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Application of Phosphate Solubilizing Fungi Indegenous Paddy Soil Increased P Availability, Rice Growth and Production

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Abstract: *Phosphate solubilizing fungi (PSF) from paddy soil can used as biofertilizer to increase P availability.Aimed this experime nt was to increase P availability, growth and paddy rice production. The randomly complete block design used that consist two factors, eg. Dosage of PSF (A) and anorganic P fertilizer (F). Factor dosage of PSF (A) with four levels: without PSF; 2 kg PSF/plot; 4 kg PSF/plot and 6 kg PSF/plot. Factor anorganic P fertilizer with three levels: without anorganic P fertilizer; 50% anorganic P fertilizer and 100% anorganic P fertilizer. Experiment result showed that application of PSF increased P availaibility, growth and plant production more high than without application of PSF. Application of anorganic P fertilizer increased P availability, growth and plant production more high than without application of anorganic P fertilizer. Interaction between application of PSF with anorganic P fertilizer (4 kg PSF/plot + 100% anorganic P fertilizer) increased P availibility, growth and plant production more high than without application of PSF and anorganic P fertilizer (control).*

Keywords: *anorganic P fertilizer, phosphate solubilizing fungi and paddy soil*

I. Introduction

By applying phosphate fertilizer to the soil, only 15-20% can be absorbed by plants. While the rest will be trapped between the soil colloids and remain as a residue in the soil (Buckman and Brady, 1956; Jones, 1982). This will cause a deficiency of phosphate for plant growth. Continuous P fertilization causes most of the high P nutrient status in the soil. In addition, the continuous use of fertilizers causes a nutrient imbalance which results in leveling off of lowland rice production. High P fertilization is not in line with the increase in P availability, this is because most of the P is bound by Al, Fe and Ca so it is not available to plants so that P fertilizer is not efficient (Doberman dan Fairhust, 2000).

Incentive and sustainable management of lowland paddy production systems can be done, one of which is the application of microbial fertilizers that play a role in increasing the efficiency of N, P, K fertilization. Various types of phosphate solubilizing fungi such as Penicillium, Scletorium, Fusarium and Aspergillus have high potential to dissolve bound phosphate. Indigenous phosphate solubilizing fungi that are explored from rice field ecosystems have advantages because they have adapted to local conditions. Besides being able to increase the availability of nutrients, phosphate solubilizing fungi are also able to increase plant resistance to disease (Setyowati et al, 2003).

From several research results, it is known that phosphate solubilizing fungi can increase the availability of P both from the soil and from fertilizers, where the application of phosphate solubilizing fungi with a dosage of fertilization pattern assistance (Urea 100 kg/ha; SP-36 25 kg/ha and KCl 50 kg). tended to only increase rice yields by 4% from 3.31 to 3.44 tons/ha, while the application of phosphate solubilizing fungi fertilizer with half-dose fertilization with the pattern of assistance (Urea 50 kg/ha; SP-36 12.5 kg/ha and KCl 25 kg) can increase rice yields by 16% from 2.67 to 3.10 tons/ha. The use of P soluble mushrooms can also reduce the need for NPK fertilizers up to 75% of the recommended dose(Saraswati et al, 2004).

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The purpose of this study was to obtain the optimum dose of phosphate solubilizing fungi and inorganic P fertilizer in increasing the availability of P as well as the growth and production of lowland rice.

II. Review of Literatures

Phosphate solubilizing fungi are a group of fungi that can convert insoluble P in the soil into a soluble form by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids (Subda Rao, 1982).

Various types of P solubilizing fungi such as Penicillium, Scletorium, Fusarium and Aspergillus have high potential to dissolve bound P to become available (Alexander, 1977; Simanungkalit, 2001). Indegenous phosphate solubilizing fungi explored from rice field ecosystems have advantages because they have adapted to local conditions. Besides being able to increase the availability of nutrients, it is also able to increase plant resistance to disease (Setyowati et al., 2003).

