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Effect of Biomineral Sources Combination on the Agronomic Character of Shallot (*Allium ascalonicum* L.) in the Offseason

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ABSTRACT: This study aims to analyse the effects combination of compound fertilizer and rhizobacteria sources on the agronomic characters of shallot in off season. The study was conducted in Sleman, Yogyakarta from February to June 2019. The experiment was arranged in a R C B D with three replications. The treatment consisted of combination between compound fertilizer (AS) first factor was dosage (150, 250 and 350 kg ha^{-1}) and 5% rhizobacteria from different three sources (rhizobacteria bamboo, rhizobacteria glyricidae and rhizobacteria peanut) each concentrasion and control. The observed were made on the growth and yield of bulb, and the data were analyzed using analysis of variance and Duncan's Multiple Range Test at $P< 0.05$. There was no interaction between indigenous rhizobacteria sources and AS fertilizer on all variables. The dosage of AS fertilizer up to 350 kg ha^{-1} did not improve the plant growt. However, there was an increase in bulb yield when 150 kg ha^{-1} at AS was applied. The application of indigenous rhizobacteria from bamboo root significantly increased the growth of shallot. The application of AS 150 kg ha^{-1} combined indigenous rhizobacteria bamboo root at 5% is recomended to promote shallot production in offseason as well as to minimize the input cost of inputs and environmental pollution.

KEYWORDS: Ammonium sulphat, harvest index, indigenous rhizobacteria bamboo, relative growth rate.
Abbreviation: AS (Ammonium sulphate), RCBD (Randomized Completly Block Design).

INTRODUCTION

In 2015-2019, there was an average decline of shallot production around 0.33% per year in Indonesia even though it is 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. While to meet the demand for shallots, it is expected to be fulfilled with domestic production without having to depend on import from other countries (Central Statistics Agency, 2015). Shallot is commonly cultivated at the beginning of dry season from April to August. In the rainy season, farmers tend not cultivate the shallot as it is very susceptible to pathogens, especially bacteria and fungi which will lead to lower production and even loss.

The increasing of shallot production is generally relied on the synthetic fertilizer to obtain a high yield but tends to cause an environmental pollution. Biofertilizer contain microorganism which mainly plays a role in nitrogen fixation, phosphate solubilzation, biocontrol of soil pathogens and produce growth regulators that can increase the growth and yield of the crop. Biofertilizers becomes more important as it is environmentally friendly, harmless, non-toxic, and also can be used to reduce the level of soil and water pollution (Kumari et al., 2010). Oliveira et al. (2014) reported that the biological fertilizer plays an important role for modern agriculture as it is environmentally friendly and sustainable. The bacteria that aggressively colonize the plant roots will produce the growth regulating substances which are capable to increasing the plant growth (Plant Growth Promoting Rhizobacteria / PGPR), produce the growth-regulating substance are capable of improving the plant growth including *Pseudomonas fluorescent* and *Bacillus subtilis*. The symbiotic free-living soil microorganism inhabiting the rhizophere of many plant species and have diverse beneficial effects on the host plant, through different mechanisms such as nitrogen fixation are generally refered to as PGPR (Rasa et al., 2016a; 2016b). These bacteria can improve plant growth by various mechanisms, such as hormonal regulation, nutrient balance, dissolving nutrients facilitating plant absorption, and increasing the resistance of pathogenic attacks (Vejan et al., 2016).

Biofertilizers can play a key role in the development of an integrated management system in the productivity of sustainable agricultural with low environmental effects (Malusa et al., 2016). Karnwal (2017) mention that the mechanisms of PGPR in increasing the plant growth are by dissolving phosphate, producing 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 functioning as a defence against the environmental.

Zrnic and Siric (2017) reported that plants with mycorrhiza were more tolerant to nutrient deficiency, water stress, soil salinity and high concentrations of heavy metals. Mycorrhizal symbiosis also 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 Helima et al. (2018) reported that biofertilizer (containing rhizobacteria and mycorrhiza) could enhance soil fertility, mineral absorpstion, growth, yield and quality of plant. PGPR has the potential to promote 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 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 (Shukla, 2018). Thus, it is necessary to study the effect various doses of ammonium sulphate fertilizer and rhizobacteria isolate from different sources on shallot production in offseason to assess the possibility of higher production.

