The effect of biostimulant in root and population of phosphate solubilizing bacteria: a study case in upland rice

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Abstract. The productivity of upland rice is still low as compared to that of irrigated rice. A cultivation effort needs to be done to increase productivity. One effort can be made by providing additional biostimulants to promote growth and beneficial bacteria. The study was conducted to determine the effect of some biostimulants on the root and population of phosphate solubilizing bacteria in upland rice (Situ Patenggang varieties). The tested treatment was a combination of biostimulants derived from seaweed, humic acid, and organic compounds. Each treatment was repeated 5 times. Parameters observed were the length and weight root, pH analysis, phosphate and C-organic levels in the soil and population of phosphate solubilizing bacteria. The results showed that the combination of biostimulant gave significant effect on plant growth parameters. The combination of a humic acid with seaweed extract gave the highest length and weight root. Humic acid also has a significant effect on the total population of phosphate solubilizing bacteria. The total population of phosphate solubilizing increased up to 150,000 cfu/mg.

1. Introduction

Rice is the main staple food source in Indonesia. The needs of rice increase as the population grows. Upland rice cultivation is one of the solutions to increase rice productivity nationally. This is due to the increasing difficulty in finding wetland [1, 2]. The area of non-rice fields in Indonesia in 2014 in the form of the moor was 12 million ha [3]. The land is potential for cultivation of upland rice. Although the production level of upland rice is only 5% of national rice production regionally, its position is strategic enough to support food security. The average productivity of upland rice is 2.8 tons/ha, this result is still far below the average productivity of paddy rice that can reach 5-6 tons/ha [4]. Therefore, cultivation is needed to increase the productivity of upland rice. The use of biostimulant is one of the ways.

Biostimulant is a substance or microorganism given to plants in order to increase the absorption of nutrients so that the plants become more resistant to biotic and abiotic stress [5]. There are four categories of biostimulant which are humic acid, hormone-containing substance, amino acid, and microorganism.

The use of humic acid in rice, corn, potato, and wheat can increase the productivity of harvest [6-9]. Humic acid can increase the availability of phosphate, nitrogen, and micronutrient because of its
ability to increase cation exchange capacity in the soil [10]. Biostimulant of material category contains hormones, for example, is seaweed extract. Application of seaweed extract on Almond can increase the number of shoots and plant biomass in low potassium soil condition [11]. According to Parrado [12], biostimulant derived from materials contains amino acids that can increase the growth and the number of tomato flowers. Similar benefits are also can be gained from biostimulant of microorganism.

The use of microbial inoculant in various food crops has been proved to increase crop productivity. Inoculation of microbes as PGPR (Plant Growth Promoting Rhizobacteria) combined with mycorrhiza can increase the yield and nutritional content in corn [13]. In rice with a salt high temperature of PGPR is able to increase the percentage of seed germination, root length, plant height and increase leaf chlorophyll content compared to control [14].

Increase in productivity of food crops may also use seaweed extract. This is because seaweed extract contains some phytohormones, polysaccharides, and micronutrient compounds that are very useful to push plant growth. Biostimulant application such as grass extract on tissue culture tobacco can induce flowering [15]. These results indicate that the content of phytohormones in seaweed extract is highly potential to induce more flowering. Similarly, application in Rice applied by seaweed of *Kappaphycus* sp and *Gracilaria* sp species can increase 41-34% of production [16]. In addition, the application of biostimulant from seaweed extract succeeds in increasing the number of Rice panicle in India [17].

Some of the results of this study indicate that the potential biostimulant to increase the productivity of upland rice is very large, even under the abiotic stress; it is also able to produce plants that resist abiotic stress. Therefore, this study aims to find an effective and efficient combination of biostimulant to increase the growth of upland rice and phosphate solvent bacteria population.