P-solvent fungi fertilizers succeeded in increasing the availability of P both from the soil and from the fertilizer itself. The results of tests conducted (Saraswati et al., 2004) at 12 transmigration sites in Lambale, Muna Regency, Southeast Sulawesi showed that the application of P-solvent fungi (200 g/ha) with assisted fertilization (Urea 100 kg/ha; SP-36 25 kg) /ha and KCL 50 kg/ha) increased rice yields by 4% from 3.31 to 3.44 tons/ha, while with half dose fertilization the pattern of assistance (Urea, 50 kg/ha; SP-36 25 kg/ha and KCL 25 kg/ha) increased rice yield by 16% from 2.67 to 3.10 tons/ha. Trials in the Muara Bogor garden giving 200 g for every 20 kg of seed can reduce the need for NPK fertilizer to 75% of the recommended dose.

III. Research Methods

This research was carried out in the rice fields of Pardamean Village, Tanjung Morawa District, Deli Serdang Regency, and North Sumatra Province from April to August 2019. The materials used were phosphate solubilizing fungi isolated from rice fields from Pardamean Village, Tanjung Morawa District, Deli Serdang Regency, North Sumatra Province. Ciherang, TSP Fertilizer. The design used was a factorial randomized block design with two treatment factors. The first factor was phosphate solubilizing fungi (A) which consisted of 4 levels, namely: A0 (without giving phosphate solubilizing fungi); A1 = 2 kg/plot; A2 = 4 kg/plot and A3 = 6 kg/plot. The second factor is the application of inorganic P fertilizer (F) consisting of 3 levels, namely: F0 (without fertilization); F1 = recommended dose and F2 = 1x recommended dose. Each treatment consisted of 3 replications, with each replication being a plot measuring 3 m x 3 m.

Ciherang rice varieties were planted 10 days after sowing with one plant per clump at a spacing of 30 cm x 30 cm and intermittently flooded with a water level of 2 cm. The application of phosphate solubilizing fungi was carried out at the time of planting according to the treatment. Inorganic P fertilizer was given at the age of 1 WAP. The variables observed were plant height, number of productive tillers, weight of 1,000 grains of grain, and P available (Bray I method) measured at flowering with 6 sample plants/ plot.

IV. Discussion

4.1 P- availability (ppm)

The treatment of phosphate solubilizing fungi could increase the P availability of compared to the control (without the addition of P solubilizing microbes). The P availability of (Table 1) in phosphate solubilizing fungi at a dose of 4kg/plot was significantly higher than the control. The results showed that the application of phosphate solubilizing fungi could increase the P available of the soil up to 44.73% (Table 1). Phosphate solubilizing fungi secrete organic acids that can form insoluble complex compounds. The formation of these complex compounds will cause P fixation to decrease thereby increasing P-available According to Mehrvarz et al. (2008) that microbes have mutualism with host plants and these microbes can increase the availability and uptake of P. Phosphate solubilizing microbes can increase the concentration of dissolved P. Inoculation of phosphate solubilizing microbes in pot and field experiments was able to increase the of P availability , so as to overcome the shortage of P available in the soil by producing organic acids (Vallverde et al. 2006).

This is in line with the results of research by Fitriatin, et al., (2009) that the application of phosphate solubilizing microbes can increase the P available content of the soil up to 8.13% and the P uptake of plants is largely determined by the concentration of P in the soil and the ability of plants to absorb nutrients. P in the soil. This is in line with Lestari (1994) that phosphate solubilizing fungi can increase the concentration of dissolved P, by 27%-47% in acid soils. The increase in P concentration due to phosphate solubilizing fungi is very effective in releasing fixed P in the soil (El-Azouni, 20008).

