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Research Article
Response, Correlation of Growth Analysis and Shallot Yield under Different Nitrogen Fertilizer Dosage and Rhizobacteria Source

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Abstract

Background and Objective: In the rainy season farmers do not want to cultivate shallot because they are afraid of crop failure and cause low shallot production. In addition to providing high dosage of fertilizer they are also sensitive to pathogenic attacks so. This study aimed to know response and correlation between growth analysis and agronomic character in the application of Ammonium Sulphate (AS) fertilizer through the sources of Plant Growth Promoting Rhizobacteria (PGPR) on growth analysis and yield of shallot in the rainy season. **Materials and Methods:** The study was conducted in Sleman, special region of Yogyakarta, Indonesia from August-November, 2019. The study was done by using Randomize Completely Block Design (RCBD) factorial with three replications. The first factor was various dosages of Ammonium Sulphate (AS) fertilizer (150, 250 and 350 kg ha^{-1}). The second factor was sources of PGP rhizobacteria from bamboo, gliricidia, peanut and control which was applied by 200 kg ha^{-1} of urea without PGPR. The observed variables were the analysis of growth and agronomic character component of shallot plant. The analyzed using analysis of variance at 5% of significant then continued by Duncan's Multiple Range Test (DMRT) at 5% of significant, it was followed by product moment correlation formula. **Results:** There were not interaction between Ammonium Sulphate (AS) fertilizer dosage with PGPR sources dosage. The application of Ammonium Sulphate (AS) fertilizer dosage or PGPR source has a significant effect on growth analysis and yield. **Conclusion:** Cultivation of shallot was in the rainy season with application of 150 kg ha^{-1} Ammonium Sulphate (AS) the best growth and highest yield provide on PGPR from bamboo source and higher growth and yield than control. There was a significant positive correlation between variables of growth analysis and yield of shallot bulb.

Key words: Crop growth rate, growth index, harvest index, yield of bulb, shallot bulb

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In 2015-2019, there is an average decline of shallot production around 0.33% per year in Indonesia even though it is projected to be surplus. Thus, an effort by the related technical directorates to support the increasing of shallot production as the main commodity in the horticulture sub-sector is needed to reach the target of developing the quality of vegetable products, especially shallot. Along with meeting the demand for shallots, it is expected to be fulfilled with domestic production without having to depend on import from other countries[1]. The shallot is commonly cultivated at the beginning of dry season from April-August. In the rainy season, farmers tend to not cultivate the shallot as it is very susceptible to pathogens, especially bacteria and fungi which will risk lower production and even fail.

The increasing of shallot production generally relies on the synthetic fertilizer to obtain a high yield, but tends to cause an environmental pollution. Biofertilizer is micro-organism which mainly plays a role in nitrogen binding, phosphate dissolution, biocontrol of soil pathogens and which produces growth regulators that can increase the growth and yield of the crop[2]. Biofertilizer becomes more important as it is environmental friendly, harmless, non-toxic and also can be used to reduce the level of soil and water pollution. Da Silva Oliveira *et al.*[3] reported that the biological fertilizer plays an important role for modern agriculture as it is environmental friendly and sustainable. The bacteria that aggressively colonize with the plant roots will produce the growth regulating substances which are capable to increasing the Plant Growth Promoting Rhizobacteria (PGPR) including *Pseudomonas fluorescent* and *Bacillus subtilis*. These bacteria can increase the plant growth by various mechanisms which are hormonal regulation, nutrient balance, dissolving nutrients facilitating plant absorption and increasing the resistance of pathogenic attacks[4].

