Table 6). The application of LOF with a concentration of 20 mL/L recorded the heaviest dry bulb weight per clump (70.42 g) and the highest production per hectare (21.91 t). However, applying LOF at a concentration of 20 mL/L recorded the highest chlorophyll index value (20.48 CCI). In the ZA fertilizer treatment, it was noted that application at a dose of 150 kg/ha consistently recorded the best effect on the heaviest dry bulb weight per clump (67.36 g), the highest production per hectare (20.96 t), and the highest chlorophyll index (20.64 CCI).

Table 6. Effect of liquid organic fertilizer (LOF) and ZA fertilizer on dry bulb weight per clump (g), production per hectare (t), and chlorophyll index (CCI)

Çizelge 6. *Sıvı organik gübre (LOF) ve amonyum süfat (ZA) gübresinin kümelenmiş kuru soğan ağırlığı (g), hektar başına üretim (t) ve klorofil indeksi (CCI) üzerindeki etkisi*

Liquid Organic Fertilizer (mL/L)	Dry Bulb Weight per Clump (g)	Production per Hectare (t)	Chlorophyll Index (CCI)
0	34.83 ± 3.60^{c}	10.83 ± 1.12^{c}	19.85 ± 0.22^{b}
10	51.07 ± 7.27^{b}	15.89 ± 2.26^{b}	20.39 ± 0.30^{a}
20	70.42 ± 4.99^{a}	21.91 ± 1.55^{a}	20.48 ± 0.09^{a}
LSD 0.05	5.54	1.72	0.49
ZA (kg/ha)	Dry Bulb Weight per Clump (g)	Production per Hectare (t)	Chlorophyll Index (CCI)
0	44.93 ± 10.43^{b}	13.98 ± 3.24^{b}	19.78 ± 0.21^{b}
50	46.75 ± 11.32^{b}	14.54 ± 3.52^{b}	20.08 ± 0.24^{ab}
100	49.39 ± 8.06^{b}	15.36 ± 2.50^{b}	20.46 ± 0.35^{a}
150	67.36 ± 11.95^{a}	20.96 ± 3.71^{a}	20.64 ± 0.10^{a}
LSD 0.05	4.91	1.53	0.57

* Means next to the identical letter are not considerably distinct according to LSD Test.

The increase in production components in dry bulb weight per clump, and production per hectare is directly influenced by applying LOF and ZA fertilizer. Linearly, it shows that increasing the dose of LOF and ZA fertilizer can increase the components of shallot production. Research conducted by Fatirahma & Kastono (2020) found a positive impact on the application of LOF on the production of shallot plants cultivated on sandy soil. This increase in production is, of course, related to the capacity to form and assimilate. These two treatment factors also influence the plant chlorophyll index. The nitrogen content in liquid organic fertilizer and ZA fertilizer directly helps in chlorophyll formation. Nitrogen is one of the main components in the structure of plant chlorophyll (Fathi, 2022).

Correlation among parameters

Parameters that have a positive correlation with the production per hectare, sorted from the smallest to the largest correlation value, are chlorophyll index (0.66), plant height (0.74), number of bulbs (0.82), number of leaves (0.84), bulb diameter (0.89), fresh bulb weight (0.96) and dry bulb weight (1.00). In this study, the relationship between the characteristics of shallot bulbs and production per hectare showed a close relationship. The correlation values between the number of bulbs, bulb diameter, and weight of fresh and dry bulbs per clump are 0.82, 0.89, 0.96, and 1.00, respectively. This indicates that the increase in bulbs' number, diameter, and weight is in line with the increase in bulb production per hectare. This was also found in a study by Elizani & Sulistyaningsih (2019), which described a positive correlation between bulb weight and shallot bulb productivity per hectare.

