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Effect of Biogas Effluent from Pig Manure and Durian Residues on Soil Chemical Property and Growth of Marigold

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The efficiency of biogas effluent fermented with pig manure and durian residues on soil chemical property and growth of marigold were investigated. The experimental design was carried out in a Completely Randomized Design (CRD) with 4 replications. Six treatments were control (no fertilizer), four concentrations (10%, 12.5%, 16.67% and 24%) of biogas effluent and chemical fertilizer. 10 days after planting, marigolds were transplanted to pots and the experiment was started. Each biogas effluent concentration was watered 400 ml per pot every 5 days. 15-15-15 and 12-24-12 formulas were used in chemical fertilizer treatment. The experiment was conducted for 90 days at Agricultural Technology Faculty in Rambhai Barni Rajabhat University. pH and electrical conductivity (EC) of soil were checked at the starting and end of experiment. The data of plant height, stem diameter, bush diameter, length around bush and SPAD value were collected every week. After flowering, number, diameter, fresh weight and dry weight of blooming flower were measured every day. The chlorophyll concentration of leaves, leaf water potential, fresh weight and dry weight of roots, branches and leaves were measured at the end of experiment. The results showed that there was no significant difference in leaf water potential among treatments. The growth of marigold in the control was lowest as compared to that in biogas effluent and chemical fertilizer treatments. At the end of experiment, the highest of height, stem diameter, bush diameter, length around bush, SPAD value, chlorophyll content, blooming flower number, fresh and dry weights of branches and fresh and dry weights of leaves expressed in marigolds treated by chemical fertilizer and all results were significantly different. On the other hand, the length, fresh weight and dry weight of roots in chemical fertilizer treatment were lower those results in biogas effluent treatment. Moreover, pH and EC of chemical fertilizer treated soil was most severe than the control and biogas effluent treatment. These may be the cause of the similar size, fresh weight and dry weight of blooming flower between biogas effluent and chemical fertilizer treatments.

Keywords: Marigold, Biogas effluent, Durian, Soil Chemical property, Growth

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Introduction

Marigold is an attractive yellow flower that can tolerance and adapt to various environmental conditions. This flower grows well in all areas and all seasons in Thailand. Marigolds have a short-harvest period of 60-70 days after planting (Department of Agricultural Extension, 2002). In the past, marigolds were primarily used for decoration and Buddhism activities. Presently, the role of this flower in Thailand has changed. Marigold is used for its nematocide, cosmetic, and medicinal properties. The essential oil of the flower contains antioxidants. Growth of marigold is influenced by chemical fertilizers. Moreover, the application of these fertilizers also increases soil and water pollution and the long-term use of chemical fertilizers results in soil structure degradation (Priyanka *et al*., 2013).

Presently, the use of biological fertilizer has been increased due to the high price of chemical fertilizers. Bio-fertilizers also contain beneficial microorganisms that improve soil chemical and biological properties. Many scientists reported that biogas effluent can promote plant growth (Kumpukul and Chantsavang, 1995; Panichsakpatana, 1995; Ausungnoen *et al*., 2014), thus, biogas effluent can be used as bio-fertilizer. However, the effluent after biogas production has not been studied as bio-fertilizer. Thus, in this experiment the effects of biogas effluent fermented with pig manure and durian residues on soil chemical properties and growth of marigold were investigated for potential use as bio-fertilizer.

Objectives:

1. To study the effect of biogas effluent fermented with pig manure and durian residues on soil chemical properties**.**
2. To study the effect of biogas effluent fermented with pig manure and durian residues on growth of marigold**.**

Materials and methods

The experimental design was a Completely Randomized Design (CRD) with 4 replications. Six treatments were control (no fertilizer), four concentrations of biogas effluent (10%, 12.5%, 16.67% and 24%) and chemical fertilizer (15-15-15 and 12-24-12). Marigolds were planted in cell plug tray with peat moss. Ten days after planting (DAP), plants were transferred to pots containing soil mixed with husk and burned husk in a ratio of 2:1:1. The chemical properties of soil and biogas effluent are shown in Table 1. The plants were watered with a total of 400 ml/pot of 10%, 12.5%, 16.67% and 24% of biogas effluent solutions every 5 days. The chemical fertilizer treatment consisted of 5g of 15-15-15 formula fertilizer dissolved in 400 ml water to water pots 13, 19 and 25 days after planting (DAP) and 5g of 12-24-12 formula fertilizer dissolved in 400 ml water to water pots 35, 45, 55, 65, 75 and 85 DAP by following the cultivation method of the Department of Agricultural Extension (2002).

Table1. Chemical properties of soil and biogas effluent at the start of the experiment.

