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Original article

Effect of Gibberellic Acid (GA3) and Humic Acid in Biofast Fertilizer on Growth and Yield of Tajuk Shallot (*Allium ascalonicum* L.) in Pasuruan Regency

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Abstract

National shallot production experienced a significant decline due to suboptimal cultivation and fertilization practices. The Tajuk variety had high yield potential but was prone to premature flowering, which can inhibit bulb development. GA_3 and humic acid played a role in enhancing growth and productivity. This study aimed to evaluate the effect of GA_3, humic acid, and their combination on shallot growth and yield to determine the optimal concentration. The study was conducted from May to August 2025 in Jeruk Purut Village, Pasuruan (±350 m above sea level). The split-plot design consisted of 16 treatment combinations and three replicates. The treatments consisted of GA_3 (0, 200, 300, and 400 ppm) and humic acid (0, 200, 300, and 400 ml/L). Growth and yield parameters were analyzed using ANOVA and the 5% HSD test when significant effect was observed. The combination of 300 ppm GA_3 + 300 ml/L humic acid provided the best growth and yield. Individually, 300 ppm GA_3 and 300 ml/L humic acid were the most effective in increasing plant height, tuber weight, and biomass. Regression analysis showed a weak relationship, with GA_3 being negatively correlated and humic acid being positively correlated with fresh tuber weight.

Keywords: Ameliorants; Biomass; Bulb; Plant Growth Regulators; Productivity

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Introduction

National shallot production experienced a significant decline. Data from the Badan Pusat Statistik (2023) showed that garlic production decreased to 1,982,360 tons in 2022 from 2,004,590 tons in 2021. The causes of the decline in shallot productivity in terms of quantity and quality, was attributed to the lack of intensification of cultivation technology and suboptimal fertilization. The use of superior varieties was considered a solution to increase shallot productivity, one of which was the Tajuk variety. This variety had several advantages such as good adaptability, high yield potential, uniform bulb shape, strong flavor, and relative resistance to several strains of soil-borne plant pathogens. The Tajuk variety had a relatively short planting period until harvest, approximately 60 to 65 days after planting, making it suitable for the intensification of shallot cultivation. However, this variety also had several disadvantages, including relatively rapid flowering and suboptimal bulb formation due to environmental conditions that did not meet its growth requirements.

Plant growth regulators (PGRs) were defined as compounds that could affect plant metabolic processes that impact plant growth and development (Saptorini et al., 2020). The role of PGRs in plants was very diverse, including decreasing plant length, increasing photosynthetic carboxylase activity, increasing chlorophyll content, and enhacing lodging resistance (Sun et al., 2022). Gibberellic acid (GA_3) was a growth hormone that played a role in inducing cell elongation, germination, and flowering. Fikriyah (2018) showed that at certain concentrations, GA_3 could act as a plant growth accelerator. The application of GA_3 was useful for stimulating vegetative growth, increasing the number of tubers, increasing tuber weight, and inhibiting premature flowering. The application of GA_3 was useful for focusing the plant's energy on bulb formation by preventing unwanted early flowering, which can interfere with the initiation and enlargement of shallot bulbs. Although the application of GA_3 at the appropriate concentration could stimulate positive growth, at the improper concentrationit has the potential to disrupt the growth balance. GA_3 application had a positive effect on shallot productivity, particularly the number of bulbs per clump (Ramadhanti et al., 2023).

Humic acid was a macromolecular organic compound produced through the decomposition of organic material. Humic acid had a hormonal effect on plants, similar to auxin, which induces cell division and enlargement, thereby increasing tuber weight and size. Humic acid could act as a biostimulant that stimulated root growth and branching, and increased resistance to environmental stress. Humic acid was useful as an ameliorant that could improved soil conditions and increased the availability of nutrients for plants. According to Wahyuningsih et al. (2017), humic acid had functional groups that capable binding with metal ions. The application of humic acid could increased the growth and productivity of shallots, particularly the number of tubers, root length, and number of leaves. The application of humic acid at a certain concentration could increased the number of bulbs and root length of of shallot plants (Hasra et al., 2021).

