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The Effect of Humic Acid on Shallots Growth and Yield In Brebes

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ABSTRACT

The effectiveness of humic acid application in increasing shallot yields for farmers must be studied, particularly in terms of quality and quantity. It is also consistent with the relatively high consumption and public demand for shallots year after year. The purpose of this study was to examine how humic acid spraying affects shallot growth and production. Humic acid was applied in two stages: fertilizer coating and foliar spray, with varying treatment dosages. Field testing was conducted in two trials. The initial test revealed that the treatment plants grew faster than the control plants, potentially increasing yields by 7−15%. The validation test (second test) with three treatments yielded the same results: treatment plants outgrew the control specimen, increasing yields by 20−25%. Based on these findings, the use of humic acid may be an alternative for enhancing the agricultural industry, particularly in shallots.

Keywords: coating, fertilization effectiveness, foliar spray

INTRODUCTION

Shallots, as a staple ingredient in human life, are a national strategic item that is in high demand on the market. In 2021, shallots were one of Indonesia's most productive horticulture crops, generating 2.01 million tons (BPS 2022). Furthermore, the Central Bureau of Statistics reported that shallot consumption climbed by 8.33% in 2021, totaling 790.63 thousand tons more than in 2020. Shallot consumption for home requirements contributed the highest, accounting for 94.16% of total shallot consumption in Indonesia in 2021 alone (BPS 2022). Based on consumption rates and society's relatively high demand, shallot production yields must be enhanced to meet market demands. As a result, an effective fertilization procedure is required to improve nutrient absorption from the soil. The productivity of each crop is also determined by the genetic character of its variety, though the absorbed nutrients of those crops also play a large part in yield growth (Oktem & Oktem 2020).

The low fertilization efficiency in the ground is caused by the leaching and volatilization process to the air, which results in low fertilizer utilization by the crops. Humic acid can improve fertilization efficiency by increasing soil cation exchange capacity (CEC) and acting as a heavy metal chelator (Smith 2016). When sprayed directly on the leaves, liquid humic acid can also increase the permeability of plat cell membranes (Tan 2014). Humic acid is an organic compound that passes through the humification process and is soluble in alkali. Humic acid can have an influence on crops directly or indirectly, gradually restoring soil fertility in terms of physical, chemical, and biological qualities. Physically, humic material contributes to soil retention and the maintenance of soil structure. Biologically, humic material can stimulate microorganism growth, and chemically, it acts as an inorganic complex absorbing and nutrient holding agent in soil (Fahraman *et al*. 2014, Smith 2016). According to Moghadam *et al*. (2014), applying humic acid by foliar spray increases resilience to drought stress.

Urea fertilizer and NPK production in Indonesia generates liquid waste, which includes liquid urea waste (LUW) and liquid NPK ash waste (LNW). The expense of converting both wastes to meet the quality standards for liquid waste so that it can be cast into the river is quite significant. LUW consists of urea and ammonium at concentrations of 1500−10000 ppm and 400−3000 ppm, respectively (Aziz *et al*. 2022). LUW and LNW have the potential to be an enrichment material for humic acid fertilizer as a means of achieving zero waste, cost lowering at wastewater treatment plant, and adding value to waste as a byproduct.

With economic considerations in mind, the national fertilizer industry can produce humic acid as a complementary product for balanced fertilization by utilizing abundant material (Arfan 2014). Because LUW and LNW have been shown to contain micronutrients required by crops, this research used both materials rather than lignite rocks. The purpose of this study was

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to investigate the effects of LUW and LNW-based humic acid on shallot growth and production yields.

METHODS

Materials

The efficacy test was conducted in two sites: Klampok Village and Terlangu, Brebes Regency. Large-scale tests were conducted from July to December 2022. The seed variety employed in this study was Bima 'Tarmo' at four months following planting. Pesticides used include fungicides (Centathene 80 WP, Emerge 300 EC, Hagan 80 WP, Octave 50 WP) and insecticides (Axer, Brofeya 53EC, Centamec 36EC, Fenapir 450 SC, Swift 550/50EC, Trigard 75WP). The fertilizing process was repeated five times with the same type and ratio of fertilizer common for the crop (Table 1). The micronutrient−humic acid employed was an IOPRI-formulated product that used LUW and LNW as a micro-enhancing agent for humic acid (Aziz *et al.* 2022).

