sustainability

MDPI

Article

Nutrient Management of Shallot Farming in Sandy Loam Soil in Tegalrejo, Gunungkidul, Indonesia

Sutardi [1], Kristamtini [1,*], Heni Purwaningsih [2], Setyorini Widyayanti [1], Forita Dyah Arianti [3], Miranti Dian Pertiwi [3], Joko Triastono [4], Raden Heru Praptana [1], Afrizal Malik [4], Intan Gilang Cempaka [5], Yusuf [5], Muhammad Prama Yufdy [5], Markus Anda [6] and Anicetus Wihardjaka [1]

[1] Research Center for Food Crops, National Research and Innovation Agency, Jl. Raya Bogor-Jakarta, Cibinong Bogor 16911, West Java, Indonesia
[2] Research Center for Food Technology and Processing, National Research and Innovation Agency, Jl. Jogja-Wonosari km. 31.5 Gading, Playen, Gunungkidul, Yogyakarta 55861, Yogyakarta, Indonesia
[3] Research Center for Sustainable Production System and Life Cycle Assessment, National Research and Innovation Agency Serpong, South Tanggerang City 15314, Banten, Indonesia
[4] Research Center for Behavioral and Circular Economics, National Research and Innovation Agency, Jl. Jend. Gatot Subroto No. 10, South Jakarta 12710, Jakarta, Indonesia
[5] Research Center for Horticultural and Estate Crops, National Research and Innovation Agency, Jl. Raya Jakarta-Bogor, Cibinong, Kabupaten Bogor 16915, West Java, Indonesia
[6] Research Center for Geospatial, National Research and Innovation Agency, Jl. Raya Bogor-Jakarta, Cibinong Bogor 16911, West Java, Indonesia
* Correspondence: krisniur@yahoo.co.id

check for updates

Citation: Sutardi; Kristamtini; Purwaningsih, H.; Widyayanti, S.; Arianti, F.D.; Pertiwi, M.D.; Triastono, J.; Praptana, R.H.; Malik, A.; Cempaka, I.G.; et al. Nutrient Management of Shallot Farming in Sandy Loam Soil in Tegalrejo, Gunungkidul, Indonesia. *Sustainability* **2022**, *14*, 11862. https://doi.org/10.3390/su141911862

Academic Editors: John Hammond, Chris Short and Lindsay Todman

Received: 26 July 2022
Accepted: 16 September 2022
Published: 21 September 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract: The serious problems of sandy soils for crop development are low water-holding capacity, nutrient retention, and low content of all nutrients. The objective of the study was to increase the nutrient content of sandy soil and evaluate nutrient types that mostly affect the high shallot yield with reasonable economic values. The field experiment was conducted on the upland sandy loam soil. Six treatments consisting of complete nutrients, N-, P-, K-, Mg- and S-omission tests were arranged in a randomly completed block design with four replicates. The observed parameters included soil physicochemical properties, tissue nutrient content, growth, yield, and input-output of shallot cultivation. The results showed that N, P, K, Mg and S application successfully increased shallot bulb, achieving 11.43 t ha^{-1} on sandy soil. The order of shallot tissue content was K > N > P~Mg > S, where the S, P, N, and Mg are limiting factors, as revealed by significantly lower relative yield (varying from 79 to 88%). The highest weight loss during storage occurred for S-omission treatment (40 to 60%), indicating insufficient S tissue is the most responsible for the quality of shallot. The complete nutrient treatment gave the highest income (7446.09 USD ha^{-1}) with a revenue cost ratio of 2.41 compared to other treatments. The tolerance limit for price reductions that do not cause losses was 58.59%.

Keywords: nutrient management; shallots; yield; sandy loam

1. Introduction

Shallots (*Allium cepa* L.) are valuable spices for both flavoring dishes and medicinal plants [1]. Shallots play a crucial role in the human body since they contain high vitamin B6 (pyridoxine), and antioxidants and may improve blood sugar levels, circulation, seasonal allergies, and heart and bone health; they also contain phosphorus, potassium, magnesium, manganese, iron and copper which are required by the human body [2].

Shallots are cultivated in many tropical countries due to their ability to propagate vegetative, short growth cycle, tolerance to disease and drought stresses, longer storage life, and distinct flavor that persists after cooking [3–6]. Shallots are widely cultivated in various climatic conditions such as hot climates and open fields or cold climates and moderate rainfall [7,8] and suitable soil types are sandy loam [9].

It was estimated that Indonesia's shallots production reached 2 million tons in 2021, an in- crease of 10.42% from 2020 (1.82 million tons), with a harvested area of 18.07 thousand ha [10]. However, the yield of shallots remains low at 8.5–10.23 t ha^{-1} [11], which is much lower than the world average of 19.32 t ha^{-1} [12–14]. The low productivity of shallots in Indonesia is related to inefficient cultivation techniques, high production costs, and excessive/uneconomical use of soil macronutrients [15,16] and soil variability properties. Adequate plant nutrition strategies involving chemical and organic fertilizers, or their combinations are critical for increasing the yield of shallot [17,18]. Soil nutrient management has an important role in shallot cultivation, especially on suboptimal land [19,20]. Therefore, an integrated approach is needed in the management of soil nutrients, including the application of organic and inorganic fertilizers and the use of high-yielding varieties [21–24].

The soils in Gedangsari, Gunungkidul, Yogyakarta are dominated by sandy soils, shallow depth, low productivity and are located on sloping relief with very prone to erosion. On the other hand, farmers rely their livelihoods on these unfertile soils. The challenge is to manage soil fertility and find suitable crops with high economic values to provide alternative crops as a source of profitable income and, at the same time, preserve the soils from degradation to promote sustainable production and protect the ecosystem. Shallots require fertile soil, containing sufficient macronutrients such as nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), and Sulfur (S); these nutrients can be supplied from urea, SP 36 (Super Phosphate, 36% P_2O_5), KCl (Potassium Chloride), Mg and ZA (Ammonium Sulphate) fertilizers. However, the suitable rate of N, P, K, Mg, and S either applied singly, or their combinations for shallots has not been elucidated on sandy soils under field conditions, especially in dry lands. Therefore, the objective of the study was to increase soil nutrient contents and evaluate nutrient types that mostly affect the high shallot yield with reasonable economic values in a sustainable manner.

2. Materials and Methods

2.1. Description of the Study Area

The field research was carried out on upland with sandy loam soil texture (64% sand) in Tegalrejo Village, Gedangsari, Gunungkidul, Yogyakarta (7°48′30″ S, 110°37′13″ E) with an elevation of 351.5 m above sea level (asl) in the dry season in 2021. The average annual temperature is 22 °C, with the highest value being 32 °C. The soil was developed from sandstone parent material on undulating to rolling slopes (15–25%) [25]. The existing land conservation technique has been implemented using bench terraces. Soil type is Lithic Troporthents, sandy loam, mixed, not acid, isohyperthermic [26,27]. For watering crops, the water is obtained from deep wells using pipes to the research site. The soil analysis before the field experiment is given in Table 1. The Gedangsari has an average annual rainfall of 1995.31 mm. The wet season (monthly rainfall > 100 mm) occurred from November to March. The moist season (100 mm < monthly rainfall > 60 mm) occurred in April, while the rest 6 months were a dry season (monthly rainfall < 60 mm).

Table 1. Chemical and physical characteristics of the soil before the study in Tegalrejo, Gedangsari, Gunungkidul.

