Golden Sun-Rise
International Journal of Multidisciplinary on Science and Management
ISSN: 3048-5037/ Volume 2 Issue 3 Jul-Sep 2025/ Page No: 35-46
Paper Id: IJMSM-V2I3P105/ Doi:10.71141/30485037/V2I3P105

Research Article

Effect of Zeolite-Based N Fertilizer to the Growth and Production of Shallot and the Dynamics of Cadmium (Cd) in Inceptisol Soil

Ibnu Rizky Ramadhan[1], Kharisun[2*], Okti Herliana[3]

[1,2,3]*Faculty of Agriculture, Universitas Jenderal Soedirman, Indonesia.*

Received: 03 July 2025 Revised: 05 July 2025 Accepted: 07 July 2025 Published: 10 July 2025

Abstract - *Cadmium is one of the heavy metals that is harmful to the environment, with high mobility, carcinogenic properties, and toxicity to living organisms. Therefore, it is necessary to immobilize Cd in the inceptisol soil using Zeolite-Based N Fertilizer. Furthermore Zeolite-Based N Fertilizer will benefit to improve the growth and production of shallot. This study aims to determine the response of shallot (Allium ascalonicum L.) plant growth, shallot yield, and Cd content in the soil and plants to various applications of Zeolite-Based N fertilizer. The study was conducted in a screenhouse and the Soil Science Laboratory of the Faculty of Agriculture, Jenderal Soedirman University from December 2023 to March 2024. The treatments tested were Zeolite-Based N fertilizer doses of 0 kg/ha, 150 kg/ha, 300 kg/ha, and 450 kg/ha, and Cd concentrations of 0 ppm, 2 ppm, and 4 ppm on shallot plant growth, shallot yield, and Cd content in the soil and plants. This study used a Randomized Block Design (RBD) with 12 treatment combinations and 3 replications. Observed variables included plant height, number of leaves, number of tillers, total chlorophyll content, proline content, number of bulbs, bulb diameter, fresh bulb weight with leaves, dry bulb weight with leaves, Cd content in the soil, Cd content in the plants, and the percentage of Cd reduction. The results showed that a dose of 450 kg/ha of Zeolite-Based N fertilizer could increase plant height by 16.65% from 2 to 4 weeks after planting (WAP); the number of leaves by 48.41% from 2 to 7 WAP; and total chlorophyll content by 44.18% compared to no fertilizer. The Cd concentration of 4 ppm reduced plant height by 13.42% at 3 WAP and increased soil Cd content by 16.66% compared to 0 ppm Cd. There was an interaction between the Zeolite-Based N fertilizer and cadmium application on plant height at 6 WAP (Weeks After Planting), with the best results obtained at a fertilizer dose of 300 kg/ha and a cadmium concentration of 4 ppm. Additionally, there was an interaction on the number of leaves at 7 WAP, with the best results achieved using an Zeolite-Based N fertilizer dose of 150 kg/ha with the addition of a cadmium concentration of 2 ppm.*

Keywords - *Zeolite-Based N Fertilizer, Cadmium, Shallot, Inceptisols.*

I. INTRODUCTION

Cadmium is one of the heavy metals that is harmful to the environment, with high mobility, carcinogenic properties, and toxicity to living organisms. Plants absorb heavy metals through their roots and accumulate cadmium (Cd) in various tissues. The accumulation of Cd in plants can inhibit growth, reduce yield, and accelerate plant death (Zuma'ah et al 2022). Agricultural activities are one of the sources of heavy metal pollution due to the use of fertilizers made from natural phosphate rock. The excessive use of synthetic chemical fertilizers, such as urea and phosphate, by onion farmers often leads to soil saturation and has the potential to increase Cd and Pb content (Suwahyono, 2011).

Shallot farmers in Brebes often use synthetic fertilizers excessively (Rinardi et al., 2019). The fertilization recommendation for shallots by the Dinas Pertanian Brebes is Urea 250 kg/ha; ZA 180 kg/ha, SP-36 150 kg/ha, and KCl 150 kg/ha, while the fertilization by farmers is urea 400 kg, SP36 200 kg, ZA 200 kg, and KCl 200 kg/ha (Haryati, 2009). The high use of urea is due to its fast-release properties, volatility, and leaching, resulting in only 30-50% of it being absorbed by the plants (Rahman et al., 2019). The nitrogen nutrient uptake efficiency of urea fertilizer in vegetable crops, sugarcane, and corn is only around 30- 37% (Balasubramanian et al., 2004). The impact of excessive fertilization has the potential to increase Cd content in the soil and in the shallot plants (Handayani et al., 2018). Shallots are a leading vegetable commodity in Indonesia in terms of production, consumption, and export volume, so it is important to pay attention to their quality. Research on Cd content in shallots has been conducted by Rosnani & Rasman (2019), showing that the Cd content in wet shallot bulb samples is 0.1931 ppm and in dry samples is 0.222 ppm, which is considered not to meet the requirements of Permentan No.53 Tahun 2018, where the maximum permissible limit for cadmium contamination in shallots is 0.05 ppm. One of the solutions that can be made to address the issues of pollution and the inefficiency of fertilization in shallot cultivation is using the application of coating technology of Zeolite-Based N fertilizer. It is an innovative N fertilizer based on rice husk charcoal developed with nano-coating technology using zeolite, montmorillonite silicate minerals, and humic acid (Kharisun et al., 2017). Zeolite has a high CEC, allowing it to adsorb heavy metal cations that are free in the soil. The tridimensional network structure of zeolite plays an important role in adsorbing heavy metal residue ions such as Cd2+ (Susilo et al., 2012).

II. MATERIALS AND METHODS

The research was conducted in the screenhouse of the Faculty of Agriculture, Jenderal Soedirman University, and in the Soil Science Laboratory of the Faculty of Agriculture, Jenderal Soedirman University. The study was carried out from January 2024 to March 2024. The materials used include shallot bulbs, polybags, Inceptisol soil planting media from Ex- Farm Unsoed, Zeolite-Based N fertilizer, SP-36 fertilizer, KCl fertilizer, biopesticides, cadmium pollutant from 3(CdSO4).8H2O (Cadmium sulfate hydrate) compound, materials for plant chlorophyll testing, materials for proline testing, and materials for Cd content testing, which include soil samples, plant samples, nitric acid, perchloric acid, and deionized water. The equipment used in this research includes a thermometer, hygrometer, lux meter, ruler, pH meter, EC meter, BOECO BBL-31 analytical balance, vernier calipers, UV-Vis spectrophotometer, Hitachi Z-2000 Atomic Absorption Spectrophotometer (AAS), measuring glass, mortar, micropipette, test tubes, vortex, and oven.

This research uses a two-factor Randomized Block Design (RBD). The first factor is the dosage of Zeolite-Based N fertilizer at 0, 150, 300, and 450 kg/ha. The second factor is cadmium application at 0, 2, and 4 ppm. These two factors are combined to produce 12 treatment combinations. Each treatment is repeated 3 times, resulting in 36 experimental units. Each experimental unit contains 3 plants, so there are a total of 108 plants or 108 polybags. Observed variables included plant height, number of leaves, number of tillers, total chlorophyll content, proline content, number of bulbs, bulb diameter, fresh bulb weight with leaves, dry bulb weight with leaves, Cd content in the soil measured using Hitachi Z-2000 Atomic Absorption Spectrophotometer (AAS), Cd content in the plants measured usingHitachi Z-2000 Atomic Absorption Spectrophotometer (AAS), and the percentage of Cd reduction. The data is analyzed using analysis of variance (ANOVA) with SPSS, followed by DMRT at a 5% error rate.

