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Research Article

Integration of Nitrogen and Biofertilizer on the Agronomic Efficiency and Quality of Shallot (*Allium ascalonicum* L.) Plant in the Rainy Season

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Abstract

Background and Objective: In the rainy season farmers don't interest to cultivate shallot because in addition to providing a high dosage of fertilizer they are also sensitive to pathogenic attacks so they are afraid of crop failure and cause low shallot production. This study aimed to knew effect of agronomic component and quality of shallot under different concentrations of biofertilizer and Ammonium Sulphate (AS) fertilizer dose in the rainy season. **Materials and Methods:** The study was conducted in Cangkring, Srandakan, Bantul, Special Region of Yogyakarta Indonesia from August to October 2019. The study was arranged in RCBD factorial with three replications. The first factor was a various dose of ammonium sulphate (100, 200 and 300 kg ha^{-1}). The second factor was various concentrations of biofertilizer (2, 3 and 4%), and control. The observed variables were the analysis of growth yield and quality component of shallot plant. The analyzed using analysis of variance at 5% of significance then continued by DMRT at 5% of significance. **Results:** There was the interaction between the application of AS dosage and biofertilizer concentration on all of variable observations. There was a significant difference between treatment with control on all of the observation variables. **Conclusion:** The combination of AS fertilizer 200 kg ha^{-1} dose and 3% biofertilizer concentration increased agronomic efficiency, growth, bulbs yields, and quality of bulbs include provitamin A, oleoresin compounds.

Key words: Biofertilizer, bulb yield, growth yield, oleoresin, provitamin E

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

The shallot is commonly cultivated at the beginning of dry season from April to 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 synthetic fertilizer to obtain a high yield but tends to cause environmental pollution. Nitrogen is normally a key factor in achieving optimal growth in the plant. Plant use efficiency of nitrogen depends of several factors including application time, dosage of application, precipitation and other climate related variable. As nitrogen fertilizer are highly dinamic in soil, its careful management was need, while grain yield and crop up take N efficiency increased[1]. Meanwhile the physiological effect of garlic can be affected by sulfur-containing compound as well as other biologically active compound such as polyphenols (mainly flavonoid), minerals (Ca, Fe, K, Mg, Na, Zn) and vitamin (A, B_1, B_2, B_6, d and C). The main sulphur compound in garlic is alliin, converted to allicin by the enzyme alliinase, which results in characteristic garlic aroma and taste[2].

Biofertilizers contain microorganism that mainly plays a role in nitrogen fixation, phosphate solubilization and biocontrol of soil pathogens as well as produces, growth regulator that can improve the growth and yield of the crop. Biofertilizers becomes more important as it as environmentally friendly, harmless, non-toxic, and also able to reduce the level of soil, water pollution, eco-friendly environment and sustainable[3, 4, 5]. These microorganisms 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[6]. Also, Karnwal[7] stated that the mechanisms of PGPR in increasing the plant growth are through the phosphate solubilization, 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 defense against the environmental. Zrnic and Siric[8] reported that plants with mycorrhiza were more tolerant to nutrients deficiency, water stress, soil salinity and high concentration of heavy metals. Also, it has been shown that mycorrhizal symbiosis positively affects plants during attacks of foliar pathogens and plant-parasitic nematodes. These effects propose the possibility of use of mycorrhizas in sustainable agroecosystems. Likewise, Itelima *et al.*[9] reported that biofertilizer containing *Rhizobacteria* and *Mycorrhiza* a key player in enhancing soil fertility, mineral absorption, growth, yield and quality of the plant. Biofertilizer has the potential to promote plant growth in various ways through phosphate solubilization, production of phytohormone, nutrient cycling and siderophore production. Microbial revitalization using plant growth promoters had been achieved through direct and indirect approaches like bio-fertilization, invigorating root growth, rhizoremediation, disease resistance etc. There is also variability in the performance of PGPR that may be due to various environmental factors that might affect their growth and proliferation in the plants[10].