Parameter	Result	Criteria
Texture		
- Sand (%)	64	Sandy loam
- Silt (%)	20	-
- Clay (%)	16	-
pH H_2O (1:25)	7.2	Neutral
pH KCl (1 = 2.5)	6.2	Slightly acid
Organic C (mg kg^{-1})	0.58	Very low
S (%)	0.05	Very low
Nisbah C/N	9	-

Table 1. *Cont.*

Parameter	Result	Criteria
Total N (%)	0.11	Low
Total C (%)	1.28	Very low
Exchangeable Ca (cmol kg^{-1})	4.57	Low
Exchangeable Mg (cmol kg^{-1})	10.57	Low
Exchangeable K (cmol kg^{-1})	0.08	Very low
Exchangeable Na (cmol kg^{-1})	0.15	Low
CEC (cmol kg^{-1})	8.33	Low
Base saturation (%)	185	Very High
Extract HCl 25%:		
- P_2O_5 (mg/100 g)	6	Very low
- K (mg/100 g)	26	Medium
Olsen/Bray:		
- P_2O_5 (mg kg^{-1})	12	Low
- K_2O (mg kg^{-1})	28	Medium

CEC = Cation exchange capacity.

2.2. Shallots Variety

The "*Tajuk*" cultivar of shallots was selected owing to the production of its high bulbs 12–16 t ha^{-1}, with harvest times ranging from 52 to 59 days, and the number of tillers is between 6 and 12/cluster (hill). The shape of the bulb is round, with the widest diameter near the root tip, and the color of the bulb is pink (Pink RHS 64D). The Tajuk cultivar is well adapted to the dry season, is resistant to rain, and has a very strong aroma [28].

2.3. Experimental Treatments and Design

The study used a randomized complete block design with six fertilization management treatments and four replicates. The treatments are listed in Table 2. The use of the nutrient omission approach to evaluate soil fertility and crop response has been successfully implemented on Alfisol in India [29]

Table 2. Treatments of complete nutrient and one nutrient omission test of shallots fertilization in sandy soils.

Treatment	Fertilizer Dosage (kg ha^{-1})				
	N	P	K	Mg	S
Complete nutrient	46	54	90	3.6	52.5
N—omitted	-	54	90	3.6	52.5
P—omitted	46	-	90	3.6	52.5
K—omitted	46	54	-	3.6	52,5
Mg—omitted	46	54	90	-	52.5
S—omitted	46	54	90	3.6	-

2.4. Experimental Procedure and Field Managements

The shallot seeds were selected from bulbs that had been dormant for 4 months. The field works included minimum tillage, levelling and construction of raised bed a week before planting. Seedlings from bulbs were cut at 1/3 end with a sterile knife carefully, then sorted and planted in experimental plots using single row plantings. Organic manure of three t ha^{-1} was applied evenly in the raised bed and N, P, K, Mg and S were given at a dose of 2/3 part before planting and 1/3 part was applied 35 days after planting. The plot size was 4 m × 5 m and divided into raised bed size 1 × 4 m^2, and shallot spacing was 20 × 20 cm within the raised bed rows. The distance between raised beds was 40 cm, and the distance between plots was 60 cm. Each raised bed was covered using black silver plastic mulch which had been perforated according to the planting spacing [30].

Shallots were maintained until harvest (60–70 DAP, days after planting). Plant maintenance, including pest control, weeding, and cultivation, was performed when required.

2.5. Soil Sampling and Analysis

Soil analysis was carried out before and after the field experiment. The surface soil samples before planting were randomly selected from the experimental field at a depth of 0–30 cm. In addition, the collected soil samples were mixed thoroughly, and a representative of 1 kg was taken as a composite for soil analysis. Soil and plant tissue analyses followed the Manual for soil analysis by the Indonesian Soil Research Institute [31].

2.6. Data Collection

Agronomic parameters included plant height, number of leaves, number of tillers, number of bulbs, the weight of fresh Stover bulbs, the weight of dry bulbs/hill, and nutrient plant tissue analysis. Growth and yield components data were observed from 5 hills which were chosen diagonally for each block. The yield data for each plot (kg plot^{-1}) was then converted to t ha^{-1}. The data of bulbs' weight loss were observed three times (2, 4 and 6 months after harvesting). Nutrient plant tissue analysis was observed from leaves of the harvested plant at 30 and 45 days after panting (DAP).

2.7. Data Analysis

Data were analyzed using the SAS program version 9.1, SAS Institute Inc., Cary, NC, USA. Statistical testing of the obtained data at a 5% level of significance was performed using analysis of variance (F-test). If the test results showed a significant effect, a comparison test between treatments was performed using a Duncan multiple range test (DMRT). In addition to the agronomic observation data, an analysis of the absolute growth rate (AGR) and crop growth rate (CGR) was also carried out following Gul et al. [32].

$$\overline{LPM} = \frac{W_2 - W_1}{t_2 - t_1}$$

$\overline{LPM}_{30–45\ \text{dap}}$ = absolute average growth rate
W_2 = dry weight of harvested plants at 45 days after planting (DAP)
W_1 = dry weight of harvested plants at 30 days after planting (DAP)
$t_2 - t_1$ = observation time interval

$$\overline{LPT} = \frac{1}{Ga} \times \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

$\overline{LPT}_{30–45\ \text{dap}}$ = average plant growth rate
Ga = land area
W_2 = dry weight of harvested plants at 45 days after planting (DAP)
W_1 = dry weight of harvested plants at 30 days after planting (DAP)
$t_2 - t_1$ = observation time interval

The relative yield percentage was designed to determine nutrient limiting factors for growth and was calculated using the formula of Safuan [33].

$$\text{Relative yield} = \frac{Treatment}{Optimum} \times 100\%$$

If the relative yield percentage is >100%, then the nutrient is not a limiting factor, on the other hand, if the relative yield percentage is <100%, then the nutrient is a limiting factor [33]. Economic feasibility analysis of farming was carried out using the Revenue Cost (RC) ratio and the break-even point. The input-output data observed consisted of the quantity and price of production inputs, as well as the quantity and price of shallots

produced. Farmers' income from shallots farming is calculated by the formula used by Ahmed et al. [34] as follows:

$$\text{Net Income} = \text{Gross Income} - \text{Total Cost}$$

In addition, the RC ratio was calculated using the formula used by Pratiwi et al. [35], Muhammad et al. [36] and Fatah et al. [37].

$$\text{Revenue/Cost} = \text{Gross Income/Total cost}$$

The break-even point is the point at which revenue equals total cost or profit is zero. There are 2 break-even points, the production break-even point (BEP-Y) and the price break-even point (BEP-P). The break-even point of production is the minimum production yield that must be achieved to avoid loss. The price break-even point is the price of output required to cover all costs at a certain level of output [38]. The break-even point is given by the following formula:

$$\text{BEP-Y} = \text{total cost/quantity produced}$$

$$\text{BEP-P} = \text{Total cost/Output price}$$

3. Results

3.1. Soil Property Changes and Nutrient Content of Tissue

The results of soil analysis after the field experiment showed there were no significant changes in soil fertility compared to initial soil properties before treatment (Table 3), meaning that most of the nutrients provided had been utilized or absorbed by plants, and probably some were lost due to leaching. Nutrient absorbed by plants was revealed by robust crop growth and the significant increase in shallot bulbs.

Table 3. Results of soil analysis after field experiment in Tegalrejo, Gunungkidul.

