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Agronomic Performance and Productivity of Sugarcane under Various Dosage Application of Biofertilizer and Inorganic Fertilizer

Performa Agronomi dan Produktivitas Tebu pada Beberapa Dosis Pupuk Hayati dan Pupuk Anorganik

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ABSTRACT

This work was conducted to investigate biofertilizer (BF) effectiveness in various doses and combination with inorganic fertilizer (IF) on sugarcane agronomic performance and productivity. The field experiment was conducted in the early rainy season (October 2020) at Kendenglembu plantation, PT Perkebunan Nusantara XII in Banyuwangi Regency, East Java, Indonesia. The results showed insignificant differences among all the treatments in germination percentage. Although significant differences were found among all the treatments in the parameter of the number of sugarcane stalks at three and six months after planting, the number of sugarcane stools at six months after planting, and sugarcane stalk height at three months after planting, there were insignificant differences for the rest of the parameters observed in the present study, including sugarcane productivity, commercial cane sugar, and sugar crystal productivity, which are the essential parameters in sugarcane agronomic research.

Keywords: Biofertilizer, dose, sugarcane, agronomic performance, productivity

ABSTRAK

Penelitian ini dilakukan untuk mengetahui efektivitas pupuk hayati pada berbagai dosis kombinasi dengan pupuk anorganik terhadap performa agronomis dan produktivitas tebu. Penelitian ini merupakan eksperimen lapangan yang dilakukan pada awal musim hujan (Oktober 2020) di Kebun Kendenglembu, PT Perkebunan Nusantara XII di Kabupaten Banyuwangi, Jawa Timur, Indonesia. Hasil penelitian menunjukkan bahwa tidak ada perbedaan nyata antar perlakuan pada parameter persentase perkecambahan. Meskipun terdapat beda nyata antar perlakuan pada parameter jumlah batang pada tiga dan enam bulan setelah tanam, jumlah rumpun pada enam bulan setelah tanam, dan tinggi batang pada tiga bulan setelah tanam, tidak ada perbedaan signifikan untuk parameter pengamatan yang lainnya, termasuk produktivitas tebu, rendemen, dan produktivitas hablur yang merupakan parameter penting dalam penelitian agronomi tebu.

Kata kunci: pupuk hayati, dosis, tebu, performa agronomi, produktivitas

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INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the essential commodities in human life. Sugar is ubiquitous in various mankind diets. The crop also has global importance in the production of bioenergy, such as bioethanol (Hoang et al., 2015). In sugarcane cultivation, a vast amount of nutrients is needed to ensure optimum growth.

Sugarcane is one of the largest biomass producers (de Oliveira et al., 2018), which can be associated with a significant crop nutrient intake from the soil (Putra et al., 2021). Nitrogen (N), phosphorous (P), and potassium (K) are the primary nutrients that sugarcane needs in great quantities and are typically given to the crop in the form of chemicals (Pawirosemadi, 2011). Continuous use of chemical fertilizers in sugarcane fields can reduce soil quality and harm the environment (Savci, 2012; Shambhavi et al., 2017; Chandini et al., 2019; Putra et al., 2020; Arifien et al., 2022). Using other types of fertilizers, such as organic and/or biofertilizers, therefore, is highly recommended to reduce both environmental pollution and cultivation costs. The use of alternative fertilizers is likely to reduce the heavy reliance on inorganic fertilizers in sugarcane farming (Dewi et al., 2022).

Biological fertilizers contain living bodies of functional groups of soil microbes that can function as nutrient providers in the soil (Simanungkalit et al., 2006). Soil microbes have a role in various physical and chemical processes in the soil, such as the decomposition of organic matter, mineralization of organic compounds, nutrient fixation, nutrient solvents, nitrification, and denitrification (Saraswati & Sumarno, 2008). Through these various processes, nutrients will become available to plants. Up to now, there have been numerous experiments on the use of biological fertilizers, especially biofertilizers containing nitrogen-fixing microbes.

