

## REDUCING CHEMICAL FERTILIZER IN SWEET POTATO CULTIVATION BY USING MIXED BIOFERTILIZER

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### ABSTRACT

Biofertilizer enable to improve nutrient cycle in soil and induce plant growth and production, but sweet potatoes farmers in Indonesia are still use only chemical fertilizer as a source of plant nutrient. The objectives of this experiment were to evaluate the effect of different doses of consortium biofertilizer to reduce chemical fertilizer dose; and maintain yield and sweetness of two sweet potato varieties. The experimental design was completely randomized block design which tested six combinations of different chemical fertilizer and biofertilizer doses. Analysis of variance was performed to determine any significant differences between the means of treatments. The results showed that response of both sweet potatoes varieties on combined application of chemical and bio fertilizer was differ. All treatments did not change tuber number and weight of sweet potato var. Awachy-1 but increased those of var. Rancing. Application of diazotrophic bacteria (*Azotobacter*, *Azospirillum* and *Acinetobacter*) mixed with phosphate solubilizing microbes (*Pseudomonas* and *Penicillium*) with reduced fertilizer doses up to 75% did not alter soil available nitrogen and phosphorous. Despite different fertilizer rates, tubers number of both sweet potato varieties in individual plot was similar. Yield did not change due to reduction of fertilizer dose up to 75% when biofertilizer was applied. However, yield was potentially decreased when chemical fertilizer was only 50%. All fertilizer treatments did not change the sweetness of tuber which indicated by constant brix. Research suggested that biofertilizer might substitute 25% of chemical fertilizer to obtain the same yield and quality of tuber, and maintain the availability soil nitrogen and phosphorous.

Key words: nitrogen, phosphorus, nitrogen fixing bacteria, phosphate solubilizing microbes, yield

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تخفيض السماد الكيماوي في زراعة البطاطا الحلوة باستعمال خليط من الاسمدة العضوية

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### المستخلص

مزارعي البطاطا الحلوة في إندونيسيا ما زالوا يستخدمون الأسمدة الكيماوية فقط كمصدر للمغذيات النباتية. وكانت أهداف هذه مزارعي البطاطا الحلوة في إندونيسيا ما زالوا يستخدمون الأسمدة الكيماوية فقط كمصدر للمغذيات النباتية. كانت أهداف هذه التجربة هي تقييم تأثير جرعات مختلفة من الأسمدة الحيوية الخاصة بالكونسورتيوم لتخفيض جرعات الأسمدة الكيماوية؛ والحفاظ على الغلة وحلاوة من اثنين من أصناف البطاطا الحلوة. كان التصميم التجريبي عبارة عن تصميم بلوك عشوائي تماما والذي اختبر ست مجموعات من الأسمدة الكيماوية المختلفة وجرعات الأسمدة الحيوية. تم إجراء تحليل التباين لتحديد أي اختلافات كبيرة بين وسائل العلاج. أظهرت النتائج أن استجابة أصناف البطاطا الحلوة على التطبيق المشترك للأسمدة الكيماوية والبيولوجية كانت مختلفة. جميع العلاجات لم تغير عدد الدرنات ووزن البطاطا الحلوة فار Awachy-1 لكن زاد من var. Rancing. إن استخدام البكتيريا ثنائية الأسطح (*Azotobacter*) و (*Azospirillum*) و (*Acinetobacter*) الممزوجة بالميكروبات الذائبة في الفوسفات (*Pseudomonas* و (*Penicillium*) مع جرعات منخفضة من الأسمدة تصل إلى 75% لم يغير من التربة المتاحة للنيتروجين والفوسفور. على الرغم من اختلاف معدلات الأسمدة، كان عدد الدرنات لكل من أصناف البطاطا الحلوة في قطع الأراضي الفردية متشابهة. لم يتغير العائد بسبب تخفيض جرعة السماد بنسبة تصل إلى 75% عندما تم تطبيق الأسمدة الحيوية. ومع ذلك، فقد انخفضت الغلة عندما كانت الأسمدة الكيماوية 50% فقط. جميع معالجات الأسمدة لم تغير حلاوة الدرنة التي يشار إليها بريكس ثابت. اتشي النتائج أن الأسمدة الحيوية قد تحل محل 25% من الأسمدة الكيماوية للحصول على نفس الغلة ونوعية الدرنات، للمحافظة على التربة النايتروجينية والفوسفور