Azospirillum can establish an association symbiosis with cereal, generally Monocotyledoneae, the association is not accompanied by the formation of new organs. *Azospirillum* benefits the plant directly, via associative nitrogen fixation synthesis of phytohormone (IAA) and modulation of plant hormonal balance[11]. Accordance of reported Okur[12] that *Azospirillum* is play role fixation nitrogen, while *Aspergillus* play role phosphate and potassium solubilizing, mycorrhiza play role phosphate mobilizing, as well as fungi belonging to Trichoderma genus interest with plant by including their defense system and promoting plant growth[13].

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 understanding enhances on the diversity of Plant Growth Promoting Rhizobacteria (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[14,15]. These beneficial soil microbes play an important role in plant growth promotion by: enhancing the availability and uptake of nutrients through fixation and mobilization and reducing the harmful effects of soil-borne plant pathogens by employing multiple mechanisms of action and producing plant growth regulators or other biologically active substances that alter endogenous levels of phytohormones[16]. Evaluation of cultivation method and sustainable agriculture practice for improving shallot bulb production. The importance of application integrated fertilizer namely organic, inorganic combined biofertilizer[17]. Therefore, it is necessary to conduct the research on shallot cultivation in the rainy season to keep higher production, efficiency agronomic and quality by providing a various dosage of ammonium sulphate fertilizer and biofertilizers concentration.

MATERIALS AND METHODS

Study area: The study was conducted in Cangkring, Srandakan, Bantul, Special Region of Yogyakarta from August-October 2019.

The type of the soil used is sandy at the altitude of ±15 m above sea level with 2000-3000 mm of rainfall per year, soil pH of 5.6-6.0, air humidity of 50-70% and temperature of 24-32°C. The tools used were hoes, a small shovel, buckets, hose, scale, measuring cup, and sprayer, while the materials used were cow manure, bulbs of shallot, biofertilizer solution, urea and AS fertilizer. Biofertilizers solution which consist of microorganism *Azospirilum* is Plant Growth Promoting Rhizobacteria and *Aspergillus nigrum* and *Tricoderma harzianum* are *Mycorrhiza*. This study was arranged in factorial Randomized Complete Block Design consisting of two factors and three replications. The first factor was various dosage of AS fertilizer (100, 200 and 300 kg ha^{-1}), and the second factor was three-level concentrations of biofertilizer (2, 3 and 4%) of 200 cc every watering, three times application with interval one week. Thus, there were 9 treatment combinations with one control 250 kg of urea fertilizer ha^{-1}, without biofertilizer.

The implementation of the research: The planting media was prepared by performing soil tillage two weeks before planting. The seedling was planted at the depth 30 cm in three blocks, and each block consisted of which consisted of 10 plots measuring 1x1 m^2 with a planting space of 20×20 cm, and distance between plots and block of 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 tons ha^{-1}. The first factor fertilization was the dosage of AS consisted of three levels namely 100, 200 and 300 kg ha^{-1}. The secondary factor was the concentration of biofertilizer solution namely 2, 3 and 4%. Each application biofertilizer is tree times, starting after the seed germinate, with interval 1 week. The pest and weed control was 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 hrs every day for one week.

Observed variables: Variable observation was made at the time of harvest (8 weeks) includes fresh weight plant clump^{-1}, fresh weight of bulb clump^{-1}, fresh weight of leave/root clump, dry weight of leave/root clumps, fresh weight of bulbs ha^{-1}, crop index, harvest index, agronomy effisiency[18], vitamin C, provitamin A and oleoresin content.

Data analysis: The significant of data was test by analysis of variance and Duncan's Multiple Range Test (DMRT) at the level of $p \leq 0.05$ by using MS STAT-C software version and SAS software[19].

Results: Based on the variance analysis, there was an interaction between the administration of AS fertilizer dosages with biofertilizer levels on the variable fresh and dry weight of leaves with root, bulb fresh weight, fresh plant weight clump^{-1}, bulb yield ha^{-1}, provitamin A, and oleoresin compounds. In addition, there was no interaction among vitamin C concentration, crop index, and harvest index. All observational variable was significantly different compared to controls.

Weight of the fresh plant clumps^{-1}: The combination of AS fertilizer dosages with biofertilizer concentration is significantly different compared to the weight of fresh plants (Table 1). The higher of AS fertilizer dosage and biofertilizer levels increase the weight of fresh plants to the optimum.

