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Response of Shame Plant Root PGPR Strain To Water Shock on Shallot

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Abstract

Shallot (Allium ascalonicum L.) is a type of tuber that is familiar to the Indonesian people because of its distinctive properties, taste, and aroma. however, in 2023 production declined in Banten Province. Factors causing are erratic climate and insufficient nutrient fulfillment. One of the efforts that can be made is the use of organic fertilizers such as Plant Growth Promoting Rhizobacteria (PGPR) based on mimosa roots. This study aims to determine the response of shame plant root PGPR to water stress in shallots (Allium ascalonicum L.) variety Bima Brebes. The research method used is a group randomized design consisting of two factors, namely the concentration of PGPR shame plant root and watering interval. The first factor is the concentration of PGPR shame plant root which consists of four concentrations, namely 0ml/L, 12.5ml/L, 25ml/L, and 37.5ml/L. The second factor is the watering interval which consists of three intervals, namely once a day, 1 day 2 times, and every 2 days. The results showed that the concentration of PGPR of shame plant root at 37.5 ml/L gave the best effect on the parameters of plant height, root length, and tuber wet weight. At a watering interval of 2 days, the best effect was on the number of tillers per clump and tuber wet weight. There was no interaction between PGPR concentration of shame plant root and watering interval on plant height, number of leaves per clump, number of tillers per clump, root length, tuber wet weight, and tuber dry weight.

Keywords: *Growth hormone; nitrogen; rhizobium*

Introduction

Shallots are a type of tuber that contains several important compounds, including antioxidants, essential oils, flavonoids, vitamin C, saponins, and many more. In addition to their culinary applications, shallots have been shown to possess therapeutic benefits, particularly in the treatment of vascular diseases (Aryanta, 2019). According to the data from the Badan Pusat Statistik (BPS) (2024), the national production of shallots during the 2021-2023 period exhibited fluctuations. Specifically, in 2021, shallot production reached 2.004 million tons. However, in 2022, there was a contraction in production to 1.982 million tons, followed by an uptick in 2023 to 1.195 million tons.

A similar phenomenon was observed in the shallot production of Banten Province, which also exhibited fluctuations during the 2021-2023 period. A notable decrease in production was observed in 2023, with the yield dropping to 860 tons from the previous year's 1,372 tons. The factors that can influence shallot production include variety selection and cultivation practices. Among the various cultivation practices, fertilization stands as a pivotal element. One type of fertilizer that can be used is biological fertilizer. The utilization of biological fertilizers can serve as a viable solution

to curtail the reliance on chemical fertilizers, which have the potential to pollute the environment and soil over time (Yaser et al., 2023).

One type of biofertilizer that can be utilized is PGPR. PGPR, or Plant Growth Promoting Rhizobacter, is a fertilizer derived from a group of root or rhizosphere bacteria. The benefits of PGPR include the acceleration of plant growth and development, the production of growth hormones, and the provision of nutrients (Hamdayanty et al., 2022). Furthermore, PGPR has been shown to enhance plant resilience to abiotic stressors, such as drought (Batool et al., 2020). One example of a plant that can be used as PGPR material is shame plant. The roots of shame plant have been observed to be in association with Azosprillum sp. bacteria, which have been identified to play a role in nitrogen fixation, the production of phytohormones, the stimulation of plant root growth, and the suppression of plant diseases (Ni'mah and Yuliani, 2022).

The findings of the research conducted by Arham et al. (2023) indicated that the PGPR concentration of 12.5 milliliters per liter (ml/L) exerted an influence on various plant characteristics, including height, the number of leaves, tuber weight, and total production. Then, Hafizh et al. (2021) have indicated that shallots require at least two waterings per day due to their shallow root system, which renders them particularly vulnerable to drought stress. Consequently, it is imperative to undertake research that involves the analysis of the growth and yield of shallot plants (Allium ascalonicum L.) of the Bima Brebes variety, with the objective of investigating the impact of PGPR (Plant Growth Promoting Rhizobacteria) on the development of shoot-like structures in response to water stress.

