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Bio-organic, bio-chemical fertilizers and N-fixer (N-bio booster) improve paddy yields in the field trials at Langkat in Medan, Indonesia

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Abstract: The objective of the present study was to evaluate the efficacy of All Cosmos Industries (ACI) bio-organic and bio-chemical fertilizers and ACI N-Fixer (N-Bio Booster) on the paddy yields based on the field trial plots at Langkat, Medan, Indonesia. This application of ACI bio-organic fertilizer (NPK 5/5/5) and ACI bio-chemical (NPK 15/15/15) fertilizer and ACI N-Fixer tests were conducted at the paddy farm at Langkat from May-October 2018. This study used a factorial randomized complete block design which consisted of two factors, namely: Factor I with four types of fertilizers while Factor II were two paddy varieties (Inpari 30 and Inpari 32). Overall, the filled grains in the ACI treatments are significantly ($P< 0.05$) higher than those in the control treatments that used Normal Chemical Compound NPK. Overall, total weight per meter² (368-617g) in ACI treatments are also significantly ($P< 0.05$) higher than those (319-371g) in the control treatments. At harvesting time at 105 days after transplanting, the significantly higher ($P< 0.05$) colony counts (13-15 x 10^6 CFU/mL) (for ACI treatments), than those (8 x 10^6 CFU/mL) in the controls positively indicated higher total yields of paddy grains per hectare. It was found that the application of ACI bio-organic and bio-chemical fertilizers and ACI N-Fixer can improve paddy yields of the two rice varieties, between 16.4-38.2% (up to 5.75 MT/ha), in the field trial plots at Langkat. These commercial fertilizers play an important role in improving the soil fertility and thereby can increase the yield of rice production. Therefore, it is highly recommended that ACI bio-organic and ACI bio-chemical fertilizers and ACI N-Fixer (N-Bio Booster) can be used to increase the paddy yield in this region.

Keywords: Bio-organic fertilizer; Bio-chemical fertilizer; Grain yield; N-Fixer.

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I. INTRODUCTION

To meet the increasing needs of rice in North Sumatera in Indonesia [1], a solution is needed to provide fertilizer with the right type and dosage. If the plants experience a lack of NPK, this can result in low quality and quantity of production. For example, if a plant has a P nutrient deficiency effect on the paddy such as an increase in the percentage of empty grain, reducing the weight and quality of the grains [2].

The total area of paddy land and yield have progressively reduced over the years in North Sumatera [1]. The rice production problem, at Medan, North Sumatera, has been a research focus by a few researchers [1, 3-4]. Barus et al. [3] found that IR 42 and Banyuasin had the best growth and high adaptability on saline soil as compared with other genotypes in the paddy growth at Paluh Merbau in Medan. Abdi et al. [4] studied the factors that influence farmers' decisions to produce paddy seeds in Deli Serdang Regency.

Except for Normal Chemical Compound NPK (15/15/15), the four treatments of different fertilizers used in this field trial plot experiment are commercial fertilizer products consisting of beneficial microorganisms, from All Cosmos Industries (ACI) Sdn Bhd. They are ACI N-Fixer, ACI NPK (5/5/5) and ACI NPK (15/15/15). The ACI N-Fixer is commercially known as N-Bio Booster *RealStrong* Fertilizer (Table 1). It contains a free-living

Table 1: Composition of different types of microbial fertilizers:

Name [Type of fertilizer]	Chemical macro and micro nutrients	Organic matter	Inert carrier (talc)	Beneficial microorganisms	
				Type	CFU/g
ACI N-Fixer [N Bio-Booster]	0.0% (w/w)	0.0% (w/w)	100.0% (w/w)	N-fixing bacteria	1.0×10^8
ACI NPK (5/5/5) [ACI bio-organic fertilizer]	50.0% (w/w)	49.5% (w/w)	0.5% (w/w)	N-fixing bacteria P-solubilizing bacteria *Bacillus* spp.	1.0×10^5 1.0×10^4 1.0×10^5
ACI NPK (15/15/15) [biochemical fertilizer]	85.0% (w/w)	14.9% (w/w)	0.1% (w/w)	N-fixing bacteria P-solubilizing bacteria *Bacillus* spp.	1.0×10^4 1.0×10^3 1.0×10^4

