JOURNAL OF WORLD SCIENCE
https://jws.rivierapublishing.id/index.php/jws P-ISSN: 2828-8726
Volume 5 No. 3 March 2026 E-ISSN: 2828-9307

Response of Shallots (Allium Ascalonicum L.) To Azolla Pinnata Bokashi and NPK Fertilizer

Yusuf L Limbongan*, Amelia A Limbongan
Universitas Kristen Indonesia Toraja, Indonesia
Email: yusuflimbongan@ukitoraja.ac.id*

ABSTRACT
Background: Shallot (Allium ascalonicum L.) is a high-value vegetable commodity in Indonesia, but its productivity remains low, particularly in North Toraja Regency. The use of organic fertilizers such as Azolla pinnata bokashi combined with inorganic NPK fertilizer offers potential for improving shallot growth and production through integrated nutrient management. Objective: This study aims to determine the response of shallot plants to the application of Azolla pinnata bokashi and NPK fertilizer. Method: A factorial experiment arranged in a randomized block design was conducted from May to August 2022. Treatments included three levels of A. pinnata bokashi (control, 30 tons/ha, 50 tons/ha) and three levels of NPK fertilizer (control, 250 kg/ha, 350 kg/ha). Data were analyzed using ANOVA and orthogonal polynomial methods. Results: The results showed that the application of 50 tons/ha A. pinnata bokashi gave the best results for all observed variables. The application of 350 kg/ha NPK fertilizer also produced the best growth and production. The interaction between 50 tons/ha A. pinnata bokashi and 350 kg/ha NPK fertilizer was the best combination treatment, significantly increasing plant height, number of bulbs, and bulb weight compared to other treatments. The response of shallot plants to the application of A. pinnata bokashi and NPK fertilizers was linear. Conclusion: The combination of 50 tons/ha A. pinnata bokashi and 350 kg/ha NPK fertilizer is recommended for optimizing shallot growth and production in highland areas. The integrated use of organic and inorganic fertilizers can improve shallot productivity through synergistic effects on plant growth parameters.

Keyword: *Shallots; Azolla pinnata; bokashi; NPK fertilizer*

INTRODUCTION

Background: Shallot (Allium ascalonicum L.) is a high-value vegetable commodity with significant economic importance in Indonesia. Although shallots are not native to Indonesia, their cultivation is widespread because they are used extensively as spices and medicines. The potential for shallot production ranges from 23.33 to 28.14 tons/ha, but the average production in Indonesia remains low, particularly in North Toraja (BPS Toraja Utara, 2021).

The harvested area for shallots between 2017 and 2019 showed fluctuations. In 2017, the harvested area was 158,172 ha. However, in 2018, the shallot harvested area decreased to 156,779 ha. In 2019, the harvested area increased again to 159,195 ha. The fluctuating shallot prices in Indonesia indicate a poor supply management system.

The decrease in shallot productivity is partly due to the high risk of farming failure, including uncertain climatic conditions, the use of low-quality seeds, poor planting media, and high pest and disease incidence, all of which contribute to yield failure (Nur, 2018). To meet domestic demand for shallots, the government has implemented various methods to improve shallot cultivation techniques (Agriculture, 2020).

Producers and the productivity of shallots need to be improved as consumer demand continues to rise in line with increasing population and consumption potential (Karim et al., 2019; Fajar, 2016).

Bokashi is an organic fertilizer produced through the fermentation of organic matter such as compost and manure using decomposing microorganisms like microbes or fermented fungi. Bokashi is made by fermenting organic matter with EM4 (Effective Microorganisms) technology, a mixed culture of various organisms beneficial for organic matter decomposition. EM4 in bokashi improves soil quality and increases crop production (Nasir, 2017). Azolla pinnata fertilizer is a sustainable organic farming technology. Bokashi has good prospects as an organic fertilizer because of its high nutrient content. Azolla pinnata bokashi is a composting method that uses aerobic and anaerobic starters for the composting process, often utilizing a mixture of molasses and water starter microorganisms (S, 2020). NPK fertilizer is an artificial fertilizer available in liquid or solid form that contains nitrogen, phosphorus, and potassium (Panataria et al., 2022). NPK fertilizer is one of the most commonly used compound fertilizers.