Procedures

Trial 1: The first trial was held in Terlangu Village from July 28th to September 19th, 2022 (58 days after planting, DAP). The application area was 2.500 m^2, with 35 beds of 1.8 × 23 m and a planting distance of 12 × 12 cm. This experiment used a complete randomized design with seven treatments, including control (4 repetitions) (Table 2). This trial employed four forms of humic acid derived from LUW and LNW, both in solid and liquid form. Liquid phase humic acid was applied via foliar spray 2, 4, and 6 weeks after planting (WAP) (in drought season) to both LUW and LNW types. Solid phase humic acid was applied as a foliar spray by dissolving 10 mg of fine humic powder in a liter of water, as well as a coating method that is applied directly to the farmers' traditional fertilizer (5%, 10%, and 15% by weight).

Trial 2: Based on the first trial, two of the best results from earlier treatments were repeated in further trials for validation. The validation test was carried out at Klampok Village, Wanasari District, from October 12th to November 29th, 2022 (48 DAP) on a 2000 m^2 plot of land with 18 beds of 1.6 × 45 m and a planting distance of 12 × 12 cm. This example plot used a randomized group design with three treatments, including control (Table 3). This trial utilized both fertilizer coating (5, 10, and 15% w/w of the standard inorganic fertilizer dose) and foliar spray (10 mg/L dose) approaches. During the rainy season, foliar spraying was applied two, three, or four WAP.

Observation

Parameters observed included vegetative and shallot yield. Plant height, leaf color, number of leaves, and number of bulbs (if produced) are among the vegetative metrics used to sample crops of 4, 6, and 8 (WAP). Crop yield characteristics observed include the wet and dry weight of the sample crop's shallot bulb (10 clumps of plant per bed), as well as the overall yield of each bed and plot for each treatment. The results were statistically examined using the Anova (*F* test) at the

Table 1 Fertilizer composition used in the study

Fertilizer	Description
1	SP-36 [30 kg] + NPK Mutiara [20 kg] + NPK Kujang [10 kg]
2	NPK Mutiara [20 kg] + DAP [20 kg] + NPK Phonska [20 kg]
3	NPK Mutiara Glower [30 kg] + NPK Holland [30 kg]
4	KMS (Ca, Mg) [25 kg] + KCl [20 kg] + KNO_3 Sondawa merah [15 kg]
5	KCl [50 kg] + KNO_3 Sondawa merah [10 kg]

Table 2 Treatments for the first field trial

Treatments		Dose	
		$_{(l)}$HA (ml/L)	$_{(s)}$HA (%, w/w)
P1	Control	–	–
P2	LUW humic acid	10	5
P3	LUW humic acid	10	10
P4	LUW humic acid	10	15
P5	LNW humic acid	10	5
P6	LNW humic acid	10	10
P7	LNW humic acid	10	15

Table 3 Treatments for the second field trial

Treatments		Dose	
		$_{(l)}$HA (mL/L)	$_{(s)}$HA (%, w/w)
P1	Control,	–	–
P3	LUW humic acid	10	10
P6	LNW humic acid	10	10

5% level. The Duncan technique (α = 5%) was used for post-hoc testing.

RESULTS AND DISCUSSION

The Effects of Humic Acid on the First Trial

Vegetative observations of shallots were made at 22 and 53 DAP. The vegetative performance of shallot at 22 DAP showed that the average growth of treated crops was higher and noticeably different from that of control specimens, although there was no difference between treatments (Table 4). The highest plant measured 33.55 cm from the solid LNW humic acid (10% dose) treated shallot, while the lowest was 30.47 cm from the control specimen. The solid LNW humic acid (5% dosage) treated shallot produced the most leaves (an average of 22.75), while the controls produced the fewest (17.73 leaf blades). For the leaf color parameter, the highest score was obtained by both solid LNW humic acid (5% dose) and solid LUW humic acid (5%) treated shallot with a score of 3, while the lowest score was obtained by the controlled specimen with a score of 2.83.