nitrogen-containing bacterium, *Bacillus* sp. which can convert nitrogen gas in the atmosphere (insoluble) to ammonia, nitrate or nitrite, which can be readily absorbed by plants for the better plant growth [5]. The ACI NPK (5/5/5) is a bio-organic fertilizer, known as *RealStrong* Soil Improver 5/5/5 (Table 1). The soil improver contains high concentration of beneficial microorganisms, and its ingredients include 65% organic matter, 30% chemical raw materials and 5% zeolite. It can perform as a soil conditioner to help increase the pH value of the soil, recovering and improving the soil fertility [6]. The ACI NPK (15/15/15) is bio-chemical fertilizer, which was a tailor-made fertilizer product for this project, as compared to Normal Chemical Compound NPK (15/15/15) which is an inorganic fertilizer. It also consists of beneficial microorganisms (Table 1). It can effectively improve the soil structure which is caused by the excessive use of inorganic fertilizers [7].

Since there has been no study conducted on the efficacy of using biofertilizers with the ACI's products in the paddy production in Indonesia, the objective of this study was to evaluate the efficacy of ACI bio-organic and bio-chemical fertilizers and ACI N-Fixer (N-Bio Booster) on the paddy yields based on the field trial plots at Langkat, Medan, Indonesia.

II. Results & Discussion

Plant heights, NPK levels in topsoils and productive tillers

Plant heights (cm) of paddy collected at 20, 30, 40 and 60 DAT, concentrations of N (%), P (%) and K (mg/100g) in the topsoils, and productive tillers collected during harvesting time (105 DAT) are presented in Table 2.

For the plant heights, there are no significant ($P > 0.05$) difference among the control treatments (T1V1 and T1V2), with other treatments). For the NPK in the topsoils collected during harvest period (105 DAT), the levels of N (0.14-0.19%) in T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2 are significantly ($P < 0.05$) higher than those (0.08%) in the control treatments (T1V1 and T1V2) However, for P levels in the *topsoils*, there are no significant ($P > 0.05$) difference between the control treatments (0.26%; T1V1 and T1V2), and those (0.21-0.26%) in treatments of T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2. For K levels, there are also no significant ($P > 0.05$) difference between the control treatments (0.59-0.64%; T1V1 and T1V2), and those (0.56-0.58%) in treatments of T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2. However, the K level (0.84%) in T3V1 is significantly ($P < 0.05$) higher than those (0.56-0.64%) in other treatments.

The productive tillers (11.5-14.5) in T2V2, T3V1, T3V2 and T4V1 are significantly ($P < 0.05$) higher than those in the control treatments (8.25-9.75; T1V1 and T1V2), T2V1 (10.3), and T4V2 (10.0). Asbur [8] reported the number of productive tillers was 48.1 based on 21 day-old seedlings based on one seedling per hill at paddy field of Deli Serdang of North Sumatera in the 2012. Syatrianty et al. [9] reported a decreasing number of tillers and number of productive tillers by increasing seedling number per hill and delay transplanting.

Number of filled grains and empty grains per panicle

Filled and unfilled grains per panicle collected during harvesting time (105 days of planting) are shown in Table 3. Overall, the filled grains (110-121) in T2V2, T3V1, T3V2 and T4V1 are significantly ($P < 0.05$) higher than those in the control treatments (71.8-83.6; T1V1 and T1V2), T2V1 (102) and T4V2 (85.7). On the contrary, the unfilled grains (26.5-38.6) in the control treatments (T1V1 and T1V2) are higher (but not significant, $P > 0.05$) than those (15.3-25.5) in T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2.

Asbur [8] reported a significant positive relation between grain yield and number of grain per panicle, where the highest grain yield per plant and per plot caused higher number of grain per panicle (113 grain) and lower number unfilled grain (26.2 grain) per panicle. Sanico et al. [10] also found a significant relation between rice grain yield and number of grain per panicle.

Table 2: Plant heights (cm), total number of productive tillers of paddy and levels of N (%), P (%) and K (mg/100g) in the topsoils in the field trial plots at Langkat. DAT= Days after transplanting.