Parameter	Complete Nutrient	N-Omitted	P-Omitted	K-Omitted	Mg-Omitted	S-Omitted
Clay (%)	16.00	16.20	16.40	16.10	15.90	16.00
Silt (%)	20.00	19.80	19.50	19.60	19.90	19.00
Sand (%)	64.00	64.00	64.10	64.30	64.20	65.00
pH H_2O (1 = 2.5)	6.80	6.20	6.40	6.80	7.10	6.90
C-organic (mg kg^{-1})	0.29	0.39	0.26	0.19	0.18	0.29
N total (%)	0.12	0.11	0.12	0.62	0.15	0.11
P_2O_5 (Olsen) (mg kg^{-1})	25	16	17	17	17	19
K_2O (HCl 25%) mg/100 g	36	30	29	29	29	36
Mg (cmol (+) kg^{-1})	5.20	5.10	5.10	6.10	5.10	4.00
S (%)	0.07	0.14	0.16	0.12	0.09	0.03

Tissue analysis showed the N, P, K, Mg and S content varied from 1.4 to 2.3%, 0.07–0.25%, 1.16–2.14%, 0.15–0.20% and 0.03–0.14%, respectively (Table 4). Mean values showed the order nutrient content from high to low were K > N > P~Mg > S. One omission nutrient test showed a significant difference compared to complete nutrient treatments. The N plant tissue was significantly higher in N-omission but was significantly lower in S-omission compared to the complete nutrient treatment. In addition, N tissue content was significantly higher for the P- and Mg-omission than for the complete nutrient treatment. For P plant tissues, the significantly highest content occurred in the complete nutrient treatment compared to all one omission treatments. Next, the content of K plant tissue of complete nutrient treatment was not significantly different from the P- and Mg-omission treatments, but K was significantly higher than either N-, K- or S-omission. The Mg plant tissues of all treatments were not significantly different, except for S-omission showed

significantly higher Mg content than the complete treatment. The S tissue content was the highest in the N-omission, while in other treatments was not significantly different. The results of observations of the content of macronutrients in the plant tissue provide information that if one essential nutrient is not adequately available, this may be responsible for the decrease in crop yield.

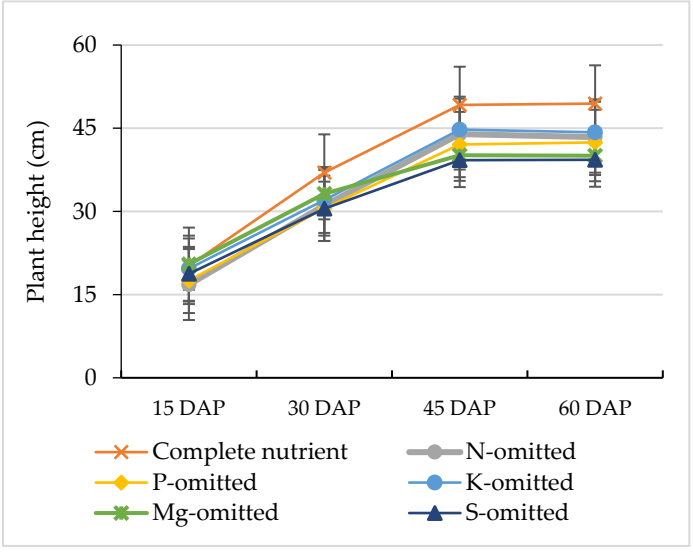
Table 4. Macronutrient content of shallot tissue at harvesting time.

Treatment	N	P	K	Mg	S
			%		
Complete nutrient	1.63 ^{d}	0.25 ^{a}	2.14 ^{a}	0.15 ^{b}	0.07 ^{b}
N-omitted	1.72 ^{c}	0.16 ^{b}	1.77 ^{b}	0.17 ^{ab}	0.14 ^{a}
P-omitted	2.26 ^{a}	0.17 ^{b}	2.09 ^{a}	0.16 ^{b}	0.06 ^{b}
K-omitted	1.68 ^{cd}	0.17 ^{b}	1.69 ^{bc}	0.18 ^{ab}	0.06 ^{b}
Mg-omitted	1.85 ^{b}	0.07 ^{c}	2.16 ^{a}	0.17 ^{ab}	0.03 ^{b}
S-omitted	1.39 ^{e}	0.16 ^{b}	1.60 ^{c}	0.20 ^{a}	0.08 ^{b}
CV (%)	2.28	15.25	3.26	10.09	29.72
Response Mean	1.76	0.16	1.91	0.17	0.07

Numbers followed by the same letter in the same column were not significantly different from the HSD test at the 5% level; CV = Coefficient of Variation.

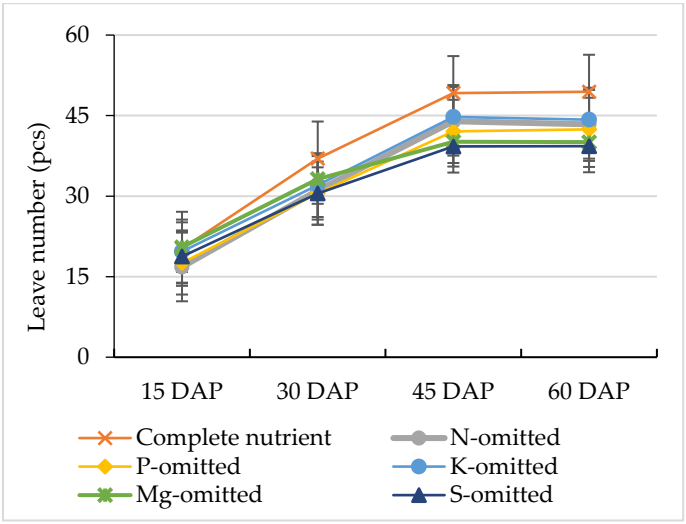
3.2. Growth and Yield of Shallot

The comparison of the effect of N-, P-, K-, Mg- and S-omitted treatments on plant height, leaf number, and tiller number at all ages did not significantly different, except for plant heights at 45 and 60 DAP (Figure 1a–c); this indicated that the absence of either N, P, K, Mg or S did not decrease shallot vegetative growth (plant height, leaf number, and tiller number).

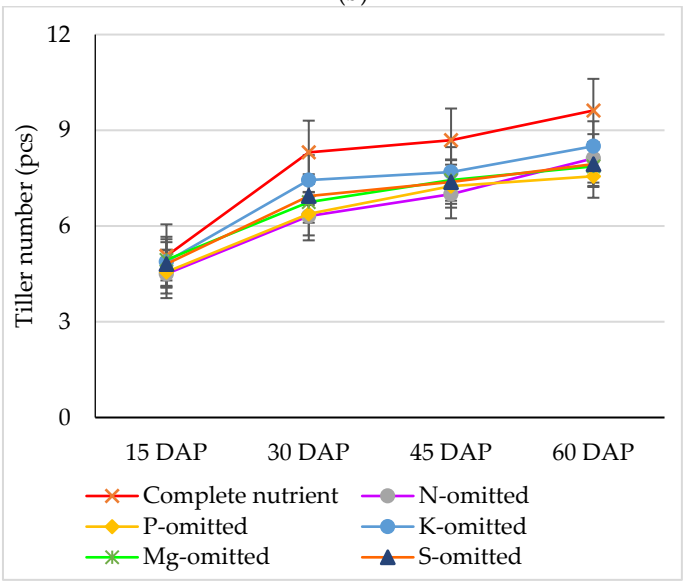


(**a**)

Figure 1. *Cont.*



(**b**)



(**c**)

Figure 1. The effect of complete and omission of one nutrient treatment on shallot growth at 15, 30, 45 and 60 days: (**a**) Plant height, (**b**) Leave number, and (**c**) Tiller number.