MATERIALS AND METHODS

The research was conducted in Gamol, Balecatur , Gamping , Sleman, Yogyakarta. The soil type used was Regosol at the altitude of ± 150 m above sea level with 2000 - 3000 mm of rainfall/year, soil pH of 5.6 - 6.0 air humidity 50 - 70% and temperatures of 24 – 32 °C. The tools used were hoes, small shovel, buckets, hose, scale, measuring cup, and sprayer, while the materials used were shallot bulb, ammonium sulphat fertilizer, and indigenous rhizobacteria from bamboo, gliricidia and peanut root. This study was arranged in factorial Randomized Complete Block Design consisted two factors. The first factor was various doses of AS fertilizer (150, 250 and 350 kg ha^{-1}) and the second factor was three sources of indigenous rhizobacteria (bamboo root, gliricidia root and peanut root). Thus, there was nine treatment combinations with one control (350 kg ha^{-1} of AS fertilizer, without indigenous rhizobacteria) with three replications within each treatment. The indigenous rhizobacteria were repared by bathing of 100 g of the root of each source (gliricidia, bamboo and peanut) (Vejan et al., 2016; Rasa et al., 2016a; 2016b), in 1 L of cold water that has been heated for three days. They were mixed with 400 g of granulated sugar, 200 g of shrimp paste, 1 kg of bran, flavoring, then added water to a volume of 10 L. The mixture was then boiled, cooled, and then filtered and put in a closed place. The solution was allowed to stand for seven days and stirred every two days until homogeneous. The concentration of indigenous rhizobacteria solutions of pure ingredients was made 5% for each source.

Shallot seedling were obtained from the local farmers in Bantul district. The planting media was prepared by performing soil tillage two weeks before planting. The seedling were planted the depth of 30 cm, in three blocks, and each block consisted of 10 plots measuring 1x1 m with a planting space of 20 x 20 cm and distance between plots and block of 50 cm. The cow manure was applied as a basic fertilizer at a doses of 0.5 kg plot $^{-1}$ (5 ton ha^{-1}). The secondary fertilization was done by adding AS fertilizer at various doses (150, 250 and 350) kg ha $^{-1}$ and several sources of indigenous rhizobacteria (gliricidia, bamboo and peanut root) according to the treatment. Pest and weeds were controled manually by removing them. The bulb were harvested at 60 days after planting. The bulbs were dried by spreading them on a bamboo mat in a room with a temperature of 27 - 28 °C for 2 hours every day for a week.

The observed variables at vegetative growth phase during 30 days (4 weeks) and at harvest time (8 weeks) included:

Crop Growth Rate = $\frac{1}{A} \times \frac{W2-W1}{T2-T1}$ g/m^2/day Relative Growth Rate = $\frac{\ln W2-W1}{t2-t1}$ mg/g/day

Net Assimilation Rate = xg / m^2/day

(Aziez et al., 2019) $\frac{W2-W1}{T2-T1}$ $\frac{\ln LA2-\ln LA1}{LA1-LA1}$

Absolute Growth Rate = $\frac{W2-W1}{T2-T1}$

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

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

and fresh weight of bulb, yield ha $^{-1.}$
(Shehu, 2014)

Where:
LA_1 = Leaf Area of plant/m^2, recorded time t_1,
ln = natural log
LA_2 = Leaf Area of plant/m^2, recorded time t_2
W_1 = Dry weight of plant/m^2, recorded time t_1 W_2 = Dry weight of plant/m^2, recorded time t_2
We = Weight economic yield
Wb = Weight biological yield
Ws = weight straw yield

The data collected were analysed by using analysis of variance and Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$.

RESULTS AND DISCUSSION

Based on the results of analysis, there was no interaction between the doses of ammonium sulphate fertilizer and sources of indigenous rhizobacteria on all observed variables (Table 1).

