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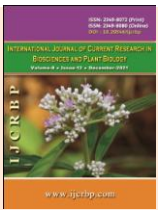

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Application of biocompost enriched with arbuscular mycorrhizae for the growth of *Allium cepa* L.

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Abstract

Synthetic technology application in the planting center of onion (*Allium cepa* L) Enrekang district, Indonesia, has passed the threshold recommendation dosage of manufacturer and agricultural extension. The synthetic fertilizer application with high dosage and inefficient nutrient absorption by plants is a problem that must be solved. So that, the proposed solution hypothesis is the application of biocompost enriched with Arbuscular Mycorrhizae (AM) as biological agents can reduce synthetic fertilizers use and absorption nutrients increase by plants. The aim of research to determine the growth of *Allium cepa* given dosage of biocompost enriched with AM, and research novelty are modification of innovation biocompost with AM as biological agent for growth of *Allium cepa*. The research was conducted for six months using model of Randomized Block Design. The treatment dosage of biocompost enriched with AM, are BM0 (control: *Allium cepa* planting method of local farmers); BM1 (Dosage of biocompost 100 kg.plot^{-1}+ AM); and BM2 (Dosage of biocompost 200 kg.plot^{-1}+AM), enrichment of biocompost with AM was carried out by mixing 2 kg of AM propagules for each treatment. The observed research variables are leaves number, root length, root diameter, root surface area, and tuber number. Observational data in the field and laboratory were analyzed using analysis of variance and Duncan's test. The results showed that the biocompost at a dose of 200 kg.plot^{-1} enriched with AM showed better growth in leaf number, root length, root diameter, root surface area, and the number of tubers compared to other treatments. So that the application of biocompost at a dose of 200 kg.plot^{-1} is the main finding in this study and can be recommended as a good dose for the production of *Allium cepa* which is environmentally friendly. This research supports sustainable and environmentally friendly agricultural systems which are the scope of healthy future agriculture.

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Introduction

Onion (*Allium cepa* L.) is one of the main commodities of horticultural crops that have long been intensively cultivated by community in Enrekang regency, Indonesia. This vegetable commodity belongs to the group of spices that function as food seasoning (Bamba et al., 2020; Marta et al., 2020) and traditional medicine (Chernukha et al., 2021; Marefati et al., 2021), which have high economic value.

Synthetic technology innovations in *Allium cepa* planting centers have been widely applied by farmers, but are still oriented towards increasing the quantity of production and not yet oriented towards improving the quality of production. (Asaad, 2014) explained that the use of organic fertilizer by *Allium cepa* farmers in Enrekang has been applied but still uses chemical fertilizers at a dose of 250 kg urea + 50 kg ZA + 50 kg SP-36 + 50 kg Ponska, and exceeded the recommended dose by agricultural extension. This allows for excessive use of nutrients so that they can become a source of pollution for water, soil, and the *Allium cepa* product.

Arbuscular mycorrhizae (AM) use as biological agents to reduce chemical fertilizers use (El-Sherbeny et al, 2022; Trejo et al., 2021), increase of water use efficient (Begum et al., 2019; El-Tohamy et al., 2021), and increase nutrient absorption (Begum et al., 2019; Li et al., 2020) has been researched and applied to various horticultural crops (Golubkina et al., 2020; Karti et al., 2021), food crops (Campo et al., 2020; Addo et al., 2020), plantation crops (Fajariza et al., 2020; Pena-Venegas et al, 2021; Rini et al., 2021), fodder forage crops (Rosita et al., 2020; Karti et al., 2021) and afforestation crops (Aji et al., 2021; Husna et al., 2021). However, the use of biocompost fertilizer has not been widely applied by *Allium cepa* farmers by utilizing microorganisms as biological agents to absorption maximized of nutrients contained in the bio compost. So that need a research on the innovation of biocompost which enriched AM as *Allium cepa* growth stimulation.