Several previous studies have examined the use of organic fertilizers and NPK on shallot production. (Achmad, 2015) investigated the effect of various dosages of Azolla pinnata and NPK fertilizer on the growth and yield of red chili, finding that the combination of organic and inorganic fertilizers significantly improved plant growth parameters (Fajjriyah, 2017). (Timpayung, 2021) examined the effect of bokashi and NPK fertilizer on the growth and production of shallots, reporting that the application of bokashi combined with NPK fertilizer increased plant height, number of bulbs, and bulb weight compared to control treatments. Similarly, (Pramantari et al., 2022) studied the effect of NPK fertilizer dosage and shallot litter on the growth and yield of shallots, demonstrating that optimal NPK application significantly enhanced shallot production. More recently, (Yoanma et al., 2022) investigated the effect of coconut shell biochar application on the effectiveness of NPK fertilizer in shallot cultivation, finding that the combination of organic amendments with NPK fertilizer improved fertilizer efficiency and crop yield.

Despite the growing body of research on organic and inorganic fertilizer combinations, a significant gap remains in understanding the specific interaction between Azolla pinnata bokashi and NPK fertilizer on shallot growth and production, particularly in the agroecological conditions of North Toraja. Most existing studies have been conducted in different geographical locations with varying soil types and climatic conditions, limiting the applicability of their findings to the specific context of highland areas in Eastern Indonesia. Furthermore, previous research has predominantly focused on either organic or inorganic fertilizers separately, with limited systematic investigation of their combined effects across different dosage levels and the nature of plant response (linear or quadratic) to these treatments.

The novelty of this research lies in its conceptual and contextual contributions. Conceptually, the study advances understanding of integrated nutrient management by systematically evaluating the interaction between Azolla pinnata bokashi and NPK fertilizer using orthogonal polynomial analysis to determine the response pattern of shallot plants. This approach allows for a more nuanced understanding of how plants respond to increasing doses of fertilizers, whether the response follows a linear or quadratic pattern, which has important implications for optimizing fertilizer recommendations. Contextually, the research provides site-specific data on shallot cultivation in the highland areas of North Toraja (750 m above sea level), an important but understudied agricultural region in Indonesia. The findings contribute to developing location-specific fertilizer recommendations that can help improve shallot productivity in similar agroecological conditions.

This study, therefore, aims to evaluate the effect of Azolla pinnata bokashi and NPK fertilizer on the growth and production of shallot plants and to determine the optimal combination of these treatments for shallot cultivation in the highland conditions of North

Toraja. The specific objectives are: (1) to determine the effect of Azolla pinnata bokashi on shallot growth and production, (2) to determine the effect of NPK fertilizer on shallot growth and production, (3) to analyze the interaction between Azolla pinnata bokashi and NPK fertilizer on shallot growth and production, and (4) to determine the response pattern of shallot plants to the application of these fertilizers. The benefits of this study include providing evidence-based recommendations for shallot farmers in North Toraja regarding optimal fertilizer combinations, contributing to the development of sustainable agricultural practices that integrate organic and inorganic fertilizers, and adding to the scientific literature on integrated nutrient management for shallot cultivation in tropical highland ecosystems. Based on the description above, a study was conducted to evaluate the effect of A. pinnata bokashi and NPK fertilizer on the growth and production of shallot plants.

METHOD

The research was conducted in Tikala, North Toraja Regency, which is located at an altitude of about 750 m above sea level. The research took place from May to August 2022. The study used a factorial experiment which was arranged in a Randomized Block Design (RBD) with 2 treatment factors, *A. pinnata* bokashi (B) which consisted of the following three treatment levels:

B0 = Control.
B1 = 3 kg/plot, equivalent to 30 tons/ha.
B2 = 5 kg/plot, equivalent to 50 tons/ha.