One of the solid commercial biofertilizers was formulated by the Indonesian Oil Palm Research Institute using environmentally-friendly local resources, i.e., by-products (waste) of oil palm and sugar cane plants to enhance crop quality. An important feature of the biofertilizer is a consortium of beneficial microbes isolated from oil palm roots that have high adaptability and association with plants and act as plant growth promoting microbes (PGPM), i.e., nitrogen-fixing bacteria, phosphate solubilizing bacteria, and indole acetic acid (IAA) producing bacteria. Kumar & Verma (2018) postulated that PGPM could enhance plant growth and development by regulating plant hormones, producing siderophores, enhancing the antioxidant system, and boosting nutrient absorption in plants. Naik et al. (2019) posited that PGPM could induce sugarcane resistance to pests and pathogens as well as abiotic stresses such as drought and soil salinity. Previous experiments of applying the BF on oil palm and onion seedlings found a positive response in the absorption of N and P. A recent study also showed that the BF enhanced soil organic matter by up to 80% and bacterial population by up to 1,000 times, causing better plant growth than only applying inorganic fertilizer (Anonymous, 2020). Although the effectiveness of using BF has been tested on various plant species, there was no report of their efficacy on sugarcane.

Positive interactions between PGPM and sugarcane have been reported by different researchers worldwide (De Oliveira et al., 2006; Rosa et al., 2022), it is also alluring to test the BF on sugarcane. The present research aimed to examine the effectiveness of the BF in various doses and in combination with IF on sugarcane growth and productivity, so that the most optimum dose combination of both fertilizer types on sugarcane growth and productivity can be known.

METHODS

This field experiment was carried out during the early rainy season (from October 2020 to October 2021) at Afdeling Kaliputih, Kendenglembu plantation, PT Perkebunan Nusantara XII in Banyuwangi Regency, East Java, Indonesia. Materials and tools used in this experiment were the Bululawang (BL) variety, BF, IF, raffia string, hoes, buckets, meters, hand counters, scales, containers for fertilizer, slate, and stationeries.

This experiment used a randomized block design with 10 treatments, each replicated 3 times. The treatments consisted of combination doses of BF and IF (Table 1). Both BF and IF were applied once at planting time. The quantity of IF applied in all the treatments was determined based on soil analysis results. Soil analysis results showed that the C and P content in the soil was low, and the K content was high. The nutrient requirements (IF) per hectare based on the soil analysis were 700 kg ammonium sulphate (AS), 400 kg triple super phosphate (TSP), and 50 kg kalium chloride (KCl).

The experimental plots consisted of 13 rows with a length of 10 meters in each row. The distance between rows of plants was 1.35 meters. Sugarcane cultivation was carried out in accordance with the standard operating procedure applied for milled sugarcane at PT Perkebunan Nusantara XII, from land preparation to harvesting.

The following growth parameters were measured in all replicates.

- Seed germination percentage at one month after planting (MAP).
- The number of stalks and the number of tillers at 3 and 6 MAP.
- Stalk height (cm) at 3, 6, and 11 MAP.
- Stalk diameter (mm) at 6 and 11 MAP.
- Sugarcane productivity (ton ha^{-1}), commercial cane sugar (CCS/ %), and sugar crystal productivity (ton ha^{-1}) at 12 MAP.

Table 1. The doses combination of biofertilizer and inorganic fertilizer used in this experiment

Tabel 1. Kombinasi dosis pupuk hayati dan pupuk anorganik yang digunakan dalam percobaan

Combination number *Kombinasi*	Treatments *Perlakuan*			
	Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})*			Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*
	AS	TSP	KCl	
1	0	0	0	0
2	0	0	0	500
3	0	0	0	1,000
4	700	400	50	0
5	525	300	37.5	1,000
6	525	300	37.5	500
7	350	200	25	1,000
8	350	200	25	500
9	187.5	100	12.5	1,000
10	187.5	100	12.5	500

All the acquired data were subsequently analysed statistically using the Analysis of Variance (ANOVA), followed by the analysis of treatments comparison using the Least Significant Difference (LSD) method at a confidence level of 95%.

RESULTS AND DISCUSSION

The results revealed that there was an insignificant difference between the combination treatments of BF and IF on sugarcane seed germination (SG) percentage at 1 MAP (P = 0.49) (Table 2). SG was almost similar in all the treatments that were below 80%.