The aim of research is to determine the *Allium cepa* growth given a dosage of biocompost enriched with AM, while research novelty is modification of bio compost innovation with AM as biological agent for *Allium cepa* growth stimulation.

Materials and methods

The research was carried out on area *Allium cepa* plantation in Sipate village, Anggeraja sub-district, Enrekang, Indonesia at an altitude of 1022 m.a.s.l which uses full synthetic chemical technology. The soil chemical properties on the land used for planting *Allium cepa* can be seen in Table 1.

Table 1. Soil chemical properties on area onion plantation in Sipate, Anggeraja sub-district, Enrekang in the district. Indonesia, and the quality of goat feces biocompost.

Items	pH	CEC	BS (%)	C/N	N (%)	P_2O_5 (ppm)	K	Mg	Na
Area onion plantation	6.72	20.00	41	6	0.17	12.94	0.17	1.07	0.24
Biocompost of goat feces	6.55	-	-	19	1.26	0.93	0.45		

The research were arranged using a randomized block design and treatment dosage of biocompost enriched with AM used were BM0 (control: local farmer's method of planting *Allium cepa*); BM1 (Dose of biocompost 100 kg.plot^{-1}+AM), and BM2 (Dose of biocompost, 200 kg.plot^{-1}+AM). Each treatment repeated in 3 plots with area of 15 m x 15 m per plot. Enrichment of biocompost with AM was carried out by mixing 2 kg of AM propagules for each treatment.

The biocompost used is delivered from the fermentation of goat feces, which is a business owned by the people of Enrekang district (the biocompost quality can be seen in Table 1), while AM used to enrich biocompost were isolated from various of crop rhizospheres in areas that have been contaminated with heavy metals of Ni, Fe, Pb Cr, Cu, dan Co. Morphological identification of AM spores, multiplication of spores using culture media and host plants have been carried out in the early stages of research.

Components of observing the effectiveness of biocompost enriched with AM included plant height, leaves number, root length, root diameter, root surface area, and tuber of *Allium cepa* number, which were carried out in the mini-laboratory of Agroplastid Farm, Parepare; while the analysis of soil characteristics was carried out at the soil chemistry and fertility laboratory

of Hasanuddin University, Makassar. Data from observations in the field and in the laboratory were analyzed using analysis of variance and Duncan's test.

Results and discussion

Number of leaves

Analysis of variance showed that the treatment of biocompost enriched with AM does significant effect on leaves number of *Allium cepa*, and the results of Duncan's test showed that *Allium cepa* with treated biocompost of 200 kg.plot^{-1} enriched with AM had a higher number of leaves and significantly different from other treatments (Fig. 1). This phenomenon is probably caused by the addition of C/N contained in biocompost enriched with AM can improve the physical, chemical, and biological properties of the soil, moreover, the addition of biological agents of AM can help the absorption of water and nutrients for plant growth.

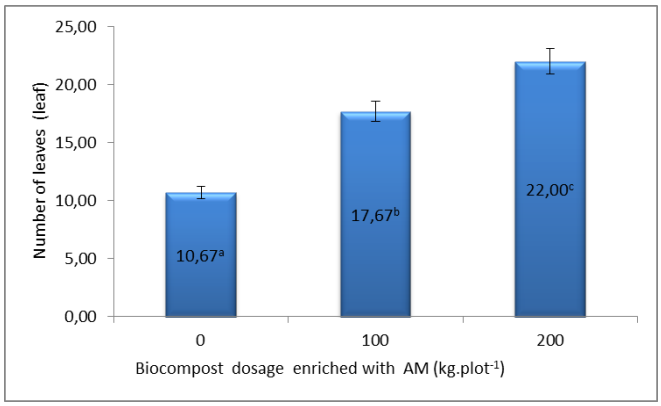

Fig. 1: Average of *Allium cepa* leaves number given biocompost enriched AM.

The high-value C/N ratio indicates that organic matter still needs process advanced of decomposition so that nitrogen (N) can be available and occur balance nutrient concentrations in the soil according to plant needs which ultimately stimulates *Allium cepa* to form new leaves.