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GA_3 and humic acid could be alternative solutions to overcome shallot cultivation constraints because they provided multiple improvements in both vegetative and generative phases. Research by Wulandari et al (2014) on cucumber plants showed that the application of GA_3 and humic acid increased plant biomass and resulted in optimal germination and stem diameter growth. Humic acid ensured nutrient availability and a healthy root ecosystem, enabling plants to respond optimally to GA_3 stimulation. However, the effects of applying both simultaneously have rarely been studied in shallot plants. This study aimed to determine the effect of GA_3, humic acid, and their combination on the growth and development of shallots. This study could provided specific information to determine the concentration of PGRs and humic acid that resulted in the best growth and development of shallot plants.

Methods

Time and Place of Research

The research was conducted from May to August 2025 on field located in Jeruk Purut Village, Gempol District, Pasuruan Regency, East Java, at an altitude of approximately 350 meters above sea level, with an average air temperature of 23-29 °C and humidity ranging from 71-98%, as well as rainfall of around 131.6 mm/year.

Tools and Materials

The tools used included a hand tractor, hand sprayer, hoe, shovel, measuring tape, measuring cup, analytical scales, and labels. The planting materials consisted of Tajuk variety shallot bulbs, 20% gibberellin (GA_3) Agrogibb 40 SL, Biofast organic liquid fertilizer, dolomite, SP 36, KCl, ZA, adhesive, and distilled water.

Experimental Design

A split-plot design was used with GA_3 concentration assigned to the main plots and humic acid concentration assigned to the subplots. Each treatment consisted of four levels, resulting in 16 treatment combinations with three replicates, producing 48 experimental units. Each experimental unit consisted of three sample plants, resulting in a total of 144 plants. The GA_3 concentrations tested were 0 ppm, 200 ppm, 300 ppm, and 400 ppm, while the humic acid concentrations tested were 0 ml/L, 200 ml/L, 300 ml/L, and 400 ml/L (Figure 1).

Research Implementation

GA_3 application was carried out by spraying the crown evenly. The application was scheduled in the morning when the plants were 25, 35, and 45 days after planting (DAP). Humic acid application was carried out by pouring 350 ml per plant onto the roots. The humic acid application was scheduled at the same time as the giberelin application. Harvesting began when the plants were 60 days old, with the harvest criterion being that 80-85% of the plant crowns had fallen over. Post-harvesting was carried out by sun-drying the bulb under shade cloth for 7-10 days, or until the outer skin of the tubers had peeled off.