In Indonesia's certification of sugarcane seeds, it is required that the minimum growth rate of sugarcane seeds be 80% (Anonymous, 2015). The addition of IF and BF did not enhance SG percentage because, in the germination phase, the nutritional requirements for plants were still low, and it was more dependent on the nutrient content of sugarcane setts (Croft, 2000). The number of germinations affect the number of stalks. The number of stalks per meter is an important agronomic parameter as it determines sugarcane productivity (Khan et al., 2012; Soomro et al., 2012; Tyagi et al., 2013).

Table 2. Sugarcane seed germination percentage at the different treatments

Tabel 2. Persentase perkecambahan benih pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan*				Seed germination (%) *Perkecambahan benih (%)*
	Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})*			Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*	
	AS	TSP	KCl		
1	0	0	0	0	43.67 a
2	0	0	0	500	48.67 a
3	0	0	0	1,000	53.00 a
4	700	400	50	0	47.33 a
5	525	300	37.5	1,000	47.67 a
6	525	300	37.5	500	47.00 a
7	350	200	25	1,000	47.00 a
8	350	200	25	500	47.67 a
9	187.5	100	12.5	1,000	49.00 a
10	187.5	100	12.5	500	48.33 a
CV (%)					8.60
P value					0.490

Note: IF = inorganic fertilizer; BF = biofertilizer
The values in the table are the average of three replicates
Different superscript letters indicated significant differences (α=0.05%), and vice versa

The results showed that the BF and IF application significantly affected the number of sugarcane stalks per meter at 3 MAP (P = 0.004) (Table 3). The highest stalk was in treatment 9, that were significantly different with treatments 1, 5, and 10. Conversely, the number of stalks at 6 MAP showed insignificant different among treatments (P = 0.399).

BF facilitates nutrient provision and organic decomposition as well as provides a better rhizosphere for plants to support growth and improved crop production (Vessey, 2003). Besides, BF contained nitrogen-fixing bacteria that could generate growth hormone (IAA). The presence of IAA increased the formation of lateral roots. This phenomenon raised the amount of root exudate and the nutrients absorbed by the roots that stimulated bacterial growth, thus enhancing the inoculation effect (Suliasih & Widawati, 2018).

Table 3. The number of sugarcane stalks per meter at the different treatments

Tabel 3. Jumlah batang per meter pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan*: Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})*			Treatments *Perlakuan*: Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*	Number of sugarcane stalks per meter *Jumlah batang tebu per meter*	
	AS	TSP	KCl		3 MAP	6 MAP
1	0	0	0	0	10.90 ^{d}	11.93 ^{a}
2	0	0	0	500	13.43 ^{ab}	12.73 ^{a}
3	0	0	0	1,000	13.83 ^{ab}	13.20 ^{a}
4	700	400	50	0	13.37 ^{abc}	13.17 ^{a}
5	525	300	37.5	1,000	11.97 ^{cd}	13.27 ^{a}
6	525	300	37.5	500	13.17 ^{abc}	12.37 ^{a}
7	350	200	25	1,000	13,73 ^{ab}	12.40 ^{a}
8	350	200	25	500	13.77 ^{ab}	12.97 ^{a}
9	187.5	100	12.5	1,000	14.13 ^{a}	12.93 ^{a}
10	187.5	100	12.5	500	12.47 ^{bc}	13.30 ^{a}
CV (%)					6.37	5.87
P value					0.004	0.399

Note: IF = inorganic fertilizer; BF = biofertilizer
The values in the table are the average of three replicates
Different superscript letters in the same column indicated significant differences (α=0.05%), and vice versa

