Effectivity Test of Compost Added By Coca-Cola Solid Waste Sludge With Water Spinach (*Ipomoea Reptans* POIR.) As an Indicator

I Dewa Made Arthagama[1*], Putu Oki Bimantara[1], Ni Made Tri Gunasih[1], Putu Perdana[1], I Wayan Narka[1]
[1]Agroecotechnology Study Program, Faculty of Agriculture, Udayana University, Jl. P.B. Sudirman, Denpasar, Bali, 80235, Indonesia
*Correspondence: arthagama@unud.ac.id

Received: 10-16-2023 **Revised:** 12-17-2023 **Accepted:** 12-29-2023

Citation: Arthagama, I.D.M., Bimantara, P.O., Gunasih, N.M.T., Perdana, P., & Narka, I.W. (2023). Effectivity Test of Compost Added by Coca-Cola Solid Waste Sludge with Water Spinach (*Ipomoea Reptans* Poir.) As an Indicator. *International Journal of Biosciences and Biotechnology*, 11(1): 16-23 https://doi.org/10.24843/IJBB.2023.v11.i01.p03

Abstract: Effectivity test of compost fertilizer added with Coca-Cola solid waste sludge with an indicator of water spinach (*Ipomoea reptans* POIR.), aiming to determine the effectiveness of the dose of compost added with Coca-Cola solid waste sludge to increase the yield of water spinach and improve some soil chemical properties. This research is a pot experiment in a greenhouse that was carried out in Kerambitan village, Tabanan region, Bali, Indonesia. Using a completely randomized design (CRD) consisting of 7 doses of compost added by Coca-Cola solid waste sludge. The compost that was used as a treatment was compost that had been added 20% of Coca-Cola solid waste sludge. The doses of compost tested were: K0 (control), K1 (3 tons of compost), K2 (6 tons of compost), K3 (9 tons of compost), K4 (12 tons of compost), K5 (15 tons of compost), Ka (250 kg urea + 50 kg phonska) per hectare, and each treatment was repeated 4 times so that 28 experimental pots were conducted. Parameters observed included: maximum plant height (cm), fresh plant weight at harvest, relative agronomic effectivities (RAE), oven-dry plant weight, soil pH, soil organic carbon (SOC), and soil CEC at harvest. Observational data were statistically analyzed, to determine the effect of the treatment being tried. If the treatment has a significant effect, then continue with the Duncans 5% test. The statistical analysis showed that the treatments had a significant effect on plant height growth, fresh and oven-dry weight of plants, as well as on some soil chemical properties. The heaviest fresh plant weight was obtained in treatment Ka (98.41 g), followed by K5 (98.35 g), K3 (98.33 g), and K4 (98.21 g) per pot. The highest value of relative agronomic effectiveness (RAE) was obtained in K5 (99.63 %), followed by K3 (99.58 %), and K4 (98.76 %). While the highest CEC was obtained in the treatment of K5 (40.25 me 100 g^{-1}), K3 (39.75 me g^{-1}) with successive organic-C levels (31.75%), (3.16 %) and pH (7.04), (7.0). The best dose of compost treatment from the results of this study was found in the K3 treatment (9 tons of compost ha^{-1}).

Keywords: Coca-Cola solid waste sludge, water spinach, compost, soil chemical properties

1. Introduction

In Indonesia, water spinach (*Ipomoea reptans* POIR.) is one of the vegetables that has great economic potential due to its high consumption. Water spinach has a lot of benefits to human health, water spinach has a high content of Selenium, Zinc, Iron, Vitamin A, Vitamin C, and Fiber, which effectively cure insomnia, stomaches, and anemia (Alam Tani, 2013). Water spinach is usually cultivated in open fields however, water spinach also could be cultivated in urban areas such as yards, pots, and polybags.

Water spinach productivity in Bali fluctuated, based on the Statistical Bureau of Bali Province (BPS) (2020). In 2017 the productivity of water spinach was 7.534 tons, then increased to 9.090 tons in 2018. In 2019 the productivity decreased to 6.683 tons. The fluctuation was affected by two factors, such as the variation of total land area each year and the decrease in soil fertility due to intensive chemical fertilizer application. According to Setyorini, *et al.* (2000) Management of fertilization had a high effect on plant productivity and unbalanced fertilization could decrease the soil quality and then decrease plant productivity by up to 40%.

