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(Research Article)

Influence of biofertilizers application to improve growth and yield of celery in Andisols

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Abstract

Increasing crop production in sustainable agriculture needs environmentally friendly inputs. Biofertilizers are fertilizers that contain beneficial soil microbes capable of facilitating the availability of soil nutrients. The experiment was carried out to examine the effect of application of biofertilizers on the growth and yield of celery on Andisols of West Java, Indonesia. The field experiment using a Randomized Block Design (RBD) consisted of five treatments with six replications. The treatments consisted of four types of biofertilizer, and one control treatment, , included: inorganic compound NPK fertilizer (control), microbial coated urea I, microbial coated urea II, mixed biofertilizer, mixed biofertilizer phosphate enriched nitrogen microbes. The microbial coated urea consists of *Azotobacter* and *Bacillus* bacteria composition, this formula is made by coating prilled urea with concentration liquid biofertilizer of microbe coated urea I 10%, and microbe coated urea II 5%. The consortium biofertilizer is formulated in liquid inoculant consists of N-fixing bacteria *Azotobacter chroococcum, A. vinelandii, Azospirillum* sp. and *Acinetobacter* sp., P-solubilizing microbes *Burkholderia cepacea* and *Penicillium* sp.. The mixed biofertilizer phosphate consists of *Burkholderia cepace*, *Pseudomonas mallei, Aspergillus niger* and *Penicillium* sp. The results showed that application of mixed biofertilizers consists of N-fixing bacteria *Azotobacter chroococcum, A. vinelandii, Azospirillum* sp. and *Acinetobacter* sp., P-solubilizing microbes *Burkholderia cepacea* and *Penicillium* sp. had better in increasing for growth and yield of celery.

Keywords: Coated; Microbial; N-fixing; P-solubilizing; Urea

1. Introduction

Andisol is a soil that has important potential as a medium for plant growth because it has a high organic matter content [1]. However, Andisols have problems such as acidic soil pH and low availability of P. The low availability of P was caused by the strong binding of P to the soil colloid and the high P retention of > 80% [2]. P retention is a problem, especially in dry acid soils with clay textures that contain a lot of Al and Fe oxides [3]. This high P retention resulted in inefficient use of P fertilizer. To overcome the problem of P in Andisols, sustainable treatment is needed through the use of soil microbes that play a role in the transformation of P.

Soil microbes play an important role in the phosphorus transformation process and are integrally a component of the P cycle in the soil that can effectively release P from inorganic and organic forms through dissolution and mineralization mechanisms [4]. Microbial biomass in the soil also contains immobilized P, so it can provide a source of P for plants [5]. Therefore, soil microbes are very important in the transformation of P from a form that is not readily available in the soil to a form available to plants and is also important in maintaining the availability of P in the soil.

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Some bacteria in the soil can convert atmospheric nitrogen into free-growing ammonia in the plant rhizosphere non-symbiotically. Non-symbiotic N_2-fixing bacteria include *Azotobacte* [6], *Azomonas* [7], *Azospirillum* [8], *Clostridium* [9], Blue green algae as well as some *Bacillus* and *Pseudomonas. Azotobacter* is an N_2-fixing bacteria capable of producing growth-promoting substances gibberellins, cytokinins and indole acetic acid, so that their use can stimulate root growth [10]. Utilization of N-fixing microbes in organic agriculture is very important in providing biological N nutrients. *Azosprillum* besides being able to fix N has been known to stimulate plant growth due to the production of phytohormones.

To support environmentally friendly agriculture, the application of biofertilizers combined with biofertilizers is practical and economical. According to several patent documents, viable microbes (vegetative cells or "non-living" cells, spores) can be mixed with triple super phosphate microbial-free dry manure compost, dry humic acid and calcium phosphate to produce microbial-inorganic fertilizers. With the addition of a polymer, *Bacillus* spores can be sprayed onto the fertilizer surface.