Furthermore, the crop growth rate (CGR) indicated the ability of plants to convert net assimilation yields into biological products (above ground crops) and economic yields (bulbs) per unit of time. The absolute growth rate (AGR) showed an increase in plant mass per unit of time (Figure 2). CGR and AGR with complete nutrient treatment were significantly greater than the growth rate of plants with incomplete treatment (one nutrient omission), except for Mg-omission, suggesting that without the addition of Mg, the absolute growth rate was similar to the plant growth rate for a complete nutrient treatment (Figure 2). However, the bulb yield showed that GCR and AGR were not always directly proportional to bulb production; it was seen from the yield of bulb production (Figure 2) of Mg-omitted treatment that had significantly lower bulb yields than the complete nutrient treatment. On the other hand, in the treatment without K, although the GCR and AGR were significantly lower than the complete nutrient treatment, the yield of shallot bulbs was comparable to the yield of bulbs with complete nutrient treatment; these results showed that the N-, P-, Mg- and S-omitted treatments resulted in a decrease in nutrient uptake capacity compared to K-omission treatment; this was probably due to an imbalance of nutrient availability in the soil for shallot requirements.

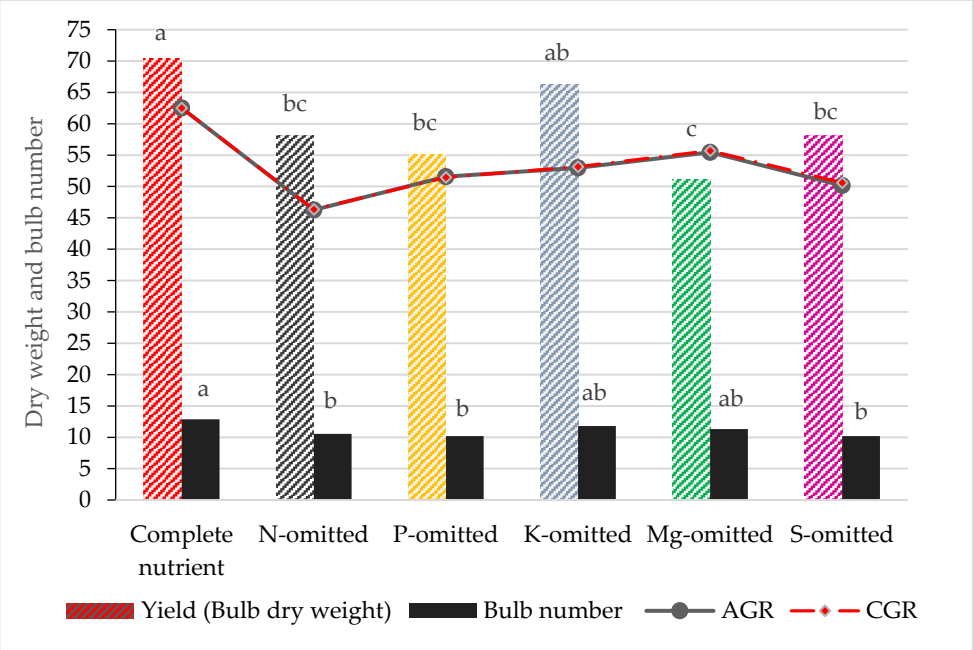


Figure 2. The effect of complete and one omission nutrient treatments on absolute growth rate (AGR), crop growth rate (CGR), yield (dry bulb weight) and the number of bulbs.

The dry weight of the bulbs with complete nutrient treatment was not significantly different from the K-omission (Figure 2). However, the dry weight of bulbs without N, P, Mg and S was significantly lower than a complete nutrient (Figure 2); this observation suggested that without K the dry weight of bulbs was not reduced, while without either N, P, Mg, or S could decrease the dry weight of bulbs.

Overall, this study showed that the absence of either N, P, K, Mg, or S source had no significant effect on vegetative crop growth rate but had a significant effect on shallot bulbs; this indicated that the vegetative shallot growth (plant height, number of leaves and number of tillers) was not significantly decreased if the completed nutrient is not applied, but when entering the generative phase of bulb formation and development, the complete nutrient should be applied. Therefore, complete nutrients should be used when growing shallots in upland sandy loam soils.

3.3. Identification of Shallot Growth and Yield Limiting Factors

To determine the nutrient type as the limiting factor for the shallot growth and production (shallot bulbs) and its consequence on potential yield reduction, the calculation of the relative yield percentage of several growth parameters (plant height, number of leaves, number of tillers, and yield parameters) was made using the total dry weight of the shallot (bulb and stem) (Figure 3).

Given the complete nutrient treatment as the reference of maximal yield (100%, red bar on top of Figure 3), the relative yield of one omission nutrient treatment was determined by the ratio of a given treatment to the complete treatment and expressed in %. The relative yields of growth and yields without nutrients of either N, P, K, Mg or S decreased in different magnitudes, indicating that the absence of any one nutrient (in fertilizer source) resulted in the decrease in the yield of shallot bulbs (Figure 3). The lowest values of the relative yield of bulb number, and bulb and leaf dry weight were shown by P- and S-omission treatments, namely 79% each, indicating that P and S were deficient in sandy loam soils, but they had a high contribution to the increase in bulb shallots. On the other hand, the highest relative yield of bulb number and bulb and leaf dry weight was shown by K-omission (92%) followed by Mg-omission treatment (88%), indicating K was sufficient while Mg was insufficient. For N-omission treatment, the relative yield of bulb number, and

bulb and leaf dry weight was 82% each, which was lower compared to K- and Mg-omission treatments but higher than P- and S-omission treatments.

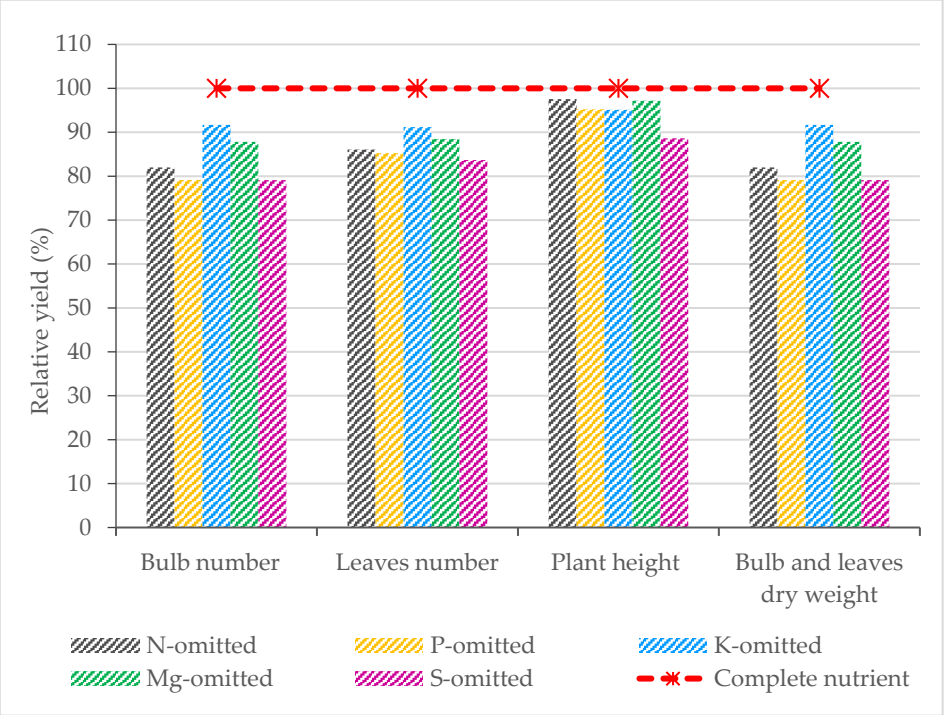


Figure 3. Percentage of the relative yield of shallot growth attributed to one omission nutrient treatment.