Table 4. The number of sugarcane stools per meter at the different treatments

Tabel 4. Jumlah rumpun tebu per meter pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan*				Number of sugarcane stools per meter *Jumlah rumpun tebu per meter*	
	Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})*			Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*		
	AS	TSP	KCl		3 MAP	6 MAP
1	0	0	0	0	3.07 a	2.80 a
2	0	0	0	500	3.23 a	2.87 a
3	0	0	0	1,000	3.20 a	2.83 a
4	700	400	50	0	3.27 a	2.67 a
5	525	300	37.5	1,000	3.03 a	2.93 a
6	525	300	37.5	500	3.23 a	2.90 a
7	350	200	25	1,000	3.13 a	2.97 a
8	350	200	25	500	3.27 a	2.93 a
9	187.5	100	12.5	1,000	3.27 a	3.47 a
10	187.5	100	12.5	500	2.93 a	2.97 a
CV (%)					8.29	14.73
P value					0.784	0.703

Note: IF = inorganic fertilizer; BF = biofertilizer
The values in the table are the average of three replicates
Different superscript letters in the same column indicated significant differences (α=0.05%), and vice versa

The results showed that the application of BF and IF did not significantly affect the number of sugarcane stools per meter at 3 MAP (P = 0.784), and 6 MAP (P = 0.703) (Table 4). The number of stools almost similar for all treatments.

In this experiment, the stalk height indicated insignificant differences among treatments at 3 (P = 0.487), 6 (P = 0.91), and 9 MAP (P = 0.202) (Table 5). The stalk height ranged from 253.55 – 304.15 cm before harvesting. Meanwhile, the stalk diameter also exhibited insignificant differences among treatments at 6 MAP (P = 0.926) and 11 MAP (P = 0.983) (Table 6). This indicated that BF did not significantly affect both stalk height and stalk diameter.

Stalk height is one of the essential agronomic parameters in sugarcane observations as it largely determines the final weight of the cane (Ardiansyah & Purwono, 2015). The higher sugarcane stalks followed by larger stalk diameter will produce more sugar per unit area of land, and vice versa (Hamida et al., 2022). In addition, the height of the sugarcane plant can also directly affect the increase in the number of leaves of the sugarcane, resulting optimal photosynthesis process. Plants with more leaves can absorb more light to be used in photosynthesis to produce carbohydrates (glucose) and oxygen (Manuhuttu et al., 2014).

Table 5. Sugarcane stalk height at the different treatments

Tabel 5. Tinggi batang tebu pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan*				Sugarcane stalk height (cm) *Tinggi batang tebu (cm)*		
	Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})*			Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*			
	AS	TSP	KCl		3 MAP	6 MAP	11 MAP
1	0	0	0	0	105.67 ^{a}	259.67 ^{a}	297.83 ^{a}
2	0	0	0	500	105.67 ^{a}	257.33 ^{a}	285.02 ^{a}
3	0	0	0	1,000	98.67 ^{a}	250.67 ^{a}	267.75 ^{a}
4	700	400	50	0	104.33 ^{a}	254.00 ^{a}	255.86 ^{a}
5	525	300	37.5	1,000	107.67 ^{a}	255.33 ^{a}	268.99 ^{a}
6	525	300	37.5	500	94.00 ^{a}	252.67 ^{a}	304.15 ^{a}
7	350	200	25	1,000	105.67 ^{a}	261.00 ^{a}	253.55 ^{a}
8	350	200	25	500	101.67 ^{a}	260.33 ^{a}	293.75 ^{a}
9	187.5	100	12.5	1,000	111.67 ^{a}	265.00 ^{a}	255.44 ^{a}
10	187.5	100	12.5	500	105.67 ^{a}	265.00 ^{a}	274.03 ^{a}
CV (%)					8.26	4.85	9.37
P value					0.487	0.910	0.202

Note: IF = inorganic fertilizer; BF = biofertilizer
The values in the table are the average of three replicates
Different superscript letters in the same column indicated significant differences (α=0.05%), and vice versa

In this experiment, stalk diameter was also observed as the size of stalks affects nutrient absorption and distribution in the plant body. The larger the diameter or size of the stalk, the greater the process of nutrient absorption and the formation of photosynthesis (Ashraf et al., 2008). Stalk height and diameter, as well as the number of stalks, were correlated to sugarcane productivity. Almost all of the parameters observed showed insignificant difference among treatments, so the productivity also showed an insignificant difference (Table 7).