Chemical properties	Soil	Biogas effluent
pH	5.31	7.71
EC (ds/m)	0.96	9.60
Nitrogen concentration (ppm)	666.67	1000
Phosphorus concentration (ppm)	5.39	141
Potassium concentration (ppm)	394.45	1974

All pots were watered daily with 400 ml water.The experiment was conducted for 90 days at the Agricultural Technology Faculty in Rambhai Barni Rajabhat University. Soil pH and electrical conductivity (EC) were recorded at the end of experiment. The data of plant height, stem diameter, bush diameter, bush circumference and SPAD value were collected weekly. After flowering, flower number, diameter, fresh weight and dry weight of blooming flowers was measured daily. The total chlorophyll, chlorophyll a and chlorophyll b concentration of leaves, root length, leaf water potential, fresh weight and dry weight of roots, branches and leaves were measured at the end of the experiment. All results were analyzed by analysis of variance and means separated by Duncan's multiple range test (DMRT).

Results

Soil chemical properties

All treatments increased soil pH compared to the chemical fertilizer treatment which resulted in a pH of 3.45. However, effluent of 16.67% and 24% resulted in higher pH compared to the remaining treatments, except the 10% effluent treatment (Table 2). Soil EC was significantly higher with the control and all effluent treatments compared to the chemical fertilizer treatment. Soil

EC as effected by the effluent treatments did not differ from the EC of the control. Treatments resulting in a low EC were 12.5% and 16.67% effluents. The control, however, resulted in the lowest EC (Table 2).

Table. 2 Soil pH, soil EC, plant height, stem diameter, bush diameter, bush circumference, root length and leaf water potential at the end of experiment

Treatment	Soil pH	Soil EC (ds/m)	Plant height (cm)	Stem diameter (mm)	Bush diameter (cm)	Bush circumference (cm)
Control (0%)	5.38±0.04[b]	0.41±0.01[b]	23.40±0.91[d]	3.88±0.26[e]	15.45±0.34[d]	40.35±1.60[e]
Effluent 10%	5.65±0.19[ab]	0.78±0.04[b]	39.93±0.92[c]	7.00±0.23[d]	30.63±1.25[c]	88.43±3.97[d]
Effluent 12.5%	5.44±0.11[b]	0.47±0.03[b]	40.45±1.18[c]	7.29±0.32[cd]	31.88±0.64[c]	95.85±3.72[c]
Effluent 16.67%	5.88±0.10[a]	0.43±0.01[b]	41.60±0.63[bc]	7.97±0.64[bc]	34.00±2.51[bc]	100.18±4.88[c]
Effluent 24%	5.83±0.11[a]	0.51±0.02[b]	43.75±1.58[b]	8.48±0.24[b]	35.43±0.97[b]	110.55±1.57[b]
Chemical fertilizer	3.45±1.10[c]	3.59±0.33[a]	51.95±1.36[a]	9.81±0.55[a]	55.28±2.58[a]	141.53±2.65[a]
F-test	**	**	**	**	**	**
CV (%)	2.24	13.35	2.84	5.47	4.83	3.43

Means with different letters in each column are significantly different ($P \leq 0.01$) according to DMRT. ** significant at $P \leq 0.01$.ns not significant at $P \leq 0.05$.

Growth parameters

Plant height was increased significantly by the chemical fertilizer treatment compared to the remaining treatments followed by the effluent treatments. The control treatment resulted in the shortest plant height of 23.40 cm (Table 2). Stem diameter was significantly increased by the chemical fertilizer treatment compared to the remaining treatments. The control treatment resulted in the smallest bush diameter followed by 10% effluent and 12.5% effluent (Table 2). Bush diameter was also increased by the chemical fertilizer treatment compared to the remaining treatments. All effluent treatments increased bush diameter compared to the control which resulted in the smallest bush diameter of 15.45 cm (Table 2). Bush circumference was significantly increased by the chemical fertilizer treatment compared to the remaining treatments. The control treatment resulted in the smallest bush circumference of 40.35 cm (Table 2).

Effluent treatment of 10%, 12.5%, 16.67%, and 24% increased root fresh weight compared to the control and the chemical fertilizer treatment. Root fresh weight was reduced by the chemical fertilizer treatment and the control treatment (Table 3). The fresh weight of branches was increased by the chemical fertilizer treatment compared to the remaining treatments followed by the effluent treatments. There was no difference in leaf fresh weight among the effluent treatments (Table 3). Leaf fresh weight was increased significantly by the chemical fertilizer treatment compared to the remaining treatments. Effluent treatment of 16.67% and 24% increased leaf fresh weight compared to the control (Table 3). The control treatment resulted in the lowest fresh weight of branches. Total plant fresh weight was increased by the chemical fertilizer treatment compared the remaining treatments. The lowest total fresh weight resulted from the control (Table 3).