The next observation for shallot vegetative condition was made at the age of 58 DAP (Table 5), showing that the average growth for treated shallots differs significantly from that of control shallots except for the leaf color parameter. The highest plant reached 46.01 cm using solid LUW humic acid (15% dose), while the lowest achieved 37.95 cm with the controlled specimen. The shallot treated with solid LUW humic acid (5% dosage) produced the maximum leaves (23.8), while the controls specimens produced only 14.38. At this age, leaf depletion occurred because of caterpillar pest attacked on the controlled specimen nearing harvest season (which occurs 1 MAP). To mitigate this, leaves that had been consumed by caterpillars or if there were visible larvae eggs were removed before they could cause further damage. The number of bulbs formed on each treated shallot differed significantly from those of control shallots, but were indistinguishable, with the highest number reaching 7.33 bulbs obtained by the solid LUW humic acid (15% dose) treated specimen, and the lowest only reaching 5.53 bulbs obtained by the controlled specimen.

Each bed yield on treated crops was higher than on control crops but not significantly different, varying by 7−15% (Table 6). P7 treatment solid humic acid LNW (15%) and P3 treatment solid humic acid LUW (10%) achieved the highest harvest yield results of 104.85 kg and 101.20 kg, respectively, on a 41.4 m^2 bed. Based on each clump observation, the harvest yield of treated specimens was lower than that of controls specimens in both wet and dry weight (Figure 1). The decaying clumps on treated specimens were identified as the factor impacting this data. Some of the clusters in treated beds were clearly exhibiting fruit rot signs. The treated shallots had more leaves and a higher plant height than the control sample, making it easier for the plant to collapse. The collapsed leaves prevent sunlight from entering the surface of bulbs, causing fruit to rot in conjunction with high rainfall intensity. Out of all beds, 7−8% of clumps showed fruit rot symptoms, primarily in deeper buried bulbs. Based on these findings, the P3 and P6 treatments were continued for validation testing. P3 and P6 were chosen due to their higher

Table 4 Vegetative observation of shallot at the age of 22 DAP (first trial)

Treatment	Parameter		
	Plant height (cm)	Number of leaves	Leaf color (BWD score)
P1 (control)	30.475 a*	17.725 a	2.825 a
P2 ($_{(s)}$HA LUW 5%)	32.975 b	21.475 b	3.000 b
P3 ($_{(s)}$HA LUW 10%)	32.700 b	21.075 b	2.975 b
P4 ($_{(s)}$HA LUW 15%)	32.675 b	21.575 b	2.975 b
P5 ($_{(s)}$HA LNW 5%)	33.425 b	22.750 b	3.000 b
P6 ($_{(s)}$HA LNW 10%)	33.550 b	22.050 b	2.975 b
P7 ($_{(s)}$HA LNW 15%)	33.200 b	21.050 b	2.975 b

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 0.05)

Table 5 Vegetative observation of shallot at the age of 58 DAP (first field trial)

Treatment	Parameter			
	Plant height (cm)	Number of leaves	Plant height (cm)	Number of bulbs
P1 (control)	37.950 a*	14.375 a	3.925 a	5.525 a
P2 ($_{(s)}$HA LUW 5%)	44.700 cd	23.800 d	3.875 a	6.675 b
P3 ($_{(s)}$HA LUW 10%)	42.600 b	19.475 bc	3.875 a	7.175 b
P4 ($_{(s)}$HA LUW 15%)	46.075 d	20.750 bc	3.850 a	7.325 b
P5 ($_{(s)}$HA LNW 5%)	43.625 bc	19.375 bc	3.825 a	6.725 b
P6 ($_{(s)}$HA LNW 10%)	44.500 cd	21.225 c	4.100 a	7.125 b
P7 ($_{(s)}$HA LNW 15%)	43.900 bc	18.200 bc	3.900 a	6.425 b

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 0.05)

Table 6 Shallot harvest yield at the age of 58 DAP (first field trial)

Treatments	Parameter			
	Bulb wet weight/clumps (g)	Bulb dry weight/clumps (g)	Bed harvest yields (kg)	Increment (%)
P1 (control)	60.90 b*	38.77 a	91.60 a	–
P2 ((s)HA LUW 5%)	58.54 a	37.57 a	97.75 a	6.71
P3 ((s)HA LUW 10%)	69.80 c	48.73 b	101.20 a	10.48
P4 ((s)HA LUW 15%)	59.90 ab	39.63 ab	104.85 a	14.46
P5 ((s)HA LNW 5%)	70.32 c	47.20 b	98.64 a	7.68
P6 ((s)HA LNW 10%)	61.10 b	37.57 a	99.96 a	9.13
P7 ((s)HA LNW 15%)	59.47 ab	36.63 b	97.79 a	6.76