Sugarcane productivity, CCS, and sugar crystal productivity were not significantly different among all the treatments (Table 7). However, we can also observe that treatment 1 (without any fertilization) resulted in the lowest sugarcane productivity and sugar crystal productivity among all the treatments. It confirmed the significance of fertilization in sugarcane cultivation to maintain sugarcane and sugar crystal productivity. The sugarcane productivity, CCS, and sugar crystal productivity at treatments 9, 8, and 6 were higher among all the treatments.

Table 6. Sugarcane stalk diameter at the different treatments

Tabel 6. Diameter batang tebu pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan* Inorganic fertilizer dose ($kg\ ha^{-1}$) *Dosis pupuk anorganik* (*$kg\ ha^{-1}$*)			Biofertilizer dose ($kg\ ha^{-1}$) *Dosis pupuk hayati* (*$kg\ ha^{-1}$*)	Diameter of sugarcane stalks (mm) *Diameter batang tebu (mm)*			
	AS	TSP	KCl		6 MAP		11 MAP	
1	0	0	0	0	24.33	a	24.73	a
2	0	0	0	500	24.33	a	25.90	a
3	0	0	0	1,000	23.67	a	26.09	a
4	700	400	50	0	24.33	a	25.19	a
5	525	300	37.5	1,000	24.33	a	25.74	a
6	525	300	37.5	500	24.67	a	25.97	a
7	350	200	25	1,000	24.67	a	24.67	a
8	350	200	25	500	24.67	a	25.93	a
9	187.5	100	12.5	1,000	24.67	a	26.01	a
10	187.5	100	12.5	500	24.33	a	25.92	a
CV (%)					3.49		7.51	
P value					0.926		0.983	

Note: IF = inorganic fertilizer; BF = biofertilizer

The values in the table are the average of three replicates

Different superscript letters in the same column indicated significant differences (α=0.05%), and vice versa

CONCLUSIONS

Despite significant differences observed among all the treatments in the parameter of the number of sugarcane stalks at three and six months after planting, the number of sugarcane stools at six months after planting, and sugarcane stalk height at three months after planting, there were insignificant differences for the rest of the observed parameters. It was mainly found that sugarcane productivity, commercial cane sugar, and sugar crystal productivity were not affected by the application of the mixed biofertilizer and inorganic fertilizer.

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Table 7. Sugarcane productivity (ton ha^{-1}), commercial cane sugar (%), and sugar crystal productivity (ton ha^{-1}) at the different treatments

Tabel 7. Produktivitas tebu (ton ha^{-1}), rendemen (%) dan produktivitas hablur (ton ha^{-1}) pada semua perlakuan

Combination number *Kombinasi*	Treatments *Perlakuan* Inorganic fertilizer dose (kg ha^{-1}) *Dosis pupuk anorganik (kg ha^{-1})* AS	TSP	KCl	Biofertilizer dose (kg ha^{-1}) *Dosis pupuk hayati (kg ha^{-1})*	Sugarcane productivity (ton ha^{-1}) *Produkti-vitas tebu (ton ha^{-1})*	Commercial cane sugar (%) *Rendemen (%)*	Sugar crystal productivity (ton ha^{-1}) *Produkti-vitas hablur (ton ha^{-1})*
1	0	0	0	0	99.65 a	8.45 a	8.4 a
2	0	0	0	500	108.57 a	7.80 a	8.5 a
3	0	0	0	1,000	103.81 a	8.75 a	9.1 a
4	700	400	50	0	117.99 a	7.48 a	8.8 a
5	525	300	37.5	1,000	103.49 a	8.45 a	8.7 a
6	525	300	37.5	500	134.57 a	8.78 a	11.8 a
7	350	200	25	1,000	124.68 a	7.56 a	9.4 a
8	350	200	25	500	113.78 a	9.23 a	10.5 a
9	187.5	100	12.5	1,000	135.02 a	7.05 a	9.5 a
10	187.5	100	12.5	500	108.14 a	7.17 a	7.8 a
CV (%)					12.44	13.82	14.61
P value					0.053	0.271	0.070

Note: IF = inorganic fertilizer; BF = biofertilizer
The values in the table are the average of three replicates
Different superscript letters in the same column indicated significant differences (α=0.05%), and vice versa

REFERENCES

Anonymous. (2015). *Permentan 53-2015 Pedoman Budidaya Tebu Giling Baik*.