III. RESULTS AND DISCUSSION

Table 1. The Results of the ANOVA Analysis on Various Observed Variables

No.	Observed Variables	Treatment		
		N	K	NxK
		(N-ZEO-SR PLUS Fertilizer)	(Cadmium)	
1	Plant height 4 MST	*	tn	tn
2	Number of leaves 7 MST	**	tn	**
3	Number of filler 7 MST	tn	tn	tn
4	Total chlorophyll content	**	tn	tn
5	Proline content	tn	tn	tn
6	Number of bulbs	tn	tn	tn
7	Bulb diameter	tn	tn	tn
8	Fresh bulb weight with leaves	tn	tn	tn
9	Dry bulb weight with leaves	tn	tn	tn
10	Cd content in the soil	tn	**	tn
11	Percentage of Cd reduction	tn	**	tn

Note: tn= not significantly different, (*) = significantly different, (**) = highly significantly different

Table 1 shows the results of the ANOVA at a 5% error rate. The N-ZEO- SR PLUS fertilizer dosage treatment had a significant effect on plant height at 4 WAP a highly significant effect on the number of leaves at 7 WAP, and a highly significant effect on total leaf chlorophyll content. The cadmium concentration treatment had a highly significant effect on cadmium content in the soil and the percentage reduction of cadmium. The interaction between the two treatments showed a highly significant interaction on the variable number of leaves at 7 WAP.

A. The Effect of Zeolite-Based N Fertilizer Application on Observed Variables

a. Plant height

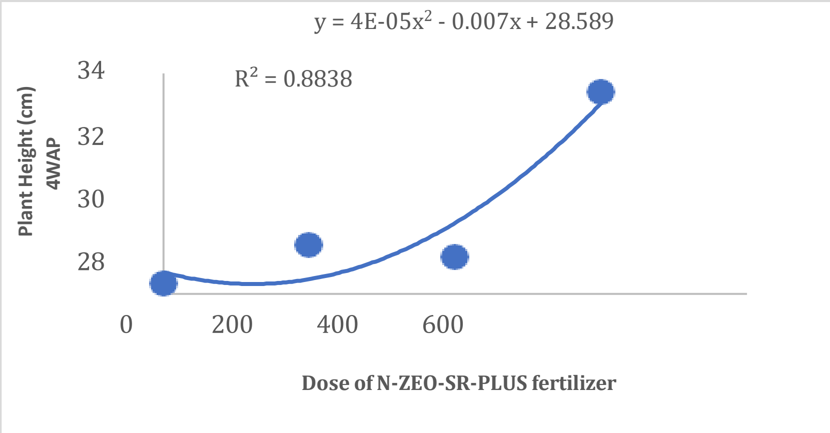

Figure 1. The Regression of Fertilizer Dosage on Plant Height at 4WAP

Dose of 450 kg/ha significantly affects the increase in plant height at 4 WAP (weeks after planting). The application of N-ZEO-SR fertilizer increases the nitrogen content in the soil. The coating technology with zeolite material allows for the gradual release of nitrogen, as demonstrated by the results from 2 WAP to 4 WAP. Nitrogen, as an essential nutrient, is crucial for plants to form new cells. The higher absorbed nitrogen content, the larger the size and volume of the cells, which impacts plant height. Plants generally absorb nitrogen in the form of nitrate ions (NO3-) or ammonium ions (NH4+). Nitrogen in plants is required for the synthesis of carbohydrates into proteins that make up protoplasm. With the formation of protoplasm, cell formation occurs, including cell division, cell elongation, and cell differentiation (Rustiana et al., 2021).

b. Number of Leaves

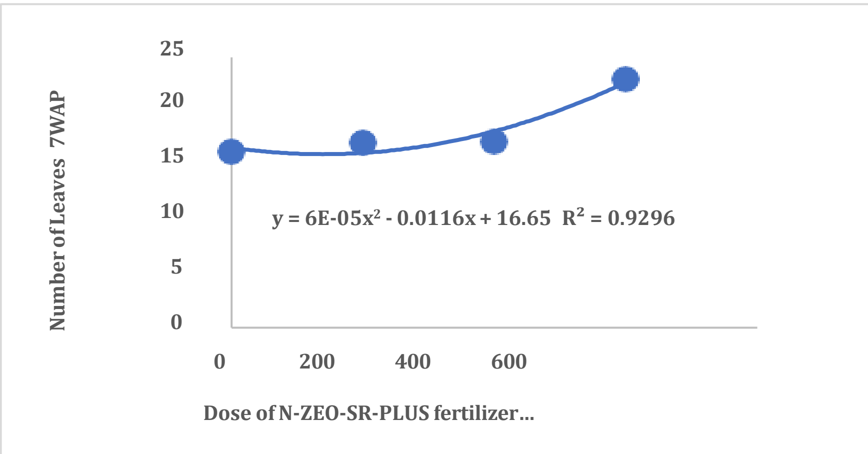

Figure 2. The Regresson of Fertilizer Dosage on Number Leaf 7WAP

The study showed that a 450 kg/ha dose resulted in the highest number of leaves, significantly different from lower doses. The optimal dose is still unknown, so testing higher doses might be useful, as higher doses could potentially increase leaf numbers. Nitrogen as a macro nutrient, is needed in large amounts during the early vegetative stage (5-300 kg N/ha) to boost protein production and cell formation in leaves. For instance, Saptorini et al. (2019) found that 400 kg/ha of Za fertilizer improved the number of red onion leaves at 2-5 WAP, and Deden (2014) noted that nitrogen doses significantly impacted leaf number at 5 WAP. Nitrogen also enhances chlorophyll production, which improves photosynthesis and increases the number of leaf blades. Zeolite-Based N contains 10-15% silica, which helps plants resist biotic and abiotic stress by strengthening cell walls and reducing transpiration. This makes plants more drought- resistant and less likely to lose leaves, as shown in Kharisun et al. (2019) with pak choi.