الكلمات المفتاحية: النيتروجين، الفوسفور، بكتيريا تثبيت النيتروجين، ميكروبات ذوبان الفوسفات، العائ

## INTRODUCTION

At least 200 varieties of local sweet potatoes grow in Indonesia and mostly exported to other countries and consumed locally as staple food. Sweet potato in Indonesia typically cultivated in upland region dominated by low to medium soil fertility includes Ultisols, Oxisols and Inceptisols. These soils order contains low nitrogen and phosphorus that limited plant productivity (9) and become a constrain to increase sweet potatoes productivity. For optimum plant growth, macro and micro nutrients must be available in balanced quantities; but nutrients released from soil is naturally too slow to meet plant needs. To overcome limited availability of nitrogen and phosphorous, farmers applied chemical fertilizer combined with organic fertilizer to increase the yield. Both chemical and organic fertilizers have different effects on soil, crops, and nutrient availability; but integrated used of both fertilizer increased sweet potatoes productivity (10). Combined use of 15t/ha farm yard manure and P fertilizer was reported to increase marketable yield of sweet potatoes (4). One of a major concern in tropical agriculture is soil quality degradation from excessive and intensive used of chemical fertilizer. Biofertilizer is an alternative to minimize the used of chemical fertilizer. Integrated use of chemical fertilizer and biofertilizer will be important for long term sustainable agriculture in low fertility soil to increase nutrient availability as well as maintain enzymatic nutrient cycle and beneficial microbe occurrence in soil. Biofertilizer application is versatile, due to its ability to reduce chemical fertilizer level, increase plant growth and yield without long term impact on soil quality (1). Nowadays nitrogen-fixing bacteria (NFB) and phosphate solubilizing microbes (PSB) are recognized biofertilizer which take an important role to supply nitrogen (N) and phosphate (P) respectively for plant uptake. Nitrogen (N) and Phosphorus (P) are macro essential nutrient for producing marketable tuber (6,14,16). Both NFB and PSB are beneficial soil microbes well known as Plant Growth Promoting Rhizobacteria. Moreover, both microbial groups synthesized and secreted phytohormones to the soil; which is in turn uptake by plant roots to

regulate cell development and elongation. Biofertilizer contribution to tuberous food crops yield was reported elsewhere. Phosphate solubilizing bacteria increased marketable potatoes, but tuber weight was markedly enhanced following nitrogen-fixer *Azotobacter* and *Azospirillum* inoculation (10). Mixed biofertilizer *Klebsiella* sp. UPM SP9, *Erwinia* sp. UPM SP10, *Azospirillum brasilense* SP7 and *B. sphaericus* UPMB 10 with one-third of recommended N fertilizer increased root dry weight and macronutrient content in shoot as well as storage roots which indicated that biofertilizer also has a potency to reduced N fertilizer (22). Seven bacterial isolates namely P18, P19, P31, P32, P35, P39, and P42 showed plant growth promoting activities were obtained from surface sterilized healthy roots of sweet potato and demonstrated the ability to reduce the dependence on chemical fertilizers in sweet potato growth (5). Research related to the use of biofertilizer on sweet potatoes in Indonesia is rarely carried out despite they are important to improve soil quality and hence sweet potatoes productivity. We had developed sweet potatoes new breed namely Awachy-1 by artificial pollinated method to fulfill orange-fleshed sweet potato demand in sweet potatoes food-based industries. Awachy-1 is more preferred by food industry than local variety namely Rancing due to phenotypic criteria, sweetness, and productivity. The objective of this experiment was to verify the role of mixed biofertilizer containing NFB and PSB to maintain both soil available nitrogen and phosphorous as well as decrease the dose of chemical fertilizer without lowering the quality and yield of both sweet potatoes varieties grown on low fertility soil.