Table 1. Effect of AS fertilizer dosage and sources of indigenous rhizobacteria on Crop Growth Rate, Absolute Growth Rate, Relative Growth Rate, Net Assimilation Rate

Treatment Dose of AS Fertilizer/ Sources of Indigenous Rhizobacteria (IR)	Observed Variables			
	Crop Growth Rate (g/m^2/day)	Absolute Growth Rate (mg/g/day)	Relative Growth Rate (m/g /day)	Net Assimilation Rate (g/m /day)
Control	2,70 b	0,10 b	0,03 b	0,10 b
150 kg ha^{-1}	2,98 b	0,12 b	0,35 b	0,11 b
250 kg ha^{-1}	3,68 b	0,15 b	0,05 b	0,15 b
350 kg ha^{-1}	2,64 b	0,10 b	0,03 b	0,10 b
Bamboo IR	1,32 b	0,05 b	0,01 b	0,05 b
Gliricidia IR	5,78 a	0,21 a	0,07 a	0,21 b
Peanut IR	2,71 b	0,11 b	0,03 b	2,71 a
No Interaction	$P \geq 0.05$	$P \geq 0.05$	$P \geq 0.05$	$P \geq 0.05$

Note: Means followed by the same letter in the same column are not significant different according DMRT at $P \leq 0.05$.

Crop Growth Rate (CGR)

Table 1 shows that CGR is not affected by the various doses of ammonium sulphate fertilizer. There is no significant difference between control and the treatments. This result shows is different from the study by Nori et al. (2012) reporting that the application of ammonium sulphate fertilizer at a dose of 250 kg ha^{-1} can increase the growth of garlic. Shallot treated with indigenous rhizobacteria from bamboo root are not significantly different with indigenous rhizobacteria from peanut and is not significantly different from the control. However, the application of indigenous rhizobacteria from gliricidia produced the best response of CGR. Accordance of to the report El- Shafery and El- Hawary (2016) inoculation biofertilizer cerealin combined with

75% nitrogen recommended increase crop growth rate of maize. This result is not consistent with the opinion of Aziez et al. (2019) that application of mycorrhiza was increased CGR.

Absolute Growth Rate (AGR)

The absolute growth rate and the yield of shallot were not affected by the application of ammonium sulphate at various doses up to 250 kg ha $^{-1}$. These result are not in accordance with the study by Mishu et al. (2013) stating that 40 kg/ha of S produced the best result in LAI (Leaf Area Index), RGR, AGR and NAR of red onion. The AGR of shallot treated with indigenous rhizobacteria from bamboo and peanut was not significantly different from the control. The indigenous rhizobacteria from gliricidia produced the best result in AGR. This result is not consistent with the opinion of Aziez et al. (2019) that application of mycorrhiza was increased AGR

Relative Growth Rate (RGR)

The application of ammonium sulphate fertilizer did not give significantly different effect compared to the control. Mishu et al. (2013) reported that the application of 40 kg ha^{-1} of S on shallot resulted the best RGR. The application of indigenous rhizobacteria peanut bamboo and peanut did not show a difference result compared to the control. Conversely, the indigenous rhizobacteria from gliricidia resulted the highst RGR. This result is consistent with the opinion of Aziez et al. (2019) that application of mycorrhiza can increase RGR.

Net Assimilation Rate

The application of ammonium sulphate fertilizer at various doses up to 350 kg ha^{-1} did not significantly affect NAR of shallot compared to the result obtained by the control. Mishu et al. (2013) reported that the application of 40 kg ha $^{-1}$ of S resulted the best NAR of the shallot, while El- Shafery and El- Hawary (2016) reported that inoculation biofertilizer cerealin combined with 75% nitrogen recommended increase net assimilation rate of maize. The best result was obtained by the application of indigenous rhizobacteria from peanut. This result is supported by Bulegon et al. (2017) who stated that the application of *Azospirillium brasilense* can increase the photosynthesis rate of *Urochloa ruziziensis*.