c. Number of Tillers

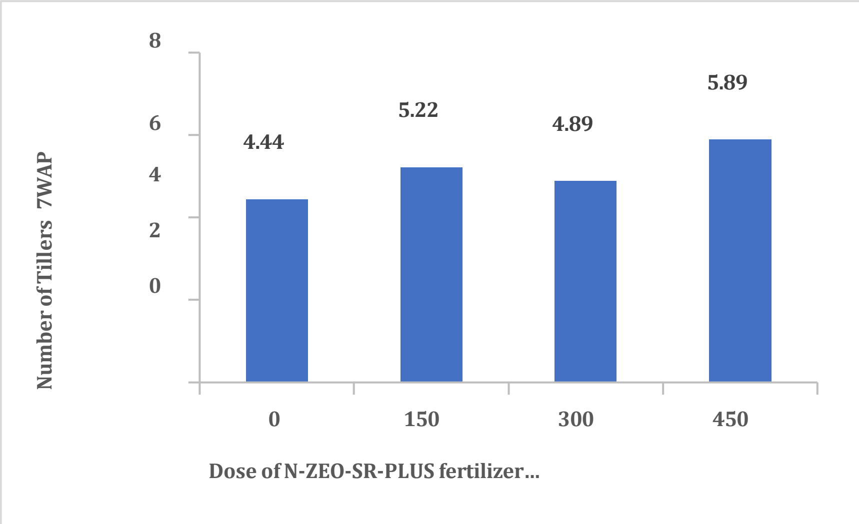

Figure 3. Average Number of Tillers in the Fertilizer Treatment

Application of Zeolite-Based N fertilizer did not significantly affect the number of red onion tillers. Although there were no significant differences, applying Zeolite-Based N at doses of 150 kg/ha, 300 kg/ha, and 450 kg/ha resulted in higher tiller numbers compared to 0 kg/ha. The 150 kg/ha dose increased tiller numbers by 14.94%, the 300 kg/ha dose by 10.13%, and the 450 kg/ha dose by 32.66%. This increase is due to the adequate nitrogen supply, which helps in cell formation and division. Nitrogen boosts photosynthesis, improves root-to- shoot ratio, and stimulates new tiller formation (Istina, 2016). However, the increase in tiller numbers was not significantly different. A similar result was observed in Napitupulu (2010), where urea at 250 kg/ha did not significantly affect tiller numbers but increased the number of tillers per clump by 16.62%.

d. Total Chlorophyll Content

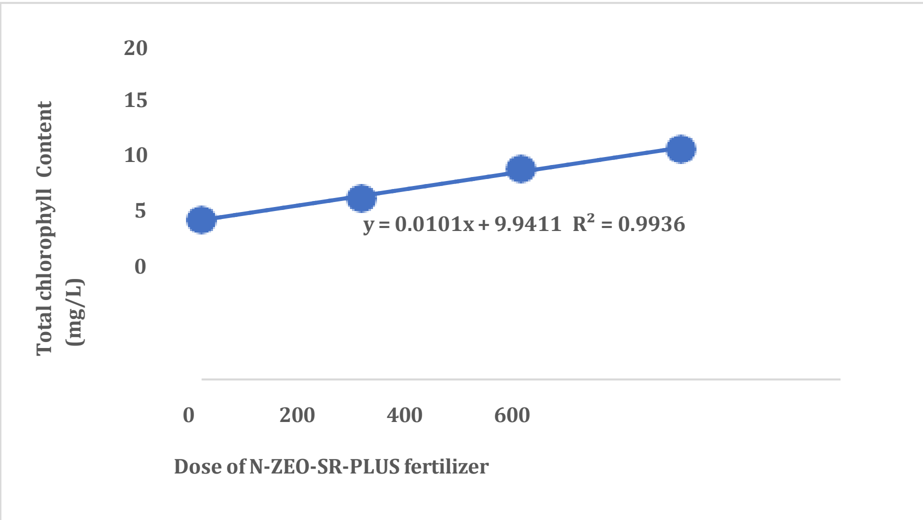

Figure 4. Regression of Fertilizer Dose on Chlorophyll

The application of Zeolite-Based N fertilizer at 450 kg/ha showed a highly significant difference from lower doses, resulting in a total chlorophyll content of 14.3854 mg/L. The increase in chlorophyll at 450 kg/ha compared to 0 kg/ha was 44.125%. Nitrogen plays a crucial role in the formation of protein molecules, purines, pyrimidines, and chlorophyll. According to Fadilah et al. (2020), 60% of the chlorophyll components are made up of nitrogen, such as in porphyrin molecules. Chlorophyll molecules in leaves are formed with magnesium as the central atom, which binds with nitrogen and hydrocarbons to create a porphyrin ring (Wirawan et al., 2016).

e. Proline Content

The application of Zeolite-Based N doses did not significantly affect proline levels. The proline content was highest with the 300 kg/ha dose (N2), followed by N1, N0, and N3. According to Sanchez et al. (2001 & 2002), increased nitrogen nutrients lead to more active ornithine pathway OAT (ornithine aminotransferase) activity, resulting in higher proline production. However, the 450 kg/ha dose had lower proline levels, possibly because less Cd (cadmium) was absorbed by the plants compared to lower doses. The zeolite content in N- Zeolite-Based N fertilizer may inhibit the exchange of Cd2+ cations at the plant roots, leading to lower stress levels in the plants and less active enzyme activity for proline production. According to Konotop et al. (2013), plants stressed by cadmium show inhibited growth but increased proline accumulation.

f. Number of Bulbs

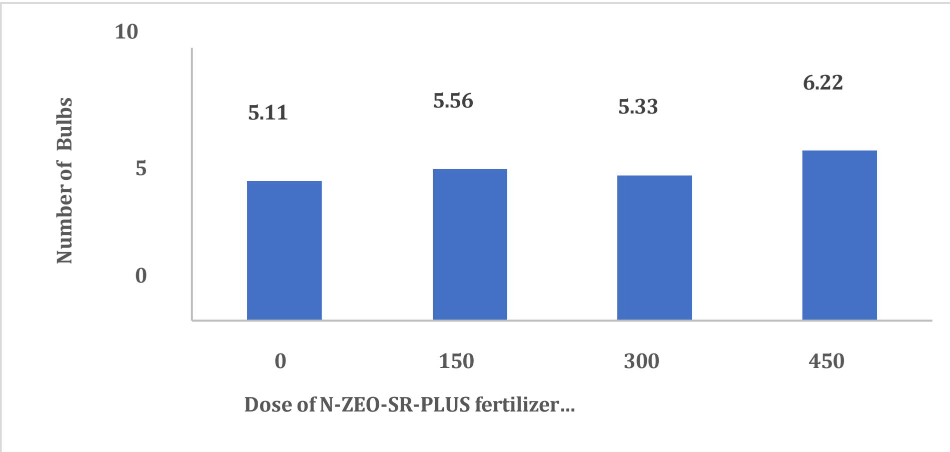

Figure 5. Average Number of Bulbs in the Fertilizer Treatment

The application of Zeolite-Based N fertilizer doses did not significantly affect the number of red onion bulbs. Similarly, Napitupulu (2010) found that while using nitrogen fertilizer at 250 kg/ha increased the number of bulbs per clump by 29%, this result was not significantly different.