Treatment	Plant heights				N	P	K	Total number of productive tillers
	20 DAT	30 DAT	40 DAT	60 DAT	105 DAT	105 DAT	105 DAT	105 DAT
T1V1	47.9[a]	73.3[a]	78.8[a]	89.5[a]	0.08[a]	0.26[a]	0.64[a]	8.25[a]
T1V2	49.9[a]	71.1[a]	88.5[a]	102[a]	0.08[a]	0.26[a]	0.59[a]	9.75[a]
T2V1	51.4[a]	75.6[a]	85.2[a]	94.0[a]	0.15[b]	0.21[a]	0.56[a]	10.3[ab]
T2V2	49.4[a]	73.7[a]	87.4[a]	99.2[a]	0.17[b]	0.23[a]	0.58[a]	11.5[c]
T3V1	49.4[a]	72.0[a]	84.9[a]	86.3[a]	0.19[bc]	0.22[a]	0.84[b]	13.3[c]
T3V2	54.4[a]	75.1[a]	88.8[a]	102[a]	0.14[b]	0.23[a]	0.58[a]	14.5[c]
T4V1	48.7[a]	73.3[a]	82.4[a]	90.7[a]	0.19[bc]	0.26[a]	0.50[a]	12.3[bc]
T4V2	54.9[a]	73.3[a]	85.4[a]	100[a]	0.16[b]	0.23[a]	0.50[a]	10.0[ab]

Note: Means with the different letters are significantly (P< 0.05) different. Details of Treatments can be referred to Table 6.

Table 3: Numbers of filled and unfilled grain per panicle collected during harvesting time (105 days of transplant) in the field trial plots at Langkat:

Treatment	Filled grain/panicle	Unfilled grain/panicle
T1V1	71.8[a]	38.6[a]
T1V2	83.6[ab]	26.5[ab]
T2V1	102[abcd]	21.6[ab]
T2V2	110[bcd]	19.9[ab]
T3V1	117[cd]	15.4[a]
T3V2	121[d]	15.3[a]
T4V1	112[bcd]	16.7[a]
T4V2	85.7[abc]	25.5[ab]

Note: Means with the different letters are significantly (P< 0.05) different. Details of Treatments can be referred to Table 6.

Grain weight per meter, grain weight per plot and total yield per hectare

Total weight per meter², total weight per plot of the paddy grains, and total yields of paddy grains per hectare, collected during harvesting time (105 DAT) are given in Table 4. Overall, total weight per meter² (368-617g) in T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2 are significantly (P< 0.05) higher than those (319-371g) in the control treatments (T1V1 and T1V2). Total weight of paddy grains per plot (8.23-11.5 kg) in T2V1, T2V2, T3V1 and T3V2 are significantly (P< 0.05) higher than those (6.93-7.49 kg) in the control treatments (T1V1 and T1V2). However, the values (6.83-7.38) for T4V1 and T4V2 are not significantly higher than those in the control treatments. Total yield per hectare (4.57-5.75 MT/ha) in T2V2, T3V1 and T3V2 are significantly (P< 0.05) higher than those in the control treatments (3.47-3.74 MT/ha; T1V1 and T1V2). Nonetheless, the values (3.41-3.69 MT/ha) for T4V1 and T4V2 are not significantly higher than those in the control treatments. With the applications, ACI NPK (5/5/5) and ACI NPK (15/15/15), and N-Fixer (N-Bio Booster), the paddy yield at Langkat can be increased up to 5.75 MT/ha. Asbur [8] reported the highest grain yield per plot 4.94 kg or 3.09 ha was obtained in one seedling per hill and 21 day-old seedlings at paddy field of Deli Serdang of North Sumatera.

Table 4: Total weight per meter² (g), total weight per plot (kg) of the paddy grains, and total yields of paddy grains per hectare (MT/ha), collected during harvesting time (105 days of planting) in the field trial plots at Langkat:

Treatment	Total weight of paddy grains per meter² (g)	Total weight of paddy grains per plot (kg)	Total yield per hectare (MT/ha)
T1V1	319[a]	6.93[a]	3.47[a]
T1V2	371[b]	7.49[a]	3.74[ab]
T2V1	423[c]	8.23[c]	4.11[abc]
T2V2	519[d]	9.14[c]	4.57[bc]
T3V1	516[d]	10.1[cd]	5.03[cd]
T3V2	617[e]	11.5[d]	5.75[d]
T4V1	367[b]	6.83[a]	3.41[a]
T4V2	381[b]	7.38[a]	3.69[ab]

Note: Means with the different letters are significantly (P< 0.05) different. Details of Treatments can be referred to Table 6.