Evaluation of nutrient status based on their effect on the relative yield of shallots is given in Table 5. The complete nutrient treatment is used as a reference yield of 100%. The average relative yields of shallot varied from 81 to 92%, with the lowest value for S- and P-omission and the highest values for K-omission. Therefore, S, P, N, and Mg were limiting factors, while K was not a limiting factor. Without either S, P, N, and Mg, a potential decrease in yield may reach 19.1, 18.1, 15.6, and 10.9%, respectively. The corresponding value for K was 7.9%.

Table 5. Evaluation of nutrient status based on their effect on reducing the relative yield of shallots.

Treatment	Relative Yield (%)			Yield Reduction Potential (%)
	Average Growth	Dry Weight of Bulbs and Stoves	Average	
Complete nutrient	100	100	100	0
N-omitted	86.9	81.99	84.44	15.6
P-omitted	84.67	79.11	81.89	18.1
K-omitted	92.42	91.69	92.06	7.9
Mg-omitted	90.32	87.81	89.07	10.9
S-omitted	82.63	79.11	80.87	19.1

Status for limiting factor criteria: ≥10% = critical yield reduction by Hochmuth et al. [39].

3.4. Shallots Bulb Quality

The weight loss during storage is a quality indicator of freshness, and the greater the weight loss, the lower the freshness of the product [40]. Under normal conditions, farmers dried shallots in an open space with a room temperature of 26–29 °C and humidity at 70–80%. In this study, the storage was carried out for six months, and weight loss during storage was observed every two months (Figure 4). The complete nutrient treatment (N, P, K, Mg, S) showed the lowest weight loss for any given period of storage (varying from 20

to 50%), while the highest weight loss occurred for S-omission treatment varying from 40 to 60% during two to six-month storage. Other treatments of nutrient omission showed relatively similar weight loss during storage. Insufficient S content in plant tissue is the most responsible factor for the reduction of shallot quality.

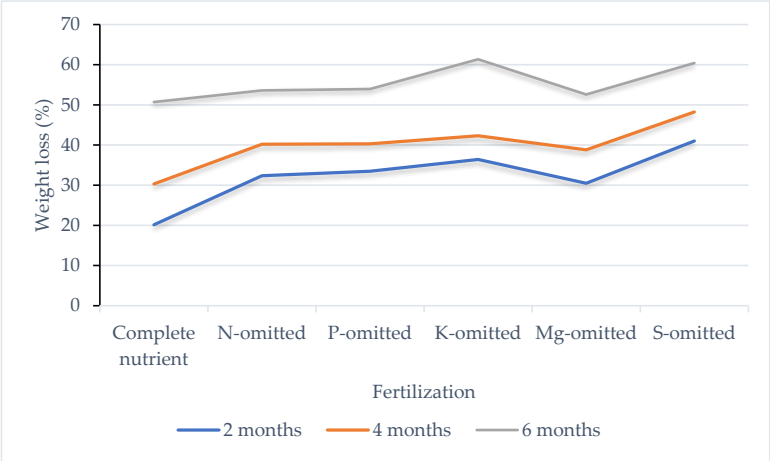


Figure 4. The effect of storage time and one omission nutrient on weight loss of shallot bulb.

3.5. Economic Assessment of Shallots Farming

An economic feasibility analysis was based on the prices and costs in the Indonesian region; it was revealed by income, RC ratio and BEP-P (Table 6). The cost of shallot farming in sandy loam soils varied among labors of each treatment, ranging from 5186.66 to 5262.47 USD ha^{-1}, with the lowest farming costs in the treatment without Mg and the highest farming costs in complete fertilization. The highest farming cost component was the cost of seeds, followed by labor, land rent and equipment depreciation, fertilizer, plastic mulch and pesticide.

Table 6. Analysis of economic feasibility of shallots farming.

No	Description	Treatments					
		Complete Nutrient	**N-Omitted**	**P-Omitted**	**K-Omitted**	**Mg-Omitted**	**S-Omitted**
1. Cost (USD ha^{-1}) (a + b + c + d + e + f)		5262.47	5250.34	5224.06	5186.66	5256.06	5224.06
	a. Seed	2122.64	2122.64	2122.64	2122.64	2122.64	2122.64
	b. Fertilizer	508.09	495.96	469.68	432.28	501.68	469.68
	c. Pesticide	165.09	165.09	165.09	165.09	165.09	165.09
	d. Plastic Mulch	252.7	252.7	252.7	252.7	252.7	252.7
	e. Labor cost	1526.28	1526.28	1526.28	1526.28	1526.28	1526.28
	f. Others (land lease etc.)	687.67	687.67	687.67	687.67	687.67	687.67
2. Production (kg ha^{-1})		11,430	9440	8930	10,750	8300	9430
3. Price (USD kg^{-1})		1.11	1.11	1.11	1.11	1.11	1.11
4. Revenue (USD ha^{-1})		12,708.56	10,495.96	9928.91	11,952.49	9228.44	10,484.84
5. Income (USD ha^{-1})		7446.09	5245.62	4704.85	6765.84	3972.37	5260.78
6. R/C Ratio		2.41	2	1.9	2.3	1.76	2.01
7. BEP-P (USD ha^{-1})		0.46	0.56	0.59	0.48	0.63	0.55

Source: Primary data analysis; Note: 1 USD = 14.480 IDR (exchange rate average in June 2022).

The income of shallot farming in dry sandy loam soil varied between treatments, which ranged from 3972.37 USD ha^{-1} to 7446.09 USD ha^{-1}, with the lowest income in the

treatment without Mg and the highest in the complete nutrient application. The R/C ratio in all treatments was >1, with the lowest R/C ratio in the treatment without Mg (1.80) and the highest in the complete nutrient treatment (2.41). For BEP-P values varied between 41.40% and 55.42% of the price, with the lowest BEP-P in the complete nutrient treatment (0.46 USD kg^{-1}), and the highest in the Mg-omission treatment (0.63 USD kg^{-1}). Based on these criteria, all treatments were economically feasible because the income was positive, the R/C ratio >1 and the BEP-P was smaller than the actual price.

4. Discussion

4.1. Environmental Conditions

The main constraint of shallot development in sandy loam soil is the low status of all nutrients, water-holding capacity, and nutrient retention. Therefore, the management strategy should overcome nutrient deficiency, increase water holding capacity, and reduce water loss to allow optimum growth of shallot. In this study, organic manure, plastic mulch, deep well irrigation and complete nutrient have been applied to allow optimum growth of shallot on sandy soil. Organic manure of three t ha^{-1} as the base treatment of the study was given to increase soil organic matter, cation exchange capacity, and nutrient and water holding capacity. Further, the use of plastic mulch was designed to reduce soil evaporation, maintain soil moisture regime, and reduce soil erosion, which in turn is effective and successful in promoting shallot growth and yield. Irrigation obtained from deep-well using pipes has also been applied to overcome water shortages during a dry season.

Organic fertilizers have a significant effect on pH, organic C, total K, N and P of the soils [41]. Sandy loam soil properties showed the available P was low (6–12 ppm) while total K was moderate (26 mg 100 g^{-1}) (Table 1), suggesting the fertilizers containing P_2O_5 and K_2O are needed to support shallot growth and production. The low soil organic C, N and cation (Tables 1 and 3) should be corrected to generate favorable conditions for shallot growth. According to Gunawan et al. [42] the application of organic matter can increase the C-organic content of the soil.