The second factor is NPK fertilizer consisted of the following three treatment levels:

N0=Control
N1=250 gram/plot, equivalent to 250 kg/ha.
N2=350 gram/plot, equivalent to 350 kg/ha.

There are 9 treatments in combinations which are:

B0N0 B1N0 B2N0
B0N1 B1N1 B2N1
B0N2 B1N2 B2N2

The experiment was repeated three times, so there were 36 plants per plot with six observed plants.

The procedure for making *A. pinnata* bokashi are as follows:

Ingredients:

1. *A. pinnata* = 100 kg
2. Bran = 30 kg
3. Diluted sugar = 600 kg
4. EM4 = 600 ml
5. Water to taste

Instructions:

1) EM4 and granulated sugar were dissolved in water.
2) The dried ingredients and *A. pinnata* were mixed with the bran until the ingredients are evenly distributed on a clean and dry concrete surface.

3) The EM4 solution with granulated sugar was sprinkled slowly into the mixture until evenly distributed and the dough had 50% water content.
4) When the dough is clenched, water doesn't drip and if you release your fist, the dough won't break.
5) Mix the dough on a clean and dry concrete surface with a height of 15-20 cm.
6) The dough was then covered with banana leaves for 7-10 days.
7) The maximum dough temperature is 50°C. If the temperature is higher than that, the dough should be stirred to lowered the temperature.
8) Cover the dough again using banana leaves.
9) Temperature checks were carried out every two days.
10. After 7-10 days, the bokashi has finished fermenting and is ready to be used as organic fertilizer.

Research Procedure

1. Seed Preparation

The bulbs were sorted to obtain uniform and unblemished seeds.

2. Preparation of Land and Planting Media

The land was prepared for planting and a trial plot was made with a size of 1 m x 1 m. the land was smoothened and left exposed to the sun. Then the soil in the experimental plots was mixed with *A. pinnata* bokashi according to the treatment. the planting media was arranged according to the trial plan and the samples were labeled. The research location was given a net and fully-fenced using bamboo and for security.

3. Planting

The spacing between plants was 15 cm x 15 cm. And the number of plants per plot was 36 plants. The selected seeds were then transplanted to the planting media. Before planting, the media was watered to lock in the moist.

4. Maintenance

Watering

The watering was done according to weather conditions, especially rain.

Application of NPK fertilizer treatment

The application of NPK fertilizer was at 30 HST because at this growing stage the NPK fertilizer was needed to support the formation of tubers.

Re-planting the seedlings

Re-planting was needed to replace the previous diseased seeds or seedlings with a healthy seeds or seedlings that have the same age. The re-planting was done at 1 and 2 weeks after planting (wap). 5.Control of weeds, pests and diseases

Control of weeds, pests and diseases was done manually by removing weeds and killing pests mechanically.

6. Harvest and post-harvest

Shallots were harvested after 75% of the upper leaves have fallen or have dried up, approximately 65 days after planting (dap). Harvesting is done by removing the plants carefully so that the bulbs are not damaged. The harvested bulbs were cleaned and dried for seven days.

Observational Variables

The growth variables of the shallot plants observed were plant height, number of bulbs per plot, and dry weight of thebulbs per plot.

Data analysis

Observational data were analyzed using analysis of variance (ANOVA) and the orthogonal polynomial method to determine the response of shallot plants to the application of *A. pinnata* bokashi and NPK fertilizers.

RESULTS AND DISCUSSION

The results of the orthogonal polynomial analysis (Table 1) on plant height variable showed that the application of *A. pinnata* bokashi had a very significant effect, the interaction between NPK fertilizer and *A. pinnata* bokashi had a significant difference in plant height. The response of shallot plants to NPK application and its interaction was linear. The linear response of the control treatment, which was unfertilized with *A. pinnata* bokashi (B0), was significantly different from the linear response of samples treated with *A. pinnata* bokashi. In essence, the control treatment (unfertilized with *A. pinnata* bokashi) did not respond to NPK fertilization.