The application of inorganic P fertilizer at a dose of 50% increased available P by 22.16%, while the application of P inorganic fertilizer at a dose of 100% increased P available by 30.71% (Table 1). This is due to the increased P transfer from P inorganic fertilizers into the soil solution. The results of the research Fitriatin, et al. (2008) that the application of P fertilizer and an increase in P dose can increase the availability of P in the soil. The results of the research by Fitriatin et al. (2009) the application of P fertilizer equivalent to P2O5 75 and 100 kg ha-1 can increase the canopy P. Plants provide optimal response to fertilization so that the application of inorganic P fertilizer in accordance with the recommended dose of fertilization increases the availability of P nutrients.

The results showed that there was an interaction between phosphate solubilizing fungi and P inorganic fertilizer on P available. The use of P + solvent microbes with P inorganic fertilizers up to a dose of 100% produced the highest P available compared to without the use of P solvent microbes using P inorganic fertilizers up to a dose of 100%. This shows that the ability of phosphate solubilizing microbes to dissolve phosphate sourced from soil minerals and fertilizers into P available forms increases with increasing doses of inorganic P fertilizers. This shows that the addition of P solvent microbes and the addition of inorganic P fertilizer can increase the P concentration in the solution. The results of Puspitawati et al. (2013) the use of P-solvent microbes can increase the availability of P. This is also supported by Wibowo et al. (2009) that the use of biological fertilizers with the addition of P inorganic fertilizer by 50% was able to increase the P availability of nutrients. Effect of dose of phosphate solubilizing fungi on available P at various doses of inorganic P fertilizers (Figure 1). Effect of inorganic P fertilizer dose on available P at various doses of phosphate solubilizing fungi (Figure 2).

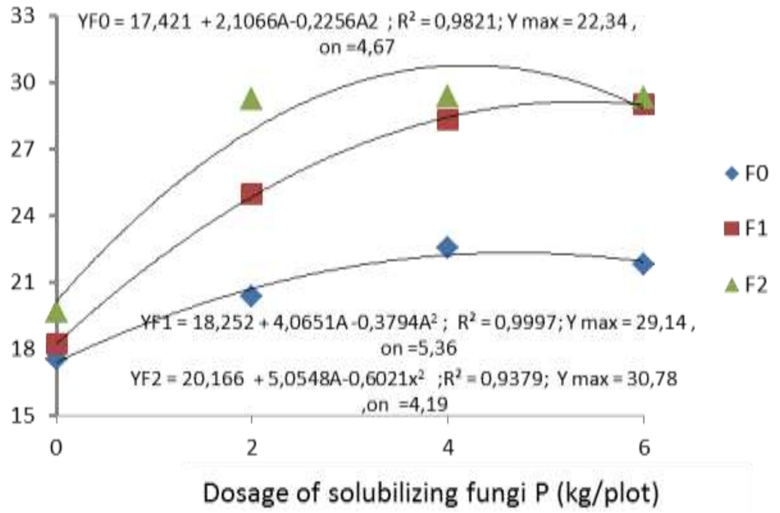

Figure 1. *Effect of Dose of Phosphate Solubilizing Fungi on Available P at Various Doses of Inorganic P Fertilizers*

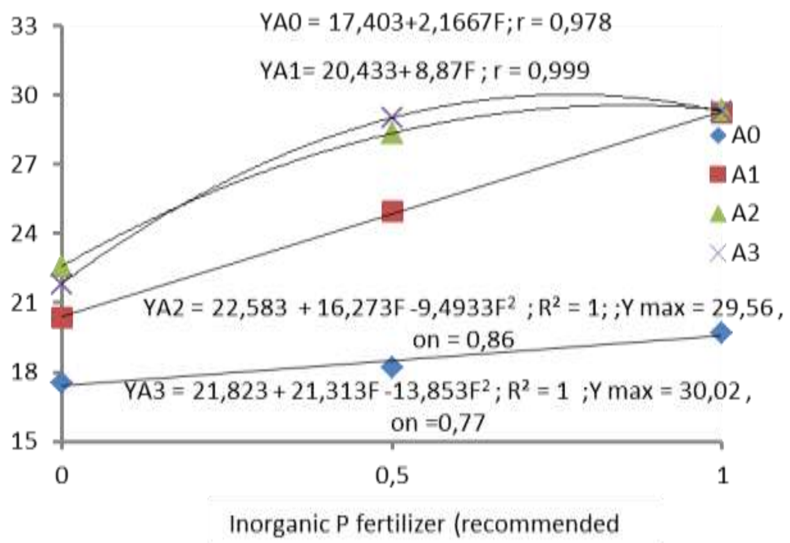

Figure 2. *Effect of Inorganic P Fertilizer Dose on Available P at Various Doses of Phosphate Solubilizing Fungi*