One strategy to maintain and increase soil productivity, fertilization efficiency, and plant productivity is the application of balanced and environmentally friendly fertilization technology, such as cow dung compost, chicken dung compost, agricultural waste, and balanced application of chemical fertilization, known as semi-organic system. These applications could maintain nutrient balance in the soil. The application of chicken dung compost had a better effect on water spinach productivity compared to the application of cow dung compost or quail (Basri, 2018). Based on Supadma *et al.* (2002) there is another potential waste that could increase the compost quality, that is solid waste sludge from the Coca-Cola industry. Coca-Cola solid waste sludge contains 80% water and is already through bioactive processes. Furthermore, Coca-Cola solid waste sludge contains 1.81% N total (very high), 522.18 ppm phosphorus (P_2O_5) (very high), 1583.33 ppm potassium (K_2O) (very high), 2.95% of salinity (medium), and 29.95 C/N ratio. Based on these parameters, solid waste sludge from the Coca-Cola industry has a high potential to become additional material for compost, this solid waste sludge could enrich compost nutrient content. This material is very cheap and easy to collect, the solid waste from the Coca-Cola industries in Mengwi, Badung regency could produce up to 5-6 tons every day, and discarded to landfills, the industry did not use the solid waste specifically. While compost materials were collected from waste from traditional markets in Denpasar City, the waste was a combination of vegetables, fruits, and other organic materials that were not worth selling by sellers.

Based on research by Supadma & Arthagama (2008), combining 50% of organic waste from the traditional market and 50% of chicken dung could increase the content of N, P, and CEC. Furthermore, could decrease the C/N ratio to 17.24, with a pH level of 7.07. To enrich the nutrient content, solid waste sludge from the Coca-Cola industry was added. The solid waste sludge from Coca-Cola industry had high concentrations of N, P, and K, which are needed by water spinach plants. Inceptisol is developing soil and relatively fertile soil. Based on Puslittanak (2003), inceptisol distribution is vast, around 70.52 million ha or 44.60% of Indonesia's area is dominated by inceptisol. Inceptisol has the economic potential to be a horticulture land. In the Province of Bali, inceptisol also has a vast distribution, almost every region in Bali is dominated by inceptisol.

Based on these backgrounds, this research was conducted to test the effectiveness of compost fertilizer added with Coca-Cola solid waste sludge, with water spinach (*Ipomoea reptans* POIR.*)* as the indicator. To improve inceptisol fertility and productivity of water spinach, effectively and sustainably.

2. Methodology

This research was a pot experiment conducted in a greenhouse on farmer land in Kerambitan village, Tabanan region, Bali, Indonesia. This research was conducted in July until November 2021. The materials used in this research were: compost, composted organic waste from the traditional market added by solid waste sludge of

Coca-Cola, water spinach seeds, labels, urea fertilizer, and phonska fertilizer. Tools used in this research were; pots, water buckets, plant sprayers, stationery, plastic rope, and laboratory equipment.

This research was a pot experiment conducted in a greenhouse, using a completely randomized design (CRD), with 7 treatments and 4 replications, the total of which were 28 pot plant samples. The compost used in this research was compost which already added 20% of solid waste sludge from the Coca-Cola industry. In this research compost treatments were divided like below:

1. Ko (Control, no compost added)
2. K1 (3ton ha^{-1} compost added)
3. K2 (6ton ha^{-1} compost added)
4. K3 (9ton ha^{-1} compost added)
5. K4 (12ton ha^{-1} compost added)
6. K5 (15ton ha^{-1} compost added)
7. Ka (250 kg urea ha^{-1} + 50 kg ha^{-1} phonska added)

Each treatment had 4 replications, so 28 total samples were needed. The calculation of fertilizer dosage per pot is based on the volume weight of the soil, and the calculation of compost dosage is based on the dry weight of compost.

Before the research was conducted, a land survey was conducted to see the field condition, then soil samples and soil for the research were taken from the field. These soils were taken from multiple subak in Tabanan region. Then soils were air dried, and after that soils were smoothed until relatively similar. Then soil was filtered by a 5 mm sieve, and a 2 mm sieve for initial soil analysis. Soil then weighed 6 kg per plot, total of 28 pots were needed. Application of compost was conducted before planting, doses were based on treatment. Otherwise, 50% application of 250 kg ha^{-1} of urea and 50 kg ha^{-1} of phonska in treatment Ka was conducted 5 days after seed planting, and the other 50% was applied after 15 days of seed planting. Compost was applied by mixing it evenly with the soil, while urea and phonska fertilizer were applied by spreading it 5 cm around the plant

Parameters observed are plant parameters and soil chemical properties, such as:

1. Plant height (cm)
2. Fresh plant weight at harvest per pot (g)
3. Relative Agronomic Effectiveness (RAE) (%) doses of compost