Number of colonies in topsoils

The numbers of colony counts in the topsoils of paddy field collected at 35, 60 and 105 DAT are presented in Table 5. At harvesting time at 105 DAT, the significantly higher (P< 0.05) colony counts (13-15 x 10^6 CFU/mL) (for T2V1, T2V2, T3V1, T3V2, T4V1 and T4V2), than those (8 x 10^6 CFU/mL) in the controls T1V1 and T1V2 positively indicated higher total yields of paddy grains per hectare. The present result was supported by Subashini et al. [11] who reported a positive correlation between the usage of microbes and consistent increase in crop yield. This indicated compatibility and integration of microbes in the bio-organic and bio-chemical fertilizers in enhancing the paddy yields in the field trial plots at Langkat.

Table 5: Numbers of colony counts (x 10^6) in the topsoils of paddy field collected at 35, 60 and 105 (harvesting time) days after transplanting (DAT) in the field trial plots at Langkat.

Treatment	Initial count (Before treatment)	35 DAT	60 DAT	105 DAT (Harvesting)
T1V1	4.50^a	5.00^a	3.00^a	8.00^a
T1V2	4.50^a	11.0^b	5.00^a	8.00^a
T2V1	4.50^a	7.00^a	7.00^{ab}	13.0^b
T2V2	4.50^a	11.0^b	13.0^b	14.0^b
T3V1	4.50^a	7.00^a	20.0^c	14.0^b
T3V2	4.50^a	19.0^c	30.0^d	15.0^b
T4V1	4.50^a	19.0^c	9.00^b	15.0
T4V2	4.50^a	21.0^c	13.0^b	13.0

Note: Means with the different letters are significantly ($P< 0.05$) different. Details of Treatments can be referred to Table 6.

The present findings show that the application of bio-organic fertilizer NPK (5/5/5) and bio-chemical fertilizer NKP (15/15/15) can positively influence the paddy yields of Inpari 30 and Inpari 32 varieties. Most interestingly, the N-Fixer (N-Bio Booster) enhanced biofertilizer can increase the paddy yield. The mechanism for this favourable effect could be attributable to enhanced absorption of nitrogen and other minerals by the plant [12]. Kader et al. [13] found that N-fixation bacteria living in rhizosphere can improve the root growth by stimulating phytohormone production such as Indole Acetic Acids that can propagandize the nutrient uptake from soils. This can affect the plant vegetative and reproductive growth. Combining these bio-organic and bio-chemical fertilizers can add nutrients to plants and improve soil quality. The presence of microorganisms in the N-Fixer biofertilizer can help plants absorb nutrients from the soil more efficiently. However, the response of paddy yields to both biofertilizer and N fertilizer could be strongly influenced by the factors of weather and seasonal growing conditions [14]. However, the relationship between the weather conditions (temperature and rainfall; Figure 1) and paddy yields at Langkat is evidently not clear to our knowledge.

The insignificant difference ($P> 0.05$) between the control treatments and T4V1 and T4V2 in the total weight of paddy grains per meter, total weight of paddy grains per plot, and total yield per hectare could be attributable to several factors. These factors included uninvited pests and human error in the measurements in which could potentially result in this negative outcomes. Of course, from ecological point of view, there are many uncontrolled factors that could not be studied at the trial plot sites. However, the positive results from T2V1, T2V2, T3V1 and T3V2, have overruled the negative results of T4V1 and T4V2. This has almost confirmed the effectiveness of using ACI bio-organic and bio-chemical fertilizers and ACI N-Fixer for improving the paddy yield at Langkat. Normal Chemical Compound NPK fertilizer is an inorganic fertilizer while ACI fertilizers used in the present study were bio-organic and bio-chemical fertilizers. Both the ACI fertilizers showed better paddy yields than inorganic Normal Chemical Compound NPK fertilizer. This can be explained by the beneficial influence of bio-organic materials in stocking the essential NPK to the plants. Therefore, they can stimulate the cation exchange capacity in the habitat soils, thus facilitating them to sustain the essential nutrients longer in the habitat soils that can promote the uptake of essential NPK in the paddy root zone. This can improve the biological activities in the habitat soils and increase the soil fertility [15]. The role of microorganisms in enhancing the growth and yield of plants and improving the soil biological properties can be found in several reports in the literature. For instance, Hauka et al. [16] reported that all the tested isolates can release potassium from mica although not equally efficient. They found that the most efficient isolate namely KRB-2 could release 7.05 ppm after 6 weeks of incubation, which was identified as *Rhizobium pusense* MF135560.