Most of the fresh weights were obtained within a AS fertilizer dose of 200 kg ha^{-1} with biofertilizer concentrations

Table 1: Effect of treatment on fresh Weight of plant, fresh weight of bulb, fresh weight of leave and root, dry weight of leave and root

Dosage of AS fertilizer - Concentration of biofertilizer	Observation of variables			
	Fresh weight of plant clump^{-1} (g)	Fresh weight of bulb clump^{-1} (g)	Fresh weight of leaf+root clump^{-1} (g)	Dry weight of leaf +root clump^{-1} (g)
100 kg-2 (%)	174.83^f	107.07^f	69.16^e	16.36^f
100 kg-3 (%)	227.85^b	137.20^a	90.65^b	22.06^c
100 kg-4 (%)	231.47^b	143.35^a	88.12^c	21.15^d
200 kg-2 (%)	196.03^e	116.06^e	79.97^d	19.45^d
200 kg-3 (%)	226.42^c	133.00^c	93.92^b	22.83^b
200 kg-4 (%)	243.48^a	144.56^a	98.93^a	24.07^a
300 kg-2 (%)	220.28^d	125.29^d	88.89^b	20.73^c
300 kg-3 (%)	229.19^d	139.67^a	89.47^b	21.73^d
300 kg-4 (%)	237.70^a	144.17^a	90.52^b	22.63^d
Average	220.81^x	132.26^x	87.74^x	21.22^x
Control	141.51^y	83.11^y	55.06^y	12.29^y

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

of 4% while the lowest fresh weight was obtained on the application of 100 kg ha^{-1} in AS fertilizer dosage with biofertilizer concentrations of 2%.

The fresh weight of leaf with roots clumps^{-1}: According to Table 1, the combination of AS fertilizer dosages and biofertilizer concentrations show a significant difference. The application of AS fertilizer and biofertilizer levels increase the fresh weight of the leaf up to optimum. The highest fresh leaf weight was obtained on a combination of AS fertilizer with dosage 200 kg ha^{-1} and 4% biofertilizer. The lowest fresh leaf weight was obtained on the combination of AS fertilizer with 100 kg ha^{-1} dosage and 2% biofertilizer concentration.

Fresh weights of bulbs clumps^{-1}: The fresh weights of bulbs clumps^{-1} are influenced by the combination of AS fertilizer dosages and biofertilizer concentrations. In addition, the higher dosage of AS fertilizer and biofertilizer concentration does not always increase the fresh weight of bulbs clumps^{-1} (Table 1). The highest of fresh weights bulbs clumps^{-1} were obtained at 200 kg ha^{-1} of AS fertilizer with 4% biofertilizers concentration. The lowest fresh weight bulbs clumps^{-1}was obtained from the addition of AS fertilizer with 100 kg ha^{-1} dosage and 2% biofertilizer concentration.

Dry weight of leaves and roots clumps^{-1}: The application of AS fertilizer dosage with biofertilizer concentration was significantly different compared to the dry weights of leaves and roots (Table 1). The highest leaves and root dry weight was obtained in the application of AS fertilizer with dosage 200 kg ha^{-1} and 4% biofertilizer, while the lowest leaves dry weight was obtained in the addition of AS fertilizer with 100 kg ha^{-1} dosage and 2% biofertilizer concentration.

Crop index: Based on Table 2, the application of AS fertilizer dosages and biofertilizer levels did not significantly differ in the interaction with the crop index. The application of AS fertilizer showed a significant difference in crop index. The high crop index was obtained at an AS dosage of 200-300 kg ha^{-1}, as well as giving biofertilizer concentrations, also showed significantly different. The high index crops were obtained by giving 3-4% biofertilizer concentration.

Harvest index: The application of AS fertilizer dosages and biofertilizer concentrations did not show a significant difference in the harvest index (Table 2). Giving a AS fertilizer dosage of 100-300 kg ha^{-1} shows no significant difference to the harvest index. Likewise, the application of 2-4% biofertilizer concentration shows no significant difference against the harvest index.