## MATERIALS AND METHODS

Field trial was performed during the dry season in experimental field of Universitas Padjadjaran in Jatinangor, West Java, Indonesia. The field was located in tropical region at 772.5 m above the sea level. The soil was silty clay Inceptisols which was slightly acid, and low in essential macronutrient content (Table 1).

**Table 1. Chemical characteristics of Inceptisols in experimental field before experiment at 0-30 cm in depth**

Characteristics	Value	Quality
pH in H <sub>2</sub> O	6.3	Slightly acid
Organic Carbon (Walkey-Black)	1.79 %	Low
Total Nitrogen (Kjeldahl)	0.16 %	Low
C/N	11	Average
K <sub>2</sub> O extractable in HCL	9.11 mg/100g	Very low
P <sub>2</sub> O <sub>5</sub> extractable in HCL	7.47 mg/100g	Very low
P <sub>2</sub> O <sub>5</sub> (Bray I)	0.19 mg/kg	Very low
K <sup>+</sup>	0.27 cmol/kg	Low
Na <sup>+</sup>	0.18 cmol/kg	Low
Ca <sup>2+</sup>	6.37 cmol/kg	Average
Mg <sup>2+</sup>	3.74 cmol/kg	High
Cation Exchange Capacity	23.73 cmol/kg	Average
Base Saturation	44.48 %	Average

Sweet potato var. Awachy-1 and Rancing has been provided by Breeding Laboratory, Universitas Padjadjaran. Liquid biofertilizer has been developed by Soil Biology Laboratory, Universitas Padjadjaran, contains non-symbiotic NFB *Azotobacter chroococcum*, *A. vinelandii*, *Acinetobacter* sp, and *Azospirillum* sp.; and PSM *Pseudomonas cepacea* and *Penicillium* sp. Bacterial and fungal density were at least 10<sup>7</sup> cfu mL<sup>-1</sup> and 10<sup>5</sup> cfu mL<sup>-1</sup> consecutively. Mixed culture of beneficial microbes was scaled up in molasses based liquid culture.

#### Experimental set up

Potatoes cutting were grown in field plots in a Randomized Block Design with 12 treatments and three replications. Two level of compound N-P-K Fertilizer (75% and 50% of recommended dose) were integrated with two liquid biofertilizer concentration (0.1% and 0.2%). Control treatments were recommended NPK fertilizer (300 kg/ha) without and with 0.1% biofertilizer. All six treatments were applied to sweet potatoes var. Awachy-1 as well as Rancing. The dimension of individual plot was 6 x 2 m and consisted of six beds of 2.0 m in length, 0.7 meter in width and 0.4 m in height; the distance between two beds was 0.3 m. Sweet potato cuttings (20-25 cm; 6 internodes) were planted in beds with 25 cm spacing within each row. Chemical fertilizer was applied at 7 and 45 days after transplanting by soil dressing; half dose each. Biofertilizer inoculation was carried out third times at bedding preparation; and 10 and 45

days after transplanting. The amount of each biofertilizer inoculation was 1.5 L/bed which was applied by soil dressing method.

#### Parameters

Primary vine length and diameter were measured at 95 days after planting. Tuber count and weight from individual plot were measured at harvest time at day 135. At harvest time, tuber number and weight from each individual pot were measured. Soil around the roots were collected and store at room temperature before N and P determination. Available Nitrogen (N-NO<sub>3</sub> and N-NH<sub>4</sub>) were analyzed by Morgan-Wolf method and available P with Bray I since the soil was slightly acid. Total soluble solids (TSS) of tuber solution was determined by using a refractometer after storing tubers in room temperature (23-27°C) for two weeks. Degree Brix indicated in refractometer is related to sugar content of tuber.