4.2 Plant Height (cm)

From Table 1, it can be seen that the plant height of A2 phosphate solubilizing fungi at a dose of 4 kg/plot showed the highest plant height followed by A1 (2 kg/plot) and A3 (6 kg/plot) phosphate solubilizing fungi and the lowest was in the treatment without administration of phosphate solubilizing fungi (control). This shows that the administration of phosphate solubilizing fungi can increase the availability of P through the phosphatase enzyme it produces and can break the phosphate bound by organic compounds thereby increasing the availability of plant P. From the analysis of the availability of P, it can be seen that by giving P-solvent fungi, it can increase the available P by 40.46% to 44.93% when compared to without P-solvent fungi, so that the P needs of plants are met. Fitriatin et al. (2009) stated that phosphate solubilizing microbes can partially or completely substitute plant needs for P fertilizers. Phosphate solubilizing fungi are very effective in releasing fixed P in soil minerals so that the availability of P in the soil can increase (El-Azou ni, 2008).

Treatment of inorganic P fertilizer F2 at the age of 10 WAP showed the highest plant height and was very significantly different from F0 and F1 treatments. Between treatments F0 and F1 were also very significantly different. The application of inorganic P fertilizer according to the recommended dose resulted in the highest plant height compared to the control. This is consistent with the ability of inorganic P in increasing the availability of plant nutrients. This result is in line with research by Fitriatin et al (2009) which showed that the application of P fertilizer and increasing the P dose to the optimum level will continue to increase the availability of P in the soil so that plant growth will be better.

Interaction of phosphate solubilizing fungi with inorganic P fertilizer was found in the A2F2 combination and was very significantly different from the other combination treatments, but not significantly different from the A1F2 combination treatment. The use of P + solvent microbes with inorganic P fertilizers up to a dose of 100% resulted in higher plant height than without the use of P solvent microbes + the use of inorganic P fertilizers up to a dose of 100%. This shows that the ability of phosphate solubilizing microbes increases when followed by the addition of inorganic P fertilizer.

Effect of dose of phosphate solubilizing fungi on plant height at various doses of inorganic P fertilizer (Figure 3). Effect of dose of doses of inorganic P fertilizer on plant height at various doses of phosphate solubilizing fungi. (Figure 4).

Table 1. Average Available P (ppm) and Plant Height (cm) Result Influence of Phosphate Solvent Fungi and Inorganic P Fertilizers and Their Interactions

Treatment	Parameter	
	P-available (ppm)	**Plant height** (cm) Age 10 WAP MST
Phosphate solubilizing fungi (A)		
A_0	18,49 c C	95,84 c C
A_1	24,87 b B	102,64 ab AB
A_2	26,76 a A	104,16 a A
A_3	26,71 a A	100,86 b B
Inorganic P fertilizers (F)		
F_0	20,58c C	97,58 c C
F_1	25,14 b B	100,98 b B
F_2	26,90 a A	103,55 a A
Interaction (Ax F)		
A_0F_0		
A_0F_1	17,54 g F	94,33 e C
A_0F_2	18,22 fg EF	97,47 cd C
A_1F_0	19,70ef DE	95,73 de CD
A_1F_1	20,39de CDE	97,93c C
A_1F_2	24,96 b B	102,07 bB
A_2F_0	29,26a A	107,93 aA
A_2F_1	22,58 c BC	101,40 bB
A_2F_2	28,35 a A	102,33 bB
A_3F_0	29,36a A	108,73 aA
A_3F_1	21,82cd CD	96,67 cdCD
A_3F_2	29,02a A	102,07 bB
	29,28a A	101,80 b B