Research Method

This research is an experiment conducted at the Experimental Garden of the Faculty of Agriculture, Sultan Ageng Tirtayasa University, Kp. Cikuya Karang Kitri, Sindang Sari Village, Kec. Pabuaran, Serang Regency, Banten. The experimental design employed was Factorial Randomized Group Design (RAK), comprising two factors: PGPR Concentration Factor Shame Plant Root consists of 4 levels, namely: P0 = 0 ml/L, P1 = 12.5 ml/L, P2 = 25 ml/L, P3 = 37.5 ml/L.The watering interval factor consists of three levels, namely: W1 = once a day, W2 = 1 day 2 times, W3 = every 2 days. Consequently, 12 distinct treatment combinations were obtained. Each treatment was replicated thrice, yielding a total of 36 experimental units. Each experimental unit consists of one plant, resulting in a total of 36 shallot plants or clumps.

The research implementation consisted of nine stages, namely: 1) the tuber preparation; 2) PGPR was made from the shame plant root; 3) preparation and making of planting media; 4) planting; 5) PGPR application; 6) maintenance and planting 7) fertilization 8) harvesting 9) observation .The following six observation parameters were utilized: 1) plant height (cm), 2) number of leaves per clump (strands), 3) The number of seedlings per clump (tillers), 4) root length (cm), 5) Wet weight of tubers (g), 6) Dry weight of tubers (g). Observations were made on shallot plants aged 1 to 8 weeks after planting. The collected data underwent analysis using variance analysis (ANOVA) at the 5% and 1% levels. In the event of a statistically significant effect, subsequent tests were conducted using the Duncan Multiple Range Test (DMRT) at the 5% level.

Results and Discussion

Effect of PGPR concentration of Shame plant roots and watering interval

Plant Height

Based on the results of variance analysis, it shows that the concentration of PGPR in the roots of Shame Plant alone has a significant effect on plant height at the age of 5 and 6 WAP. The average height of shallot plants at the age of 1 to 8 WAP is presented in Table 1.

Table 1. Average height of shallot plants aged 1 to 8 WAP

Plant Age (WAP)	PGPR of Shame Plant Root (P)	Watering Interval (W)			Average
		W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
			.....cm.....		
1	P_0 (0 ml/L)	2,68	2,98	3,25	2,97
	P_1 (12.5 ml/L)	2,31	3,01	2,81	2,71
	P_2 (25 ml/L)	2,99	3,01	3,22	3,07
	P_3 (37.5 ml/L)	3,12	2,10	2,44	2,85
	Average	2,77	2,10	2,93	
2	P_0 (0 ml/L)	21,72	23,78	22,58	22,69
	P_1 (12.5 ml/L)	20,13	21,70	19,18	20,34
	P_2 (25 ml/L)	18,10	20,19	23,46	20,88
	P_3 (37.5 ml/L)	24,45	23,22	21,32	22,10
	Average	21,32	22,22	21,64	
3	P_0 (0 ml/L)	28,31	27,02	26,98	27,43
	P_1 (12.5 ml/L)	25,41	25,79	24,53	25,27
	P_2 (25 ml/L)	26,57	25,96	26,14	26,22
	P_3 (37.5 ml/L)	28,21	26,04	25,48	26,57
	Average	27,14	26,20	25,78	
4	P_0 (0 ml/L)	31,57	30,21	28,19	29,10
	P_1 (12.5 ml/L)	29,13	32,94	27,51	29,86
	P_2 (25 ml/L)	30,14	30,51	31,43	30,69
	P_3 (37.5 ml/L)	33,89	30,25	32,41	32,18
	Average	31,18	30,98	29,89	
5	P_0 (0 ml/L)	38,95	38,96	34,51	37,50b
	P_1 (12.5 ml/L)	37,18	38,04	35,94	37,05b
	P_2 (25 ml/L)	38,97	36,80	37,93	37,89b
	P_3 (37.5 ml/L)	42,11	39,10	41,95	41,05a
	Average	39,30	38,23	37,60	
6	P_0 (0 ml/L)	42,97	44,10	38,83	41,97b
	P_1 (12.5 ml/L)	44,57	46,27	41,33	44,05ab
	P_2 (25 ml/L)	45,23	43,17	42,23	43.54ab
	P_3 (37.5 ml/L)	46,50	45,30	46,57	46,12a
	Average	44,82	44,71	42,24	
7	P_0 (0 ml/L)	44,30	44,43	40,50	43,08
	P_1 (12.5 ml/L)	46,50	47,17	42,70	45,44
	P_2 (25 ml/L)	46,70	44,70	43,40	44,91
	P_3 (37.5 ml/L)	48,47	46,70	48,07	47,73
	Average	46,48	45,73	43,66	
8	P_0 (0 ml/L)	44,57	44,83	44,00	44,47