Bulb Yield

The highest yield of shallot was obtained by the application of ammonium sulphate fertilizer at a dose 150 kg ha^{-1} (Figure 1). Nevertheles, the increasing doses of AS fertilizer up to 350 kg ha^{-1} decreased the yield of shallot bulbs as the concentration of the AS solution in the soil can inhibit the nutrients adsorption leading to lower weight of shallot bulb. This result is supported by de De Souza et al. (2015) stating that the application of S at a dose of 45 kg (equivalent to 200 kg of AS fertilizer) can result higher shallot bulbs than the application at the doses up to 90 kg. Likewise Diriba-Shiferaw (2016) reported that inorganic fertilizers S 60 – 120 kg ha $^{-1}$ was recommended to increase both yield potential and quality of garlic crop.

The various sources of indigenous rhizobacteria increased shallots yield compared to the control. The highest bubl yield was observed in shallot treated with indigenous rhizobacteria from bamboo. This result is consistent with the study by Ahmad et al (2017) reporting that innoculation of multi-strain biofertilizer improved the productivity of chickpea under drought. Tuhuteru et al. (2018) mentioned that the application of PGPR isolate (*Burkholderia seminalis*) could encrease the yield of shallot cultivar tuk-tuk. Likewise, the average grain yield of cultivar Ibaa99, three times application of EM spraying and their interaction showed the highest values of 3.89 and 4.31, 3.85 and 4.36 and
4.11 and 4.58 ton ha^{-1}, respectively (Al- Naqeeb et al., 2018).

Meanwhile Einizadeh and Shokouhian (2018) reported that the application of 2% EM could increase fresh weight stroberry fruits, likewise report Yousaf et al. (2018) inoculation of *Rhizobium yaponicum* and *Pseudomonas flourescens* improve biomassa yield of soybean, The result is also in accordance with the opinion of Bertham et al. (2019) mentioning that the application of biofertilizers can increase soybean yield, as well as Mahmood et al. (2019) inoculation PGPR was increased the yield of lentil.

Growth Index (GI)

The application of various doses of ammonium sulphate fertilizer and several sources of indigenous rhizobacteria did not give significant effect on the growth index compared to the control (Figure 2). The result is not in accordance with the study conducted by Gholami et al. (2012), reporting that *Azotobacter* and *Azospirillum* inoculation could increase Growth Index of maize grain**.**

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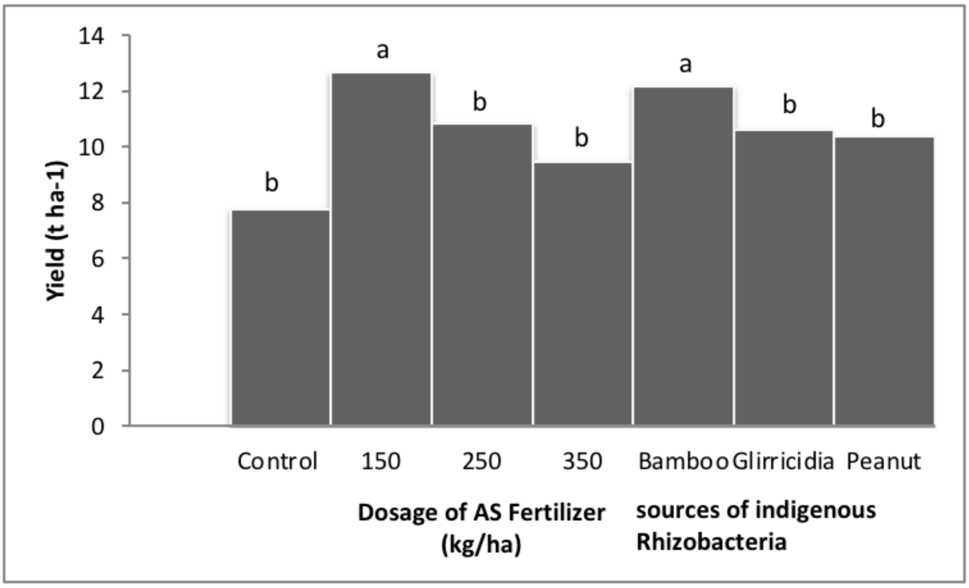

Figure 1. Yield of bulbs as affected by various doses of ammonium sulphate and several of sources of indigenous rhizobacteria.