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 0.05)

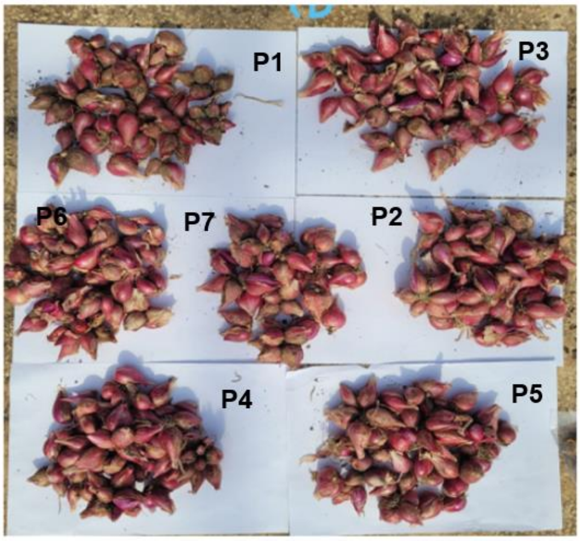

Figure 1 Dry harvest yield of 10 clumps for each bed (first trial).

harvest outcomes (±10%) and reduced add-on fees compared to P4 and P6.

Based on observation data, humic acid spraying has a good influence and significantly affects shallot growth and yield. According to Hasra *et al*. (2021), applying humic acid at a dose of 300−400 mL/L improved shallot root length, leaf number, and bulb size. Humic acid application improved root development and nutrient absorption, resulting in increased growth (number of shoots, plant height, and harvest yield) (Mahmood *et al*. 2020). According to Hermanto *et al*. (2013), fertilizer with nitrogen and humic acid at the same time can increase nitrogen supply in soil by slowing nitrogen release into nitrate. Selladurai and Purkayastha (2015) revealed that humic acid can retain N, P, and K elements in the soil. Krisna (2020) confirmed that nitrogen functions as a key vegetative growth enhancer in plants, specifically to enlarge and heighten plants in general; also, nitrogen has an essential role in the vegetative state, improving growth and the number of shoots. According to Maschner (2012), humic acid can stimulate the activity of H^+ ATPase in roots, allowing nutrients to be absorbed more efficiently throughout the plant. Humic acid can also boost N, P, and K adsorption, resulting in higher harvest yield (Selladurai & Purkayasha 2015).

Humic acid is important for microbial activity in soil, which promotes root growth (Canellas *et al*. 2015). Humic acid is chemically capable of securing nutrients such as N, P, and K for plants. Humic acid with negative charge (dissociation of H^+) has a higher CEC (more than 200 meq/100 g). This ability allows soil to bind, trap, and exchange cations, reducing and suppressing nutrient loss (Suwardi & Darmawan 2009, Azeem *et al*. 2014, Istiqomah *et al*. 2017). Suntari *et al*. (2013) and Ismillayli *et al*. (2019) added that humic acid-coated urea fertilizer with greater CEC can lower the nitrogen cycle rate and avoid leaching due to its complicated bind with NH_4^+. This complex bind generates a slow-release effect for fertilizer, which reduces nutrient loss and increases plant nutrient efficiency.

The Effects of Humic Acid on the Second Trial

Vegetative observations were made at the ages of 15, 30, and 48 DAP (harvest season). According to Table 7, the vegetative growth of treated plants at 15 DAP has a higher average value than the controls. The solid LNW humic acid (10%) treated shallot achieved the highest plant height of 30.43 cm, whereas the controlled specimen achieved the lowest at 26.63 cm. The greatest number of leaves were acquired by a shallot treated with solid LNW humic acid (10%), with a maximum of 19 leaf blades, whereas the controlled specimen only 16.4 leaf blades. Based on leaf color analysis, the maximum score was 3.13 for the solid LUW humic acid (10%) treated shallot, and the lowest was 2.93 for the control specimen.