#### Statistical analysis

All data were subjected to analysis of variance (F test at significant level of 95%). If the effect of experimental treatment were significant in F-test, then Duncan Multiple Range Tests at the same significant level were conducted to verify the significance between treatments.

## RESULTS AND DISCUSSION

#### Vine length and diameter

Analysis of variance showed that fertilizer treatments influenced vine length, but did not change vine diameter. The effect of fertilizer treatments on vine length and diameter was only significant on Awachy-1 (Table 1).

**Table 1. Vine length and diameter of two varieties of sweet potato grown under different fertilizer treatments at 95 days after planting**

Fertilizer Treatments	Vine length (cm)		Vine Diameter (cm)	
	Awachy	Rancing	Awachy	Rancing
100% CF <sup>1</sup>	133.21 b	82.25 a	0.32 a	0.31 a
100% CF, 0.1% BF <sup>2</sup>	148.26 c	87.64 a	0.31 a	0.28 a
75% CF, 0.1% BF	145.89 c	84.51 a	0.32 a	0.25 a
75% CF, 0.2% BF	138.72 b	83.83 a	0.33 a	0.32 a
50% CF, 0.1% BF	146.54 c	89.45 a	0.31 a	0.30 a
50% CF, 0.2% BF	123.83 ab	87.55 a	0.29 a	0.27 a

Note: numbers in a column followed by same letters were not significantly different based on 95%

Duncan's Multiple Range Test. <sup>1</sup>Chemical fertilizer; <sup>2</sup>Biofertilizer

Vine length of Awachy-1 genetically were shorter than those of Rancing. In control treatment (recommended doses of chemical fertilizer) vine length of Awachy-1 was 133.21 cm while those of Rancing was only 82.25 cm (Table 1). Vine length of Awachy-1 was longer in plot with 100%, 75% as well as 50% of NPK fertilizer in combination with 0.1% biofertilizer compared to those in plot without biofertilizer. However, there was no change in Awachy-1 vine length when 50% chemical fertilizer was applied with 0.2% biofertilizer. Sweet potatoes var. Rancing was local variety which is well adapted to local soil and climate condition but their vegetative growth didn't response to fertilizer (Table 1).

### Tuber yield

Chemical fertilizer combined with biofertilizer did not show any significant effect on tuber number and weight of var. Awachy-1 but did on Rancing (Table 2).

**Table 2. Tuber yield per plot of sweet potato var. Awachy-1 grown under different fertilizer treatments at 135 days after planting**

Fertilizer Treatments	Tuber number	Tuber weight (kg)	Brix value (% TSS)
100% CF <sup>1</sup>	25.00 a	5.20 a	15.96 c
100% CF, 0.1% BF <sup>2</sup>	22.00 a	5.07 a	14.22 b
75% CF, 0.1% BF	25.67 a	5.03 a	15.25 bc
75% CF, 0.2% BF	21.00 a	5.40 a	15.26 bc
50% CF, 0.1% BF	31.00 a	4.60 a	13.64 a
50% CF, 0.2% BF	30.67 a	6.00 a	14.09 b

Note: numbers in a column followed by same letters were not significantly different based on 95% Duncan's Multiple Range Test. <sup>1</sup>Chemical fertilizer; <sup>2</sup>Biofertilizer

Application of 50% and 75% chemical fertilizer followed by biofertilizer inoculation in Awachy-1 plot gave similar tuber number and weight compared to control treatment. In contrast, application of chemical-and biofertilizer clearly increased tuber number and weight of var. Rancing (Table 3).