Organic fertilizers can provide good growing environment for plants (Shang et al., 2020; Anggraini et al., 2021), so organic fertilizers must be applied in large quantities to provide macro- and micro-nutrients needed for optimal plant growth and performance (Adekiya et al., 2020; Kumar et al., 2021). However, organic fertilizer obtained from goat manure generally has a C/N value greater than 30, so it must be decomposed first, as good manure must have a C/N value less than 20 (Trivana and Pradhana, 2017; Batubara et al., 2021).

Root length

Variance test showed that the *Allium cepa* root length variable was significantly affected by biocompost enriched with AM. Whereas, Duncan's test showed that the application of 100 and 200 kg.plot^{-1} biocompost enriched with AM gave root length not different effect significantly (Fig. 2). This phenomenon is possibly caused by the provision of biocompost enriched with AM can contribute K elements for the growing roots of *Allium cepa* (Table 1), so that roots grow more actively to nutrients absorb contained in biocompost which present at layer soil on the depth of 5 to 15 cm. Besides that symbiosis of roots and AM is also very supportive of the absorption of water and nutrients through external hyphae.

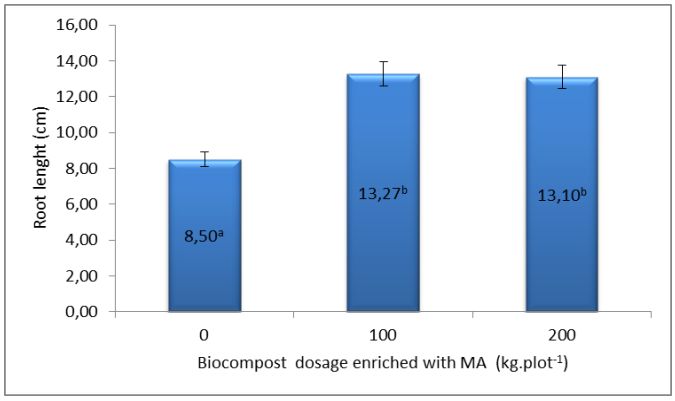

Fig. 2: Average of *Allium cepa* root length given biocompost which enriched AM.

According to Sustr et al. (2019) and Kumar et al. (2021) that one of the potassium element functions is to stimulate root meristem cell division so that grows lengthwise to absorb water and nutrients. The results of Song et al. (2015) and Sustr et al. (2019) showed that potassium deficiency could inhibit lateral root length, lateral root number, and total root length in cotton sprouts.

Potassium is a macronutrient that has roles in regulating plant physiological processes such as cell division, photosynthesis, opening and closing of stomata, regulating water distribution in tissues and cells, transporting nutrients from roots to leaves, accumulation and translocation of sucrose, filling seeds and tubers, root growth, cellulose synthesis, strengthen cell walls and stems, play a role in enzymatic systems, plant resistance, protein synthesis, pH regulation, affect

the quality (taste, color, and weight) of fruit and flowers, increase plant resistance to drought, pests/diseases, accelerate the growth of meristem tissue (Hasanuzzaman et al., 2018; Xu et al., 2020; Sardans and Penuelas, 2021).

Root diameter

Results of variance analysis showed that the treatment of biocompost enriched with AM had a significant effect on root diameter variables of *Allium cepa*. Furthermore, Duncan's test showed that the highest mean value of root diameter obtained on the application of 200 kg.plot^{-1} biocompost enriched with AM and was significantly different from other treatments (Fig. 3). This phenomenon is probably caused by the addition of nitrogen (N) and phosphate (P) elements derived from biocompost enriched with AM (Table 1) which can increase the assimilating production in leaves through the photosynthesis process and accumulate to plant lower organs for root growth including root diameter so that expanding absorption area. Besides that, the absorption of water and nutrients is also carried out by external hyphae of AM.