Growth, development and yield of crop plants, together with factors affecting them, occupy a position of primary importance in crop production. Growth and yield are physiologically correlated. Growth characters are functions of dry weight increase or dry matter production per unit time. The dry matter produced (assimilates) was translocated and partitioned to various plant organs (yield characters). The interrelationship or association between growth analysis and yield were evidenced in the highly positive correlations observed between growth character and yield characters in this study[5]. Biofertilizers can play a key role in the development of integrated management system in the productivity of sustainable agricultural cultivation with low environmental effects[6]. Also, it was stated[7] that the mechanisms of PGPR in increasing the plant growth are through the phosphate dissolution, producing the growth hormone (Indole acetic acid/IAA, ammonia and siderophore), producing an enzyme activity that can degrade cell walls such as; cellulase (chitinase and proteases), producing HCN and as a defence against the environment. Zrnic and Siric[8] reported that plants with mycorrhiza are more tolerant to nutrients and water stress, soil salinity and high heavy metals concentrations. Also, it has been shown that mycorrhizal symbiosis positively affects plants during attacks of foliar pathogens and plant-parasitic nematodes. These effects proposed the possibility of use of mycorrhiz as in sustainable agroecosystems. Likewise the report of Itelima *et al.*[9] that biofertilizer (rhizobacteria and mycorrhiza) a key player in enhancing soil fertility, mineral absorption, growth, yield and quality of plant. The PGPR possess potential to promote the plant growth in various ways through phosphate solubilization, production of phytohormone, nutrient cycling and siderophore production. The potential applicability of PGPR is steadily increasing in agriculture because it offers a promising approach to replace the use of chemical fertilizers, pesticides and other supplements. Recent progress in our understanding enhances on the diversity of PGPR in the rhizosphere along with their colonization ability and mechanism of action that would facilitate their wider application in the management of sustainable agricultural crop production[10]. Thus, it was necessary to conduct the research on shallot cultivation in rainy season to keep higher production by providing various dosage of ammonium sulphate fertilizer and sources of PGPR and it's correlation.

MATERIALS AND METHODS

Implementation of the research: The shallot seedling was obtained from the local farmers in Bantul regency. The soil was cultivated and the planting media were prepared, the tillage was carried out in 2 weeks before planting in 30 cm of depth, 3 blocks were made, each of which consisted of 10 plots measuring 1×1 m^2. The planting space was done in 20×20 cm^2, while the distance between plots was 50 cm and so were the blocks. The cow manure was applied as a basic fertilizer at a dose of 0.5 kg per plot equal to 5 t ha^{-1}. The first factor fertilization was dosage of AS consisted of three level namely 150, 250 and 350 kg ha^{-1}. The secondary factor was sources of rhizobacteria what mean is PGPR according to treatment. Preparation of PGPR sources: take 100 g of the root of each ingredient (gliricidia, bamboo and peanut root), bathed in 1 L of cold water that has been heated for 3 days.

Mixed 400 g of granulated sugar, 200 g of shrimp paste, 1 kg of bran, flavoring, add water to a volume of 10 L. Then the mixture is boiled until it boils and then cooled. Then the mixture is filtered until obtained and put in a closed place, then the solution is allowed to stand for 7 days, every 2 days stirring until homogeneous. Preparation of PGPR solutions of pure ingredients 5% of each. The pest and weed control were done manually by removing the pest and the weed. The harvest time was done when the plants were in ±60 days old. The drying step was done by spreading the bulbs on a bamboo mat in a room with a temperature of 27-28°C for about 2 h every day for one week. The study was conducted in Sleman, special region of Yogyakarta, Indonesia from August-November, 2019.

Observed variables: The destruction of observed variables in the plant aged 30 days (4 weeks) and at harvest time (8 weeks) were the observed variables at vegetative growth phase during 30 days (4 weeks) and at harvest time (8 weeks) by following the formula of Aziez *et al.*[11] and Shehu[12]:

$$\text{Crop growth rate} = \frac{1}{A} \times \frac{W2 - W1}{T2 - T1}\,\text{g m}^2/\text{day}$$

$$\text{Relative growth rate} = \frac{\text{In}W2 - W1}{t_2 - t_1}\,\text{mg g}^{-1}/\text{day}$$

$$\text{Net assimilation rate} = \frac{W - W1}{T2 - T1} \times \frac{\text{In}\,LA_2 - \text{In}\,LA_1}{LA_1 - LA_1}\,\text{g m}^2/\text{day}$$

$$\text{Absolute growth rate} = \frac{W2 - W1}{T2 - T1}$$

$$\text{Crop index} = \frac{We}{Ws} \times 100\%$$

$$\text{Harvest index} = \frac{We}{Wb} \times 100\%$$

and fresh weight of bulb, yield × ha^{-1}.