Table 1. Orthogonal polynomial plant height test, number of bulbs per plot and weight of bulbs per plot

Source of Variation	Plant height		Number of bulbs/plot		Weight of bulbs/plot	
Block	3.62	*	0.29	ns	0.19	ns
Treatment	8.97	**	5.36	**	5.91	**
Bokashi (B)	20.08	**	8.37	**	9.07	**
NPK (N)	2.60	*	8.02	**	8.78	**
N Linear	22.36	**	5.04	*	5.97	*
N Quadratic	4.00	ns	5.06	*	5.61	*
Interaction B x N	6.59	**	2.52	*	2.89	*
N linear on B	11.18	**	3.52	*	3.99	*
N Quadratic on B	2.00	ns	2.53	ns	2.80	ns

Description: ns = non-significant, * = significant at 1% level; **= significant at 1% test level

Source: Processed primary data from research (2022)

The response of shallot plants given *A. pinnata* bokashi at 30 tons/ha was better than the other treatment combinations (Figure 1). This response shows that *A. pinnata* bokashi should be applied in combination with NPK fertilizer. These results are in line with (Harumi, 2019) on lettuce; (Putra, 2013) on sweet corn; (Haryati, 2015) on tamarillo, and (Ismoyo, 2013) on peanuts.

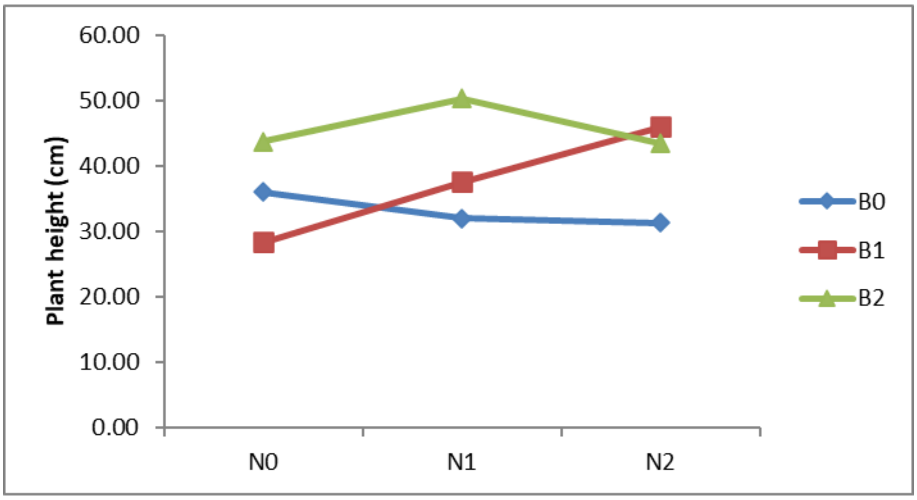

Figure 1. Graph of shallot plant height in response to NPK fertilization at each level of *A. pinnata* bokashi application.

Source: Processed primary data from research (2022)

The orthogonal polynomial analysis of the number of bulbs per plot showed that the application of *A. pinnata* bokashi and NPK fertilizer was very significant compared to the control. The interaction between *A. pinnata* bokashi and NPK fertilizer on the number of bulbs per plot was also significant compare to the control treatment. The response of shallot plants to NPK fertilizer and the interaction between NPK fertilizer and *A. pinnata* bokashi was linear. The linear response of the shallot plants without *A. pinnata* bokashi application (B0) was different significantly compared to the linear pattern of shallots applied with *A. pinnata* bokashi. The response means that the plants without *A. pinnata* bokashi application did not respond to NPK fertilization.