**Table 3. Tuber yield per plot of sweet potato var. Rancing grown under different fertilizer treatments at 135 days after planting**

Fertilizer Treatments	Tuber number	Tuber weight (kg)	Brix value (% TSS)
100% CF <sup>1</sup>	69.33 a	8.87 b	13.59 b
100% CF, 0.1% BF <sup>2</sup>	100.00 c	10.43 c	14.10 b
75% CF, 0.1% BF	82.00 bc	9.47 bc	14.72 b
75% CF, 0.2% BF	85.00 bc	9.13 bc	14.02 b
50% CF, 0.1% BF	73.31 b	10.60 c	13.46 b
50% CF, 0.2% BF	77.00 b	9.53 bc	13.09 a

Note: numbers in a column followed by same letters were not significantly different based on 95% Duncan's Multiple Range Test. <sup>1</sup>Chemical fertilizer; <sup>2</sup>Biofertilizer

The highest Rancing's tuber number was in the plot received NPK recommended dose and 1% biofertilizer but higher tuber weight was demonstrated in plot with 0.1% biofertilizer combined with either 100% or 50 NPK fertilizer. For Awachy-1, brix value of two-week old tubers decreased after biofertilizer application irrespective of chemical fertilizer dose; but fertilizer treatment maintained brix value of Rancing. In general brix value of Awachy-1 was higher than those of Rancing. This experiment was carried out in the extreme dry season; plants suffer from drought due to high temperature and limited irrigation. Highest tuber yield of Awachy-1 was only 6 t/ha harvested from the plot with 50% NPK fertilizer combined with 0.2% biofertilizer. Tuber yield of var. Rancing clearly increased after biofertilizer inoculation; the highest tuber yield per plot was 10.6 kg, equal to 8.8 t/ha which is obtained from plot with 50% NPK fertilizer and 0.1% biofertilizer. In this field experiment, tuber yield of both varieties were low since optimal yield of Awachy-1 and Rancing were up to 21 t ha<sup>-1</sup> and 27 t ha<sup>-1</sup> respectively. However, this results verified that even in drought seasons, mixed biofertilizer might substitute a part of chemical fertilizer. Fertilizer treatment influenced brix value significantly, irrespective of the fertilizer treatments, all brix value was still in the range of food industry requirement (Table 2), 9-16 and mostly 13.6. In general Brix value of Awachy-1 was higher than Rancing; Awachy-1

highest brix value was in tuber from plant treated with 75% NPK with 10.1% and 2% biofertilizer. The highest brix value in Rancing was around 14.

#### Available N and P in soil

After the harvest, soil around tubers from each plot was collected for available N and P analysis. This parameter will provide the information concerning the availability of two essential macronutrients for the next crops, either sweet potato or other food crops. Fertilizer treatment had a significant effect on available N-NH<sub>4</sub><sup>+</sup> and P in soil but did not on N-NO<sub>3</sub><sup>-</sup>, but the response was depended on sweet potato varieties (Table 4 and Table 5).

**Table 4. Available P and N in soil around roots of sweet potato var. Awachy-1 grown under different fertilizer treatment at 135 days after planting**

Fertilizer Treatments	Available N (mg kg <sup>-1</sup> )		Available P (mg kg <sup>-1</sup> )
	N-NH <sub>4</sub> <sup>+</sup>	N-NO <sub>3</sub> <sup>-</sup>	
100% CF <sup>1</sup>	0.65 a	1.11 a	1.52 a
100% CF, 0.1% BF <sup>2</sup>	0.35 a	1.19 a	2.59 b
75% CF, 0.1% BF	0.65 a	1.39 a	2.40 b
75% CF, 0.2% BF	0.60 a	1.25 a	2.51 b
50% CF, 0.1% BF	0.72 ab	1.49 a	1.77 a
50% CF, 0.2% BF	1.32 b	1.46 a	2.97 b

Note: numbers in a column followed by same letters were not significantly different based on 95% Duncan's Multiple Range Test. <sup>1</sup>Chemical fertilizer; <sup>2</sup>Biofertilizer

**Table 5. Available P and N in soil around roots of sweet potato var. Rancing grown under different fertilizer treatment at 135 days after planting**