Soil properties after the study such as pH, C-organic, and total N content did not change, indicating shallot have used the nutrient released from organic manure and that treatment at least maintained the soil properties (not decrease after harvesting). Inorganic fertilization (N, P, K, Mg and S) effectively provides nutrient for shallot and replenish absorbed nutrient by crops. In this study, those fertilizer applications accompanied by three t ha^{-1} organic manure provide high and sustainable yields and provide economic efficiency while maintaining the balance of nutrients in the soil [43].

4.2. Performance Shallot Growth and Productivity

Treatment with a nutrient omission provides good information to determine which nutrient is a limiting factor and its effect on plant growth. According to Kumar et al. [29] "if any element is omitted while other elements are applied at suitable rates and plants grow weakly, then the tested element is a limiting factor for crop growth". The N and P application optimized the height, tiller and fresh-dry bulbs weight of shallot [44]. The nutrient balance in soil plays an important role in the synthesis of carbohydrates and protein to promote the increase in shallot bulbs [45]. Mawardiana et al. [46] reported that the application of fertilizers containing S and Mg improved the quality and quantity of shallots.

Sutardi and Purwaningsih [43] reported that to produce 10–15 t ha^{-1} of shallot, the required fertilizer is 100 kg ha $^{-1}$ Urea, 250 kg ha^{-1} ZA, and 150 kg ha^{-1} SP-36. Shallot plants required a continuous supply of N, P, K, S and Mg for vegetative growth, bulb growth and bulb quality. Lack of N, P, K, S and Mg causes shallot plants susceptible to disease and low bulb production [47,48]. N, P, K, S and Mg have several functions in the shallot production system, namely increasing resistance to pests and diseases, photosynthetic processes, osmotic regulation, enzyme activity, stimulation, and transport of assimilating, protein synthesis, ion homeostasis, stability between monovalent cations and divalent

in the transport of water through the movement of stomata, helps plant turgor, stress tolerance, and stimulation of enzymes [49,50].

The result of the study on sandy soil with 150 kg KCl ha^{-1} showed a high relative yield (120%), and the production of shallot bulbs reached 12.75–13.6 t ha^{-1} [51]; this result is lower than the result reported by Rahayu, et al. [52] in Central Sulawesi that showed the application of 700–900 kg ha^{-1} NPK fertilizer (NPK 16:16:16) produced bulb shallots up to 16.3 t ha^{-1} which is much high than the shallot bulb in the present study (11. 43 t ha^{-1}); this difference is owing to the good soil properties (non-sandy soils) in the study of Rahayu et al. compared to sandy soil in the present study.

The low S in sandy soil is responsible for the low quality of shallot in this study (Figure 4). Sulfur plays an important role in plant metabolism, which is related to several parameters that control the quality of crop yields. The sharp aroma of shallots was determined by the sulfur availability in the soil [51]. Furthermore, Mg plays an important role in the process of perfect leaf formation and the formation of carbohydrates, fats, and oils. In addition, magnesium also plays an important role in phosphate transport in plants so the phosphate content in plants can be increased by adding Mg. The application of Mg can increase nutrient uptake, sugar synthesis, and starch translocation due to the importance of Mg in phosphate transport [53].

4.3. Growth Limiting Factors and Yield of Shallot

The nutrient limiting factor is assessed using relative yields expressed in %. P and S became the main limiting factors of shallot in dry sandy loam soils because the insufficient P and S may decrease bulb production by 18.1 and 19.1%, respectively (Figure 3) from the yield obtained from the complete nutrient application. In the study area, P and S are not applied by all farmers in shallot cultivation, although these nutrients potentially increased shallot bulb production. In addition, bulb production of Mg-, and N- omission also reduces the yield of shallot to 10.9 and 15.6%, respectively.

The results of this study offer an opportunity for the development of shallot farming in dry land with sandy loam soils, since shallot cultivation in Indonesia is carried out mostly in irrigated paddy fields associated with better soil properties. Soils with a high sand fraction are considered to have problems of low fertility. However, results from this study showed that the application of complete macronutrient nutrients (N, P, K, Mg, S) is successfully overcome the problems of sandy loam soil for the shallot establishment.

4.4. Shallots Bulb Quality

The weight loss of shallot during storage depends on the storage period and chemical composition of the bulb. The smallest weight loss (20–50% depending on the length of time storage) was revealed by complete nutrient (N, P, K, Mg and S) fertilization, while the highest weight loss (41–60%) was revealed by yield with no S fertilization; this indicates that the low S content of bulb shallot is responsible for the low bulb quality (high weight loss during storage). According to Sudomo [54] the weight loss of bulbs was about 5–30% during storage. The longer shelf life (2–3 months) bulb shallot depends on moisture content, texture (firmness) and amount of dissolved solids.

4.5. Economic Assessment of Shallot Farming

The cost of shallot farming in this study is greater than the cost of shallot farming on clay-dominant soils in several locations of 1352.99–4480.25 USD ha^{-1} [55,56] owing to the high input of shallot production to overcome the limiting factors of sandy soils. Shallot farm income in the present study varied from 9228.44 to 12,708.56 USD ha^{-1}, in which the complete fertilizer application gave the highest income, followed by K-, N-, S-, P-, and Mg-omission. The difference in income among treatments was related to the productivity of shallots on sandy loam soils varying between 8300 kg ha^{-1} and 11,430 kg ha^{-1}.

The income obtained from shallot farming with the use of complete nutrients in a period of three months is 7446.09 USD ha^{-1}, or 2482.03 USD per month ha^{-1}. On the

other hand, the regional minimum wage in the study area is USD 128.03 per month per person [57], so the income from shallot farming is 19.39 times higher than the regional minimum wage.

The tolerant limits for a price reduction that did not cause losses were 58.59% in the complete nutrient treatment, 56.61% in the treatment K-omitted, 50.18% in the treatment S-omitted, 49.98% in the treatment N-omitted, 47.39% in the treatment P-omitted, and 43.04% in the treatment Mg-omitted. If there is a decrease in price, complete fertilization treatment is the most stable compared to other treatments. In general, findings from this study provide promising economic benefits for farmers due to the optimal use of terracing land in the dry season. The land is only cultivated for two seasons a year, while in the dry season is fallow. The presence of a deep well allows intensive planting of shallots, resulting in an audition income of 7446.09 USD ha^{-1}. From the environmental aspect, shallot cultivation on dry sandy loam soil with a slope of 15–25% should attempt to reduce land degradation by reducing erosion and greenhouse gas emissions to promote sustainable agriculture and protect the environment.

5. Conclusions

The complete N, P, K, Mg and S fertilizer application on sandy loam soil successfully increased shallot bulb production, achieving 11.43 t ha^{-1}. Shallot tissue content of N, P, K, Mg and S varied from 1.4 to 2.3, 0.07 to 0.25, 1.16 to 2.14, 0.15 to 0.20 and 0.03 to 0.14%, respectively. The order of nutrient content from high to low is K > N > P~Mg > S. The S, P, N, and Mg are limiting factors as revealed by significantly lower relative yield varying from 79 to 88%.

Insufficient P and S resulted in a decrease in shallot bulbs of 18 and 19%, respectively. The highest weight loss during storage occurred for S-omission treatment (40 to 60%), indicating insufficient S content in tissue is responsible for the low shallot quality. The complete N, P, K, Mg and S fertilizer application gave the highest income of 7446.09 USD ha^{-1} with a revenue cost ratio of 2.41 and the tolerance limit for the price reduction without causing losses is 58.59%. The decreased income was 1161.59 USD ha^{-1} for N-omission, 1347.74 USD ha^{-1} for P-omission, 588.24 USD ha^{-1} for K-omission, 811.62 USD ha^{-1} for M-omission, and 1442.20 USD ha^{-1} for S-omission.