The present finding on positive relationships between biofertilization and increased microbial counts in the paddy have been well supported by many reported studies in other commercial plants. EI-Sawah et al. [17] recommended the use of the dual bacterial inoculum which containing *Azotobacter chroococcum* MF135558 and *Klebsiella oxytoca* MF135559 in the presence of 75% dose of N for enhancing growth and yield of wheat plants and reduce chemical fertilizers usage. Gao et al. [18] showed that combined application of the biofertilizer mixture (*Azotobacter chrocoocum*, AMF, and *Bacillus circulans*) with organic fertilizers enhanced maize growth, yield, and nutrient uptake. Finally, their results of bio-organic fertilization on the growth parameters and yield of maize pointed to their use as an alternative tool to reduce chemical fertilizers. Afify et al. [19] showed that the microbial inoculation leads to a significant increase in growth parameters (foliage heights, number of leaves and dry weights) of onion plants.

The use of microorganisms in the biofertilizers of ACI's products are well supported by many reported in the literature. Khan [20] found that the greater advantages of biofertilizer application with microbes *Azospirillum* and *Trichoderma*. This can supplement chemical N fertilizer with optimal paddy yields. In Philippines, Banoya et al. [21] showed the positive effect on paddy grain yields by using three different biofertilizers including *Trichoderma* and *Azospirillum*. Subashini et al. [11] also reported the positive effect of biofertilizers (with N-Fixer *Azospirillum*) on the paddy yields of rice

varieties at Puducherry, India. Simarmata et al. [22] summarized that application of 400 g per ha of consortia of biofertilizers or 400 g of biofertilizers-*Trichoderma* combined with 2.5–7.5 ton per ha of composted straw improved the induced systemic resistance and rice productivity. Therefore, the present study using ACI's biofertilizers holds a good future perspective in the paddy rice plantation [23-24] in this region.

III. Conclusion

Overall, the filled grains in the ACI treatments are significantly ($P< 0.05$) higher than those in the control treatments that used Normal Chemical Compound NPK. Overall, total weight per meter² (368-617g) in ACI treatments are also significantly ($P< 0.05$) higher than those (319-371g) in the control treatments. At harvesting time at 105 days after transplanting, the significantly higher ($P< 0.05$) colony counts (13-15 x 10^6 CFU/mL) (for ACI treatments), than those (8 x 10^6 CFU/mL) in the controls positively indicated higher total yields of paddy grains per hectare. It was found that the application of ACI bio-organic and bio-chemical fertilizers and ACI N-Fixer can improve paddy yields of the two rice varieties, between 16.4-38.2% (up to 5.75 MT/ha), in the field trial plots at Langkat. Based on the present field trial plots at Langkat, it can be concluded that that the ACI bio-organic NPK (5/5/5) fertilizer, ACI bio-chemical NPK (15/15/15) fertilizer, and ACI N-Fixer (N-Bio Booster) which was applied in the field trial plots at Langkat can improve the paddy yields of the two rice varieties (Inpari 30 and Ipari 32). Most importantly, the application of the ACI fertilizers can increase paddy yields between 16.4-38.2% in the field trial plots at Langkat. Therefore, it is highly recommended that ACI bio-organic and bio-chemical fertilizers and ACI N-Fixer can be used to increase the paddy production in this region.

IV. Materials & Methods

Study area and experimental design

The field trial plots were conducted on the irrigated paddy land ecosystem in North Sumatra in Pasar Miring (Deli Serdang, Langkat, Medan, Indonesia; Figure 1), from May to October 2018. This study used a factorial randomized complete block design which consisted of two factors, namely: factor I. Type and dosage of fertilizer consisted of 4 levels, namely: T1: Control (Normal Chemical Compound with NPK ratio as 15/15/15 plus urea), T2: ACI chemical fertilizer with NPK ratio of 5/5/5) plus ACI N-Fixer plus urea, T3: ACI chemical fertilizer with NPK ratio of 15/15/15 plus ACI N-Fixer plus urea, and T4: ACI chemical NPK fertilizer with NPK ratio of 5/5/5 plus NPK ratio of 15/15/15 plus N-Fixer plus urea. The second factor is rice paddy varieties consisting of V1: Inpari 30 and V2: Inpari 32.