Where:

LA_1 = Leaf area of plant/m^2, recorded time t_1
LA_2 = Leaf area of plant/m^2, recorded time t_2
W1 = Dry weight of plant/m^2, recorded time t_1
W2 = Dry weight of plant/m^2, recorded time t_2
We = Weight economic yield
Wb = Weight biological yield
Ws = Weight straw yield
In = Natural log

Data analysis: The data were analyzed by using variance at $p \leq 0.05$ of significant level, continued with Duncan's Multiple Range Test (DMRT) at the level of $p \leq 0.05$ and followed by product moment correlation formula[13]:

Product moment correlation formula:

$$\frac{\in XY}{\sqrt{\ }(\in X^2)(\in Y^2)} = \frac{\in (X - Y^-)(X - Y^-)}{\sqrt{\ }[\in (X - X^-)][\in Y - Y^-]} = \frac{\in (X - X^-)(Y - Y^-)}{\sqrt{\ }\{\in (X - X^-)^2\}\{\in (Y - Y^-)\}^2}$$

RESULTS

Based on the results of analysis, there was no interaction between the various dosages of ammonium sulphate fertilizer and the sources of PGPR in all observed variables. There was no interaction between various dosages of ammonium sulphate fertilizer and sources of PGPR in all observed variables. The ammonium sulphate fertilizer dosages did not affect the growth analysis of shallot, while sources of PGPR from gliricidia was influential (Table 1) to agronomic character (Table 2). There is no significant difference between the treatment and control.

Crop growth rate: The application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to crop growth rate, while application of sources of PGPR significant different, PGPR from gliricidia obtained higher than PGPR from bamboo or peanut (Table 1). Based on the data of Table 3 which shown there is a positive correlation between crop growth rate with growth index.

Absolute growth rate: Based on the data of Table 1, the application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to absolute growth rate, while application of sources of PGPR significant different, PGPR from gliricidia obtained higher than PGPR from bamboo or peanut. There is no significant difference between the treatment and control. Accordance Table 3 shown absolute growth rate has a positive correlation with GI and CGR.

Relative growth rate: Table 1 showed, the application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to relative growth rate, while application of sources of PGPR significant different, PGPR from gliricidia obtained higher than

Table 1: Crop growth rate, absolute growth rate, relative growth rate and net assimilation rate

Treatments Dosages of AS fertilizer /sources of PGPR	Observed variables Crop growth rate ($g\ m^{-2}$/day)	Absolute growth rate ($g\ m^{-2}$/day)	Relative growth rate ($mg\ g^{-1}$/day)	Net assimilation rate ($g\ m^{-2}$/day)
Control (urea 200 kg ha^{-1})	2.71^{b}	0.10^{b}	0.03^{b}	0.10^{b}
150 kg ha^{-1} AS	2.98^{a}	0.12^{a}	0.35^{a}	0.11^{a}
250 kg ha^{-1} AS	3.68^{a}	0.15^{a}	0.05^{a}	0.15^{a}
350 kg ha^{-1} AS	2.64^{a}	0.10^{a}	0.03^{a}	0.10^{a}
PGPR from bamboo	1.32^{b}	0.05^{b}	0.01^{b}	0.05^{b}
PGPR from gliricidia	5.78^{a}	0.21^{a}	0.07^{a}	0.21^{b}
PGPR from peanut	2.71^{b}	0.11^{b}	0.03^{b}	2.71^{a}
No Interaction	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$

Means followed by the same letter in the same column are not significantly different accordance to DMRT at $p \leq 0.05$

Table 2: Fresh weight of bulb, growth index, yield and harvest index

Various dosages of AS fertilizer/sources of PGPR	Observed variables Fresh weight of bulbs (g/clumps)	Growth index (%)	Yield of bulbs (t ha^{-1})	Harvest index (%)
Control (urea 200 kg ha^{-1})	8.68^{b}	1.48^{a}	7.98^{b}	0.45^{a}
150 kg ha^{-1} AS	9.75^{a}	1.53^{a}	12.66^{a}	0.46^{a}
250 kg ha^{-1} AS	9.51^{a}	1.48^{a}	10.85^{b}	0.47^{a}
350 kg ha^{-1} AS	9.33^{a}	2.05^{a}	9.44^{b}	0.48^{a}
PGPR of bamboo	11.40^{a}	1.72^{a}	12.15^{a}	0.48^{a}
PGPR of gliricidia	10.10^{b}	1.88^{a}	10.60^{b}	0.47^{a}
PGPR of peanut	9.73^{b}	1.30^{a}	10.40^{b}	0.46^{a}
No Interaction	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$