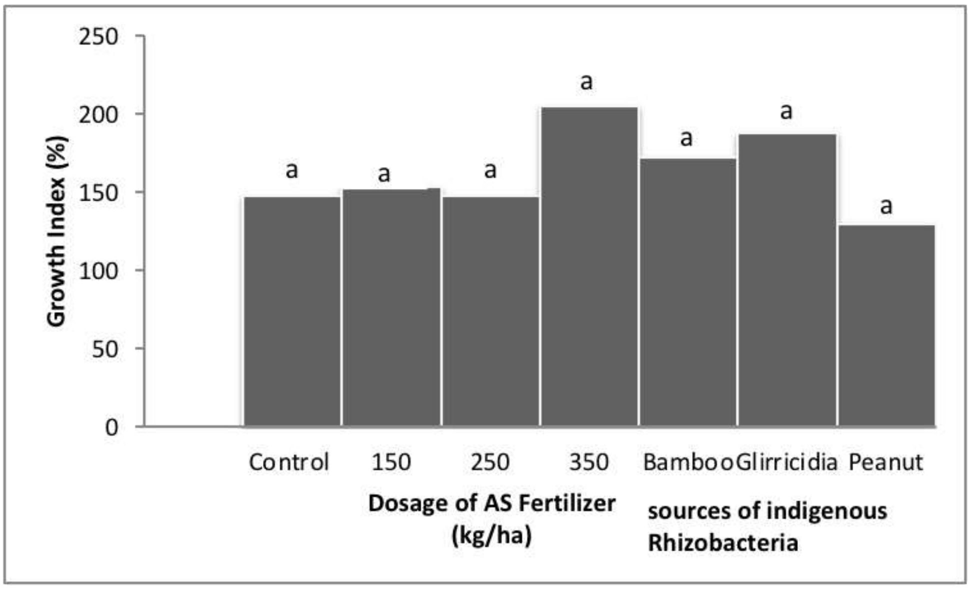

Figure 2. Growth index as affected by various doses of ammonium sulphate and several sources of indigenous rhizobacteria.

Fresh Weight of Bulb per Clumps

Figure 3 shows that the doses 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 indigenous rhizobacteria from bamboo. This result is not in line with the result by Mukhongo et al. (2017) stating that a combination of biofertilizer and nitrogen fertilizer could increase the sweet potato biomass. Likewise Ali et al. (2017) reported that use rhisobia could improve the growth of corn plant, and chikpea rhizobia were more effective than lentil rhizobia. Furthermore, the use of multi- strain rhizobial consortium can be a better strategy in improving the growth of crops. According to the report Jamshaid et al. (2018) bacterial inoculation prominently increased the root length of chickpea. Significantly higher shoot biomass was observed in response to inoculation with bacterial isolates as compared to un-inoculated control.