Fertilizer Treatment	Available N (mg kg <sup>-1</sup> )		Available P (mg kg <sup>-1</sup> )
	N-NH <sub>4</sub> <sup>+</sup>	N-NO <sub>3</sub> <sup>-</sup>	
100% CF <sup>1</sup>	1.29 b	1.79 a	2.20 b
100% CF, 0.1% BF <sup>2</sup>	0.55 a	1.50 a	4.84 b
75% CF, 0.1% BF	0.67 a	1.38 a	2.59 b
75% CF, 0.2% BF	0.56 a	1.43 a	2.16 b
50% CF, 0.1% BF	0.76 ab	1.47 a	2.78 b
50% CF, 0.2% BF	1.73 a	1.45 a	1.73 a

\*Numbers in a column followed by same letters were not significantly different based on 95% Duncan's Multiple Range Test.

Reducing chemical fertilizer followed by biofertilizer application increased available P in soil and maintained the availability of N compared to control treatment. For Awachy-1 cultivar, decreasing chemical fertilizer up to 50% with 1% or 2% biofertilizer increased N-NH<sub>4</sub><sup>+</sup> and P while for Rancing, 50% NPK with 0.1% biofertilizer increased said nutrient content. This experiment demonstrated that beneficial effect of both PGPR groups in combination with reduced chemical fertilizer provided available nitrogen (N) and phosphorus (P). The source of N and P recovered after the harvest the residue of chemical fertilizer and microbial activities. Non-symbiotic NFB and PSM group is widely used biofertilizer due to their ability to provide available soil N and P. Plant absorbs the available nitrogen in the form of ammonium (NH<sub>4</sub><sup>+</sup>) and nitrate NO<sub>3</sub><sup>-</sup> (12); and available P in the form of phosphate (13). The *Azotobacter*, *Azospirillum* and endophytic *Acinetobacter* are NFB that convert atmospheric N<sub>2</sub> to NH<sub>3</sub> that can be changed enzymatically to either NH<sub>4</sub><sup>+</sup> or NO<sub>3</sub><sup>-</sup> which can be used by plants. The *Pseudomonas cepacea* and *Penicillium* sp. are PSM which produced organic acid to mobilize insoluble inorganic phosphates and can be absorbed by plant roots (19). Phosphate-solubilizing microorganisms have been regarded as best promising rhizobacter for P nutrition in agriculture (15). Since N and P are limiting essential nutrition in plant growth, these findings suggest that adaptability of exogenous NFB and PSM allow them to reduce NPK fertilization doses. Reducing chemical fertilizer dose allow to decrease important macronutrient nitrogen and phosphorous especially in low fertility soil. Biofertilizer can take an important role to provide a part of those major nutrients. The use of biofertilizer in tuber plant production showed a similar result with our experiment. A mixture of free living N<sub>2</sub>-fixers *A. chroococcum*, *A. lipoferum*, and potassium releasing bacteria *Bacillus circulans*, increased tuber weight of potato var Spunta grown in field with 50% of recommended P fertilizer; while mixture of *A. chroococcum* and *A. lipoferum*) increased significantly tuber weight and marketable potato (10). Based on the field experiment,

cattle manure and biofertilizer was a good alternative for the sweet potato organic fertilization (15). Inoculation of sweet potato with the beneficial microbe included N fixing bacteria reduced N fertilizer rate to give highest tuber dry weight than un-inoculated plants (10). Brix value indicate total soluble solid mostly sugar which is a product specification in food industry. Food industry require orange-fleshed sweet potato to have Brix value between 9 to 16, but in general 13.6 is accepted as an ideal value. Brix degree is influenced by sweet potato variety, cultivation method, and soil and climate condition. Brix value listed in Table 2 is higher than that of sweet potato cv. faara and sauti, 12.00 - 13.13, which is a raw material for nonalcoholic beverage (8). This field experiment demonstrated that fertilization with nitrogen fixers and phosphate solubilizing microbe had a positive residual effect on available N and P which is an important chemical characteristic to determine soil quality. For sweet potatoes, N might influence the yield by increasing agronomic traits includes plant dry weight, leaf area index and number of leaves per plant (3). Phosphorous showed a clear role on leaf and vine length but excessive P may decrease tuber yield (18). The experiment showed that reduced chemical fertilizer in combination with mixed biofertilizer only increased vine lengths of var. Awachy-1 (Table 1) but the yield of said variety did not affected. Rancing was influenced by fertilizer treatments (Table 3). All dose of chemical fertilizer comined with all concentration of biofertilizer only increased the tuber number and weight of var. Rancing. In this experiment, the effect of treatment on those traits was depend on sweet potatoes variety. For both varieties fertilizer dose up to 75% with any concentration of biofertilizer did not change the yield. When 50% chemical fertilizer was applied, the yield was potentially decreased. The used of PGPR as biofertilizer has become prominent in providing nutrient and phytohormones. Those beneficial microbes are hence important to reduce and even replace chemical fertilizer in sustainable crop production. Our results is in accordance wuth the effect of NFB *Azotobacter*, *Azospirillum* and *Acinetobacter* which enable