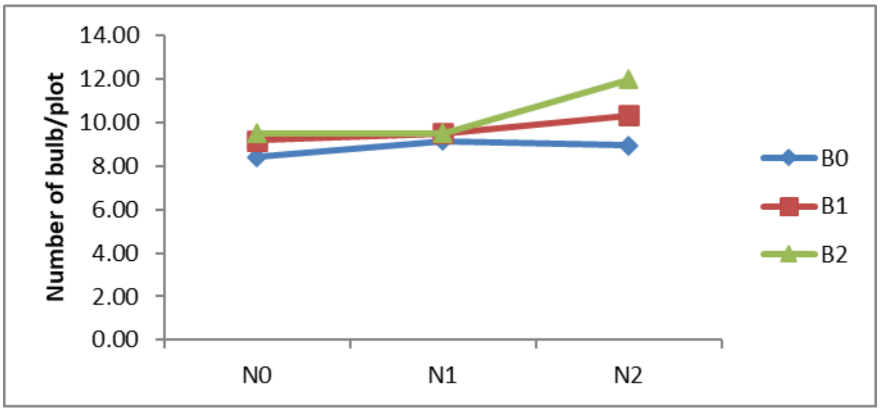

Figure 2. Number of bulbs per plot in response to NPK fertilization at each level of *A. pinnata* bokashi application

Source: Processed primary data from research (2022)

The response of the number of shallot bulbs given *A. pinnata* bokashi at 30 tons/ha was better than the other treatment combinations (Figure 2). The result shows that *A. pinnata* bokashi should be applied with NPK fertilizer. The plant growth stage is influenced by the nitrogen (N) content in *A. pinnata* bokashi, that absorbed by plants and has an impact on the formation of chlorophyll which is very useful for photosynthesis. In addition, the phosphorus

(P) content in *A. pinnata* bokashi is essential for vegetative growth and tiller formation. According to (Lestari et al., 2019), organic fertilizer application can increase nutrient reserves in the soil, improve soil structure, and increase soil organic matter content.The dose of *A. pinnata* bokashi can provide nutrients such as N, P, and K to support plant growth. According to (Rahmah et al., 2019) bokashi has good prospects for being used as organic fertilizer because of its high nutrient content.

The orthogonal polynomial analysis of the number of bulbs per plot (Table 1) showed that the application of *A. pinnata* bokashi and NPK fertilizer was highly significant compared to the control. A significant difference was also revealed in the weight of tubers per plot of *A. pinnata* bokashi and NPK fertilizer interaction. The response of shallot plants to NPK application and the interaction between *A. pinnata* bokashi and NPK fertilizer was linear. The linear response of unfertilized shallot plants (B0) displayed a significantdifference from plants treated with *A. pinnata* bokashi 30 tonnes/ha and 50 tonnes/ha (Figure 3). The plants without *A. pinnata* bokashi application responded less to NPK fertilization (Rahmawati & Widyasunu, 2013).

Table 2. **Average of the plant height, number of bulbs per plot, and weight of bulbs per plot at each level of *A. pinnata* bokashi and NPK fertilization treatments**

Treatments	Variables					
	Plant height		Number of bulb/plot		Weight of bulb/plot	
Control	36,08	ab	8,42	a	336,7	a
No bokashi-250kg/ha NPK	32,00	a	9,17	ab	366,7	ab
No bokashi-350kg/ha NPK	31,33	a	8,96	a	358,4	a
Bokashi 30 ton/ha-no NPK	28,38	a	9,17	ab	366,8	ab
Bokashi 30 ton/ha-250 kg/ha NPK	37,58	ab	9,50	ab	380,0	ab
Bokashi 30 ton/ha-350 kg/ha NPK	46,08	bc	10,33	ab	413,3	ab
Bokashi 50 ton/ha-no NPK	43,83	bc	9,50	ab	380,0	ab
Bokashi 50 ton/ha-250 kg/ha NPK	50,33	c	9,50	ab	380,0	ab
Bokashi 50 ton/ha-350 kg/ha NPK	43,54	bc	12,00	b	485,7	b

Source: Processed primary data from research (2022)

Table 2 shows that treatment 50 tons/ha of *A. pinnata* bokashi and 350 kg/ha of NPK fertilizer gave the highest plant height,number of bulbs, and weight of bulbs. The treatment was also significantly different from the other treatment combinations. The role of NPK fertilizer can improve the physical and chemical properties of the soil that supports plant growth and soil management. Fertilizer application supports the root zone in preparing an optimal environment for plant growth. The optimal root zone facilitates the formation and enlargement of bulbs to a maximum and increases the production of shallots (Mandal et al., 2020). The promising results of the *A. pinnata* bokashi and NPK fertilizer combination treatment are in line with the results of (Pramantari et al., 2022) on shallots, (Yoanma et al., 2022) on the combination of NPK fertilizer and coconut shell biochar, and (Prasetyo et al., 2020) in the combination of NPK fertilizer with coffee husk organic fertilizer.