Root dry weight was increased by all effluent treatments. The control and chemical fertilizer treatments resulted in the lowest root dry weight (Table 4).The chemical fertilizer treatment increased dry weight of branches compared to the remaining treatments followed by all effluent treatments. The control treatment resulted in the lowest dry weight of branches. Leaf dry weight was increased by the chemical fertilizer treatment followed by the effluent treatments. Leaf dry weight was reduced by the control treatment .Total dry weight was increased by the chemical fertilizer treatment as compared to the remaining treatments and reduced by the control treatment (Table 4).

Table. 3 Fresh weight of root, branch, leaf and total of marigold plants at the end of experiment

Treatment	**Fresh weight (g)**			
	Root	**Branch**	**Leaf**	**Total**
Control (0%)	2.33 ±0.20^{d}	2.27 ±0.29^{d}	2.03 ±0.23^{d}	6.63 ±0.48^{d}
Effluent 10%	13.37 ±0.35^{b}	16.72 ±0.20^{c}	13.01 ±0.94^{cd}	43.101.25^{c}
Effluent 12.5%	14.56 ±0.71^{ab}	19.85 ±1.19^{c}	16.52 ±1.41^{bcd}	50.93 ±1.44^{c}
Effluent 16.67%	15.25 ±4.29^{ab}	22.63 ±2.79^{bc}	21.06 ±1.09^{bc}	58.95 ±7.69^{bc}
Effluent 24%	18.09 ±2.12^{a}	32.94 ±1.99^{b}	30.17 ±2.03^{b}	81.20 ±2.38^{b}
Chemical fertilizer	6.79 ±0.84^{c}	106.90 ±13.22^{a}	119.39 ±17.78^{a}	233.08 ±30.58^{a}
F-test	**	**	**	**
CV (%)	17.15	16.69	21.82	16.38

Means with different letters in each column are significantly different (P≤0.01) according to DMRT. **significant at P≤0.01.

Root length was decreased by the chemical fertilizer treatment compared to the remaining treatments. Root length did not differ among the effluent treatments and ranged from 43.50 cm to 48.18 cm (Table 4).

Table. 4 Root length and dry weight of root, branch, leaf and total of marigold plants at the end of experiment

Treatment	Dry weight (g)				Root length (cm)
	Root	Branch	Leaf	Total	
Control (0%)	0.21±0.01[c]	0.45±0.06[d]	0.35±0.03[d]	1.02±0.09[d]	33.63±2.21[b]
Effluent 10%	1.80±0.08[b]	3.87±0.10[c]	2.65±0.17[c]	8.32±0.27[c]	48.18±6.31[a]
Effluent 12.5%	2.08±0.12[ab]	4.72±0.28[c]	3.20±0.20[c]	10.00±0.49[c]	44.90±5.03[ab]
Effluent 16.67%	2.36±0.94[ab]	5.32±0.56[c]	3.70±0.15[bc]	11.37±1.56[c]	46.13±9.93[ab]
Effluent 24%	2.66±0.06[a]	7.70±0.30[b]	5.28±0.26[b]	15.64±0.12[b]	43.50±5.85[ab]
Chemical fertilizer	0.94±0.13[c]	16.22±1.52[a]	21.91±2.14[a]	39.07±3.45[a]	16.33±3.95[c]
F-test	**	**	**	**	**
CV (%)	23.49	10.70	14.39	10.97	15.56

Means with different letters in each column are significantly different ($P \leq 0.01$) according to DMRT. **significant at $P \leq 0.01$.

Table. 5 Number, diameter, fresh weight and dry weight of blooming flower at the end of experiment

Treatment	Blooming flower			
	Number	Diameter (mm)	Fresh weight (g)	Dry weight (g)
Control (0%)	1±0[d]	41.40±2.08[b]	1.99±0.10[c]	0.22±0.13[b]
Effluent 10%	10±2[c]	55.81±3.08[a]	6.24±1.03[ab]	0.88±0.12[a]
Effluent 12.5%	12±1[c]	56.81±2.40[a]	6.67±0.58[ab]	0.90±0.04[a]
Effluent 16.67%	14±3[c]	56.30±5.74[a]	7.06±1.63[ab]	0.95±0.21[a]
Effluent 24%	20±2[b]	57.67±2.53[a]	7.31±1.01[a]	1.13±0.41[a]
Chemical fertilizer	42±4[a]	51.86±2.31[a]	5.08±0.67[b]	0.84±0.67[a]
F-test	**	**	**	*
CV (%)	14.50	6.14	16.79	41.52

Means with different letters in each column are significantly different ($P \leq 0.01$) according to DMRT. ** significant at $P \leq 0.01$.* significant at $P \leq 0.05$.

The number of flowers was significantly increased by the chemical fertilizer treatment compared to the remaining treatments. Flower number did not differ among the effluent treatments of 10%, 12.5%, 16.67%. However the 24% effluent treatment increased flower number compared to the control and the remaining treatments (Table 5). Flower diameter and flower dry weight were reduced by the control treatment and flower diameter did not differ among the remaining treatments. Flower fresh weight was reduced by the control treatment and the chemical fertilizer treatment. There was no difference in flower fresh weight among the effluent treatments (Table 5).