	P_1 (12.5 ml/L)	46,77	47,93	44,17	46,29
	P_2 (25 ml/L)	47,00	44,67	43,83	45,17
	P_3 (37.5 ml/L)	49,07	48,37	49,00	48,81
	Average	46,85	46,45	45,25	

Information : Numbers followed by the same letter on the same row indicate that they are not significantly different based on the 5% DMRT test

Table 1. Shows that the DMRT test results for plant height aged 5 and 6 WAP in the treatment were 37.5 ml/L (P_3) has a significant effect with the highest averages of 41.05 (5 MST) and 46.12 (6 WAP). This shows the influence of PGPR bacteria which are able to associate well with shallot roots to fix N optimally. According to Roidelindho et al. (2025) the element N can influence the rate of photosynthesis so that it has an impact on cell division processes such as increasing plant height. Apart from that, these results also show the role of PGPR bacteria in producing the hormones auxin and cytokinin. According to Wulandari et al. (2018) these two hormones act as stimulants for plants to carry out the process of cell division and encourage cells to differentiate.

Number of leaves per clump

Based on the results of variance analysis, it shows that the two factors, both the concentration of PGPR of the roots of Shame Plant and the watering interval, do not have a significant effect on the parameters of the number of leaves per clump. Then, in this parameter there is also no interaction with the growth of the number of leaves per clump. The average number of tillers per hill at the age of 1 to 8 WAP is presented in table 2

Table 2. Average Number of Tillers per Clump Age 1 to 8 WAP

Plant Age (WAP)	**PGPR of Shame Plant Root (P)**	**Watering Interval (W)**			**Average**
		W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
			.....sheets.....		
1	P_0 (0 ml/L)	5,00	6,33	7,70	6,33
	P_1 (12.5 ml/L)	4,00	6,70	4,00	4,90
	P_2 (25 ml/L)	5,00	5,00	6,33	5,44
	P_3 (37.5 ml/L)	5,70	6,33	4,70	5,56
	Average	4,92	6,08	5,70	
2	P_0 (0 ml/L)	9,33	9,33	11,33	10,00
	P_1 (12.5 ml/L)	10,33	8,00	10,70	9,70
	P_2 (25 ml/L)	10,00	8,33	10,70	9,70
	P_3 (37.5 ml/L)	9,70	9,70	8,00	9,11
	Average	9,83	8,83	10,17	
3	P_0 (0 ml/L)	11,70	11,33	13,00	12,00
	P_1 (12.5 ml/L)	12,33	13,33	13,33	13
	P_2 (25 ml/L)	13,70	13,33	14,33	13,80
	P_3 (37.5 ml/L)	13,33	13,00	10,70	12,33
	Average	12,75	12,75	12,83	
4	P_0 (0 ml/L)	16,70	17,70	21	18,44
	P_1 (12.5 ml/L)	15,00	20,33	22,00	19,11
	P_2 (25 ml/L)	22,33	14,33	22,00	19,60