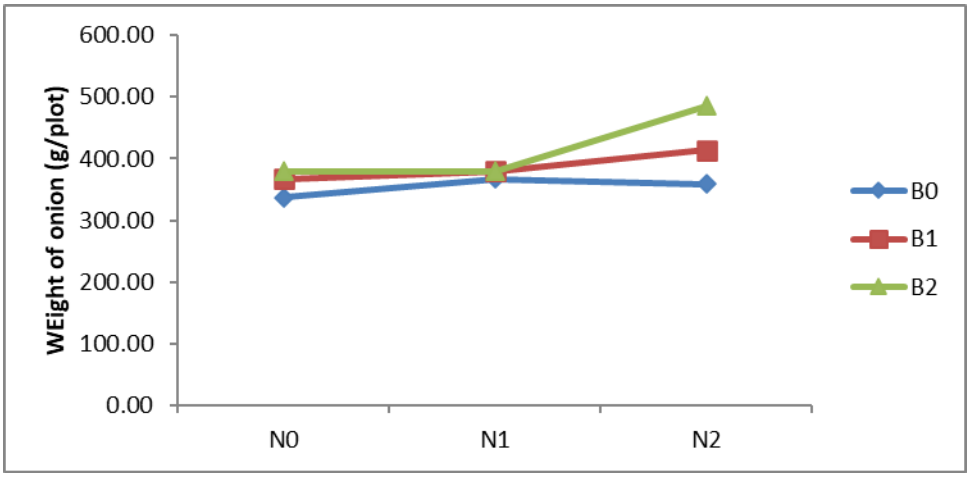

Figure 3. **Bulb weight response on NPK fertilizer application at each level of A. pinnata bokashi application.**

Source: Processed primary data from research (2022)

NPK fertilizer is a fertilizer that contains two or more nutrients (Dolla, 2020). Preparing the soil and applying the exact dose of NPK fertilizer, the increasing growth and production of shallots should be expected. The treatment combination of 50 ton/ha *A. pinnata* bokashi and 350 kg/ha NPK fertilizer gave the best effect on growth variables and plant production because *A. pinnata* bokashi and NPK fertilizer combination treatment supports the performance of the enzyme activator cells.

CONCLUSION

Based on the results, it can be concluded that: 1) *A. pinnata* bokashi affects the growth and production of shallots with a treatment of 5 kg is the best treatment, 2) the application of NPK fertilizer at 350 kg/ha is the best treatment that affects the growth and production of shallots, 3) the interaction between *A. pinnata* bokashi and NPK fertilizer had the best effect on shallot growth and production. The interaction between 50 tons/ha *A. pinnata* bokashi and 350 kg/ha NPK fertilizer was the best treatment, and 4) the response of shallot plants to the NPK fertilizer application and the *A. pinnata* bokashi and NPK fertilizer interaction was linear. Plants without *A. pinnata* bokashi had less response to the NPK fertilizer application. Further research is recommended to test the combination of *A. pinnata* bokashi and NPK fertilizer across different seasons and soil types to validate these findings. Farmers in highland areas are encouraged to apply 50 tons/ha *A. pinnata* bokashi combined with 350 kg/ha NPK fertilizer to optimize shallot production. Additionally, studies on the economic analysis of this fertilizer combination would be valuable to determine its cost-effectiveness for smallholder farmers.

REFERENCES

Achmad, F. (2015). *The Effect Of Various Dosage Of Azolla (Azolla Pinnata) And Npk Fertilizer On Growth And Yield Of Red Chili (Capsicum Annum L)*.

Agriculture, M. of. (2020). *Horticultural Innovation to Increase People's Income*. IAAD Press.