Author Contributions: S., K., H.P., S.W., F.D.A., M.D.P., J.T., R.H.P., A.M., I.G.C., Y., M.P.Y., M.A. and A.W.; conceptualization, S., K., H.P., S.W., M.D.P. and J.T.; performed research and analyzed data, S., K., S.W., M.D.P. and J.T.; wrote the original manuscript and draft preparation, S.; wrote, reviewed, and edited, S., K., H.P., S.W., F.D.A., M.D.P., J.T., R.H.P., A.M., I.G.C., Y., M.P.Y., M.A. and A.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Indonesian Agency for Agricultural Research and Development through the Yogyakarta Assessment Institute for Agricultural Technology for this work through a research project entitled "Downstream agricultural technology innovation, water harvesting, water conservation in the Gunungkidul dry land agro-ecosystem area", grant number: DIPA-018.09.2.633975/2021.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available yet but will be in due course.

Acknowledgments: The authors express their gratitude to the Indonesian Agency for Agricultural Research and Development, Yogyakarta Assessment Institute for Agricultural Technology and thank Sunardi, Suparto, and Tigor, who have helped with data collection and implementation of research activities.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Swamy, K.R.M.; Gowda, V.R. Leek and shallot. In *Handbook of Herbs and Spices*; Series in Food Scence Technology and Nutrition; Woodhead Publishing: Sawston, UK, 2006; Volume 3, pp. 365–389.
2. Sun, W.; Shahrajabian, M.H.; Cheng, Q. The insight and survey on medicinal properties and nutritive components of Shallot. A review. *J. Med. Plant Res.* **2019**, *13*, 452–457. [CrossRef]
3. Currah, L.; Proctor, F.J. Onions in tropical regions. *Natl. Res. Inst. U.K. Bull.* **1990**, *35*, 245.
4. Grubben, G.J.H. *Amaranthus L. Plan Resources of South East Asia*; Siemonsma, J.S., Piluek, K., Eds.; Prosea: Bogor, Indonesia, 1994; pp. 82–86.
5. Sumiati, E. Response of shallot and garlic to different altitudes. *Acta Hortic.* **1994**, *358*, 395–400. [CrossRef]
6. Abbey, L.; Kanton, R.; Braimah, H. Susceptibility of shallots to the timing and severity of leaf damage. *J. Hortic. Sci. Biotechnol.* **1996**, *73*, 803–805. [CrossRef]
7. Pasigai, M.A.; Thaha, A.R.; Maemunah; Nasir, B.; Lasmini, S.A. *Shallot Technology of Lembah Palu Variety*; Untad Press Publisher: Central Sulawesi, Indonesia, 2016.
8. Kahsay, Y. Effect of intra-row spacing on yield and quality of some onion varieties (*Allium cepa* L.) at Aksum, Northern Ethiopia. *Afr. J. Plant Sci.* **2013**, *7*, 613–622. [CrossRef]
9. Rahayu; Ali, B.V. *Shallot*; Penebar Swadaya Publisher: Jakarta, Indonesia, 2007.
10. Dihni, V.A. Shallot Production in Indonesia 2017–2021. Statistic Center Agency. 8 June 2022. Available online: https://databoks.katadata.co.id/datapublish/2022/06/09/produksi-bawang-merah-ri-naik-1042-pada-2021 (accessed on 16 July 2022).
11. Aldila, H.F.; Fariyanti, A.; Tinaprilla, N. Shallot competitiveness in production center areas in Indonesia. *J. Manaj. dan Agribisnis.* **2017**, *14*, 43–53. [CrossRef]
12. Indonesian Ministry of Agriculture. *Outlook for Agricultural Commodities in Horticultural Sub-sector (Shallots)*; Center for Data and Agricultural Information Systems, Ministry of Agriculture: Jakarta, Indonesia, 2015.
13. FAO. *World Food and Agriculture—Statistical Yearbook*; FAO: Rome, Italy, 2021; 368p, Available online: https://doi.org/10.4060/cb4477en (accessed on 1 June 2022).
14. Shura, G.; Beshir, H.M.; Haile, A. Improving onion productivity through optimum and economical use of soil macronutrients in Central Rift Valley of Ethiopia. *J. Agric. Food Res.* **2022**, *9*, 100321. [CrossRef]
15. Pranata, A.; Umam, A.T. Effect of shallot prices on shallot production in Central Java. *Jejak* **2015**, *8*, 36–44. [CrossRef]
16. Rai, I.N. *Fundamentals Agronomic*, 1st ed.; Pelawa Sari Publisher: Bali, Indonesia, 2018.
17. Kharisun; Budiono, M.N.; Ri'fan, M. The Effect of Zeolit-Based Slow-Release Nitrogen Fertilizer and Sulfur on the Dynamics of N, P, K and S Soil Nutrients, Growth and Yield of Shallot (*Allium cepa* L.). *Adv. Biol. Sci. Res.* **2021**, *9*, 288–292.
18. Khokhar, K.M. Mineral nutrient management for onion bulb crops—A review. *J. Hortic. Sci. Biotechnol.* **2019**, *94*, 703–717. [CrossRef]
19. Serri, F.; Souri, M.K.; Rezapanah, M. Growth, biochemical quality and antioxidant capacity of coriander leaves under organic and inorganic fertilization programs. *Chem. Biol. Technol. Agric.* **2021**, *8*, 33. [CrossRef]
20. Azurianti, A.; Wulansari, R.; Athallah, F.N.F.; Prijono, S. The relation study of soil nutrient to productivity of productive tea plants in pagar alam tea plantation, South Sumatra. *J. Tanah Sumberd. Lahan.* **2022**, *9*, 153–161. [CrossRef]
21. Aghaye, N.Y.; Souri, M.K.; Delshad, M. Effects of soil application of amino acids, ammonium, and nitrate on nutrient accumulation and growth characteristics of sweet basil. Commun. *Soil Sci. Plant Anal.* **2019**, *50*, 2864–2872. [CrossRef]
22. Rustiana, R.; Suwardji, S.; Suriadi, A. Integrated nutrient management in Porang cultivation (Review). *J. Agrotek Ummat.* **2021**, *8*, 99. [CrossRef]
23. Thi, L.H.M.; Thi, L.D.; Insixiengmai, O.; Nguyen-Sy, T. Modeling nitrogen uptake in eight common leafy vegetables in Red River Delta. *AGRIVITA J. Agric. Sci.* **2022**, *44*, 266–275. [CrossRef]
24. Muliana; Anwar, S.; Hartono, A.; Susila, A.D.; Sabihan, S. Management and fertilization of phosphorus and potassium on shallot intensive cultivation in four villages in Brebes. *J. Hortik. Indones.* **2018**, *9*, 27–37. [CrossRef]
25. Center for Soil and Agroclimate Research. *Survey and Mapping of Land Resources for the Development of Dry Land Agriculture and Forest Conservation in the Special Region of Yogyakarta*; Center for Soil and Agroclimate Research: Bogor, Indonesia, 1994. (In Indonesia)
26. Hermiyanty; Bertin, W.A.D.S. Soil Observation Technical Guide. *J. Chem. Inf. Model.* **2017**, *8*, 1–58.
27. Center for Research and Development of Agricultural Land Resources. *Technical Instructions Chemical Analysis of Soil, Plants, Water and Fertilizer*, 2nd ed.; IAARD: South Jakarta, Indonesia, 2013.
28. *Number 045/Kpts/SR.120/D.2.7/5/2016*; Shallot of Tajuk variety. Decree of Minister of Agriculture Republic of Indonesia: Jakarta, Indonesia.
29. Kumar, B.; Sharma, G.K.; Mishra, V.N.; Chandraka, T.; Kumar, T. Crop Responses Based Assessment of Soil Fertility through Nutrient Omission Technique in Alfisol of Bastar District of Chhattsgar State in India. *Int. J. Curr. Microbiol. Appl. Sci.* **2020**, *9*, 40–50. [CrossRef]
30. Sutardi; Partono. Black Silver Plastic Mulch Holes Tool. Indonesia Patent 500201802844, 27 July 2018.
31. Indonesian Soil Research Institute. *Technical Instructions for Chemical Analysis of Soil, Plants, Water, and Fertilizers*; Indonesian Soil Research Institute: Bogor, Indonesia; Indonesian Agency for Agriculture Research and Development, Ministry of Agriculture: Bogor, Indonesia, 2009.