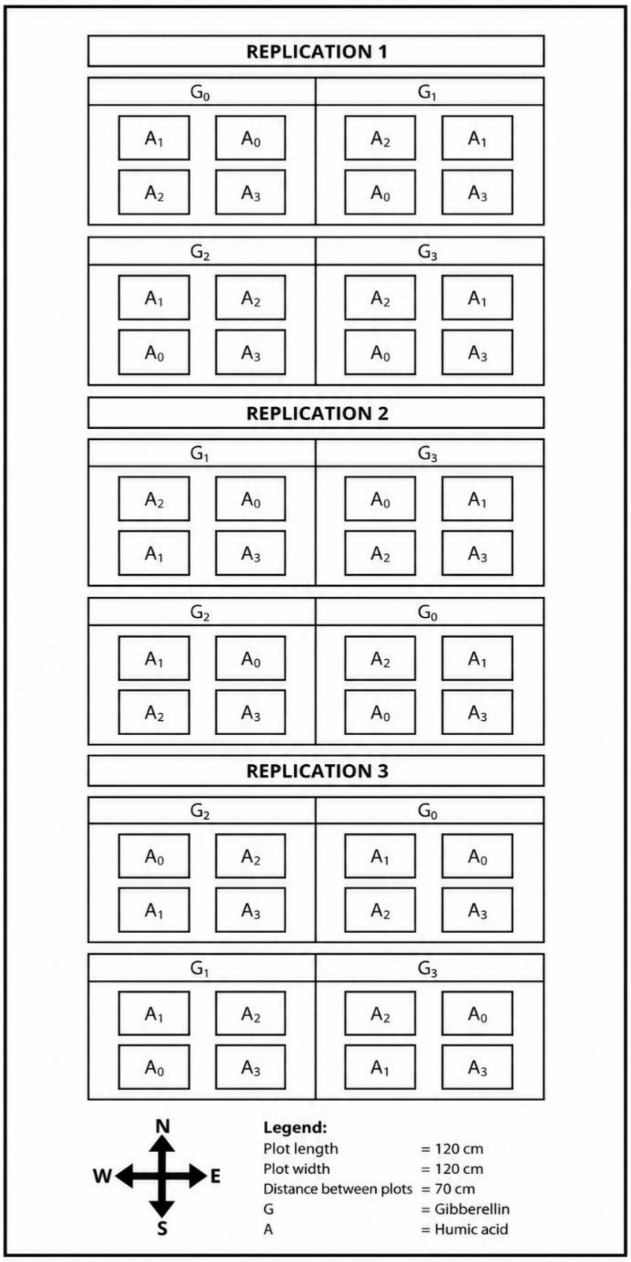

Fig. 1. Experimental plot plan

Plant Length and Bulb Diameter Measurement

Plant length was measured using a measuring tape from the base of the plant to the longest part of the plant. The observation began at 28 DAP, with intervals of 7 days. The diameter of the bulbs per clump was measured by measuring fresh shallots using calipers. The fresh weight of the bulbs per clump was measured by weighing the bulbs that had been cleaned of soil using an analytical scale.

Biomass and Bulb Weight Measurement

The fresh weight of the biomass was measured by weighing all parts of the plant that had been cleaned of soil immediately after harvest using an analytical scale. The dry weight per clump was measured by weighing the bulbs using an analytical scale.

Statistical Analysis

The data obtained was then analyzed using analysis of variance. If the analysis of variance showed a significant effect, it was followed by a 5% level Honest Significant Difference (HSD) test.

Results

Plant Length

The results of the analysis of variance showed that the combination of GA_3 and humic acid concentrations had a significant effect on the lenght of shallot plants at 28 and 35 DAP. The treatment combination of 300 ppm GA_3 and 300 ml/L humic acid produced the highest average plant lenght at the observation times listed in Table 1, with plants at 35 DAP having an average lenght of 41.19 cm. The treatment combination with the lowest average value was found in combination of 300 ppm GA_3 and 0 ml/L humic acid at 35 DAP, which measured 31.95 cm.

Table 1. Average Length of Shallot Plants Due to GA_3 and Humic Acid Concentration Treatment at 28 and 35 DAP

Plant Ages	GA_3 Concentration (ppm)	Plant Length (cm)			
		Humic Acid Concentration (ml/L)			
		Control	200	300	400
28 DAP	Control	25.84			
	200	30.50c	27.50a	30.78c	29.72b
	300	25.83a	32.73c	34.53d	30.33c
	400	28.50ab	29.50b	27.78a	27.72a
	HSD 5%	2,05			
35 DAP	Control	31.05			
	200	36.22b	32.11a	35.56b	34.83a
	300	31.95a	39.44c	41.19d	38.00c
	400	32.33a	34.78ab	35.50b	32.61a
	HSD 5%	3,63			
42 DAP	Control	38.05			
	200	39.05	37.00	39.89	37.72
	300	37.78	42.61	45.00	37.66
	400	36.17	37.05	38.78	36.94
	HSD 5%	ns			
49 DAP	Control	42.11			
	200	44.44	42.89	45.67	43.61
	300	44.17	46.11	47.86	45.25
	400	42.11	43.28	43.95	45.05
	HSD 5%	ns			
56 DAP	Control	42.78			
	200	46.44	45.06	47.33	45.28
	300	45.83	47.42	50.12	47.40
	400	45.56	45.89	47.11	48.78
	HSD 5%	ns			