	P_3 (37.5 ml/L)	19,33	22,00	16,00	19,11
	Average	18,33	18,58	20,25	
5	P_0 (0 ml/L)	22,00	23,33	23,00	22,80
	P_1 (12.5 ml/L)	17,33	24,70	24,00	22,00
	P_2 (25 ml/L)	26,00	20,70	26,00	24,22
	P_3 (37.5 ml/L)	26,33	29,70	19,70	25,22
	Average	22,92	24,58	23,17	
6	P_0 (0 ml/L)	28,33	26,00	29,70	28,00
	P_1 (12.5 ml/L)	25,33	31,70	30,33	29,11
	P_2 (25 ml/L)	26,33	26,70	30,70	27,90
	P_3 (37.5 ml/L)	26,70	32,00	20,33	26,33
	Average	26,70	29,08	27,75	
7	P_0 (0 ml/L)	31,00	26,70	31,00	29,60
	P_1 (12.5 ml/L)	31,33	36,33	31,00	32,90
	P_2 (25 ml/L)	31,70	29,33	33,00	31,33
	P_3 (37.5 ml/L)	29,00	37,70	28,00	31,60
	Average	30,75	32,50	30,75	
8	P_0 (0 ml/L)	31,00	28,00	31,33	30,11
	P_1 (12.5 ml/L)	31,33	36,33	31,00	32,90
	P_2 (25 ml/L)	32,00	29,33	33,00	31,44
	P_3 (37.5 ml/L)	29,00	37,70	28,00	31,60
	Average	30,83	32,83	30,83	

Table 2. Shows that the results of the DMRT test on the number of leaves per clump did not contain any factors that had a real effect and interacted with the parameters of the number of leaves per clump at the age of 1 to 8 WAP. This shows that there are external or environmental factors (such as high rainfall) that greatly influence the treatment given. The water requirement for shallots is around 350-600 ml/L, so excess water volume can certainly hinder plant growth and development activities. Apart from that, environmental factors are very important factors that can determine whether a treatment is optimal or not (Ichwan, et al., 2022).

The number of seedlings per clump

Based on the results of variance analysis, it shows that the watering interval factor has a significant effect on the number of tillers per hill at the age of 3 and 4 WAP. The PGPR concentration factor had no significant effect on the parameter number of tillers per hill and there was no interaction. The average number of tillers per hill at the age of 1 to 8 WAP is presented in table 3.

Table 3. Average Number of Shallots per Clump of Shallots Aged 1 to 8 WAP

Plant Age (WAP)	**PGPR of Shame Plant Root (P)**	**Watering Interval (W)**			**Average**
		W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
		.....children....			
1	P_0 (0 ml/L)	2,33	1,67	3,00	2,33
	P_1 (12.5 ml/L)	3,00	2,67	2,67	2,80
	P_2 (25 ml/L)	2,33	2,00	3,00	2,44
	P_3 (37.5 ml/L)	2,33	2,00	2,33	2,22
	Average	2,50ab	2.08b	2.75a	