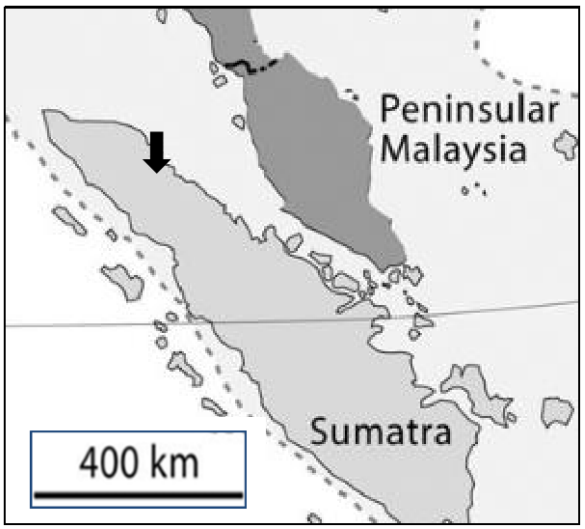

Figure 1: Location map of the field trial plots Deli Serdang, Langkat, Medan, Indonesia (arrow).

This study consisted of four replications. The combinations of the two factors tested with four treatments and two paddy varieties are presented in Table 6. The trial plot area was 400 cm x 500 cm, the distance between the plots was 50 cm and the distance between replications was 1 m. Manuring programs and the methods of application in the field trial plots at Langkat are presented in Table 7. Figure 2 shows the temperature and rainfall from May to October 2015 at Kuala Langkat, North Sumatera, Indonesia [25].

Table 6: Combinations of treatments and paddy variety in the field trial plots at Langkat, Medan, Indonesia:

Factor 1: Fertilizers	Factor II: Variety	Treatments
T1 (Control): Normal Chemical Compound NPK (15/15/15) + Urea	V: Inpari 30	T1V1
T1 (Control): Normal Chemical Compound NPK (15/15/15) + Urea	V: Inpari 32	T1V2
T2: ACI (NPK 5/5/5) + ACI (N-Fixer) + Urea	V: Inpari 30	T2V1
T2: ACI (NPK 5/5/5) + ACI (N-Fixer) + Urea	V: Inpari 32	T2V2
T3: ACI (NPK 15/15/15) + ACI (N-Fixer) + Urea	V: Inpari 30	T3V1
T3: ACI (NPK 15/15/15) + ACI (N-Fixer) + Urea	V: Inpari 32	T3V2
T4: ACI NPK (5/5/5) + ACI (NPK 15/15/15) + ACI (N-Fixer) + Urea	V: Inpari 30	T4V1
T4: ACI NPK (5/5/5) + ACI (NPK 15/15/15) + ACI (N-Fixer) + Urea	V: Inpari 32	T4V2

Table 7: Manuring programs and methods of application in the field trial plots at Langkat, Medan, Indonesia.

Treatments	Days after transplanting (DAT)	Fertilizer	Rate (kg/ha)	Method of Application
T1V1 T1V2	7DAT	Normal Chemical Compound NPK	150	Broadcast granules to field
		Urea	50	Broadcast powder to field
	30DAT	Normal Chemical Compound NPK	150	Broadcast granules to field
		Urea	50	Broadcast powder to field
	50DAT	Normal Chemical Compound NPK	150	Broadcast granules to field
		Urea	50	Broadcast powder to field
T2V1 T2V2	-7 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	7 DAT	ACI NPK (5/5/5)	450	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	30 DAT	ACI NPK (5/5/5)	450	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	40 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	50 DAT	Urea	50	Broadcast powder to field
T3V1 T3V2	-7 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	7 DAT	ACI NPK (15/15/15)	150	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	30 DAT	ACI NPK (15/15/15)	150	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	40 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	50 DAT	Urea	50	Broadcast powder to field
T4V1 T4V2	-7 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	7 DAT	ACI NPK (5/5/5)	250	Broadcast pellets to field
		ACI NPK (15/15/15)	65	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	30 DAT	ACI NPK (5/5/5)	250	Broadcast pellets to field
		ACI NPK (15/15/15)	65	Broadcast pellets to field
		Urea	50	Broadcast powder to field
	40 DAT	ACI N-Bio Booster	10	Diluted with water and sprayed onto field
	50 DAT	Urea	100	Broadcast powder to field

Rice agronomic data and soil samplings

The levels of NPK in the top soils of the paddy farms were analysed after treatment (harvest period; collected at 105 days after transplanting (DAT)). The colony growth in the paddy soils were analysed before and after treatments. For the paddy plant samples, the plant heights were measured at 20, 30, 40, 60 DAT. The total numbers of productive tillers were counted at 60 DAT. Numbers of filled and unfilled grain, total weight of paddy grains per meter^2, total weight of paddy grains per plot and total yield per hectare were determined at harvest period at 105 DAT.