Note: Numbers followed by the same letter in the same column show results that are not significantly different based on DMRT

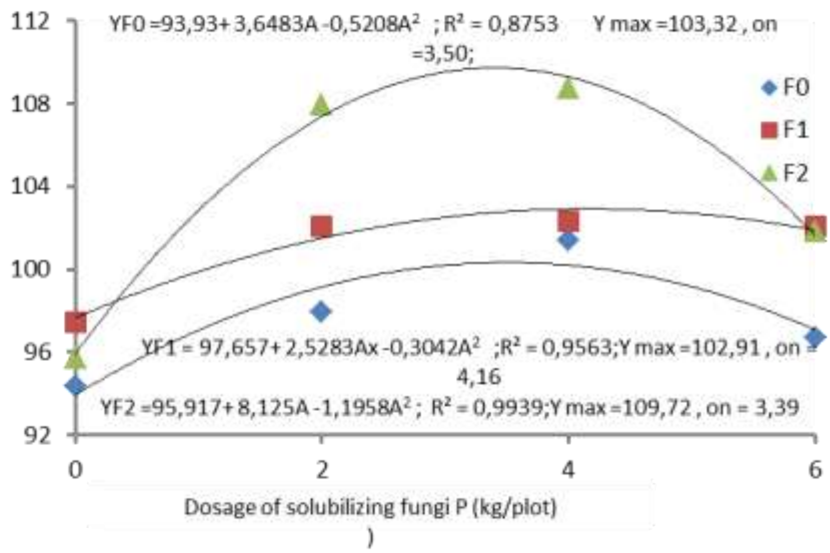

Figure 3. *Effect of Dose of Phosphate Solubilizing Fungi on Plant Height at Various Doses of Inorganic P Fertilizer*

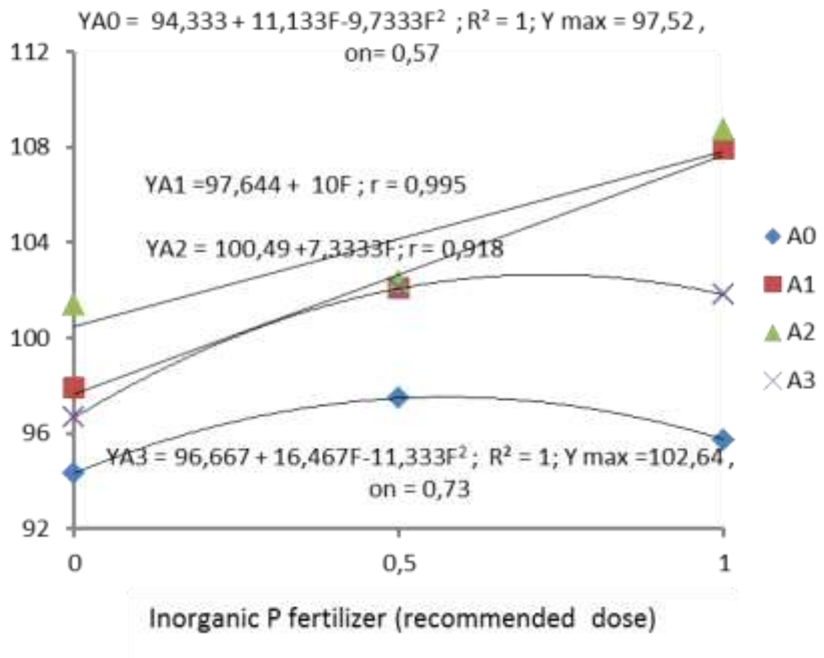

Figure 4. *Effect of Dose of Doses of Inorganic P Fertilizer on Plant Height at Various Doses of Phosphate Solubilizing Fungi*