Dolla, M. (2020). *The Effect of Giving Sprouts Extract and Bokashi from Goat Livestock Waste on the Growth and Production of Shallots (Allium ascolonicum L.)*.

Fajar, A. (2016). Agricultural Extension Capacity in Efforts to Increase Agricultural Productivity in East Java. *Agrieconomics*, *5*(2), 125–136.

Fajjriyah, N. (2017). *Shallot Success Tips*. Bio Genesis.

Harumi, D. E. (2019). *Application of Bokashi Fertilizer and Azolla microphylla Liquid Organic Fertilizer on the Growth and Yield of Lettuce (Lactuca sativa L.)*.

Haryati, B. S. (2015). The Effect of Bokashi Azola Fertilizer on the Growth of Tamarillo (Cypomandra betacea Sendt) Seedlings. *Journal of Agrosaint*, *6*(2), 22–32.

Ismoyo. (2013). The Effect of Azolla Compost and Organic Potassium on the Availability of Potassium and Peanut Yields in Alfisols. *Journal of Soil Science and Agro-Climatology*.

Lestari, S. U., Mutryarny, E., & Susi, N. (2019). Chemical Composition Test of Azolla Mycrophylla Compost and Azolla Mycrophylla Liquid Organic Fertilizer (Poc). *Agricultural Scientific Journal*, *15*(2).

Mandal, J., Acharyya, J. P., Bera, R., & Mohanta, S. (2020). Response of Onion to NPK, S and Micronutrients. *International Journal of Current Microbiology and Applied Sciences*, *9*(6), 1137–1144.

Nur, A. (2018). *Utilization of Azolla Plants (Azolla Pinnata) As Liquid Organic Fertilizers and Compost for the Growth of Large Chili Plants (Capsicum Annum L.)*.

Panataria, L. R., Simanjuntak, P., & Barus, S. W. (2022). Effect of Mulch and NPK on Production of Shallots (Allium ascalonicum L.). *IOSR Journal of Agriculture and Veterinary Science*, *14*(9), 42–46.

Pramantari, A. G., Priyono, & Bahri, S. (2022). The Effect of NPK Fertilizer Dosage and Shallot Litter on the Growth and Yield of Shallots (Allium ascalonicum L.). *Journal of Agricultural Innovation*, *24*(1).

Prasetyo, Setyowati, N., Nurjanah, U., Marlina, Y., & Chozin, M. (2020). Response of Red Onion (Allium ascalonicum, L.) Growth and Yield Response on Coffee Husk Organic Fertilizer and Nitrogen at Various Dosages. *Gontor AGROTECH Science Journal*, *6*(1).

Putra. (2013). The Effect of Giving Various Forms of Azolla and N Fertilizers on the Growth and Yield of Sweet Corn (Zea Mays Var. saccaharata). *Plant Production*, *1*(4), 353–360.

Rahmah, S. Y., Imansyah, A. A., Trihaditia, R., Rizal, A. N., Taufiq, R., & Jartmika, D. (2019). Potential Bokashi Azolla Sp. With Mole Bamboo Shoots Bioactivator on the Growth of Pandanwangi Rice in the Vegetative Phase. *Agroscience*, *9*(2).

Rahmawati, & Widyasunu, P. (2013). Influence of Bokashi Azolla microphylla and Lemna polyrhiza Biomass Based on N Uptake and Yield of Pakchoy (Brassica chinensis L.), and Soil Porosity of Inceptisols. *Agrin*, *17*(2).

S, B. P. (2020). *North Toraja in Numbers*. Central Bureau of Statistics, North Toraja Regency.

Timpayung, R. (2021). *The Effect of Bokashi and NPK Fertilizer on the Growth and Production of Shallots (Allium ascalonicum)*.

Yoanma, A. D., Oktafri, Triyono, S., & Haryanto, A. (2022). Effect of Coconut Shell Biochar Application on the Effectivity of NPK Fertilizer in Red Onion (Allium ascalonicum L.) Cultivation. *Lampung Agricultural Engineering Journal*, *11*(1), 1–14.