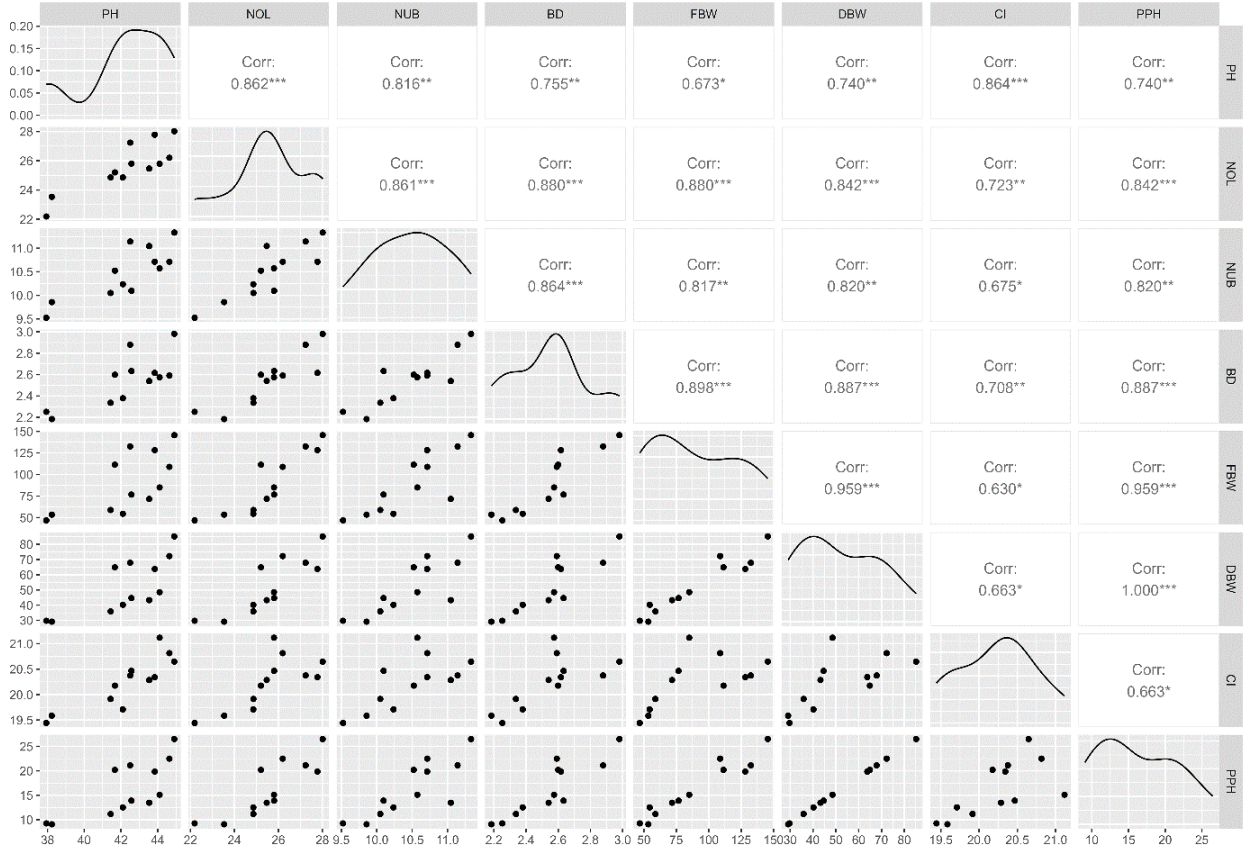

Figure 1. Correlation Maps Among Parameter. PH (plant height), NOL (number of leaves), NUB (number of bulbs), BD (bulb diameter), FBW (fresh bulb weight), DBW (dry bulb weight), CI (chlorophyll index), and PPH (production per hectare).

Şekil 1. *Parametreler Arası Korelasyon. PH (bitki boyu), NOL (yaprak sayısı), NUB (soğan sayısı), BD (soğan çapı), FBW (taze soğan ağırlığı), DBW (kuru soğan ağırlığı), CI (klorofil indeksi) ve PPH (üretim hektar başına).*

CONCLUSSIONS

Based on the research conducted, it can be concluded that the interaction between the application of liquid organic fertilizer (20 mL/L) and ZA fertilizer (150 kg/ha) recorded the highest average fresh bulb weight. Applying liquid organic fertilizer (20 mL/L) can increase the average plant height, number of leaves, number of bulbs, bulb diameter, dry bulb weight per clump, production per hectare, and chlorophyll index of shallot plants. On the other hand, zwavelzure ammonium fertilizer (150 kg/ha) influences plant height, number of leaves, dry bulb weight per clump, production per hectare, and chlorophyll index of shallot plants. Then, the correlation between various parameters were quite strong, with a correlation value range of 0.66 to 1.00. Parameters that have a positive correlation with the production per hectare, sorted from the smallest to the largest correlation value, are chlorophyll index (0.66), plant height (0.74), number of bulbs (0.82), number of leaves (0.84), bulb diameter (0.89), fresh bulb weight (0.96) and dry bulb weight (1.00).

Data Availability

Data will be made available upon reasonable request.

Author Contributions

Conception and design of the study: SHA; sample collection: SHA; analysis and interpretation of data: SHA; statistical analysis: MR, SHA; visualization: MR, FH; writing manuscript: SHA, MR, FH.

Conflict of Interest

There is no conflict of interest between the authors in this study.

Ethical Statement

We declare that there is no need for an ethics committee for this research.

Article Description

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