Table 2 shows that the single GA_3 concentration treatment had a significant effect on plant length at 14 DAP and a very significant effect at 35 DAP. The 300 ppm GA_3 concentration treatment produced the longest shallot plant length at 35 DAP, namely 37.64 cm, and the 400 ppm GA_3 concentration treatment produced the shortest shallot plant length at 35 DAP, measuring 33.80 cm. The single humic acid concentration treatment had a significant effect on shallot plant length at 35, 42, and 56 DAP. The treatment with a humic acid concentration of 300 ml/L produced the highest shallot plant length at 56 DAP, namely 47.57 cm, and the lowest shallot plant length at 56 DAP was 46.00 cm.

Table 2. Average Length of Shallot Plants Due to Single Treatment of GA_3 and Humic Acid Concentration at 35-56 DAP

Treatments	Plant Length (cm)		
	35 DAP	42 DAP	56 DAP
Control	32,86	38,51	45.01
GA_3 Concentration (ppm)			
200	34,68 a	38,41	46.02
300	37,64 b	40,76	47.69
400	33,80 a	37,23	46.83
HSD 5%	2,62	ns	ns
Humic Acid Concentration (ml/L)			
Control	32,88 a	37,76 a	45.15 a
200	34,99 ab	39,08 ab	46.00 ab
300	36,40 b	40,50 b	47.57 b
400	34,69 ab	37,58 a	46.83 ab
HSD 5%	1,89	1,84	1,62

Bulb Diameter

The results of the analysis of variance showed that the combination treatment of GA_3 and humic acid concentrations did not have a significant effect on the bulb diameter per clump of shallots (*Allium ascalonicum* L.). Conversely, the single factors of GA_3 and humic acid concentrations had a significant effect on the bulb diameter per clump of shallots. The table shows that the 300 ppm GA_3 concentration treatment produced the largest bulb diameter per clump, 31.89 mm, and the 200 ppm GA_3 concentration treatment produced the smallest bulb diameter per clump, 29.03 mm. For humic acid, the 400 ml/L humic acid concentration treatment produced the largest average bulb diameter per clump, 31.70 mm, whereas the 200 ml/L humic acid concentration produced the smallest average bulb diameter per clump at 29.28 mm.

Table 3. Average Bulb Diameter per Clump of Shallot Plants Due to GA_3 and Humic Acid Concentration Treatment.

Treatments	Bulb Diameter per Clump (mm)
Control	30,91 b
GA_3 Concentration (ppm)	
200	29,03 a
300	31,89 b
400	31,75 b
HSD 5%	0,48
Humic Acid Concentration (ml/L)	
Control	31,08 b
200	29,28 a
300	31,51 b
400	31,70 b
HSD 5%	2,62

Fresh Weight of Bulb per Clump

Table 4 shows that the treatment of 300 ppm GA_3 + 300 ml/L humic acid produced the highest fresh weight of bulbs per clump, amounting to 78.66 g, while the treatment with a concentration of 200 ppm GA_3 + 400 ml/L humic acid produced the lowest fresh weight of bulb per clump at 63.10 g.

Table 4. Average Fresh Weight of Bulb per Clump Due to the Combi nation of GA_3 and Humic Acid Concentrations.

GA_3 Concentration (ppm)	**Fresh Weight of Bulb per Clump (g)**			
	Humic Acid Concentration (ml/L)			
	Control	200	300	400
Control	64,33			
200	63,88a	74,00c	78,07d	63,10a
300	72,32c	75,75c	78,66d	68,22b
400	66,43b	76,00c	68,00b	69,10b
HSD 5%	0,66			

Fresh Biomass Weight per Clump

Table 5 showed that the treatment of 300 ppm GA_3 + 0 ml/L humic acid produced the highest average fresh biomass weight per clump, which was 124.55 g. The lowest average fresh biomass weight per clump was obtained in the treatment with a concentration of 400 ppm GA_3 + 300 ml/L humic acid, which was 83.11 g.