Vitamin C: The application of AS fertilizer dosages and biofertilizer concentrations did not impact vitamin C concentration (Tab. 2). The application of AS fertilizer dosages showed significant differences in vitamin C concentration. The highest vitamin C concentration was obtained in AS fertilizer with a dosage of 300 kg ha^{-1}. Furthermore, the application of biofertilizer concentrations showed significantly different. The highest vitamin C concentration was obtained at the application of 3% biofertilizers concentration.

Bulb yield ha^{-1}: The combination of AS fertilizer dosage with biofertilizer concentration affects bulb yield ha^{-1} (Fig. 1). The high bulb yield was obtained by giving AS fertilizer with doses of 100-200 kg ha^{-1} and 4% biofertilizer concentration as well as AS fertilizer dosage 300 kg with 3-4% biofertilizer concentration. The lowest bulb yield ha^{-1} was shown in the application of AS fertilizer with 100 kg ha^{-1} doses and 2% biofertilizers concentration.

Agronomic efficiency: The application of AS fertilizer dosages with biofertilizer concentrations has a significantly different

Table 2: Effect of treatment on crop Index, harvest Index and concentration of vitamin C

Treatment: ammonium sulphate dosage and biofertilizer concentration	Observation of Variable		
	Crop Index (%)	Harvest Index (%)	Vitamin C (%)
AS dosage (kg ha^{-1})			
100 kg ha^{-1}	149.12^{b}	59.23^{a}	0.71^{c}
200 kg ha^{-1}	260.89^{a}	61.22^{a}	1.09^{b}
300 kg ha^{-1}	260.80^{a}	61.42^{a}	1.70^{a}
Biofertilizer (%)			
2%	144.40^{b}	62.16^{a}	1.11^{b}
3%	152.30^{b}	58.55^{a}	1.30^{b}
4%	267.40^{a}	60.46^{a}	1.10^{b}
Average	205.81^{x}	60.51^{x}	1.17^{x}
Control (Urea 250 kg)	157.10^{y}	100.00^{x}	0.56^{y}