g. Bulb Diameter

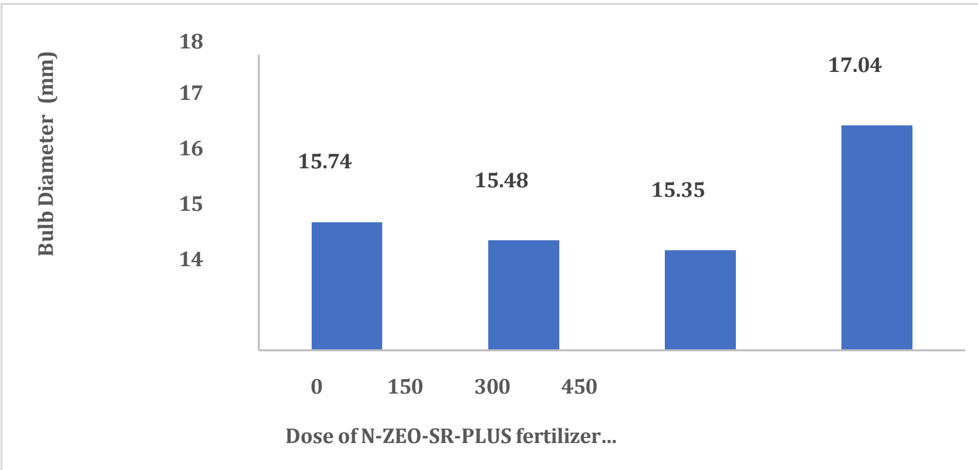

Figure 6. Average Bulb Diameter in the Fertilizer Treatment

The Zeolite-Based N fertilizer did not significantly affect the bulb diameter. Similarly, the application of N-ZEO-SR fertilizer at doses of 100 kg/ha to 300 kg/ha did not show significant differences in red onion bulb diameter, with average values ranging from 1.49 cm to 1.71 cm (Kharisun et al., 2021). According to Khan et al. (2021), garlic bulb diameter can be significantly increased with a nitrogen fertilizer dose of 180 kg N/ha, with the best average bulb diameter being 3.34 cm (Khan et al., 2021).

h. Fresh Bulb Weight with Leaves

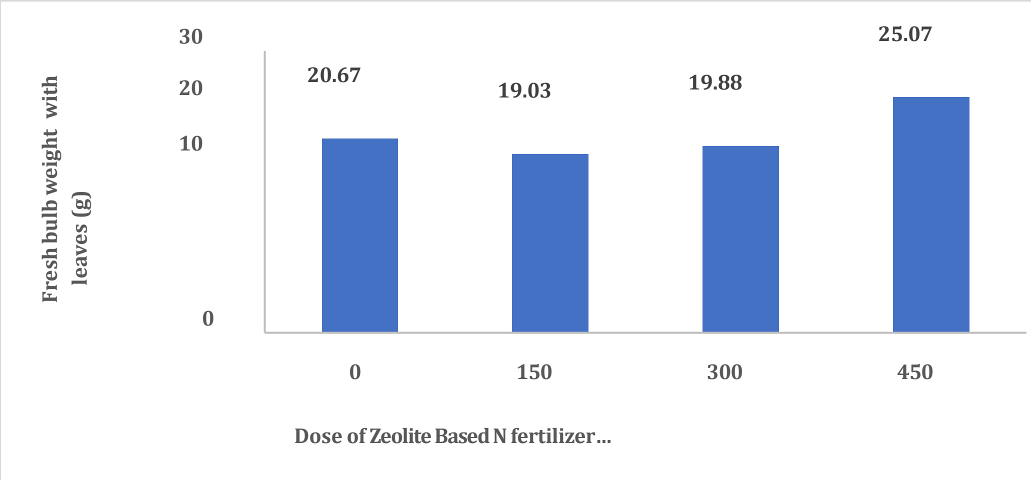

Figure 7. Average Fresh Bulb Weight with Leaves in Fertilizer Treatment

The Zeolite-Based N fertilizer dose did not significantly affect the fresh weight of bulbs with leaves. The 450 kg/ha dose was able to improve the vegetative phase of the plants, as indicated by the height and number of leaves; thus, photosynthetic production also increased. According to Syamsi et al. (2015), nitrogen nutrient absorption has a positive correlation with the fresh weight of red onion bulbs. Using higher nitrogen doses, such as 161 kg N/ha or 350 kg/ha, was necessary to achieve significant differences in this variable.

i. Average Fresh Bulb Weight with Leaves

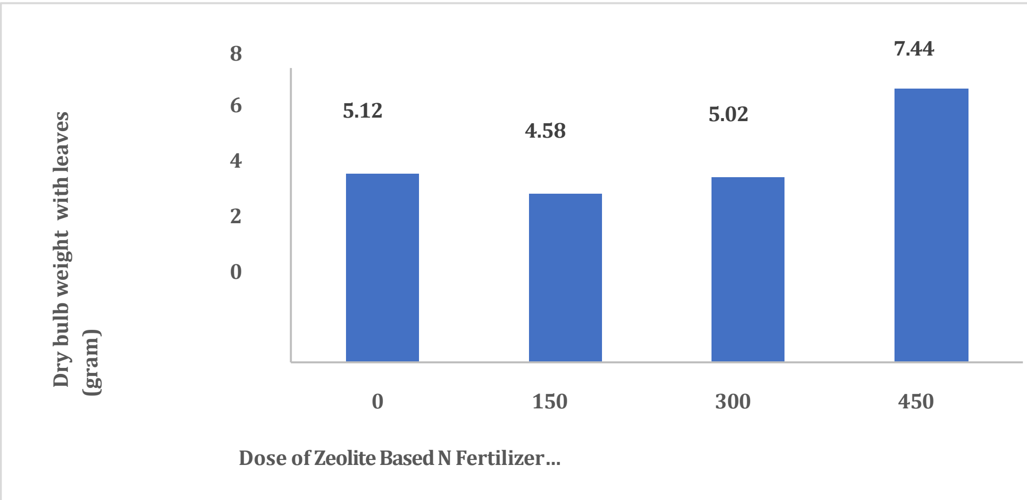

Figure 8. Average Dry Bulb Weight with Leaves in Fertilizer Treatment

The Zeolite-Based N fertilizer dose did not significantly affect the dry weight of bulbs with leaves. A similar finding was reported by Kharisun et al. (2020), where doses of N-ZEO-SR at 0 kg/ha, 100 kg/ha, 200 kg/ha, and 300 kg/ha did not show significant differences. Similarly, Hardiansyah (2020) found that dry bulb weight with urea fertilizer doses of 150 kg/ha, 200 kg/ha, 250 kg/ha, and 300 kg/ha did not show significant differences, with values of 4.71, 5.56, 5.56, and 5.81 grams, respectively.