The development of microbial-coated inorganic fertilizers (and organic matter) is the first and important step to initiate balanced fertilization in sustainable vegetable crop cultivation. In Indonesia, this commercial product has not yet been developed and research on microbial-coated NPK is very limited. NPK fertilizers coated with starch and cellulose have been shown to release nutrients slowly [11]. Nitrogen release studies showed that multilayer chitosan-alginate, and chitosan-pectin as coating materials were able to reduce nitrogen release of layered NPK fertilizers [12]. However, the effect of coating inorganic fertilizers by bacteria on N release has not been reported. Bacillus heterotrophic bacteria have been used to coat urea [13]. Therefore, research is needed to examine the effect of biofertilizers and inorganic fertilizers coated with microbes on the growth of celery in Andisols.

2. Material and methods

Field experiment were conducted at karyawangi village, Parongpong district of Bandung Barat Regency (6^o 48'27''S and 107^{o}34'41"E) between July and September 2020. The site is a typical Soil in trial field is tropical volcanic soil (Andisols) with slightly acid soil reaction, organic carbon (C) of 1.62%, total N of 0.19%), the content of total P_2O_5 and K_2O were as high as 60.78 mg/kg and 44.21mg/kg respectively; available P_2O_5 was 10.75 mg/kg. The cation exchange capacity of soil was as high as 27.58 cmol/kg. In general, the soil had a limited C amount of C and N, and a low ratio of C to N. Nonetheless the P_2O_5 and K_2O were high.

The trials were laid in a randomized complete block design. The treatment included five treatments, four types of biofertilizer, and one control treatment, included:

- NPK fertilizer (control)
- Microbial coated urea I (10%)
- Microbial coated urea II (5%)
- Mixed biofertilizer
- Mixed biofertilizer phosphate enriched nitrogen microbes

Each treatment was replicated 6 times. The microbial coated urea consists of *Azotobacter* and *Bacillus* bacteria composition, this formula is made by coating prilled urea with concentration liquid biofertilizer of microbe coated urea I 10%, and microbe coated urea II 5%. The consortium biofertilizer is formulated in liquid inoculant consists of N-fixing bacteria *Azotobacter chroococcum, A. vinelandii*, *Azospirillum* sp. and *Acinetobacter* sp., P-solubilizing microbes *Pseudomonas cepacea* and *Penicillium* sp. The mixed biofertilizer phosphate consists of *Pseudomononas cepace, Pseudomonas mallei, Aspergillus niger*, and *Penicillium* sp. The application of NPK fertilizer (control treatment), microbial coated urea I, II, and mixed biofertilizer was carried out after one week after planting, while the mixed biofertilizer phosphate enriched nitrogen microbes was applied three days before planting by mixing with the soil.

Plots of the celery were 1x3 m and the distance between plots was 30 cm. the celery was grown in a plastic house with a bamboo frame and ultraviolet plastic a lower light intensity during the day. The cow manure was the application in all beds soil a week before planting with 20 t/ha. Doses of NPK was 200 kg/ha, microbial coated urea and mixed biofertilizer phosphate enriched nitrogen microbes were 100 kg/ha, while the dose of liquid mixed biofertilizer was 10 L/ha. The number of individual plants in each plot was 100. The celery was then maintained for 8 weeks at the end of the experiment, a whole plants harvested from six plant sample in each plot.

The height of shoot celery was measured once in two weeks from two weeks after planting until harvest time. A fresh and dry weight of shoots and roots plants harvest time at 8 weeks. Both shoots and roots biomass were wrapped in a paper bag and stored in the oven for 2 days at 60^{o} C until constant weight. And then the ratio of shoot and root was calculated based on the dry weight of shoots and roots. All of the data celery were subjected to analysis of variance (p< 0, 05) using Duncan multiple range test. The analysis has been carried out by using software IBM SPSS Statistic version 24.