Means followed by the same letter in the same column are not significantly different to DMRT at $p \leq 0.05$

Table 3: Correlation between growth analysis and agronomic character

Correlation	GI	CGR	AGR	RGR	NAR	FWB	BY	HI
GI	1.000							
CGR	0.528*	1.000						
AGR	0.528*	0.985*	1.000					
RGR	0.493*	0.985*	0.969*	1.000				
NAR	0.588*	0.969*	0.969*	0.969*	1.000			
FWB (ha^{-1})	0.466*	0.547*	0.457*	0.547*	0.457*	1.000		
BY (ha^{-1})	0.620*	0.359*	0.539*	0.296*	0.322*	0.569*	1.000	
HI	-0.488	-0.488	-0.488	-0.476	-0.517	-0.488	-0.482	1.000

GI: Growth Index, CGR: Crop growth rate, AGR: Absolute growth rate, NAR: Nett assimilation rate, FWB: Fresh weight of bulb, YB: Yield of bulb, HI: Harvest index, *p (5%), -: Negative correlation

PGPR from bamboo or peanut. There is no significant difference between the treatment and control. There is a positive correlation between relative growth index with growth index, crop growth index and absolute growth rate (Table 3).

Nett assimilation rate: Accordance of the application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to crop growth rate, while application of sources of PGPR significant different, PGPR from peanut obtained higher than PGPR from bamboo or gliricidia. There is no significant difference between the treatment and control. Accordance of Table 3 shown that net assimilation rate has a positive correlation with growth index, crop growth index, absolute growth rate and relative growth rate.

Fresh weight of bulb plant: Accordance of the application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to fresh weight of bulbs clumps, while application of sources of PGPR significant different, PGPR from bamboo obtained higher than PGPR from gliricidia or peanut. There is no significant difference between the treatment and control (Table 2). There is a positive correlation between fresh weight of bulb with growth index, crop growth index, absolute growth rate, relative growth rate and nett assimilation rate (Table 3).

Growth index: The application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to crop growth rate, while application of sources of PGPR significant different, PGPR from gliricidia obtained higher than PGPR from bamboo or peanut. There is no significant difference between the treatment and control.

Fresh weight of bulb/ha: Accordance of the application of AS fertilizer dosage 150-350 kg ha^{-1} are significant different to fresh weight of bulbs/ha, the application of AS fertilizer dosage 150 kg the higher than 250 and 350 kg ha^{-1} dosages. The application of sources of PGPR significant different, PGPR from bamboo obtained higher than PGPR from gliricidia or peanut. Accordance of Table 3 shown there is a positive correlation between Fresh weight of bulb/ha with growth index, crop growth index, absolute growth rate, relative growth rate, nett assimilation rate and fresh weight of bulb plant.

Harvest index: Based of the application of AS fertilizer dosage 150-350 kg ha^{-1} are not significant different to yield of harvest index, likewise application of sources of PGPR is no significant different. Based on Table 3 shown harvest index has a negative correlation with all other variables.

DISCUSSION

The source of rhizobacteria from gliricidia increased the agronomic character of shallot, while PGPR from bamboo increased the yield of shallot bulb. The application of ammonium sulphate and PGPR from bamboo in shallot cultivation off season increased the growth analysis and agronomic character which was capable of reducing the application of AS fertilizer with a dosage of 150 kg ha^{-1}. Accordance of Table 1, this result is no significant different between control and treatment. This result is different from the study by Nori *et al.*[14], but consistent the opinion that application of mycorrhiza was increased CGR[11]. Data of Table 3 presented the results of correlations between CGR and GI which indicated that it was positively correlated significant (r = 0.528*). Similar result was reported by Zakari *et al.*[15].