Anonymous. (2020). Bioneensis, Pupuk Hayati Produksi Pusat Penelitian Kelapa Sawit. Retrieved from https://www.iopri.org/Bioneensis-pupuk-hayati-produksi-pusat-penelitian-kelapa-sawit/.

Ardiansyah, B., & Purwono. (2015). Disetujui 14 November 2015 / Published online 12 Desember 2015. *Bul. Agrohorti*, *3*(3), 350–356.

Arifien, Y., Putra, R. P., Wibaningwati, D. B., Anasi, P. T., Masnang, A., Rizki, F. H., Suradi, A. R., Rismaya, R., L. Marlina, S., Anggarawati, ., Prihatini, R., Sunardi, & Indrawati, E. (2022). *Buku pengantar ilmu pertanian* (Issue May).

Ashraf, M. Y., Hussain, F., Akhter, J., Gul, A., Ross, M., & Ebert, G. (2008). Effect of different sources and rates of nitrogen and supra optimal level of potassium fertilization on growth, yield and nutrient uptake by sugarcane grown under saline conditions. *Pakistan Journal of Botany*, *40*(4 SPEC. ISS.), 1521–1531.

Chandini, Kumar, R., Kumar, R., & Prakash, O. (2019). The Impact of Chemical Fertilizers on our Environment and Ecosystem InBook: Research Trends in Environmental Science Chapter 5. *Research Trends in Environmental Science*, *4*(February), 69–86.

Croft, B. J. (2000). Literature Review of Methods of Improving the Germination of Sugarcane. In *BSES Publication* (Issue 1995).

De Oliveira, A. L. M., De Canuto, E. L., Urquiaga, S., Reis, V. M., & Baldani, J. I. (2006). Yield of micropropagated sugarcane varieties in different soil types following inoculation with diazotrophic bacteria. *Plant and Soil*, *284*(1–2), 23–32. https://doi.org/10.1007/s11104-006-0025-0

Dewi, V. A. K., Putra, R. P., & Afrianto, W. F. (2022). Kajian Potensi Vinase sebagai Bahan Fertigasi di Perkebunan Tebu (Saccharum officinarum L.). *Jurnal Ilmiah Universitas Muhammadiyah Buton*, *8*(1), 71–84.

Hamida, R., Djumali, Heliyanto, B., Abdurrachman, Adikadarsih, S., & Murianingrum, M. (2022). Yield and growth performance of potential sugarcane (Saccharum officinarum L.) hybrid clones. *IOP Conference Series: Earth and Environmental Science*, *974*(1). https://doi.org/10.1088/1755-1315/974/1/012017

Hoang, N. V., Furtado, A., Botha, F. C., Simmons, B. A., & Henry, R. J. (2015). Potential for genetic improvement of sugarcane as a source of biomass for biofuels. *Frontiers in Bioengineering and Biotechnology*, *3*(NOV), 1–15. https://doi.org/10.3389/fbioe.2015.00182

Khan, I. A., Bibi, S., Yasmin, S., Khatri, A., Seema, N., & Abro, S. A. (2012). Correlation studies of agronomic traits for higher sugar yield in sugarcane. *Pakistan Journal of Botany*, *44*(3), 969–971.

Kumar, A., & Verma, J. P. (2018). Does plant—Microbe interaction confer stress tolerance in plants: A review? *Microbiological Research*, *207*(August 2017), 41–52. https://doi.org/10.1016/j.micres.2017.11.004

Manuhuttu, A. P., Rehatta, H., & Kailola, J. J. . (2014). Pengaruh Konsentrasi Pupuk Hayati Bioboost Terhadap Peningkatan Produksi Tanaman Selada (Lactuca sativa. L). *Agrologia*, *3*(1). https://doi.org/10.30598/a.v3i1.256