   RAE is calculated from oven-dry plant weight and fresh plant weight using the formula according to Engelstad (1978) as follows:

   $$RAE\ (\%) = \frac{Y\ (\text{compost doses}) - Y\ (\text{Control})}{(\text{Fertilizer}) - Y\ (\text{Control})} \times 100 = \ldots\ \%Y$$

4. Oven-Dry plant weight per pot (g)
5. Hypothetical fresh production of water spinach plants per hectare (planting distance 20 cm x 20 cm) (number of plant clusters per hectare = 250,000 plant clusters per hectare) (tons)
6. Soil chemical properties at harvest: pH, soil organic carbon (SOC) (Walkley-Black), CEC (NH4OAc.pH7), analyzed at the Laboratory of Soil Chemistry and Fertility of the Faculty of Agriculture, Udayana University.

To understand the effect of treatment on each parameter, analysis of variance (ANOVA) was conducted. with a completely random design (CRD) with one factor (Sastrosupadi, 2000). If the treatment has a significant effect then it is continued with the post hoc test using Duncan (DMRT) at the 5% level. To determine the closeness of the influence relationship between parameters, the correlation test was conducted.

3. Results

Statistical analysis showed that the treatments had a significant effect on plant growth parameters and plant yields, such as plant height, fresh weight, oven-dry weight, and hypothetical production of water spinach at harvest per hectare. Furthermore, treatments also showed a significant effect on SOC content and soil CEC, however no significant effect on soil pH (Table 1).

Table 1. Signification of treatment on plant parameters and soil chemical properties

No	Parameters	Significant (K)
1	Plant height at harvest	*
2.	Fresh plant weight	*
3.	Relative Agronomic Effectiveness (RAE) (%) doses of compost	*
4.	Oven-Dry plant weight	*
5.	Hypothetical fresh production of water spinach plants per hectare	*
6.	Soil pH after harvest	ns
7.	Soil organic carbon after harvest	*
8	Soil CEC after harvest	*

Water spinach plant heights among the treatments were quite varied and highly affected by doses of compost, with K0 treatment having the lowest plant height of 36.55 cm, and the lightest fresh and oven-dry plant weight of 82,30 and 19,11 g pot^{-1} and also the lowest hypothetical production at 20,57 ton ha^{-1}. (Table 2).

Table 2. Effect of treatment on plant height, fresh weight, oven-dry weight of water spinach plants pot^{-1}, and hypothetical production ha^{-1}.

Treatment	Plant height (cm)	Fresh plant weight (g pot^{-1})	Oven-dry plant weight (g pot^{-1})	Hypothetical production (ton ha^{-1})
Ka	41,80 a	98,41 a	29,10 a	24,60 a
K0	36,55 c	82,30 c	19,11 d	20,57 c
K1	40,31 ab	95,32 b	28,12 c	23,83 b
K2	40,52 ab	95,51 b	32,90 b	23,88 b
K3	41,60 a	98,33 a	34,39 a	24,58 a
K4	40,80 ab	98,21 a	34,46 a	24,55 a
K5	40,53 ab	98,35 a	34,67 a	24,59 a

Note: Numbers followed by the same letter are not significantly different in the Duncans 5% test.

Based on the fresh weight of the water spinach plants, the Relative Agronomic Effectiveness (RAE) value of each dose of compost tested was found, the highest RAE value was found at K5 treatment (99.63%), followed by K3 treatment (99.58%), and K4 (98.76 %). The RAE value of the compost dosage is almost close to the optimal effectiveness value of inorganic NPK fertilizer, the RAE value is close to 100% (Table 3.). The RAE value of the compost fertilizer tested shows how much effectiveness each dose of compost fertilizer tested is compared with the effectiveness of NPK inorganic fertilizer given at the optimal dose. In this study, water spinach was used as an indicator plant. It appears from the results of this research that compost fertilizer doses of 9 tons, 12 tons and 15 tons per hectare show good effectiveness, almost close to 100%.

Table 3. Relative Agronomic Effectiveness (RAE) value of compost doses

Treatment	RAE values (%)
Ka (inorganic fertilizer)	100,0
K0 (control)	-
K1 (3ton ha-1 compost added)	80,82
K2 (6ton ha-1 compost added)	82,04
K3 (9ton ha-1 compost added)	99,58
K4 (12ton ha-1 compost added)	98,76
K5 (15ton ha-1 compost added)	99,63

The results of the analysis of compost from traditional market waste contain levels of total nitrogen (TN) (1.53% very high), available-K (1083.35 ppm very high), available-P (402.20 ppm very high), SOC 31.60%, C/N ratio (20.65), pH (7.21), and salt content (2.18 medium) (Table 4.).