4.3 Number of Productive Tillers (clump-1)

From Table 2 it can be seen that the highest number of productive tillers was found in A2 phosphate solubilizing fungi, followed by A3 and A1 phosphate solubilizing fungi (6 kg/plot) and the lowest was in the treatment without phosphate solubilizing fungi (control). Microbial feeding Figure 7 . The relationship between the number of productive tillers and the dose of phosphate solubilizing fungi at various doses of inorganic phosphate solubilizing P fertilizer at a dose of 2-6 kg/plot significantly showed the highest average number of productive tillers when compared with no phosphate solubilizing fungi (control). Aerobic soil applied in SRI cultivation supports phosphate solubilizing microbial activity so that the availability of plant P nutrients increases, where the P nutrients will stimulate the addition of tillers. This is in accordance with the research of Puspitawati et al. (2013) that the use of P-solvent microbes resulted in a higher number of productive tillers than the application of inorganic P fertilizer at a dose of 100% without the addition of phosphate-solvent microbes. According to Prihatini et al. (1977) Phosphate solubilizing microbial inoculants have the same potential as TSP fertilizers to be absorbed by plants.

Effect of dose of phosphate solubilizing fungi on the number of productive tillers at various doses of inorganic P fertilizer (Figure 5). Effect of inorganic P fertilizer dose on the number of productive tillers at various doses of phosphate solubilizing fungi (Figure 6).

ADCC induced by monoclonal antibody therapy can result in tumor elimination, as well as antigen uptake, processing, and presentation by DCs and other professional antigen presenting cells, resulting in adaptive T-cell-mediated immune responses. Improved ADCC can be mediated by monoclonal antibodies, which should improve antigen presentation and T cell activation. [38] This can be done by boosting antibody affinity for tumor antigen targets or modifying antibody Fcy domains to boost Fc receptor affinity (s). As previously mentioned, it may be able to fine-tune antibody engineering to selectively activate activating rather than inhibiting Fcy receptors. Alternatively, antibodies that selectively disrupt the interactions of tumor antigen-specific antibodies with inhibitory Fcy receptors may be beneficial. Antibody architectures can also be changed to include immunostimulatory motifs that selectively induce, shape, and amplify antigen processing, presentation, and costimulation in order to facilitate the induction of therapeutically effective host anti-bodies. [34] Tumor antigen-specific antibodies could be coupled with other treatments that improve antigen presentation (e.g., toll receptor agonists), costimulation (e.g., anti-CTLA-4 antibody), or T-cell activation or expansion instead of direct modification of antibody structures (e.g., interleukin-2). Other immunological therapies, such as DC vaccinations, may benefit from antibody therapy as well [40]. It's worth noting that several clinically useful antibodies that mediate ADCC are frequently used in combination with chemotherapy agents; more research is needed to see if chemotherapy-based tumor destruction works in tandem with monoclonal antibody therapy to promote adaptive, tumor antigen-specific immunity. The link between tumor antigen-specific immune responses induced by anti-idiotypic antibodies and clinical responses highlights the necessity for randomized clinical trials to prove the efficacy of this vaccination technique. Furthermore, methods should be developed to strengthen anti-idiotype antibodies' ability to generate a significant tumor antigen-specific immune response, with the hope of improving their anti-tumor effects. [35] The characterization of the structural basis of tumor antigen mimicry by the corresponding anti-idiotypic antibodies, as well as the relationship between the extent of antigen mimicry and the immunogenicity of a mimic, will be beneficial to these studies. This knowledge will make it easier to replace anti-idiotypic antibodies with peptide mimics, which are more responsive to changes to improve performance. [36]