2	P_0 (0 ml/L)	3,00	3,00	3,33	3,11
	P_1 (12.5 ml/L)	3,33	3,00	2,67	3,00
	P_2 (25 ml/L)	3,00	2,67	3,00	2,90
	P_3 (37.5 ml/L)	2,70	3,00	2,67	2,80
	Average	3,00	2,92	2,92	
3	P_0 (0 ml/L)	3,00	3,00	3,67	3,22
	P_1 (12.5 ml/L)	3,67	3,00	3,33	3,33
	P_2 (25 ml/L)	3,33	3,00	3,67	3,33
	P_3 (37.5 ml/L)	3,33	3,00	3,33	3,22
	Average	3,33ab	3,00b	3,50a	
4	P_0 (0 ml/L)	3,00	3,00	3,70	3,22
	P_1 (12.5 ml/L)	3,67	3,00	3,33	3,33
	P_2 (25 ml/L)	3,33	3,00	3,67	3,33
	P_3 (37.5 ml/L)	3,33	3,00	3,33	3,22
	Average	3,33ab	3,00b	3,50a	
5	P_0 (0 ml/L)	4,33	4,33	4,00	4,22
	P_1 (12.5 ml/L)	3,67	5,33	4,67	4,56
	P_2 (25 ml/L)	4,00	3,67	6,00	4,56
	P_3 (37.5 ml/L)	4,33	4,33	3,67	4,11
	Average	4,08	4,42	4,58	
6	P_0 (0 ml/L)	4,67	4,33	5,67	4,89
	P_1 (12.5 ml/L)	4,33	6,00	4,67	5,00
	P_2 (25 ml/L)	5,67	3,67	5,67	5,00
	P_3 (37.5 ml/L)	4,33	5,33	3,67	4,44
	Average	4,75	4,83	4,92	
7	P_0 (0 ml/L)	5,33	4,67	6,00	5,33
	P_1 (12.5 ml/L)	4,67	6,67	6,67	6,00
	P_2 (25 ml/L)	5,67	3,67	6,67	5,33
	P_3 (37.5 ml/L)	4,67	7,00	4,00	5,22
	Average	5,08	5,50	5,83	
8	P_0 (0 ml/L)	5,67	4,67	6,00	5,44
	P_1 (12.5 ml/L)	5,00	7,33	6,67	6,33
	P_2 (25 ml/L)	6,00	4,00	6,67	5,56
	P_3 (37.5 ml/L)	4,67	7,00	4,33	5,33
	Average	5,33	5,75	5,92	

Information : numbers followed by the same letter in the same row indicate that they are not significantly different based on the 5% DMRT test

Table 3. Shows that the results of the DMRT test are the number of tillers per hill at the age of 3 and 4 WAP treated with a watering interval of 2 days 1 time (W_3) has a significant effect, with the highest average of 3.50 (3 and 4 WAP). This shows that the watering interval is sufficient to meet the water needs of shallot plants during the growth phase, not too humid and not too wet compared to treatments 1 and 2. The availability of adequate water and in the right volume during the growth and development phase of shallots will definitely influence the formation of shallot seedlings and bulbs (Sumarianti, et al., 2022). According to Manurung et al, (2022) Excess water conditions can reduce the oxygen supply to plants so that it can inhibit plant growth.

Root length

Based on the results of variance analysis, it shows that the PGPR concentration factor of Shame Plant roots has a significant effect on root length. Meanwhile, the watering interval factor had no significant effect and there was no interaction. The average root length of shallot plants is presented in table 4.

Table 4. Average Root Length of Shallot

PGPR of Shame Plant Root (P)	Watering Interval (W)			Average
	W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
		.....cm.....		
P_0 (0 ml/L)	9,00	6,67	5,83	7,12b
P_1 (12.5 ml/L)	6,00	6,83	7,83	6,89b
P_2 (25 ml/L)	9,83	6,12	7,83	7,94b
P_3 (37.5 ml/L)	9,83	10,12	10,50	10,12a
Average	8,67	7,46	8,00	

Information : numbers followed by the same letter in the same row indicate that they are not significantly different based on the 5% DMRT test

Table 4. shows that the DMRT test result for root length treated with a PGPR concentration of 37,5 ml/L (P_3) has a real effect with the highest average of 10,12. This shows that the PGPR of Shame Plant root can produce the hormone IAA. According to Sumarna et al. (2024) the hormone IAA (Indole Acetic Acid) is a hormone that can help the root initiation process. The greater the concentration given, the more IAA hormone produced. The results of the study demonstrate that PGPR have the capacity to produce the hormone ethylene, which plays a crucial role in facilitating continued root growth under conditions of stress (Rismansyah et al., 2024).