Table 4. Results of compost and solid waste sludge analysis

No	Parameter	Compost	Solid waste sludge
1	Total N (%)	1,53	1,81
2	Available-P (ppm)	402,20	522,18
3	Available-K (ppm)	1083,35	1583,33
5	SOC (%)	31,60	54,21
6	pH (1: 2.5) H_2O	7,21	7,30
7	Salinity (%)	2,18	2,95
8	C/N ratio	20,65	29,95

Meanwhile, the nutrient content of the Inceptisol soil used as a planting medium in this study is relatively less fertile, the pH is slightly acidic (6.30), the TN content is very low (0.20%), the available-P is high (22.96 ppm), low available-K (89.48%), and low organic-C content (1.50%) (Table 5.). However, because the compost is highly rich in nutrients, it is able to provide N, P, K, and other nutrients. This is quite adequate, thus providing high growth and yield of water spinach plants, such as hypothetical production of K5 (24.59 tons), K3 (24.57 tons), and K4 (24.55 tons) per hectare, respectively (Table 2).

Table 5. Effect of compost dose treatment on changes in soil chemical properties after harvest

Treatment	Soil pH	SOC (%)	CEC (me g^{-1})
Ka	6,68 a	1,58 c	18,10 d
K0	6,69 a	1,55 d	17,18 de
K1	6,75 a	2,41 b	30,21 c
K2	6,86 a	2,95 b	35,10 b
K3	7,00 a	3,16 a	39,75 a
K4	6,98 a	3,08 a	39,16 a
K5	7,04 a	3,17 a	40,25 a

4. Discussion

Plant height and compost doses had a positive correlation, higher doses of compost increase plant height. This is due to soil under compost treatment had better conditions such as more loosening so the water spinach plant root could easily grow.

Water spinach plant heights among the treatments were quite varied and highly affected by doses of compost, with K0 treatment having the lowest plant height of 36.55 cm. This result showed similar results to research by Nirmalayanti *et al.* (2017), that compost could increase plant growth. A positive relationship was observed between fresh weight of water spinach and water spinach height. The highest fresh weight of water spinach plant at harvest was found at Ka (98.41 g pot^{-1}) treatment, however, no significant difference was found compared to K3 (98,33 g pot^{-1}), K4 (98,21 g pot^{-1}) dan K5 (98,35 g pot^{-1}) treatments (Table 2.). control (K0) had the lowest fresh weight of water spinach plant at harvest, with a weight was only 82,30 g pot^{-1}. This result was due to the low availability of soil nutrients, such as nitrogen (N). which plays an important role in the vegetative growth of water spinach plants. This condition is following the results of the Inceptisol soil analysis at the start of the study, with deficient soil nitrogen levels of 0.20 %.

The increase in height and weight of water spinach plants as well as the RAE value was due to fairly high nutrient content in compost and Coca-Cola solid waste sludge. This solid waste sludge contains, very high nitrogen (N-total) (1.81%), very high phosphorus (P_2O_5) (522.18 ppm), very high potassium (K_2O) (1583.33 ppm), neutral pH (7.30), and moderate salt content (2.95%) (Table 4).

Application of compost, not only could increase yields and RAE values but could also improve several chemical properties of the soil or soil fertility after harvest. CEC value of the soil increased after the compost application, the highest CEC values were found in treatment K5 (40.25 me 100 g^{-1}), K3 (39.75 me g^{-1}) with SOC levels respectively (3.17 %), (3.16 %), and pH (7.04), (7.0). The increase in SOC and soil CEC values after harvest is due to the application of high doses of compost, due to its ability to release nutrients into the soil after undergoing further weathering. Compost also produces humus as a soil colloid, which could increase the soil CEC (Griest *et al*., 1991).

5. Conclusion

Based on the results of this research, several conclusions can be drawn, namely that the treatment of market waste compost fertilizer doses added with Coca-Cola solid waste sludge, has a significant effect on plant height growth, fresh weight, and oven-dry weight of plants, as well as changes in SOC and soil CEC. The heaviest fresh weight of water spinach plants due to the application of compost fertilizer doses was obtained in treatment K5 (98.35 g pot^{-1}), followed by K3 (98.33 g pot^{-1}), and K4 (98.21 g per pot^{-1}), or an increase of 19.50%, 19.48%, and 19.33% respectively compared to the control. The highest RAE value for the compost dose was achieved by treatment K5 (99.63%), followed by K3 (99.58%), and K4 (98.76%). The RAE values for this compost dose were very effective, almost approaching 100%. Changes in soil chemical properties, such as the highest soil CEC, were obtained in treatments K5 (40.25 me 100 g-1), K3 (39.75 me g-1) with SOC levels respectively (3.17%), (3.16 %), and pH (7.04), (7.00). Based on the results of this research, it can be suggested as follows: Cultivation of water spinach plants on Inceptisol can be done by application of compost with a dose of 9 tons ha^{-1}, or 15 tons ha^{-1}.