Soil and plant analyses

Soil and plant analyses were conducted at the laboratory of Institute for Agricultural Technology (BPTP) in Medan, North Sumatra, Indonesia. The chemical parameters of the soils were determined quantitively based on the criteria of soil analysis of the Soil Research Institute (Balai Penelitian Tanah; BPT) of Bogor [26]. The methods of NPK determinations followed the FAO's standard methods [27].

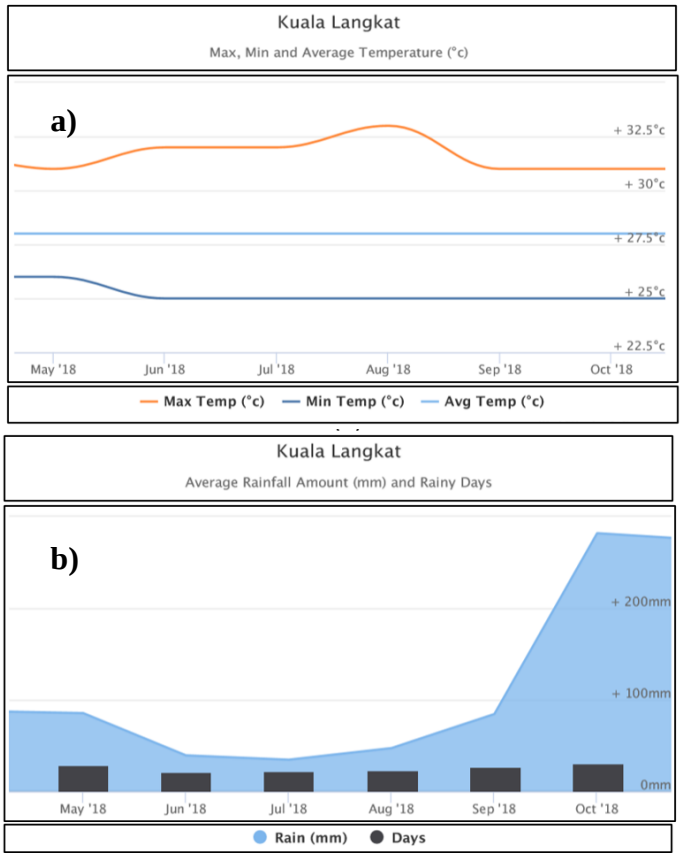

Figure 2: Temperature (°C; **a)** and rainfall (mm); **b)** from May to October 2015 at Kuala Langkat, North Sumatera, Indonesia (Graphs cited and edited from the original source of World Weather Online [25]).

Microbial colony analyses

Number of colony counts (x 10^6) in the topsoils of paddy field were determined at 35, 60 and 105 (harvesting time) DAT. Analysis of the number of colony was carried out in the microbiology laboratory of the University of North Sumatra, followed the standard test method Automated Colony Forming Unit (CFU) Assays by ASTM [28].

Briefly, 10 g of soil samples were suspended in 100 ml of sterile phosphate saline buffer and shaken using an orbital shaker (DLAB SK-0330-PRO, China) at 200 rpm for 30 minutes to produce a homogenous soil suspension. Serial dilutions of the soil suspensions were diluted to a factor of 10^{-7} using sterile distilled water. Diluted suspensions (0.10ml) were transferred aseptically onto nutrient agar and spread in duplicates using a flame-sterilized glass spreader. The inoculated plates were then incubated in an incubator (Memmert IN110, Germany) for 3 to 5 days at 28°C. The CFU of each plate was recorded on a daily basis. The type of microorganisms counted was total bacterial count.

Statistical analysis

For data analysis, the means of all parameters were statistically tested based on Duncan Multiple Range Test in order to see if there is any significant difference ($P< 0.05$) among the four treatments [29]. Data analysis was performed using the SPSS program (SPSS 15.0 (2006 by SPSS Inc); Chicago; USA).

Authors' Contributions: SHTP initiated, designed, and monitored the whole experiment. SMH, NFMS, and NAT performed the soil analysis, plant analysis and the chemical analysis of the paddy, and performed the microbiological measurements. RA, MHZ, CTKT, PK and EWC prepared the biofertilizers and assisted in monitoring the experiment in the field. SMH performed the statistical data. CKY wrote the first draft of the manuscript, revised and edited the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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