Wet weight of tubers

Based on the results of variance analysis, it showed that the PGPR concentration factor of Shame Plant roots and the watering interval had a significant effect on the wet weight of the tubers. However, the two did not have an interaction that affected the wet weight of the tubers. The average wet weight of tubers is presented in table 5.

Table 5. Average Wet Weight of Tubers

PGPR of Shame Plant Root (P)	Watering Interval (W)			Average
	W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
		.....gram.....		
P_0 (0 ml/L)	17,67	30,33	18,33	22,11b
P_1 (12.5 ml/L)	22,33	31,67	19,67	24,56b
P_2 (25 ml/L)	28,33	24,67	23,33	25,44b
P_3 (37.5 ml/L)	33,33	32,33	30,00	31,89a
Average	25,42ab	29,75a	22,83b	

Information : Numbers followed by the same letter in the same row indicate that they are not significantly different based on the 5% DMRT test

Table 5. Shows that the results of the DMRT test for the wet weight of tubers treated with a PGPR concentration of Putri Malu roots of 37.5 ml/L and a watering

interval of 1 day 2 times had a significant effect with the highest average of 31.89 (P_3) dan 29.75 (W_2). This shows that for the PGPR of Shame Plant roots given there is a working mechanism of the elements N and P which can influence the yield of photosynthate which can be used by shallot plants for bulb formation and tuber maturation (Sumarna, et al., 2024). Then, these results also show that the root system of shallot plants influences the amount of water needed. A shallow root system will need water more often so the plant is very dependent on moisture conditions at the soil surface. If the soil surface is dry, the plants will also experience dryness quickly (Hafizh, et al., 2021)

Dry weight of tubers

Based on the results of variance analysis, it showed that the PGPR concentration factor of Shame Plant roots and the watering interval did not have a significant effect on the dry weight of the tubers. Then, there is no interaction between the two that affects this parameter. The average dry weight of tubers is presented in table 6.

Table 6. Average Dry Weight of Tubers

PGPR of Shame Plant Root (P)	**Watering Interval (W)**			**Average**
	W_1 (once a day)	W_2 (1 day 2 times)	W_3 (every 2 days)	
		.....gram.....		
P_0 (0 ml/L)	13,67	23,33	15,67	17,56
P_1 (12.5 ml/L)	18,67	25,00	16,00	19,89
P_2 (25 ml/L)	20,67	20,00	19,00	19,89
P_3 (37.5 ml/L)	23,67	24,67	19,33	22,56
Average	19,17	23,25	17,50	

Information : Numbers followed by the same letter in the same row indicate that they are not significantly different based on the 5% DMRT test

Table 6. Shows that the results of the DMRT test, the dry weight of tubers treated with the PGPR concentration of Shame Plant roots and the watering interval did not have a significant effect. This shows that there are environmental factors that interfere with the drying process so that the shallot bulbs are not dried optimally and evenly. During the drying process, the rainfall was very high, which resulted in the sun's rays and long periods of exposure not being radiated optimally. According to Subagya et al., (2018) stated that the drying process is influenced by several aspects, namely the initial moisture content of the material, the moisture content during drying, temperature, humidity, drying time, and air speed.

Conclusion

The conclusion of this research is: 1). The treatment of PGPR concentration of shame plant root as much as 37.5 ml/L gave the best effect on the parameters of plant height (age 5 and 6 WAP), root length, and wet weight of tubers.; 2). The treatment of watering intervals of every 2 days gave the best effect on the parameter of the number of tillers per clump (age 3 and 4 WAP), while the treatment of watering intervals of 1 day 2 times gave the best effect on the parameter of tuber wet weight.; 3). There was no interaction between PGPR concentration of shame plant root and watering interval on the 6 parameters observed.

It is necessary to have good preparation and planning to be able to anticipate weather or unfavorable climate that can affect the results of the study and there is a need for further research on PGPR of shame plant roots and the level of concentration on the growth and yield of shallots so that the sources of reference and knowledge related to this are wider.

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