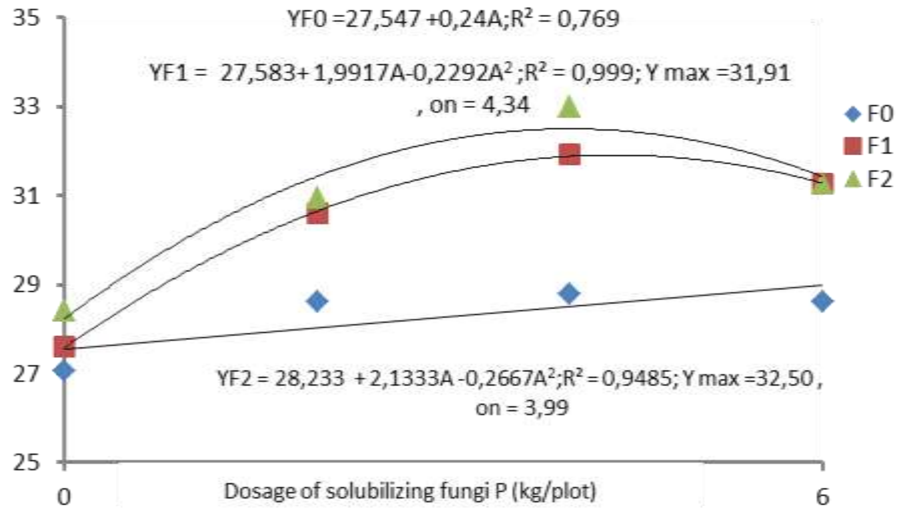

Figure 5. *Effect of Dose of Phosphate Solubilizing Fungi on the Number of Productive Tillers at Various Doses of Inorganic P Fertilizer*

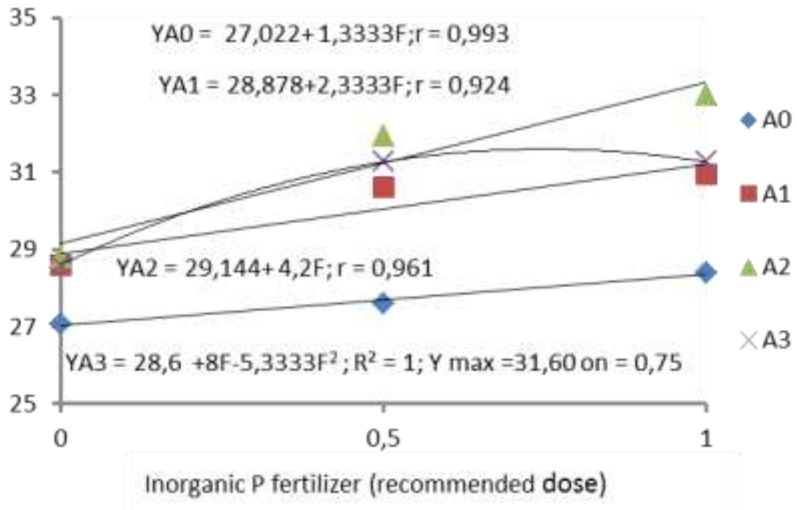

Figure 6. *Effect of Inorganic P Fertilizer Dose on the Number of Productive Tillers at Various Doses of Phosphate Solubilizing Fungi*

4.4 Weight of 1000 Grains of Paddy (g)

From Table 2, it can be seen that the administration of phosphate solubilizing fungi in treatments A1, A2 and A3 showed the highest weight of 1000 grains of paddy and was very significantly different from the control. The increase in production was in line with the increase in plant growth, the number of productive tillers and available P. Yafizham (2003) stated that phosphate solubilizing microbes alone can increase plant production by 20 to 73% and can directly increase the solubilization of soil bound P so that the available P in the soil increases. This is in accordance with the literature of Fitriatin et al, (2009) which states that phosphate solubilizing microbes can substitute part or all of the plant's need for P fertilizer. The application of inorganic P fertilizer with a dose of 50% or a dose of 100% can increase the weight of 1000 grains of paddy. The increase in the weight of 1000 grains of paddy was in line with the increase in available P in the soil due to the addition of inorganic P fertilizer.