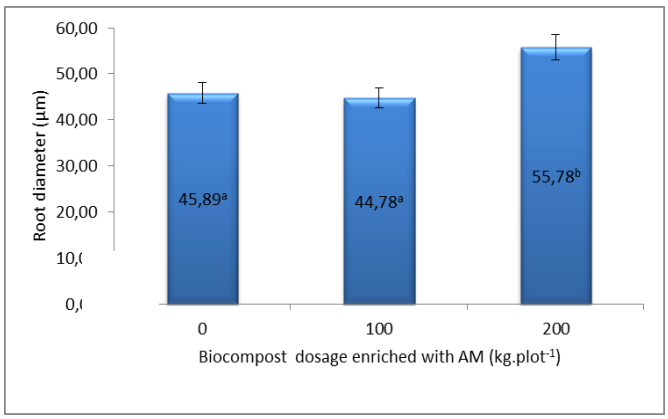

Fig. 3: Average of *Allium cepa* root diameter given biocompost which enriched AM.

According to Shrestha et al. (2020) and Savarino et al. (2021), N as macronutrient function to stimulate plant growth, assimilate produced through the photosynthesis process are a source of energy for plants to carry out further metabolic processes (Walker et al., 2020; Stephens et al., 2021), which also a source of energy for AM as a form of mutualistic symbiosis between plants and mycorrhizae (Sugiura et al., 2020; Yu et al., 2020). Besides that, the photosynthesis product in the form of assimilate constitute the source of energy used for three activities, namely: (1) for plant growth (Ajdanian et al., 2020; Yavari et al., 2021), (2) stored as food reserves (Siahpoosh, 2014; Aluko et al., 2021), and (3) stored as a sink which is a form of plant economic yield (Arifin et al., 2019; Sales et al., 2021).

Phosphate (P) is the second essential element after N which plays an important role in photosynthesis and stimulates root development. Roots that are not well developed cannot absorb more nutrients (Szulc et al., 2020; Vysotskaya et al., 2020; Etesami et al., 2021).

Root surface area

Analysis of variance showed that treatment of biocompost enriched with AM had a significant effect on the root surface area of *Allium cepa*, and then Duncan test results showed that shallots treated with 200 kg.plot^{-1} biocompost enriched with AM, had a wider root surface area than other treatments (Fig. 4). This phenomenon was closely related to the variables of root length and root diameter. Plants that have a high value of root length and diameter will have a wide root surface area.

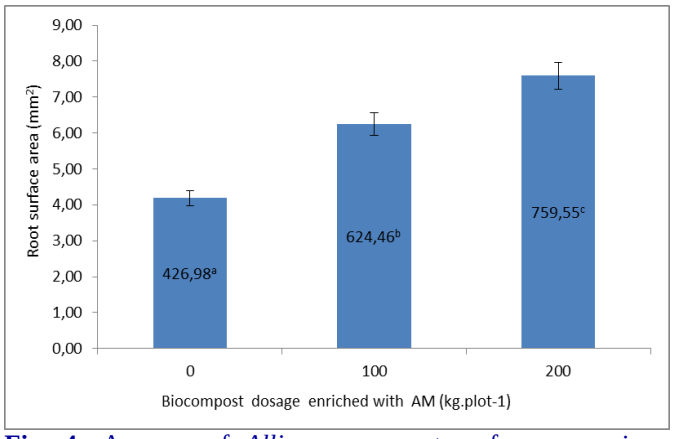

Fig. 4: Average of *Allium cepa* root surface area given biocompost which enriched AM.

The wide root surface will cause the absorption of water and nutrients to be very effective because the contact between the surface of soil particles and root surface is wider, besides that surface contact also occurs between the external hyphae of AM with the surface of soil particles so as to further increase the absorption of water and nutrients to meet plant needs. According to (Huang et al., 2020; Etesami et al., 2021). that one of the roles of arbuscular mycorrhizae is to increase the root's specific surface area so that can reach nutrients in the soil.