B. The Effect of Cd Concentration on Observation Variables
a. Plant Height

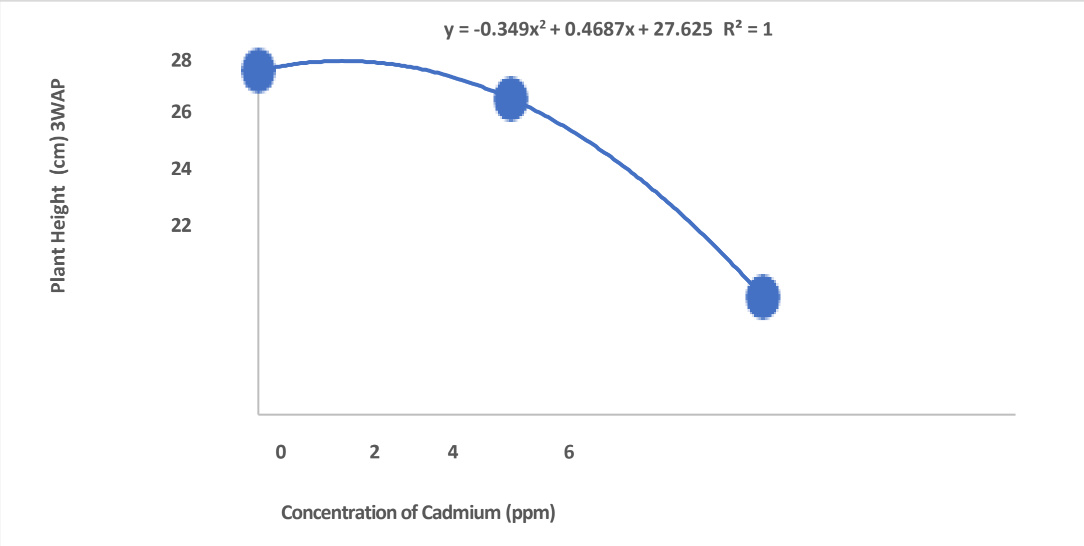

Figure 9. The Regression of Fertilizer Dosage on Plant Height at 3WAP

The concentration of Cd significantly affects the reduction in plant height at 3 WAP. The treatment with 4 ppm Cd decreased plant height by 15.51% compared to the 0 ppm treatment. It is suspected that at 3WAP, red onion plants are still vulnerable to abiotic stress. Cd enters plants in the same way as other nutrients in the form of ions, and Cd can compete with other nutrients with similar structures, such as Mg and Ca (Handayani et al., 2018). According to Jaiswal et al. (2021), Cd accumulation in the roots of red onion plants disrupts cell division, resulting in impaired root development. Furthermore, Cd contamination also has the potential to trigger the plant to produce reactive oxygen species (ROS) such as superoxide (O2-), hydroxyl (OH-), hydrogen peroxide (H2O2), and singlet oxygen, which can damage importan molecules like DNA, protein, and lipids (Farooq et al, 2016).

C. The Effect of Cd Concentration on Observation Variables
a. Cd Content in Soil with Zeolite-Based N Fertilizer Treatment

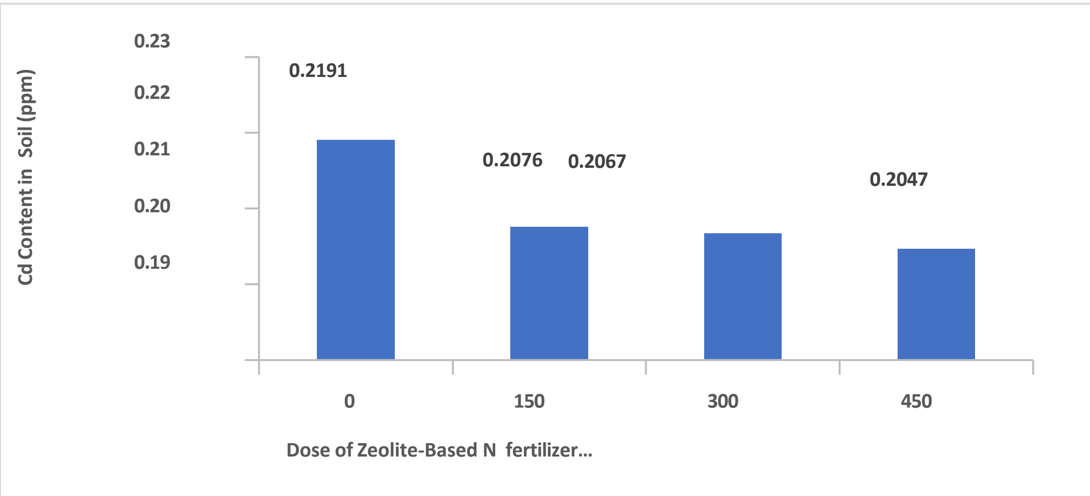

Figure 10. Average Cd Content in Fertilizer Treatment

The dose of Zeolite-Based N fertilizer does not significantly affect the Cd content in the soil. Applying Zeolite-Based N fertilizer at doses of 150 kg/ha, 300 kg/ha, and 450 kg/ha can reduce the Cd content in the soil compared to a dose of 0 kg/ha, although the differences are not statistically significant. Without the addition of adsorbent materials such as zeolite, the Cd content in the soil is higher compared to the treatments with 150 kg/ha, 300 kg/ha, and 450 kg/ha. According to Dewi et al. (2022), synthetic chemical fertilizers generally contain Cd contamination. Some commonly used fertilizers in red onion cultivation include KCL Mahkota (0.52 ppm), ZA Mahkota (0.09 ppm), NPK Mutiara (0.43 ppm), Urea (0.07 ppm), SP-36 (0.51 ppm), and Petroganik (0.32 ppm). Zeolite, as an adsorbent, has a high cation exchange capacity (CEC) and a three- dimensional network structure, which enables it to adsorb free cations in the soil (Susilo et al., 2011). According to Raziah et al. (2017), nano-zeolite added to a Cd solution has an adsorption efficiency of 81.813%. The adsorption efficiency of zeolite in planting media might not be as high as in solution conditions, which may explain why the results of the study were not significant. Additionally, the pH of the media might also affect the efficiency of Cd heavy metal adsorption by zeolite from the N- Zeolite-Based N fertilizer.

b. Cd Content in Soil at Different Cadmium Concentrations

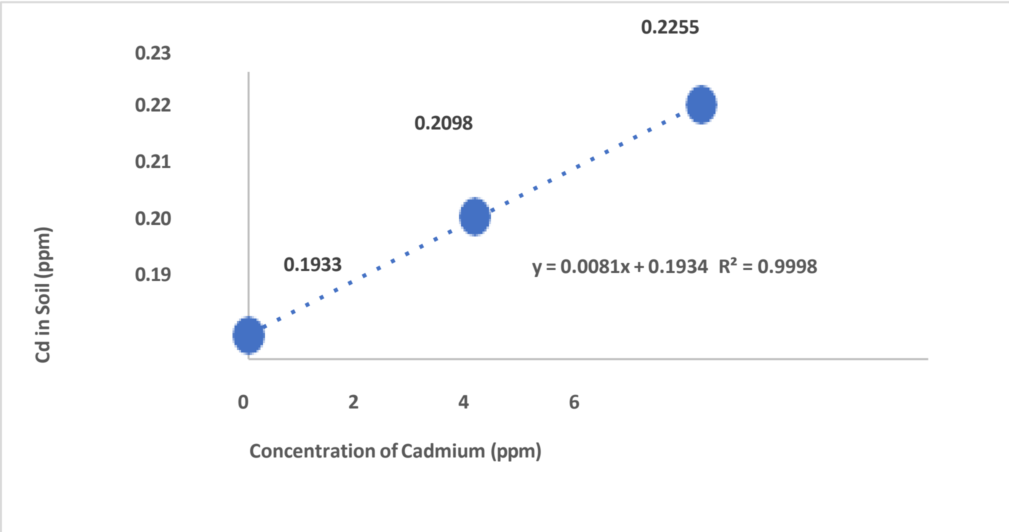

Figure 11. Regression of different Cd Concentrations against Cd Content in Soil

The concentration of Cd significantly affects the increase in Cd content in the soil after harvesting red onions. The 2 ppm cadmium treatment increased the final Cd content by 8.54%, while the 4 ppm cadmium treatment increased the final Cd content by 16.66%. As the Cd concentration added increases, the Cd content in the soil also rises. The reduction in Cd values after harvest is suspected to be due to Cd being absorbed by the plants or dissolved by water. The use of hydrated cadmium sulfate as a contaminant in plant toxicity testing is also reported in Dang et al. (1990), which was used for testing garlic plants up to a very high concentration of 400 ppm.