Plant physiological parameters

SPAD value was significantly increased by the chemical fertilizer treatment compared to the remaining treatments. The control resulted in the lowest SPAD value (Table 6). The chemical fertilizer treatment increased total chlorophyll, chlorophyll a and chlorophyll b in leaves compared to the remaining treatments. There was no difference in total chlorophyll, chlorophyll a and chlorophyll b between the control and effluent treatments (Table 6). Leaf water potential did not differ among treatments (Table 6).

Table. 6 Concentrations of total chlorophyll, chlorophyll a and chlorophyll b in marigold leaves, root length and leaf water potential at the end of experiment

Treatment	**SPAD value**	**Total chlorophyll (µg/cm^2)**	**Chlorophyll a (µg/cm^2)**	**Chlorophyll b (µg/cm^2)**	**Leaf water potential (bar)**
Control (0%)	20.62±3.35^c	9.49±1.10^b	4.68±0.58^b	6.33±0.73^b	-3.56±0.13
Effluent 10%	26.10±1.48^{bc}	12.37±3.87^b	5.76±0.81^b	8.24±2.57^b	-3.75±0.20
Effluent 12.5%	27.70±1.71^{bc}	10.51±1.24^b	5.94±0.61^b	7.00±0.83^b	-3.69±0.24
Effluent 16.67%	27.08±6.23^{bc}	11.40±2.89^b	6.49±1.85^b	7.60±1.93^b	-3.38±0.25
Effluent 24%	30.44±1.45^b	14.71±1.46^b	8.67±1.03^b	9.81±0.97^b	-3.88±0.52
Chemical fertilizer	47.24±2.89^a	29.53±5.87^a	19.66±3.95^a	19.69±3.92^a	-3.56±0.31
F-test	**	**	**	**	ns
CV (%)	11.08	25.59	35.49	32.18	8.6

Means with different letters in each column are significantly different (P≤0.01) according to DMRT. **significant at P≤0.01.

Discussion

The results of this experiment showed that the growth of marigold increased after watering with various concentrations of biogas effluent and growth was greater compared to the control. This indicated that biogas effluent can promote the growth of marigold as a bio-fertilizer. Results in this experiment agreed with many reports that showed the efficiency of biogas effluent as bio-fertilizer (Kumpukul and Chantsavang, 1995; Panichsakpatana, 1995; Ausungnoen *et al*., 2014).

However, the growth of marigold plants treated with biogas effluent was less than plants treated with chemical fertilizer. This may be due to the difference in nitrogen, phosphorus and potassium concentrations between treatments. Namely, total amount of nitrogen, phosphorus and potassium which plants received from chemical fertilizer treatment was 5.85, 9.45 and 5.85 g, respectively, while plants treated with 24% biogas effluent received only 1.70 g of nitrogen, 0.24 g of phosphorus and 3.13 g of potassium. The total amount of nitrogen, phosphorus and potassium applied to plants gradually decreased with the concentration of biogas effluent. The treatment containing the lowest nutrient concentration was the control treatment. Thus, most plant growth parameters resulting from the chemical fertilizer treatment were increased compared to the other treatments. Moreover, the results in this experiment showed that total chlorophyll, chlorophyll a and b concentration in plants treated with chemical fertilizer were significantly higher than the control and biogas effluent treatments. Chlorophyll concentration is also an important factor for plant growth (Taiz and Zeiger, 2006), therefore, the plants containing the high chlorophyll concentration could produce more growth than those containing low chlorophyll (Bi *et al*., 2010). This could be one more reason to explain the highest plant growth of marigold plants treated with chemical fertilizer.

In the case of soil chemical properties, the results showed that soil pH of plants treated with chemical fertilizer was lowest in comparison with the other treatments. This indicated that chemical fertilizer can effect soil acidity. These result agreed with the research of Bi *et al*. (2010) which reported that soil pH decreased after applying high rates of chemical fertilizer. In addition, Bi *et al*. (2010) also reported that soil EC increased after applying high rates of chemical fertilizer which was the same as the result of soil EC in this experiment.

Numerous scientists found that low pH of soil or media caused a decrease in root length (Malkanthi *et al*., 1995; Yan *et al*., 1992; Belachew and Stoddard, 2017). In this experiment, root length of plants treated with chemical fertilizer was shortest which may be due to low soil pH. Simultaneously, the effect of short roots may influence the diameter, fresh weight and dry weight of blooming flowers. In conclusion, the results of this experiment showed that biogas effluent could be utilized as bio-fertilizer. However, the suitable concentration of biogas effluent for promoting plant growth should be further investigated.

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