Table 5. Average Fresh Biomass Weight per Clump for the Combined Treatment of GA_3 and Humic Acid Concentrations

GA_3 Concentration (ppm)	**Fresh Biomass Weight per Clump (g)**			
	Humic Acid Concentration (ml/L)			
	Control	200	300	400
Control	71,00			
200	90,66b	90,88b	84,77a	86,10a
300	124,55d	114,22c	120,77cd	97,77b
400	110,88c	89,10a	83,11a	85,88a
HSD 5%	1,39			

Dry Weight of Bulb per Clump

Table 6 showed that the treatment of 300 ppm GA_3 + 0 ml/L humic acid produced the highest average dry weight of bulb per clump, that is 59.77 g. The lowest average dry weight of bulb per clump was obtained in the treatment with a concentration of 300 ppm GA_3 + 400 ml/L humic acid, which was 44.55 g.

Table 6. Average Dry Weight of Bulb per Clump Due to Treatment with GA_3 and Humic Acid Concentrations

GA_3 Concentration (ppm)	**Bulb Dry Weight per Clump (g)**			
	Humic Acid Concentration (ml/L)			
	Control	200	300	400
Control	48,99			
200	51,88b	54,66c	58,55c	56,44c
300	59,77d	49,55b	58,99c	44,55a
400	55,33c	50,77b	54,55b	48,44a
HSD 5%	1,42			

Regression of Fresh Bulb Weight on GA_3

The regression analysis results in Figure 2 showed the equation y = -0.0246x + 79.07, indicating a negative correlation between GA_3 concentration and the fresh weight of bulbs per clump. This equation showed that an increase in GA_3 concentration was associated with a decrease in fresh bulb weight per clump. Specifically, an increase of 1 ppm GA_3 could reduce the fresh bulb weight by approximately 0.0246 grams, starting when the bulb has a wet weight of 79.07 grams. However, the R^2 value of 0.1532 indicated that the relationship between the two factors is only about 15.32%, which is relatively weak, while 84.68% of the variation in fresh bulb weight per clump was influenced by factors not included in this studied.

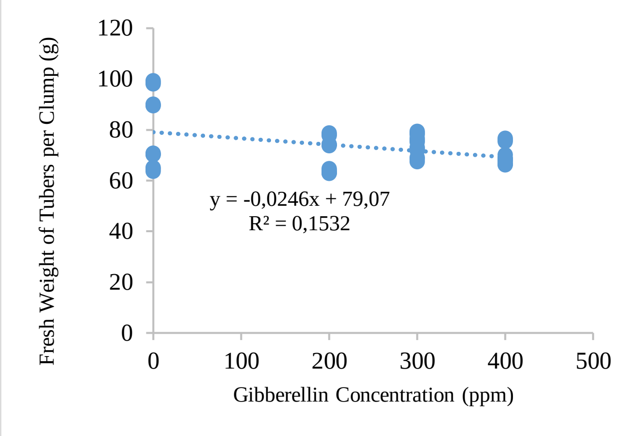

Fig. 2. Regression curve of fresh weight of bulb per clump with GA_3 concentration