c. Percentage Reduction of Cd in N- Zeolite-Based N Fertilizer Treatment

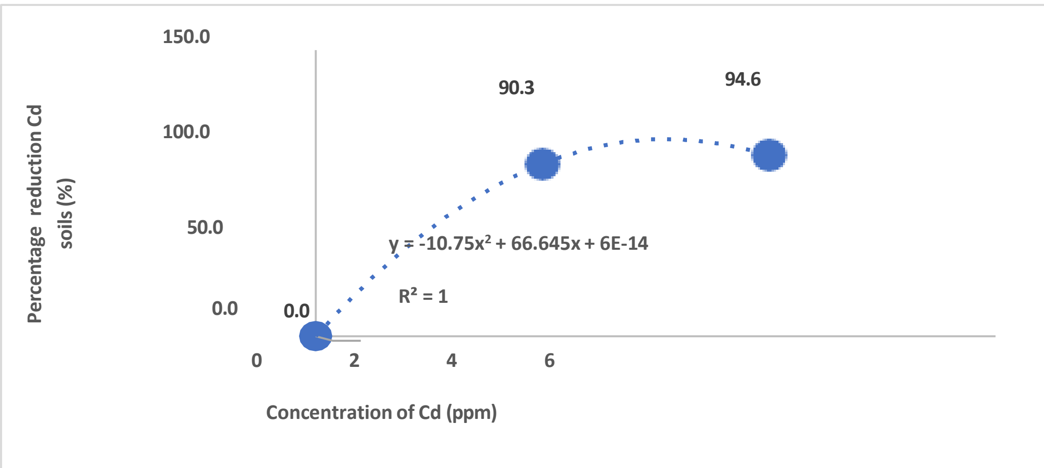

Figure 12. Average Percentage Reduction of Cd in Fertilizer Treatment

The dose of Zeolite-Based N fertilizer does not significantly affect the percentage reduction of cadmium after the study. The insignificant percentage reduction of Cd is suspected to be due to the insufficient amount of zeolite applied to the soil medium. It is suspected that the amount of zeolite was not adequate to reduce the heavy metal cadmium content in the soil in the polybags, which weigh 7.8 kg. According to Hu et al. (2018), the use of nano-zeolite at 20 grams to 60 grams per kg of growing media can reduce exchangeable (EXE) or available cadmium by 31.3%, compared to ordinary zeolite, which only reduces it by 24.5%.

d. Percentage Reduction of Cd in Cadmium Concentration Treatment

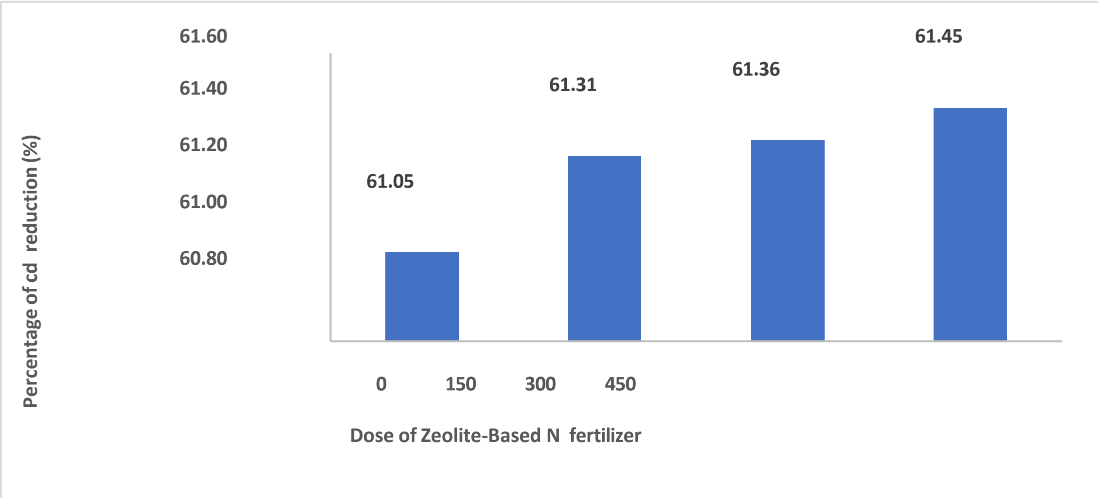

Figure 13. Regression of Cadmium Concentration against the Percentage Decrease of Cd

The highest reduction in cadmium was observed at a concentration of 4 ppm, followed by 2 ppm and 0 ppm. This result can be attributed to the high difference value. The 4 ppm treatment increases the initial soil content, calculated based on the addition of the treatment + initial Cd (4 + 0.1606) or 4.16 ppm, whereas at the end of the study, the heavy metal was 0.23 ppm.

e. Cadmium Content in Shallot Bulbs

Maximum Contamination Limit (BMC) f cadmium in red onion bulbs, according to Minister of Agriculture Republic of Indonesia Regulation No. 53 of 2018, is 0.05 ppm. The cadmium content in the bulbs can be better controlled with the addition of N-Zeolite-Based N fertilizer.

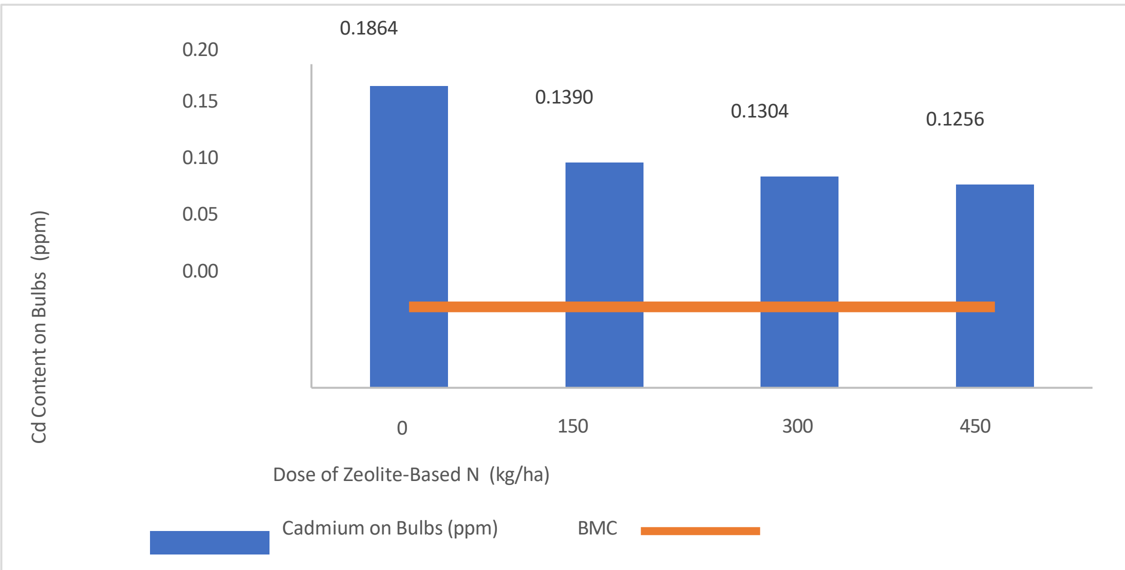

Figure 14. Cd Content on Bulb in Fertilizer Treatment

Zeolite in fertilizers is useful for reducing the availability of free heavy metals. Cd^{2+} ions will be strongly bound when they enter the zeolite cavities. This is supported by the research of Susilo et al. (2011), which found that the application of 60 mg/pot of natural zeolite was able to reduce Cd absorption in green onion plants by 19.4%