3. Results and discussion

Application of microbial coated urea and mixed biofertlizers had no effect on plant height of celery at two until eight weeks after transplanting. Figure 1 shown that plant height of celery with NPK application and microbial coated urea were not significantly different. This showed that NPK 100% (200 kg/ha) had the same effect as Urea fertilizer coated with microbes (100 kg/ha). From this experiment, it can be seen that the application of microbial coated urea can reduce the need for inorganic fertilizers. This is because the microbes coated in urea contain *Azotobacter* which are able to fix N and *Bacillus* as P solubilizing bacteria. Research by Hindersah el al. [14] reported that urea was coated with solid inoculant of N-fixing *A. vinelandii* and *A. chrococcum*, and phosphate-solubilizing *B. subtilis* and *B. megaterium* consortia was able to increase the growth of strawberry and reduce the need for 50% of conventional urea.

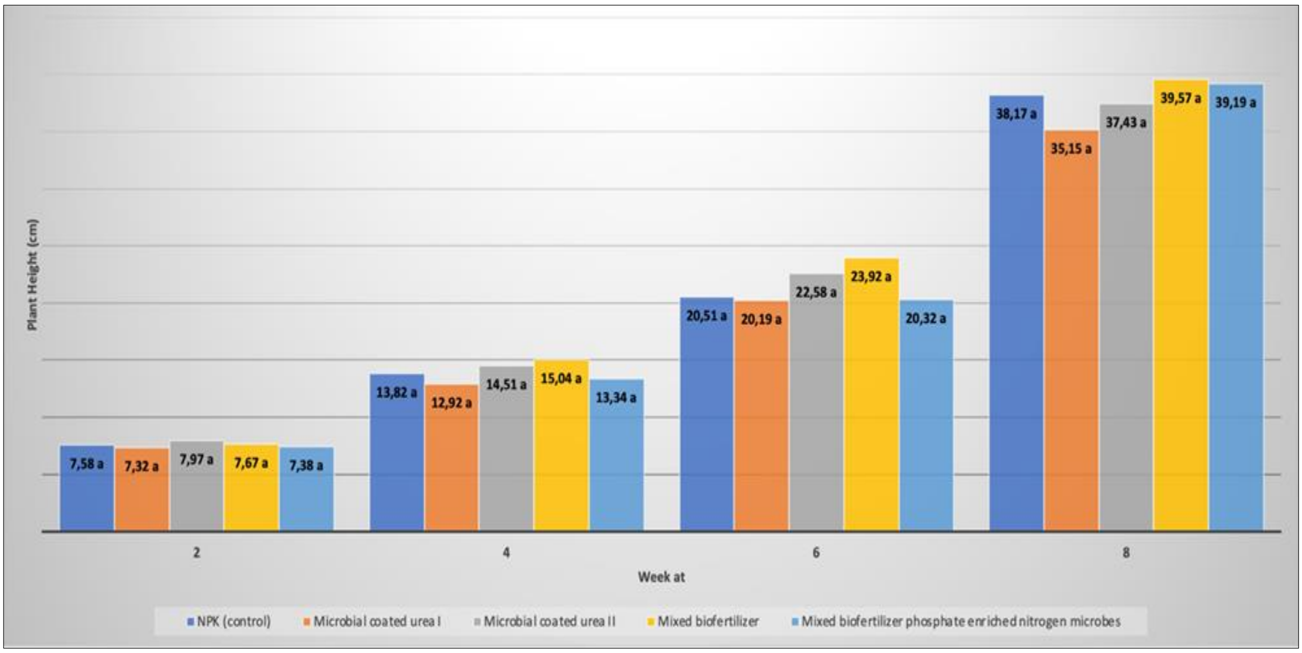

Figure 1 Plant height of celery at 2-8 after plantation

The result showed that application of microbial coated urea and mixed biofertlizers did not increase the fresh and dry weight of shoots and celery roots significantly. Based on Figure 2 it can be seen that mixed biofertilizer phosphate enriched nitrogen microbes had the potential to increase shoot fresh weight higher than other treatments with an increasing of up to 19,03%. This showed that the ability of biofertilizers containing *Pseudomononas cepace, Pseudomonas mallei, Aspergillus niger*, and *Penicillium* sp and N-fixing bacteria (*Azotobacter vinelandii* and *A. chrococcum*) able to facilitate the availability of nutrients and stimulate plant growth thereby increasing the fresh weight of shoot celery. According to Kaur et al. [15] that the microbial consortium of nitrogen fixing and P-solubilizing microbes enhanced the growth and physiological parameters of barley (*Hordeum vulgare* L.). Wang et al. [16] reported that N2-fixing bacteria, P-solubilizing microbes, K-solubilizing and IAA-producing bacteria can significantly increase available nitrogen, phosphorus potassium in the soil improved N/P/K uptake and plant growth of wheat.

Based on Figure 3 it can be seen that the application of beneficial microbes, either given by being coated in urea fertilizer or as biofertilizer, has the potential to increase the dry weight of celery up to 16.48%. The results of experiment showed that fresh and dry weight of celery with NPK applicaton and microbial coated urea were not significantly different. This showed that NPK 100% (200 kg/ha) had the same effect as Urea fertilizer coated with microbes (100 kg/ha). These results are in line with research Elkoca et al. [17] and Lei et al. {18] reported that N-fixing bacteria and P-solubilizing could substitute costly NP fertilizers in chickpea production.

Andisols used in research are often fertilized continuously as a vegetable growing medium, however this soil has a low available P and low N content. Furthermore, celery did not show N and P nutrient deficiencies syndrome. This showed that all treatments are able to provide sufficient N and P nutrients for celery growth.