Number of bulbs

Results of variance analysis showed that treatment of biocompost enriched with AM had significant effect on number of tubers *Allium cepa*. The dose of biocompost 200 kg.plot^{-1} enriched with superior AM gave a different effect with the dose of biocompost 100 kg.plot^{-1} enriched with superior AM and without giving biocompost enriched with AM (Fig. 5). This phenomenon can be suspected that additional nutrients N, P, and K from biocompost caused plants to experience better growth and increase the tuber number of *Allium cepa*, which also cannot be separated from the war of AM as an agent biological in absorption water and nutrients.

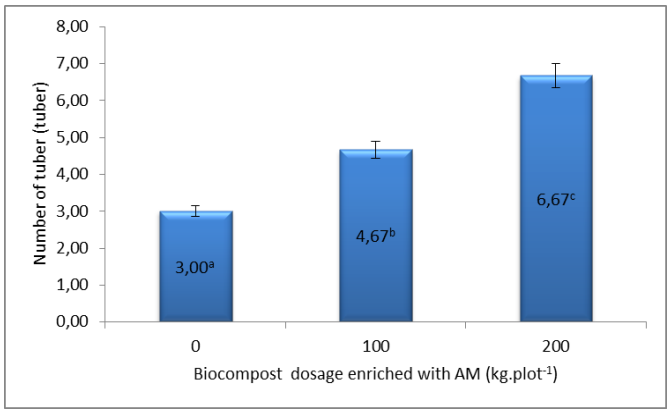

Fig. 5: Average number of *Allium cepa* tuber in biocompost enriched with AM.

Allium cepa require input of nutrients are used as a source of energy for the growth process. Nutrients nitrogen, phosphate, and potassium are important factors and must always be available to plants, because they function in the metabolic and biochemical processes of plant cells (Feng et al., 2020; Paiman et al., 2021; Wang et al., 2021). Nitrogen as a builder of nucleic acids, proteins, bioenzymes, and chlorophyll (Raul et al., 2016; Feng et al., 2020; Kishorekumar et al., 2020). Phosphorus as a builder of nucleic acids, phospholipids, bioenzymes, proteins, metabolic compounds, and is an important part of ATP in energy transfer (Stigter and Plaxton, 2015; Kolodiazhnyi, 2021). Potassium regulates the balance of ions in cells, which functions in regulating various metabolic mechanisms such as photosynthesis, carbohydrate metabolism and translocation, protein synthesis plays a role in the respiration process and increases plant resistance to pests and diseases (Hasanuzzaman et al., 2018; Dar et al., 2021; Torabian et al., 2021).

Mutualism symbiosis between MA and the root system of *Allium cepa*, both provide mutual benefits. Mycorrhizae work by infecting the root system of *Allium cepa* in producing an external hyphae network that grows expansively and penetrates the sub-soil layer of the soil, thereby increasing the root's capacity to absorb nutrients and water. Manan et al. (2021) and Rubin and Gorres (2021) explained that the extensive mycelium system (vegetative part of the fungus) effectively scoured the soil substrate to obtain soil inorganic nutrients including macronutrients N, P and K and several micronutrients, Cu, Fe and Zn (Begum et al., 2019; Xue and Wang, 2020; Liu et al., 2021), with some of capacity to obtain organic nitrogen and phosphorus (Li et al., 2019; Lin et al., 2020). The nutrients obtained are not only important for the development of the mycorrhizae themselves but are also partially transferred to the host plant (Begum et al., 2019; Sagar et al., 2021).

Conclusions

The growth and production of *Allium cepa* by giving biocompost 200 kg.plot^{-1} enriched with AM resulted in better growth of leaf number, root length, root diameter, root surface area and number of tubers compared to other treatments. This dose can be a solution to reduce the use of synthetic fertilizers, increase the efficiency of nutrient absorption, and filter the absorption of heavy metals so that system of healthy agricultural, sustainable, and environmentally friendly can be realized to maintain human health and save our earth.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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