The next observation was when the shallots reached 30 DAP (Table 8). The vegetative growth data of treated shallots were higher than those of control. The tallest plant gained by the solid LNW humic acid (10%) treated plants was 43.80 cm, whereas the lowest gained by the control specimen was 39.22 cm. The solid LNW humic acid (10%) treated shallot specimen had the most leaves, with 32.58 leaf blades, while the controlled specimen had just 26.85. Based on the leaf color study, the solid LNW humic acid (10%) had the maximum score of 3.10, while the controlled specimen only 3.00.

Further vegetative observations of plants were made at 48 DAP (Figure 2 and Table 9). The vegetative performance at 48 DAP exhibited better growth and was clearly different from the control, although there was no significant difference between treatments. The solid LNW humic acid (10%) treatment resulted in the highest plant height of 46.00 cm, whereas the P1 (control) treatment resulted in the lowest plant height of 40.55 cm. The solid LNW humic acid (10%) treatment yielded the most leaves (28.52 leaf blades), while the controlled shallot specimen yielded the fewest (23.27). The number of bulbs in the treatment differed considerably from the control, but there was no significant difference between treatments. The solid LNW humic acid (10%) treatment produced the most bulbs (8.80), while the controlled specimen produced the fewest (7.18).

The observation included the wet weight of each clump from a total of ten sample plants per bed, as well as the wet weight of shallot yield per bed (Table 10). The harvest yield for each bed of treated shallot was larger and distinct from the controlled specimen, although there was no significant difference between the treatments. The increase in harvest yield for each bed ranged from 20 to 25%, with the highest of 240.33 kg/bed for the solid LNW humic acid (10%) treatment in a 64 m^2 bed. The same was true for each clump's harvest yield, where treated plants outperform controls, with the maximum of 86.40 kg/clump for the solid LNW humic acid (10%) treated specimen. According to the validation results, both vegetative parameters and harvest yields have a substantial influence on humic acid-treated specimens.

CONCLUSIONS

According to the results of both trials in Terlangu and Klampok, LUW and LNW-based humic acid application can consistently improve the growth and harvest production of Bima Tarmo Shallot in Brebes. In the first trial, treated shallots outperformed control specimens in all plant growth indices, resulting in a 7−15% increase in harvest output. The validation test

Table 7 Vegetative observation of shallot at the age of 15 DAP (second trial)

Treatment	Plant height (cm)	Number of leaves	Leaf color (BWD score)
P1 (control)	26.63 a*	16.40 a	2.93 a
P3 ($_{(s)}$HA LUW 10%)	29.67 b	18.45 b	3.13 b
P6 ($_{(s)}$HA LNW 10%)	30.43 c	19.00 b	3.05 ab

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 005)

Table 8 Vegetative observation of shallot at the age of 30 DAP (second trial)

Treatment	Plant height (cm)	Number of leaves	Leaf color (BWD score)
P1 (control)	39.22 a*	26.85 a	3.00 a
P3 ($_{(s)}$HA LUW 10%)	41.92 b	30.93 b	3.03 ab
P6 ($_{(s)}$HA LNW 10%)	43.80 c	32.58 b	3.10 b

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 0.05)

Table 9 Vegetative observation of shallot at the age of 48 DAP (second trial)

Treatment	Parameter		
	Plant height (cm)	Number of leaves	Leaf color (BWD score)
P1 (control)	40.55 a*	23.27 a	7.18 a
P3 ($_{(s)}$HA LUW 10%)	44.38 b	25.95 b	8.15 b
P6 ($_{(s)}$HA LNW 10%)	46.00 b	28.52 b	8.80 b

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 005)

Figure 2 Harvest yield of 10 clumps of shallot for each bed (second trial).

Table 10 Observation of shallot harvest yields at the age of 48 DAP (second trial)

Treatment	Wet weight of bulbs for each clump (g)	Dry weight of bulbs for each clump (g)	Harvest yield for each bed (kg)	Increment (%)
P1 (control)	6497 a*	41.05 a	192.67 a	–
P3 ($_{(s)}$HA LUW 10%)	7820 b	48.40 b	231.33 b	20.07
P6 ($_{(s)}$HA LNW 10%)	86.40 c	53.05 b	240.33 b	24.74

Remark: *) Numbers in same columns followed by the same letters indicate the indifference rate based on multiple distance test in Duncan method (α = 0.05).

(second trial) employing three of the best treatments from the first experiment produced consistent results in terms of improved plant growth and harvest yield, reaching 20−25% for treated shallots compared to the control specimen.

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