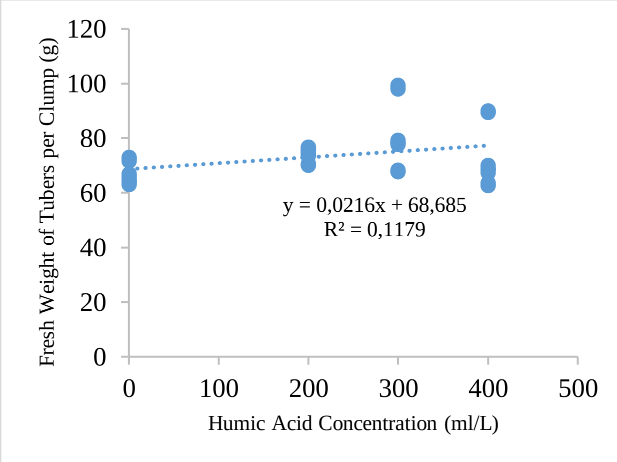

Fig. 3. Regression curve of fresh weight of bulb per clump with humic acid concentration

Regression of Fresh Bulb Weight on Humic Acid Concentration

The regression analysis results in Figure 3 showed the equation y = 0.0216x + 68.685, indicating positive correlation between humic acid concentration and fresh weight of bulb per clump. This equation demonstrated that an increase in humic acid concentration was associated with an increase in fresh weight of bulb per clump. The addition of 1 ml/L of humic acid could increase the fresh weight of bulb by approximately 0.0216 grams, starting from an initial fresh bulb weight of 68.685 grams. However, the R^2 value of 0.1179 indicated that the correlation between the two factors explained only about 11.79% of the variation, which is relatively weak, while 88.21% of the variation in fresh weight of bulb per clump is influenced by factors not included in this studied.

Discussion

The combination of GA_3 and humic acid treatments had a significant effect with noticeable differences in each treatment on the growth and productivity parameters of shallots, including plant length at 28 DAP, plant length at 35 DAP, fresh weight of bulbs per clump, fresh weight of biomass per clump, dry weight of bulbs per clump, and bulb diameter per clump.

Interaction between GA_3 and humic acid concentrations revealed a complementary mechanism during the vegetative phase of shallot plants, especially regarding plant length. GA_3, as substances that stimulate cell division and elongation, worked more effectively when applied in conjuction with humic acid. That effect occurred because humic acid played an important role in optimizing GA_3 uptake by improving soil properties and increasing the availibility of nutrients for plants. This finding is relevant with the finding of Wang et al. (2020), which shows that adequate nutrient availability in the soil increases the effectiveness of gibberellin-mediated growth responses.

The interaction between GA_3 and humic acid indicates that improved vegetative performance can enhance assimilate production and subsequently support generative phase through a source-sink corelation. Adequate growth during the vegetative phase will ultimately lead to increased growth potential during the generative phase, such as bulb initiation and bulb enlargement. GA_3 stimulates vegetative growth in plants, while humic acid supports plant physiological processes. The combination of the two enhances photosynthetic efficiency and the translocation of photosynthates to the bulb, resulting in more optimal bulb enlargement as sink organs and increased yields. According to Krishnamorthy et al. (2025), vegetative growth can be a phenotypic indication of plant productivity.

At certain concentration, the combination of GA_3 and humic acid can increase bulb productivity, as evidenced by higher fresh and dry bulb weight per clump compaed to treatment combination with lower yield and untreated plants. The consistent increase observed in fresh and dry tuber weight also indictes that the treatment not only increased water content and tuber size but also promoted greater dry matter accumulation in the bulbs. A similar statement was made by Ibrahim et al (2025), who proved that the application of GA_3 and humic acid can increase onion bulb weight. The combination of these two treatments works by increasing photosynthetic efficiency and photosynthate translocation to the bulbs.

The fresh weight parameters of biomass per clump showed different results, with the combination treatment of 300 ppm GA_3 and 0 ml/L humic acid showing the best results compared to other treatments and the control. The concentration of GA_3 without the addition of humic acid proved to be effective in inducing elongation and division of vegetative cells, resulting in more optimal biomass accumulation in the canopy. This is in line with the findings reported by Hendarsyah et al (2023), which show that the application of GA_3 has an effect on increasing plant size. In addition, at higher concentrations of humic acid, plants tend to shift photosynthesis to storage organs such as bulb rather than the plant canopy (Miceli et al., 2019). These findings are reinforced by research from Arianti et al. (2022), which states that GA_3 application plays a role in stimulating the dry weight of plants and shallot bulbs through the stimulation of cell division and elongation.