Naik, K., Mishra, S., Srichandan, H., Singh, P. K., & Sarangi, P. K. (2019). Plant growth promoting microbes: Potential link to sustainable agriculture and environment. *Biocatalysis and Agricultural Biotechnology*, *21*(August), 101326. https://doi.org/10.1016/j.bcab.2019.101326

Oliveira, M. W. de, Macêdo, G. A. R., Martins, J. A., Silva, V. S. G. da, & Oliveira, A. B. de. (2018). Mineral Nutrition and Fertilization of Sugarcane. *Sugarcane - Technology and Research*, *May*. https://doi.org/10.5772/intechopen.72300

Pawirosemadi, M. (2011). *Dasar-dasar Teknologi Budidaya Tebu dan Pengolahan Hasilnya* (Vol. 1, pp. 0–811).

Putra, R. P., Ranomahera, M. R. R., Arini, N., & Afrianto, W. F. (2021). Tindakan Pengembalian Residu Panen Tebu untuk Meningkatkan Kualitas Tanah dan Produktivitas Tebu (Saccharum officinarum L.). *Buletin Tanaman Tembakau, Serat & Minyak Industri*, *13*(1), 48. https://doi.org/10.21082/btsm.v13n1.2021.48-66

Putra, R. P., Ranomahera, M. R. R., Rizaludin, M. S., Supriyanto, R., & Dewi, V. A. K. (2020). Short communication: Investigating environmental impacts of long-term monoculture of sugarcane farming in Indonesia through dpsir framework. *Biodiversitas*, *21*(10), 4945–4958. https://doi.org/10.13057/biodiv/d211061

Rosa, P. A. L., Galindo, F. S., Oliveira, C. E. da S., Jalal, A., Mortinho, E. S., Fernandes, G. C., Marega, E. M. R., Buzetti, S., & Teixeira Filho, M. C. M. (2022). Inoculation with Plant Growth-Promoting Bacteria to Reduce Phosphate Fertilization Requirement and Enhance Technological Quality and Yield of Sugarcane. *Microorganisms*, *10*(1). https://doi.org/10.3390/microorganisms10010192

Saraswati, R., & Sumarno. (2008). Pemanfaatan Mikroba Penyubur Tanah sebagai Komponen Teknologi Pertanian. *Iptek Tanaman Pangan*, *3*(1), 41–58.

Savci, S. (2012). Investigation of Effect of Chemical Fertilizers on Environment. *APCBEE Procedia*, *1*(January), 287–292. https://doi.org/10.1016/j.apcbee.2012.03.047

Shambhavi, S., Kumar, R., Sharma, S. P., Verma, G., Sharma, R. P., & Sharma, S. K. (2017). Long-term effect of inorganic fertilizers and amendments on productivity and root dynamics under maize-wheat intensive cropping in an acid Alfisol. *Journal of Applied and Natural Science*, *9*(4), 2004–2012. https://doi.org/10.31018/jans.v9i4.1480

Simanungkalit, R. D. M., Suriadikarta, D. A., Saraswati, R., Setyorini, D., & Hartatik, W. (2006). Pupuk Organik Dan Pupuk Hayati Organic Fertilizer and Biofertilizer. In *Balai Besar Litbang Sumberdaya Lahan Pertanian*.

Soomro, A. F., Tunio, S., & Oad, F. C. (2012). Effect of Supplemental Inorganic NPK and Residual Organic Nutrients on Sugarcane Ratoon Crop. *International Journal of Scientific & Engineering Research*, *3*(10), 1–11.

Suliasih, & Widawati, S. (2018). The Effect of Biofertilizer Combined with Organic or Inorganic Fertilizer on Growth of Caesalpinia pulcherrima and Bacterial Population in Soil. *IOP Conference Series: Earth and Environmental Science*, *166*(1). https://doi.org/10.1088/1755-1315/166/1/012024

Tyagi, V. K., Sharma, S., & Bhardwaj, S. B. (2013). Pattern of Association Among Cane Yield, Sugar Yield and Their Components in Sugarcane (sahharum officinarum L.). *Plant Archives*, *13*(2), 789–794.

Vessey, J. K. (2003). Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil*, *255*(2), 571–586. https://doi.org/10.1023/A:1026037216893