The AGR and the yield of shallot were not affected by the application of AS, these result are not in accordance with the study by Mishu *et al.*[16]. The PGPR from gliricidia produced the best result in AGR, this result is not consistent with the opinion of Aziez *et al.*[11]. The AGR had a significantly positive correlation with GI and (r = 0.528*) CGR (r = 0.895*), similar result was reported by Zakari *et al.*[15]. Accordance of the Table 1, application of AS fertilizer did not give significant different effect RGR compared to the control different with Mishu *et al.*[16] study. Conversely PGPR from gliricidia resulted the highest RGR. This result is consistent with the opinion of Aziez *et al.*[11]. Based to the Table 3 showed a significantly positive correlation between RGR and GI (r = 0.493*), as well as CGR (r = 0.985*) and AGR (r = 0.969*). This is in accordance with the opinion from another research[17,18].

The application of AS fertilizer at various doses up to 350 kg ha^{-1} did not significantly affected NAR of shallot compared to the result obtained by the control (Table 1)[16,19,20]. The correlation between NAR with GI were significantly positive correlated with r of 0.588*, CGR of 0.969*, AGR of 0.969* and RGR of 0.969*. This was not in accordance with the report[11,17]. Table 2 showed that the dosages of AS fertilizer up to 350 kg ha^{-1} did not significant affect the bulb fresh weight per clump, while the highest bulb fresh weight per clump was observed in shallot treated with PGPR from bamboo, this result is not in line with the result of research[21,22]. Fresh weight of bulb had a significantly positive correlation with growth index (r = 0.466*), CGR (r = 0.547*), AGR (r = 0. 457*), RGR (r = 0.547*) and NAR (r = 0.547*), the similar result was reported[15,17]. The result is not in accordance with the study conducted by Gholami *et al.*[23], who reported that *Azotobacter* and *Azospirillum* inoculation could increase growth index of maize grain. Based on the Table 3 shown the correlations between G I with CGR and AGR which indicated that it was positively correlated significant (r = 0.528*) and positively correlation significant others variable, similar result was reported[15].

The highest yield of shallot was obtained by the application of ammonium sulphate fertilizer at a dosage 150 kg ha^{-1}, this result sported another research [24-26]. Based to Table 3, the significantly positive correlation was found between YB and GI (r = 0.620*), CGR (r = 0.359*), AGR (r = 0.539*), RGR (r = 0.296*), NAR (r = 0.328*) and also FWB (r = 0.569*). Similar result was reported[17] that a positive correlation between seed yield with harvest index and biological yield, like wise Zakari *et al.*[15] who stated that a positive correlation was found in yield of bulb with growth index, RGR and CGR on garlic. The application of ammonium sulphate fertilizer and various sources of rhizobacterium could not increase the HI (Table 2). This result is not accordance with the report by Ahmed *et al.*[27], meanwhile this is not in accordance with opinion of Turk *et al.*[28]. To the contrary, Kobata *et al.*[29] reported that there was no correlation between the HI and biological results on wheat species. (Table 3). Based on the results of the research it is recommended that the cultivation of shallots is better in the rainy season. This cultivation can be carried out by administering low-dose US fertilizer 250 kg ha^{-1} thereby reducing costs. To improve plant resilience and fixation of N fertilizer, biological fertilizer is used from PGPR bamboo root sources.

CONCLUSION

The application of ammonium sulphate dosage 250 kg ha^{-1} fertilizer and PGPR bamboo sources were increased to agronomic character (fresh weight of bulbs/ha) of *Allium ascalonicum* L. There was a significant positive correlation between variables of growth analysis and agronomic character variables except for the harvest index. Harvest index variable had a negative correlation to all components of the analysis of the growth and agronomic character of the *Allium ascalonicum* L. plant.

SIGNIFICANCE STATEMENT

Until now farmers only cultivate shallots once a year, so that it affects the production of low shallot. This experiment would help shallot farmer, that in the rainy season conducting shallot cultivation will not fail if it is done by providing PGPR or mycorrhiza with a concentration of 5% and ammonium sulphate dosage of 150 kg ha^{-1}. The cultivation of shallots with this method is expected to increase the production of shallots.

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