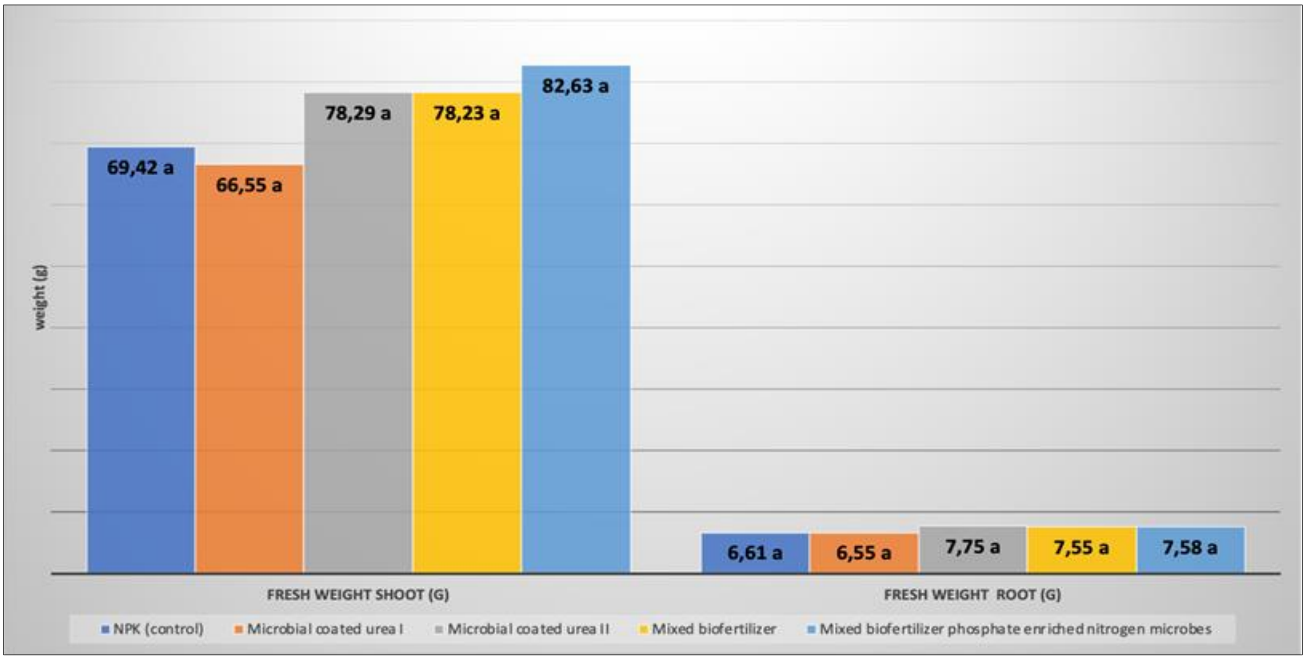

Figure 2 The fresh weight of shoot and root celery

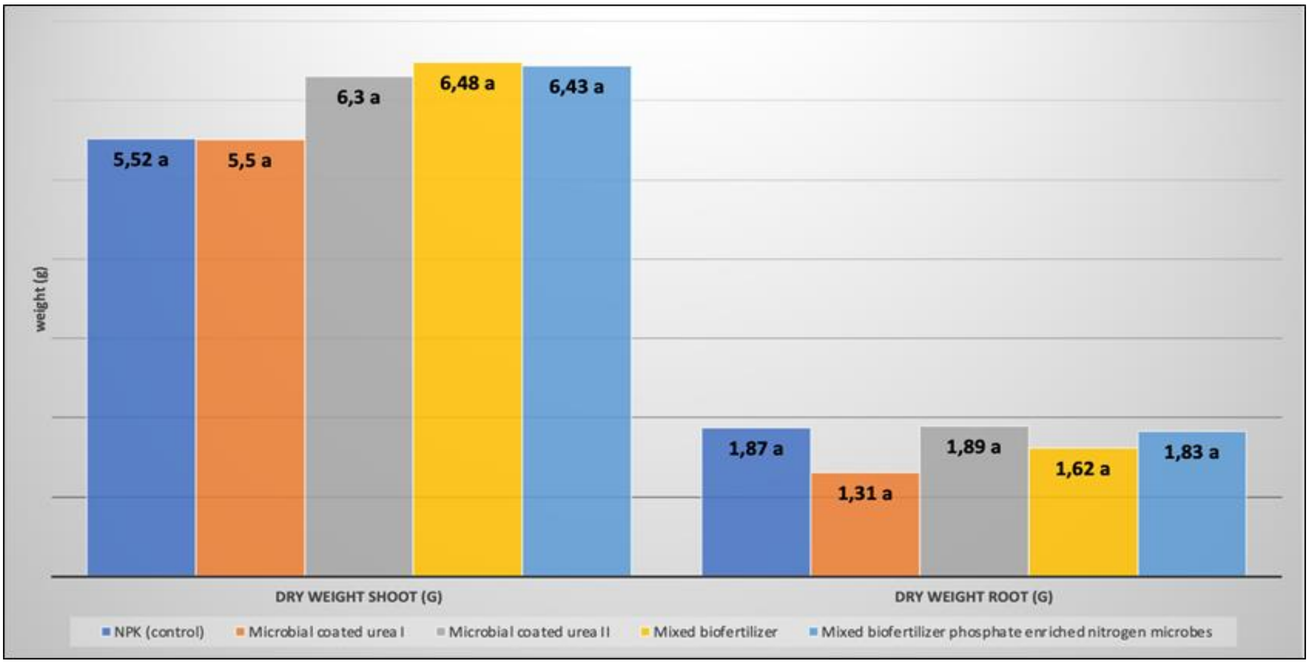

Figure 3 The dry weight of shoot and root celery

4. Conclusion

Based on the results of the field experiments on Andisols, the growth and yield of celery were not affected by the type of fertilization, in this case NPK fertilizer, microbial coated urea or a mixture of biofertilizers. The mixed biofertilizer phosphate enriched nitrogen microbes had the potential to increase shoot fresh weight higher than other treatments with an increasing of up to 19, 03%. The application of beneficial microbes, either given by being coated in urea fertilizer or as biofertilizer, has the potential to increase the dry weight of celery up to 16.48%. NPK 100% (200 kg/ha) had the same effect as Urea fertilizer coated with microbes (100 kg/ha). In addition, biofertilizers can increase fertilization efficiency by reducing the dosage of inorganic fertilizers.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors report no conflicts of interest in this work.

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