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

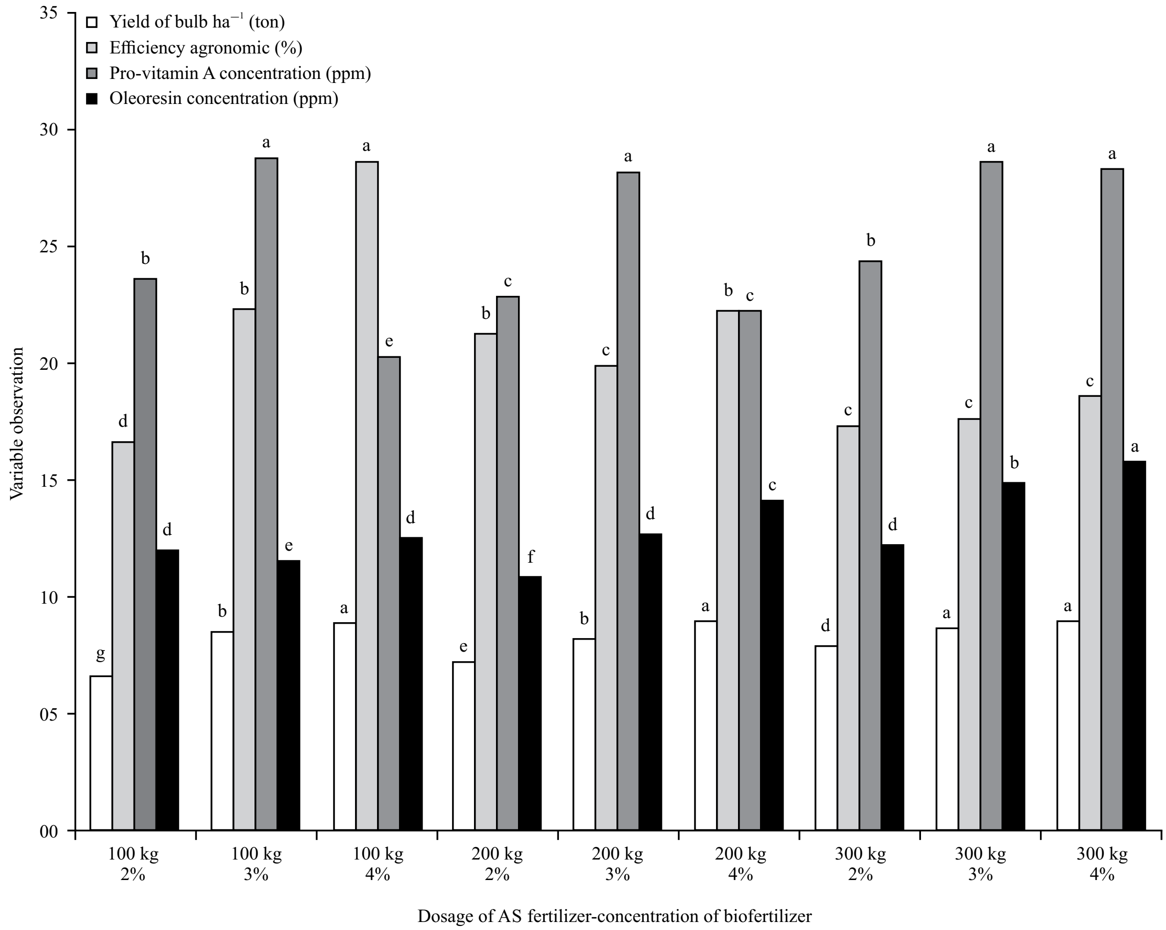

Fig. 1: Average of Fresh Yield of Bulb, Efficiency Agronomic, Provitamin A and Oleoresin Content. Mean followed by the same letters in the same column are not significantly different accordance to DMRT at $p \leq 0.05$

effect on agronomic efficiency (Fig. 1). The highest agronomic efficiency was obtained by giving AS fertilizer with doses of 100 kg ha^{-1} and 4% biofertilizer concentration while increasing fertilizer doses with biofertilizer concentrations showed low agronomic efficiency. The lowest agronomic efficiency was shown in the application of AS fertilizer with 100 kg ha^{-1} doses and 2% biofertilizers concentration.

Provitamin A: The application of AS fertilizer dosage and biofertilizer concentration was significantly different against the provitamin A concentration (Fig. 1). The high concentrations of provitamin A were obtained from the application of AS fertilizers with dosages of 100-200 kg ha^{-1} and 3% biofertilizer concentrations, as well as AS dosages 300 kg and 3-4% biofertilizer concentration, while the lowest levels of provitamin A were obtained at the application of AS fertilizer at dosages of 100 kg h^{-1} and 4% biofertilizers concentration.

Oleoresin compounds: Based on Fig. 1, the application of AS fertilizer dosage and biofertilizer shows no significant difference against the levels of oleoresin compounds. The highest levels of oleoresin compounds were obtained in the administration of AS fertilizers with dosages of 300 kg ha^{-1} and 4% biofertilizer concentration, while the lowest levels of oleoresin compounds were obtained in the application of AS fertilizer dosages of 200 kg ha^{-1} and 2% biofertilizer concentration.

DISCUSSION

In a present study, the application of AS fertilizer dosages and biofertilizers have an impact on growth commons, bulbs yields, agronomic efficiency, and bulbs quality of shallot plants. The combination of AS fertilizer and biofertilizer was significantly different compared to control. Table 1 shows that the fresh weight of plants was obtained at a combination AS fertilizer dosage with biofertilizer concentration. This is not in accordance with the report of Kuan *et al.*[20], PGPR inoculation increase biomass of corn plant, this is supported by Sulistiono *et al.*[21]. The combination AS fertilizer dosage and biofertilizer concentration increase fresh weight leave and root clumps^{-1}, this is in accordance with the previous report[22, 23]. In contrast, the combination of macroelements and microelements in biofertilizers increases the fresh weight of chickpea leaves var Gisa 195 varieties[24]. Fresh bulbs weight clumps^{-1} height was obtained from the AS fertilizer dosage and biofertilizer concentration. This is not in accordance with research Husna *et al.*[25] showed that the application of local mycorrhiza is effective in increasing the biomass of Kuku wood (*Pericopsis mooniana* Thw.), as well with a study conducted by Tuhuteru *et al.*[26]. The combination of AS fertilizer dosage and biofertilizer gives the highest dry weight of leaves and roots clumps^{-1}. This is not in accordance with Sadheep *et al.*[27] that the combination of *Pseudomonas fluorescence* and *Trichoderma harzianum* increases the dry weight of canopy shoots, as well with another ressearch[28, 29], meanwhile PGPR inoculation during the rainy season increases the dry weight of lentils[30].