32. Gul, H.; Khan, A.Z.; Khalil, S.K.; Rehman, H.U.R.; Anwar, S.; Saeed, B.; Farhatullah; Akbar, H. Crop growth analysis and seed development profile of wheat cultivars in relation to sowing dates and nitrogen fertilization. *Pak. J. Bot.* **2013**, *45*, 951–960.
33. Safuan, L.O. Development of Fertilization Recommendation for Nitrogen, Phosphorus, and Potassium on Pineapple (*Ananas comosus* (L) Merr.) Smooth Cayenne Be Based on Soil Nutrient Status. (L). Ph.D Thesis, Bogor Institute of Agriculture, Bogor, Indonesia, 2007.
34. Ahmed, K.D.; Burhan, O.; Amanuel, A.; Diriba, I.; Ahmed, A. Technical efficiency and profitability of potato production by smallholder farmers: The case of Dinsho District, Bale Zone of Ethiopia. *J. Dev. Agric. Econ.* **2018**, *10*, 225–235. [CrossRef]
35. Pratiwi, L.F.L.; Hardyastuti, S.; Waluyati, L.R. Profitability and farmers conservation efforts on sustainable potato farming in Wonosobo Regency. *Agric. Sci.* **2016**, *1*, 31–36. [CrossRef]
36. Muhammad, C.N.; Hariyati, Y. Prestigious perception of potato farming: An overview of the economy, socio-culture, and its existence. *Agric. Soc. Econ. J.* **2021**, *21*, 25–32. [CrossRef]
37. Fattah, M.A.; Mardiyati, S. Income and feasibility of onion business (Case Study in Tangru Village Malua District Enrekang Regency). *J. Pemikir. Masy. Ilm. Berwawasan Agribisnis.* **2022**, *8*, 367–375. [CrossRef]
38. Soekartawi. *Farming Analysis*; UI Press: Jakarta, Indonesia, 2002.
39. Hochmuth, G.; Maynard, D.; Vavrina, C.; Hanlon, E.; Simonne, E. Plant Tissue Analysis and Interpretation for Vegetable Crops in Florida. In *Nutrient Management of Vegetable and Row Crops Handbook*; A Series of the Horticultural Sciences Department, UF/IFAS Extension; University of Florida: Gainesville, FL, USA, 2018; Available online: https://edis.ifas.ufl.edu/pdf/EP/EP08100.pdf (accessed on 3 June 2022).
40. Purwaningsih, H.; Kristamtini; Fajri, M.; Indrasari, S.D.; Wiranti, E.W. Production, physical, and organoleptic characteristics of superior varieties specific location "Srikayang" Special Region of Yogyakarta. *J. Hort.* **2020**, *30*, 153–158. [CrossRef]
41. Nurjani, S.H.U.; Widya, N. Nutrient uptake of N,P,K in rice plants with various durations of using organic fertilizers on Sragen vertisols. *J. Soil Environ. Sci.* **2010**, *10*, 1–13.
42. Gunawan, G.; Wijayanto, N.; Budi, S.W. Characteristics of soil chemical properties and soil fertility status of vegetables agroforestry based on *Eucalyptus* Sp. *J. Trop. Silvic.* **2019**, *10*, 63–69. [CrossRef]
43. Sutardi; Purwaningsih, H. Environment-friendly cultivation of shallot on sandy land as specified location in Yogyakarta. *J. Sumberd. Hayati.* **2018**, *4*, 1–6. [CrossRef]
44. Napitupulu, D.; Winarto, L. The effect of N and K fertilizer on growth and yield of shallots. *J. Hort.* **2010**, *20*, 27–35.
45. Tambunan, W.; Sipayung, R.; Sitepu, F. Growth and production of shallots (*Allium ascalonicum* L.) by application of biological fertilizers in various planting media. *J. Agroekoteknologi Univ. Sumatera Utara.* **2014**, *2*, 825–836. [CrossRef]
46. Mawardiana; Karnilawati; Juana. Effectivity test of organic mulch and ZA fertilizer on the growth and yield of shallots (*Allium ascalonicum* L). *J. Real Ris.* **2021**, *3*, 92–96.
47. Grant, C.A.; Flaten, D.N.; Tomasiewicz, D.J.; Sheppard, S.C. The importance of early season phosphorus nutrition. *Can. J. Plant Sci.* **2001**, *81*, 211–224. [CrossRef]
48. Sutardi. Fertilization on shallot cultivation in specific location on sandy land. *Agrin* **2017**, *21*, 155–168.
49. Zhao, F.J.; Tausz, M.; De Kok, L.J. Role of sulfur for plant production in agricultural and natural ecosystems. In *Sulfur Metabolism in Phototropic Organisms*; Hell, R., Dahl, C., Knaff, D., Leustek, T., Eds.; Springer: Dordrecht, The Netherlands, 2008; pp. 425–443. [CrossRef]
50. Tränknera, M.; Tavakolband, E.; Jakli, B. Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photoprotection. *Physiol. Plant.* **2018**, *163*, 414–431. [CrossRef] [PubMed]
51. Muhammad, H.; Sabiham, S.; Rachim, A.; Adijuwana, H. The effect of sulphur and sugar cane filter mud application on the growth and yield of shallot in inceptisol soil. *J. Hortik.* **2003**, *13*, 95–104.
52. Rahayu, S.P.; Muchtar; Saidah. The feasibility and farmer perceptioan of true shallot seed technology in Sigi District, Central Sulawesi, Indonesia. *Asian J. Agric.* **2019**, *3*, 16–21. [CrossRef]
53. Harris, K.; Vanajah, T.; Puvanitha, S. Effect of foliar application of boron and magnesium on growth and yield of green chilli (*Capsicum annum* L.). *AGRIEAST J. Agric. Sci.* **2018**, *12*, 26–33. [CrossRef]
54. Soedomo, R.P. Packaging type and storability effect of shallots seed bulbs on growth and yield in the field. *J. Hortik.* **2006**, *16*, 188–196.
55. Motamedi; Chelan, J.M.M.; Rahmanpour, S.; Souri, M. Economic evaluation of shallot utilization in Varnasa Rangeland, Naghadeh, Iran. *J. Rangel. Sci.* **2018**, *8*, 240–252.
56. Mahfudz, M.; Saleh, S.; Antara, M.; Anshary, A.; Bachri, S.; Made, U.; Hasanah, U.; Rauf, R.A. Adoption and advantages of eco-friendly technology application at the shallot farming system in Indonesia. *Agron. Res.* **2019**, *17*, 1679–1687. [CrossRef]
57. Susanawati; Jahmari; Masyhuri; Darwanto, D.H. Factors influencing income of shallot farming in Java Indonesia using UOP profit function model. *Adv. Eng. Res.* **2018**, *172*, 68–74.