The physiological role of GA_3 in vegetative and generative growth through hormonal regulation affects plant organ metabolism and development (Fadillah et al., 2022). GA_3 stimulates stem elongation and increases leaf area through cell expansion and cell division. It can also eliminate the influence of DELLA proteins on plant growth and development. GA_3 stimulates the expression of enzymes involved in cell wall loosening and genes that regulate cell division and microtubule rearrangement (Hauvermale, *et al*., 2012).The application of GA_3 itself has a significant effect on various growth parameters and shallot yields. A concentration of 300 ppm provides the best plant response compared to other concentration parameters, as seen from the consistent increase in vegetative and generative parameters. This shows that at this concentration, GA_3 was able to work effectively in regulating plant physiological processes, especially those related to crown growth and bulb formation. This finding reinforces the statement by Hantari et al. (2025) that GA_3 application effectively increases shallot productivity, particularly in terms of the number of bulbs and dry weight of shallot bulbs, thereby improving photosynthetic efficiency and the translocation of photosynthetic products to the bulbs. However, the regression results show that increasing the GA_3 concentration beyond its optimum point tends to reduce the fresh bulb weight per clump. This is in line with the opinion of Putri & Rahmadina (2025), who state that GA_3 application can affect plant growth and reproductive organ formation, although the effect depends on the dose used and the type of plant.

The results also showed that the application of humic acid had a positive effect on the growth and productivity of shallots, with a concentration of 300 ml/L being the optimal concentration of humic acid. Increased vegetative growth indicated that humic acid played a role in improving the root environment and maximizing nutrient uptake, thereby promoting cell division and elongation in plant tissues. Humic acid is known to improve the physical, chemical, and biological properties of soil, particularly by increasing cation exchange capacity (CEC), the availability of macro and micronutrients, and soil microorganism activity. Yuniarti et al. (2024) reported that the application of humic acid itself had a significant effect on shallot growth parameters because it was able to increase nutrient uptake efficiency and improve the root-to-shoot ratio, resulting in more intensive vegetative growth. The application of humic acid has been proven to increase shallot productivity. Regression analysis showed that an increase in humic acid concentration has a positive correlation with the fresh weight of bulbs per clump. Humic acid acts as a soil conditioner or ameliorant that is useful in preventing the loss of nutrients due to leaching and ensuring the availability of nutrients for plants. Alaydia et al. (2022) stated that improving soil conditions and increasing nutrient uptake efficiency will have a direct impact on increasing the fresh weight and dry weight of shallot plants.

Based on these results, the combination of 300 ppm GA_3 and 300 ml/L humic acid was the best combination because it was at the optimum point, which was able to create a balance between hormone stimulation and nutrient availability and had implications for increasing plant productivity. Therefore, determining the optimum dosage is a crucial factor in the success of combined treatments in shallot cultivation. However, the results obtained in this study were conducted on land with fine-grained soil, which, according to Mahaguna et al. (2018), has a relatively low carrying capacity and is susceptible to soil quality degradation if not improved. These conditions can affect nutrient availability, water retention, and plant response to treatments. The results obtained in this study may yield different results when applied to different agroecosystems.

Conclusion

This study showed that a combination of 300 ppm GA_3 and 300 ml/L humic acid was the best treatment for supporting shallot growth and productivity, although in terms of fresh weight of the bulbs, the best combination was obtained from a concentration of 300 ppm GA_3 and 0 ml/L humic acid. In addition, GA_3 concentration had a negative correlation with fresh weight of bulbs per clump, and humic acid concentration had a positive correlation with fresh weight of bulbs per clump. Further testing is needed on various land types to strengthen the generalizability of the research results.

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