Author Contributions

Contributions: Conceptualization, Arthagama, I.D.M. and Bimantara, P.O.; methodology, Gunasih, N.M.T;

software, Perdana, P.; validation, Narka, I.W.; formal analysis, Arthagama, I.D.M.; investigation, Arthagama, I.D.M.; resources, Arthagama, I.D.M.; data curation, Narka, I.W.; writing—original draft preparation, Arthagama, I.D.M.; writing—review and editing, Arthagama, I.D.M and Bimantara, P.O.; visualization, Bimantara, P.O.; supervision, P.S.; project administration, Bimantara, P.O.; funding acquisition, Arthagama, I.D.M. All authors have read and agreed to the published version of the manuscript.

Funding

Not applicable

Informed Consent Statement

Not applicable

Data Availability

Not applicable

Acknowledgments

This study was supported by the grant from Udayana University 2021, through Penelitian Unggulan Program Studi (PUPS) scheme.

Conflicts of Interest

The authors declare there no conflict of interest

References

Alam Tani, (2013). Budidaya kangkung darat organik. https://alamtani.com/budidaya-kangkung-darat-organik/.

Badan pusat statistik Provinsi Bali. (2020). Produksi tanaman hortikultura (sayuran) di daerah Bali. https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html.

Basri, H. (2018). Pengaruh tiga jenis pupuk kandang terhadap pertumbuhan kangkung cabut (*Ipomoea reptans* POIR.) [Unpublished Bachelor Thesis]. Universitas Negeri Alauddin.

Engelstad, O.P. (1978). *Relative agronomic and economic effectiveness values for phosphate rock*. Paper presented at Proceedings of Seminar on Phosphate Rock for Direct Application. International Fertilizer Development Centre. Haifa, Israel. P.291-303.

Griest, W. H., Tyndall, R. L., Stewart, A. J., Ho, C. H., Ironside, K. S., Caton, J. E., Caldwell, W. M., Tan, E. (1991) Characterization of explosives processing waste decomposition due to composting. *United States*. https://doi.org/10.2172/5598569.

Notohadiprawiro, T., Suryanto, Hidayat, & Asmara, A.A., (1991). Nilai pupuk sari kering limbah (*sludge*) kawasan industri dan dampak penggunaannya sebagai pupuk atas lingkungan. *Agriculture Science*. 4(7), 12-14.

Nirmalayanti,K.A., Subadyasa, N.N., & Arthagama, D.M., (2017). Pengaruh jenis pupuk organik terhadap pertumbuhan bayam merah (*Amaranthus amoena*) pada tanah Inceptisol Pegog. *Agroekoteknologi Tropika*. 6(1), 1-10. https://ojs.unud.ac.id/index.php/JAT/article/view/26471.

Novisan. (2002). *Petunjuk pemupukan efektif*. Jakarta, Indonesia: Agromedia.

Puslittanak (2003). Usahatani pada lahan kering, badan penelitian dan pengembangan pertanian. Departemen Pertanian.

Sastrosupadi, A. (2000). Rancangan percobaan praktis bidang pertanian. Magelang, Indonesia: Kanisius.

Setyorini,D., J.S. Adiningsih & S. Rohayati. (2003). *Uji tanah sebagai dasar penyusunan rekomendasi pemupukan*. Bogor, Indonesia: Balai Penelitian Tanah.

Supadma, A.A.N., & D.M. Arthagama, (2008). Uji formulasi kualitas pupuk kompos yang bersumber dari sampah organik dengan penambahan limbah ternak ayam, sapi, babi, dan tanaman pahitan. *Jurnal Bumi Lestari*. 8(2), 113-121. https://ojs.unud.ac.id/index.php/blje/article/view/2430.

Supadma, A.A.N., K.D. Susila dan D.M, Arthagama. (2002). Pengaruh takaran limbah pabrik coca cola dan tambahan gergajian kayu terhadap mutu pupuk kompos. Fakultas Pertanian Universitas Udayana.