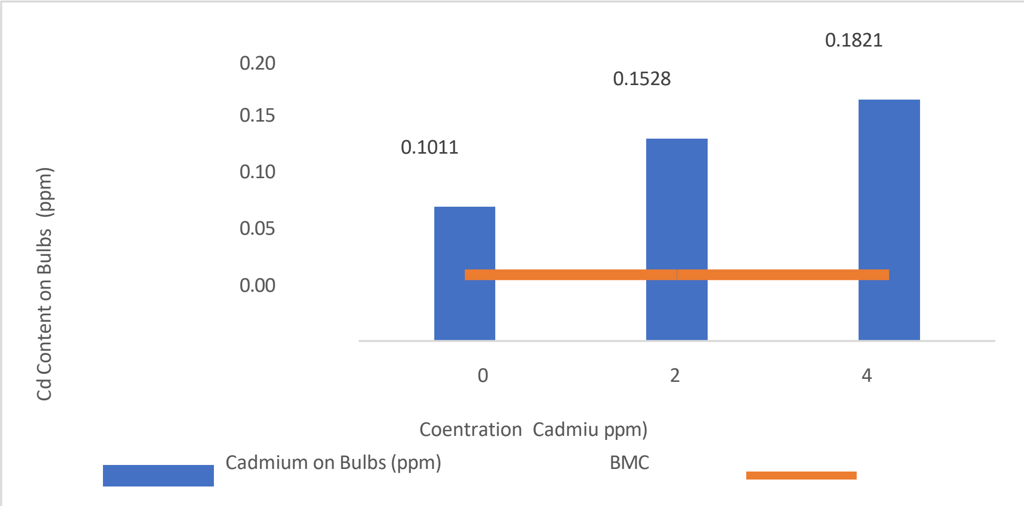

Figure 15. Cd Content on Bulb in Cd Concentration Treatment

The increase in cadmium in the bulbs for treatments K1 and K2 compared to K0, when expressed as a percentage, is 51.12% and 80.08%, respectively, or 0.51 times and 0.8 times.

D. Interaction of Treatments on Observed Variables

a. Plant Height

Table 2. Interaction of Treatments in Plant Height 6WAP

Treatments	Plant Height 6 WAP (cm)		
	K0	K1	K2
N0	36,67 abA	29,67 aAB	27,50 bB
N1	32,33 abA	33,33 aA	32,17 abA
N2	30,50 bA	37,67 aA	36,50 aA
N3	39,77 aA	31,67 aAB	34,17 abB

The 4 ppm of concentration cadmium treatment (K2) showed the highest plant height at a dose of 300 kg/ha (N2), which is 36.50. This indicates that zeolite in the N-ZEO- SR PLUS fertilizer at a high dose will increase, thus ensuring that its distribution in the planting medium effectively fills the soil cavities. Excessive Cd in the soil causes plants to struggle to absorb other nutrients, leading to bioaccumulation that disrupts plant physiology, such as impaired nitrogen absorption (Handayani et al., 2018).

b. Number of Leaves

Table 3. Interaction of Treatments in Number of Leaves 7WAP

Treatments	Number of Leaves 7 WAP		
	K0	K1	K2
N0	19.67 bA	11.67 bB	17.67 abAB
N1	13,00 bA	22.67 aB	15.67 bB
N2	18.00 bA	19.00 aA	14.67 bA
N3	27.00 aA	19.33 aAB	22.67 aB

The 2 ppm of concentration cadmium treatment showed the highest number of leaves at fertilizer doses of 300 kg/ha, 450 kg/ha, and 150 kg/ha. The 4 ppm cadmium treatment showed the highest number of leaves at a dose of 450 kg/ha, with a value of 22.67. Without the application of zeolit based N fertilizer, Cd would dominate in quantity, leading to increased accumulation. In addition to reducing the dominance of Cd^{2+} ions, the high content of nano-zeolite in Zeolite-Based N fertilizer (44-64%) can stabilize free Cd^{2+} ions in the soil (Hu et al., 2016).

IV. CONCLUSION

The application of Zeolite-Based N fertilizer at a dose of 450 kg/ha increase the height of red onion plants from 2 MST to 4 MST with an average increase of 16.65% compared to no fertilizer; the number of leaves from 2 MST to 7 MST by 48.41% compared to no fertilizer; and the total chlorophyll content in leaves by 44.18% compared to no fertilizer. The application of 4 ppm cadmium reduce the plant height at 3 MST by 13.42% compared to no cadmium treatment and increase the cadmium content in the soil by 16.66% compared to no cadmium treatment. There is an interaction between N- Zeolite-Based N fertilizer and cadmium application on plant height at 6 MST, with the best results at a fertilizer dose of 300 kg/ha with 4 ppm cadmium concentration, and on the number of leaves at 7 MST, with the best results using Zeolite-Based N fertilizer at a dose of 150 kg/ha with 2 ppm cadmium concentration

Acknowledgements

The authors would like to thank the LPDP, Ministry of Finance, Indonesia for funding of this research (Research of inovative productive/RISPRO).