to provide significant amount of nitrogen and has the capacity to produce phytohormones (8,12). Phosphate solubilizing bacteria such as *Pseudomonas* sp. has been prooved to improve soil quality through their prominent role to increase P availability in low P content soil (20). Like *Pseudomonas*, soil fungi of *Penicillium* spp. was able to convert chemical P into soluble forms  $H_2PO_4^-$  and  $HPO_4^{2-}$  that can be uptake by plant roots (4). Mixed biofertilizer In this experiment, mixed biofertilizer contain *Azotobacter* and *Pseudomonas* sp. which has been proved to synthesise phytohormone. The *Azotobacter chroococcum* produce IAA 0.52 mg/L IAA, 0.97 mg/L cytokinins and 0.41 mg/L gibberrelins; while *A vinelandii* 0.82 mg/L IAA, 0.46 mg/L cytokinins and 0.35 mg/L gibberrelins in free nitrogen culture. In Pikovskaya broth, *Pseudomonas cepacea* produce 70.89 mg/L IAA, 5.11 mg/L cytokinins and 109 mg/L gibberrelins. Inceptisols used in our experiment had low organic carbon so that cow manure was added before experiment. Soil was low in nitrogen but had enough C/N ratio; 11.2, which induce heterotrophic microbial proliferation by using organic matter as carbon source. Microbial growth also required essential nutrient P and K. Sweet potato roots compete with microbe for the same nutrient. Nutritional management with appropriate combination of chemical and biofertilizer would be environmentally advantageous and economically important in sustainable food crops cultivation (23). Reducing chemical fertilizer level in both sweet potatoes varieties did not decrease the yield as well as quality. Lower doses of chemical fertilizer reduced the environmental risk especially related to N pollution due to its mobility in soil. For Indonesian farmers, the results of this experiment is the prominent information to start reducing chemical fertilizer in sweet potato cultivation.

#### CONCLUSION

Application of reduced chemical fertilizer followed by liquid mixed biofertilizer of NFB and PSB demonstrated positive effect on yield of sweet potato var. Awachy-1 and var. Rancing. The findings revealed that mixed biofertilizer at the concentration of 0.1%, might substitute at least 25% of NPK fertilizer

to obtain the same yield and quality of tuber as well as brix degree. Sweet potatoes var. Rancing was more responsive to inoculation of mixed biofertilizer which is showed by increased in tuber yield significantly after substituting a part of chemical fertilizer with mixed biofertilizer. However, the vine length and diameter of var. Rancing didn't influence by all biofertilizer treatments. Brix value of sweet potatoes cv Awachy-1 decreased after biofertilizer application; but inoculating biofertilizer to sweet potatoes cv Rancing maintained brix value. In general brix value of Awachy-1 was higher than those of Rancing. After harvesting the tuber, fertilizer treatments contain similar amount of residual nitrate and phosphorous but lower ammonium compared to control treatments. This experiment verified that reduced NPK fertilizer dose with mixed biofertilizer may be used to maintained the sweet potatoes yield.

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