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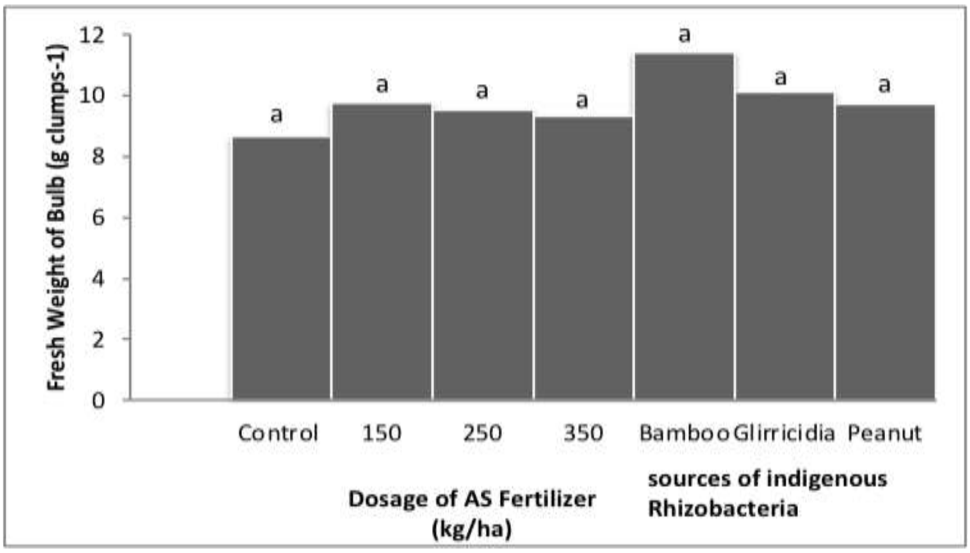

Figure 3. Fresh weight of bulb as affected by various dose ammonium sulphate and several sources of indigenous Rhizobacteria.

Harvest Index

The application of ammonium sulphate fertilizer and various sources of rhizobacterium could not increase the harvest index (Figure 4). This result is not accordance with the report by Ahmed et al. (2011), stating that biofertilizers (yeast and Azotobacter) as liquid form directly on plant 20 L sprayer and organic fertilizer 20 m^3 fed^{-1} dosages can increase harvest index of wheat plant.

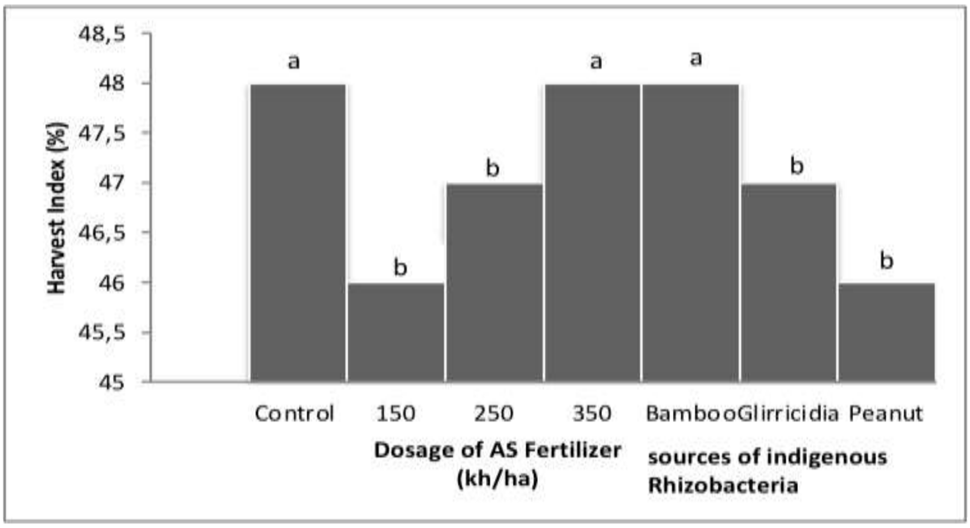

Figure 4. Harvest index as affected by various ammonium sulphate doses and several sources of indigenous Rhizobacteria.

CONCLUSION

There was no interaction effect between doses of ammonium sulphate fertilizer and sources of rhizobacteria on all observed variables. The doses of ammonium sulphate fertilizer did not affect the growth and yield of shallot. The indigenous Rhizobacteria from gliricidia significantly increased the growth of shallot, while indigenous Rhizobacteria from bamboo significantly increased the yield of shallot bulb. The application of indigenous rhizobacteria from bamboo could improve the agronomic traits of shallot as it was capable of reducing the highest doses of AS. Hence, the use of AS fertilizer at a doses 150 kg ha^{-1} and indigenous Rhizobacteria from bamboo is recomended to improve shallot production in off season as well as to minimize the inputs cost and environmental pollution, leading to ecofriendly and sustainable agriculture.

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