The results showed that the interaction of phosphate solubilizing fungi with inorganic P fertilizer could increase the weight of of 1000 grains of paddy compared to the control. The use of phosphate solvent + microbe with inorganic P fertilizer up to a dose of 100% resulted in a thousand grain weight higher than the control. This shows that the addition of phosphate solvent microbes and the addition of inorganic P fertilizer can synergistically increase the P concentration in the soil solution so that crop production increases. The results of the research by Puspitawati et al (2013) using phosphate solvent microbes + 50% inorganic P fertilizer can increase the weight of a thousand grains of grain which is not significantly different from the application of 100% inorganic P fertilizer. The effect of phosphate solubilizing fungi on the weight of 1000 grains of paddy (Figure 7). The effect Dosage of inorganic P fertilizer on the weight of 1000 grains of paddy (Figure 8).

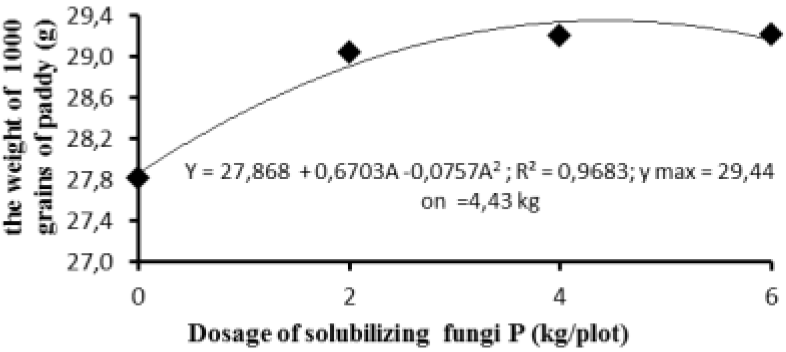

Figure 7. *The Effect of Phosphate Solubilizing Fungi on the Weight of 1000 Grains of Paddy*

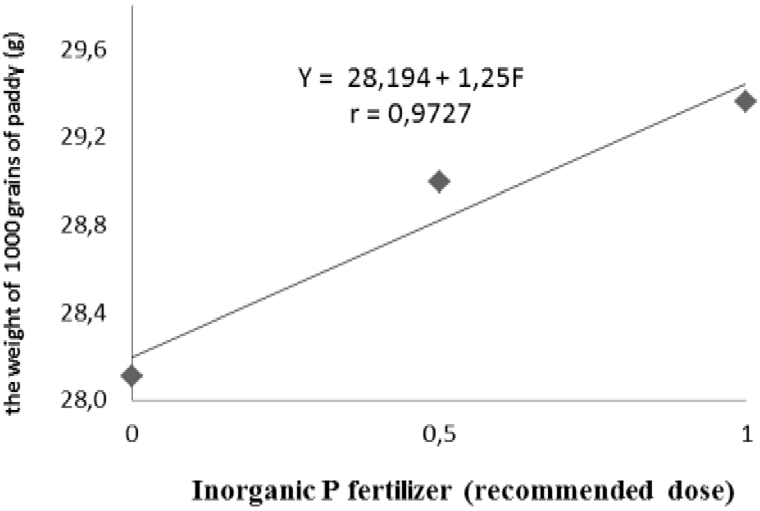

Figure. 8. *The Effect Dosage of Inorganic P Fertilizer on the Weight of 1000 Grains of Paddy*

IV. Conclusion

From the results of the study it can be concluded that:

1. The application of phosphate solubilizing fungi could increase the availability of P, plant height, number of productive tillers and the weight of a thousand grains of dry grain higher than without the application of phosphate solubilizing microbes.
2. The application of inorganic P fertilizer can increase the availability of P, plant

height, number of productive tillers and the weight of a thousand grains of dry grain higher without the application of inorganic P fertilizer.

3. The interaction of phosphate solubilizing fungi with inorganic P fertilizers could increase the availability of P, plant height, number of productive tillers and the weight of a thousand grains of dry grain higher than without the application of phosphate solvent microbes and inorganic P fertilizers. The best combination treatment is on the A2F2 combination.

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