V. REFERENCES

1. BPS, "Horticultural Statistics 2021," Central Statistics Bureau, 2022. Publisher Link
2. Y. P. Dang, R. Chhabra, and K. S. Verma, "Effect Of Cd, Ni, Pb And Zn On Growth And Chemical Composition Of Onion And Fenugreek," *Communications In Soil Science And Plant Analysis*, pp. 717–735, vol. 21, no. 9–10, 1990. Google Scholar | Publisher Link
3. Deden, "Effect of Nitrogen Fertilizer Dosage on Nitrogen Uptake, Growth, and Yield in Several Varieties of Shallot (Allium ascalonicum L.)," *Agrijati: Scientific Journal of Agricultural Sciences*, vol. 27, no. 1, 2016.
4. T. Dewi, E. Martono, E. Hanudin, and R. Harini, "Impact Of Agrochemicals Application On Lead And Cadmium Concentrations In Shallot Fields And Their Remediation With Biochar, Compost, And Botanical Pesticides," *IOP Conference Series: Earth And Environmental Science*, vol. 1109, no. 1, pp. –, 2022. Google Scholar | Publisher Link
5. A. N. Fadilah, S. Darmanti, and S. Haryanti, "Effect of Irrigation Using One-Day and Fifteen-Day Fermented Rice Washing Water on Photosynthetic Pigment Levels and Vegetative Growth of Green Mustard (Brassica juncea L.)," *Bioma: Scientific Periodical of Biology*, vol. 22, no. 1, pp. 76–84, 2020. Google Scholar | Publisher Link
6. M. A. Farooq et al., "Cadmium Stress In Cotton Seedlings: Physiological, Photosynthesis And Oxidative Damages Alleviated By Glycinebetaine," *South African Journal Of Botany*, vol. 104, pp. 61–68, 2016. Google Scholar | Publisher Link
7. C. O. Handayani, T. Dewi, and A. Hidayah, "Bioaccumulation and Translocation of Cadmium Heavy Metal in Shallot Plants with Ameliorant Application," *Journal of Soil and Land Resources*, vol. 5, no. 2, pp. 841–845, 2018. Google Scholar | Publisher Link
8. V V. Hardiansyah and B. Guritno, "Effect of Different Bulb Sizes and Nitrogen Fertilizer Doses on Growth and Yield of Shallot (Allium ascalonicum L.)," *Plantropica: Journal of Agricultural Science*, vol. 7, no. 1, pp. 69–80, 2022. Google Scholar | Publisher Link
9. Y. Haryati and A. Nurawan, "Potential Development of Sex Pheromones in Controlling Onion Caterpillar Pests (Spodoptera exigua) on Shallots," *Agricultural Research and Development Journal*, vol. 28, no. 2, pp. 72–77, 2009. Google Scholar | Publisher Link
10. Q. Hu et al., "Effect Of Nano Zeolit On The Transformation Of Cadmium Speciation And Its Uptake By Tobacco In Cadmium-Contaminated Soil," *Open Chemistry*, vol. 16, no. 1, pp. 667–673, 2018. Google Scholar | Publisher Link
11. I I. N. Istina, "Increasing Shallot Production Through NPK Fertilization Techniques," Agro Journal, vol. 3, no. 1, pp. 36–42, 2016. Google Scholar | Publisher Link

12. I. U. Khan et al., "Impact Of N-Fertilization On Onion Bulb Production Of Different Genotypes Through Onion-Set," *International Journal Of Emerging Technologies*, vol. 12, no. 2, pp. 161–170, 2021. Google Scholar | Publisher Link
13. Kharisun, M. Rif'an, M. N. Budiono, and R. E. K. Kurniawan, "Development And Testing Of Zeolite-Based Slow Release Fertilizer Nzeo-SR In Water And Soil Media," *Sains Tanah: Journal Of Soil Science And Agroclimatology*, vol. 14, no. 2, pp. 72–82, 2017. Google Scholar | Publisher Link
14. Kharisun, R. Noorhidayah, and M. A. Cahyani, "Effect of Silica (Si) Fertilization and Water Stress Conditions on Growth and Yield of Pakcoy (Brassica rapa L.) on Inceptisol Soil," *Proceedings of the National Seminar of LPPM Unsoed*, vol. 9, no. 1, 2019. Google Scholar | Publisher Link
15. Kharisun, M. N. Budiono, and M. Rif'an, "The Effects Of Zeolite-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.)," *Proceedings Of The 2nd And 3rd International Conference On Food Security Innovation (ICFSI 2018–2019)*, Atlantis Press, 2021. Google Scholar | Publisher Link
16. Y. Konotop et al., "Defense Responses Of Soybean Roots During Exposure To Cadmium, Excess Of Nitrogen Supply And Combinations Of These Stressors," *Molecular Biology Reports*, vol. 39, pp. 10077–10087, 2012. Google Scholar | Publisher Link
17. D. Napitupulu and L. Winarto, "Effect of N and K Fertilizer Application on Growth and Yield of Shallot," *Horticulture Journal*, vol. 20, no. 1, pp. 27–35, 2010. Google Scholar | Publisher Link
18. O. L. T. Rahman and Setyono, "Optimization of Growth and Yield of Edamame (L. merril) Through Nitrogen Fertilizer and Green Soybean Sprout Extract (Glycine max)," *Agronida Journal*, vol. 5, no. 2, 2019. Google Scholar | Publisher Link
19. H. Rinardi, N. N. Masruroh, N. N. Maulany, and Y. Rochwulaningsih, "Impact of Green Revolution and Agricultural Technology Modernization: A Case Study of Shallot Farming in Brebes Regency," *Citra Lekha Historical Journal*, vol. 4, no. 2, pp. 125–136, 2019. Google Scholar
20. Rosnaini and Rasman, "Analysis of Cadmium (Cd) Content in Shallots (Allium cepa) in Mataran Village, Anggeraja Subdistrict, Enrekang Regency," *Sulolipu Journal: Academic and Community Communication Media*, vol. 19, no. 2, 2019. Google Scholar | Publisher Link
21. R. Rustiana, Suwardji, and A. Suriadi, "Integrated Nutrient Management in Porang Cultivation," *Agrotek Ummat Journal*, vol. 8, no. 2, pp. 99–109, 2021. Google Scholar | Publisher Link
22. E. Sánchez et al., "Prolin Metabolism In Response To Nitrogen Deficiency In French Bean Plants (Phaseolus Vulgaris L. Cv Strike)," *Plant Growth Regulation*, vol. 36, pp. 261–265, 2002. Google Scholar | Publisher Link
23. S. Saptorini and Taufik, "Testing ZA Fertilizer Application on Growth and Yield of Shallot Plant Bauji Variety," *Agrinika Journal: Journal of Agrotechnology and Agribusiness*, vol. 3, no. 2, pp. 134–148, 2019. Google Scholar | Publisher Link
24. B. S. Susilo, Kharisun, and M. Rif'an, "Study of Natural Zeolite Application to Reduce Availability and Uptake of Heavy Metals in Leek Cultivation on Pesticide-Contaminated Andisol Soil," *Agronomika Journal*, vol. 11, no. 1, 2011. Google Scholar | Publisher Link
25. U. Suwahyono, "Prospects of Critical Land Remediation Technology with Humic Acid," *Environmental Technology Journal*, vol. 12, no. 1, pp. 55–65, 2011. Google Scholar | Publisher Link
26. A. Syamsi and F. Puspita, "Response of Shallot (Allium ascalonicum L.) to Formulated TKKS Trichocompost and Nitrogen Fertilizer on Peat Soil," *Photon: Journal of Science and Health*, vol. 6, no. 1, pp. 5–13, 2015. Google Scholar | Publisher Link
27. B. D. S. Wirawan, E. T. S. Putra, and P. Yudono, "Effect of Magnesium, Boron, and Silicon Application on Physiological Activity, Structural Strength of Fruit Tissue, and Yield of Banana (Musa acuminata) 'Raja Bulu'," *Vegetalika*, vol. 5, no. 4, pp. 1–14, 2016. Google Scholar | Publisher Link
28. H. Zu'amah, C. O. Handayani, and T. Dewi, "Cadmium (Cd) Heavy Metal Content In Central Java Shallot Production Center," *IOP Conference Series: Earth And Environmental Science*, vol. 1099, no. 1, 2022. Google Scholar | Publisher Link