2. Materials and Methods

The research was conducted at the greenhouse of the Indonesian Research Institute for Biotechnology and Bioindustry from May to October 2016. There were 18 treatments with 5 replications. The treatment is as follows P2 (Soil + seaweed extract (ERL) 10 ppm 2x), P3 (Soil + ERL 10 ppm 3x), P4 (Ground + ERL) 0 ppm 2x), P1 (Soil + ERL 0 ppm 2x), P1 (Soil + ERL 0 ppm 2x), P5 (Soil + ERL 0 ppm 3x), P6 (Soil + organic material + ERL 0 PPM 2x), P7 (Soil + organic material + ERL 0 PPM 2x), P8 (Soil + organic material + ERL 10 PPM 2x), P9 (Ground + organic material + ERL 10 PPM 3x), P10 (Soil + organic material + ERL 40 PPM 2x), P11 (Soil + organic material + ERL 40 PPM 3x), P12 (Soil + Humic Acid 0 PPM 2x), P13 (Soil + Humic Acid + ERL 0 PPM 3x), P14 (Soil + Humic Acid + ERL 10 PPM 2x), P15 (Soil + Humic Acid + ERL 10 PPM 3x), P16 (Soil + Humic Acid + ERL 40 PPM 2x), P17 (Soil + Humic acid + ERL 40 PPM 3x). Rice variety used was Situ Patenggang. Observation parameters were root length, root dry weight, pH, P, C-organic and total population of phosphate solvent bacteria.

3. Results and Discussion

Biostimulant treatment had significant effects on root length. The highest root length was found on humic acid treatment followed by organic matter. Root length increased and varied between 11-22% (Figure 1). Biostimulant treatment also increased root dry weight. The increase of root dry weight was due to a good plant growth so that the roots of the plant grew well. This was in accordance with a research conducted by Suwardi and Wijaya [17] where humic acid treatment can increase the length and dry weight of rice and corn roots. Anwar [18] also stated that humic acid increased the dry weight of wheat.

Biostimulant used affected total population of phosphate solubilizing bacteria. There was an increase in population up to 50,000-90,000 cfu/mg in the treatment of organic matter and an increase in the total population between 70,000-150,000 cfu/mg in humic acid treatment (Figure 2). Organic material and humic acid have a high carbon content that can be utilized by microorganisms as a source
of energy [19] As a result, there were more population of phosphate solubilizing bacteria in the soil treated by biostimulant.

Figure 1. Length and weight of upland rice roots. Data are the mean value of 5 replicates for each treatment (P1-P18)

Provision of biostimulant increased the soil pH. The increase in pH was between 15-75% (Table 1). The increase in pH was due to the decomposition of organic matter causing the ligand exchange reaction between the anions to free OH⁻ ions at the exchange site so it affects the increase of OH⁻ number in the soil [20]. The increase in pH was also followed by an increase in C-organic and available-P. According to Winarso [20], the increase in pH can release P bound by Al so that P will be available by soil. The existence of biostimulant benefits, especially those derived from the humic acid
group is very useful to increase plant growth by increasing the available nutrients and beneficial bacteria especially phosphate solvent bacteria.

![Bar chart showing the population of phosphate solubilizing bacteria in upland rice.](image)

**Figure 2.** The population of phosphate solubilizing bacteria in upland rice. Data are the mean value of 5 replicates for each treatment (P1-P18)

| Treatments | C-organic (%) | pH    | Available-P (%) |
|------------|---------------|-------|-----------------|
| P1         | 1.29          | 6.02  | 6.7             |
| P2         | 1.35          | 6.02  | 7.8             |
| P3         | 1.54          | 6.05  | 9.8             |
| P4         | 1.47          | 6.07  | 19.1            |
| P5         | 1.52          | 6.05  | 14.9            |
| P6         | 1.66          | 6.03  | 18.9            |
| P7         | 1.95          | 6.17  | 22.2            |
| P8         | 2.01          | 6.27  | 27.6            |
| P9         | 2.23          | 6.18  | 45.9            |
| P10        | 1.74          | 6.23  | 31.3            |
| P11        | 2.12          | 6.15  | 29.9            |
| P12        | 2.53          | 6.22  | 30.6            |
| P13        | 3.67          | 6.76  | 43.2            |
| P14        | 4.07          | 6.62  | 45.5            |
| P15        | 3.72          | 6.68  | 44              |
| P16        | 4.08          | 6.74  | 48.8            |
| P17        | 4.01          | 6.56  | 57.4            |
| P18        | 3.8           | 6.65  | 50.5            |
4. Conclusions

Biostimulant increased the length and dry weight of upland rice roots. In addition, humic acid biostimulant in particular increased phosphate solvent bacteria population.

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