Accordance to Table 2 shows that AS fertilizer dosage increases the crop index, while 4% biofertilizer concentration can increase the crop index of shallot plants. This is similar with the report by Gholami *et al.*[22] that giving PGPR in *Azotobacter* and *Azospirillum* increased crop index of corn plants, in contrast, with the other research[24]. The application of AS fertilizer with s well biofertilizer concentration did not affect the harvest index, this is not supported other studies report[31], but similar with the other research report[32]. Increasing the dosage of AS fertilizer can increase the vitamin C concentration of shallot bulbs, whereas biofertilizer concentration have no effect on vitamin C concentration. This is in accordance with Dehnavard *et al.*[33] reported that the application of high AS liquid fertilizer with 200 mM increase the vitamin C concentration in tomatoes, this is not supported by other researches[34-36].

The high of yield bulbs ha^{-1} was obtained from a combination AS fertilizer with biofertilizer concentration (Fig. 1), this is supported by the previous researche[37]. The highest of agronomic efficiency (28%) was obtained at a combination as fertilizer with biofertilizer. This is not in accordance with the report of Subandi *et al.*[38] likewise Yadav *et al.*,'s [39] report. The high provitamin A concentrations obtained in a combination of AS fertilizer dosages with biofertilizers concentration. This is supported by Shedeed *et al.*[40] that combination of 75% RDF+1.65 tons of vermicompost + *Azotobacter* Nitrogen fertilizer increase the carotenoid onion content. The high levels of oleoresin compounds in bulbs were obtained in a combination of AS fertilizer dosages with biofertilizer concentration. This is consistent with the report of Raju *et al.*[41] that the application of vermicompost + 75% RDF + *Azotobacte*r fertilizer increases 0.024% of the oleoresin content in bulbs, this is in accordance with other studies[42, 43].

In the present research showed that the application of low-dosage AS fertilizers produced plant growth and high agronomic efficiency, Increasing doses of AS fertilizer application tend to reduce the growth and agronomic efficiency of shallot plants were reported by other researchers[38,39]. But on the contrary the combination of AS fertilizer and low levels biofertilizer obtained low quantity and quality yield. Conversely on the results of quantity and quality in the administration of a combination of AS fertilizers and low levels of biofertilizers produces a low quantity and quality, the higher the dosage of the combination the better the yields in both quantity and quality were reported[37,40,41]. The experiment could provide future assistance to researchers with choice of AS fertilizer dosage 300 kg ha^{-1} and 3% biofertilizer concentration, which made high yield both the quantity and quality of bulbs and were effective fertilizer.

CONCLUSION

The combination of AS fertilizer and biofertilizer influenced growth components, agronomic efficiency, and quality of shallot include provitamin A, and vitamin C. In addition, the combination of AS fertilizer and biofertilizer had no impact on crop index, harvest index, and vitamin C. The combination of AS fertilizer with 200 kg ha $^{-1}$ dosage and 3% biofertilizer concentration increased growth, bulbs yields, provitamin A, oleoresin compounds, and agronomic efficiency in onion plants. Furthermore, providing an integrated fertilizer combination between chemical fertilizers and biofertilizers is recommended to improve agronomic efficiency and quality of shallot bulbs in the rainy season and reduce the use of chemical fertilizers. Therefore, reducing production costs and environmental pollution towards sustainable agriculture.

SIGNIFICANCE STATEMENT

The research discovers a method of cultivation on shallot in the rainy season that can beneficial for farmers and entrepreneurs shallot. This study will help the researcher to uncover the critical area of reduced shallot production in the rainy season that many researcher were not able to explore. Thus a new theory on high production of shallot cultivation in the rainy season may be arrived at.

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