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Effects of different compost manures application on growth of lettuces (*Lactuca sativa* L.)

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Abstract The results showed that the difference of livestock manures showed differences in nutrients and amount. The composted chicken manures contained the highest nutrients and showed an optimum C/N ratio, in which the value was less than 1/20. Three lettuces (green oak, fillice iceberg, and green cos) were treated by different compost manures and they were a response to the compost manures in a similar trend. The three lettuce types grew after the application of chicken compost manure had higher on plant height, plant width, leaf length, leaf width, leaf number per plant, SPAD unit, root length, and plant fresh weight as well as chemical fertilizer. On the other hand, the three lettuces grown after the application of cow, goat compost manures, and bio-fermented fertilizer had the lowest of plant growth similar to control (without fertilizer). The results suggested that the chicken manure compost is suitable for lettuce production.

Keywords: Chicken manure, Cow manure, Goat manure, Organic fertilizer

Introduction

Agricultural production areas were damaged by using synthetic fertilizers and pesticides for a long time. The problem was not affected only soil but also human health and the ecosystem. The amount of chemically toxic and improve soil conditions, new agricultural practices have been tried to reduce by various organic agricultural systems like sustainable agriculture (Chowdhury, 2004). At present, farmers have been used organic fertilizers instead of chemical fertilizers for sustainable agriculture to improve soil quality and increasing crop yield (Masarirambi *et al*., 2010). The main sources of organic fertilizers are the plant–residues, and the industrial wastes (Shennan, 1992), legume crop (Manojlovic *et al*., 2010), and composted animal manures (Adediran *et al*., 2003). The livestock manure compost was the main nutrient source of organic fertilizer because of its content more nutrients than other

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sources (Esmailpour *et al*., 2013; Schmitz and Fischer, 2003). Livestock in Thailand has been done mainly cattle, poultry, sheep, pig, buffalos, and goat. The livestock wastes have been recycled for plant production and improved farmland (Ahmad *et al*., 2007). The cattle and poultry manures were the highest volumes and the most used in farmland. In recently, the poultry manure was produced as commercial organic fertilizer, especially chicken manure because it is uniform physical appearance and rich in nutrients (Moore *et al*., 1995, Irshad *et al*., 2013). On the other hand, small farmers have been using cattle manure in order to reduce the cost of crop production.

Lettuce, romaine lettuce, crisphead lettuce, and butterhead lettuce are the most commonly grown species that belong to *Lettuce sativa*. Lettuce is grown as leafy vegetables and mainly consumed as in salads. The vegetables are rich minerals like vitamin C, iron, magnesium, and phosphorus. However, the quality and quantity of lettuce depend on varieties, environments, and management. Fertilizer application was the most important to achieve maximum yield (Stewart *et al*., 2005). Organic fertilizers have been applied to many crop production, especially vegetables like lettuce and it can decrease nitrate accumulation in plant leaves (Bassyouni, 2016). In Thailand, lettuce production is cultivated mainly conventional in the greenhouse and hydroponic system. However, consumers concerned the chemical residues in lettuce products, thus the organic farms have been increased. Lettuce production has been specifically planted in seasonings, varieties, climate conditions, management practices, soil properties, and fertilizer management and organic fertilizer (Worthington, 2001). However, there are a lack of information of using the different compost manures on the growth of lettuces. Therefore, the aim of the research was to apply different types of organic fertilizers from livestock manures on the growth and quality of lettuces.

Materials and methods

Experimental design

Three different cultivars of lettuces (Green Oak, Frillice Iceberg and Green Cos) were treated with six different fertilizers including cow manure compost (CM), chicken manure compost (CHM), goat manure compost (GM)), bio-fermented fertilizer (BF), chemical fertilizer formula 24-7-7 (CF) and without fertilizer (NF) (negative control). The cow, chicken, and goat manures were collected from a commercial dairy cows, egg chicken, and beef goat farms, respectively, while BF was fermented from waste of tilapia fish. The experiment was designed by Randomized Complete Block Design (RCBD)

with three replications and 10 plants per each. The plants were grown under field conditions at the Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand from October to November 2018 growing seasons. The place is located between 13° 43′49″ N and 100° 46′57″ E.

Organic fertilizer preparation

The organic fertilizers used in this study were three manure composts (cow, chicken and goat manures) and liquid fertilizers (bio-fertilizer), chemical fertilizer (24-7-7) (positive control) and without fertilizer (negative control). Three manure composts were prepared from mixed rice bran, molasses, and lactic acid bacteria from commercial company then fermented for one month under ambient condition and high relative humidity conditions. On the other hand, liquid fertilizer was prepared by using the fish waste fermented with molasses, lactic acid bacteria and sterilized water in a ratio of 3:1:1:10 and fermented for one month. The organic fertilizers were analyzed the nutritional properties after fermented for a month. The pH and EC of compost was measured using pH meter and EC meter, respectively. The organic matter was determined by loss on ignition at 430 ˚C for 24 h. The total nitrogen was determined by the Kjeldahl digestion method. The carbon to nitrogen (C/N) ratio were calculated from organic matter by the total nitrogen. The P_2O_5, K_2O, Ca, Mg, Fe, Mn, Cu, Zn, and B was extracted by the Dry Ashing method and determined by Atomic Absorption Spectroscopy.

Seedling preparing and transplanting

Green Oak, Frillice Iceberg, and Green Cos seeds were sown in polystyrene flatted trays filled with peat moss and grown in a greenhouse. The trays were irrigated daily in the morning for 20 days. The seedlings were transplanted to plastic pots size 8 inch in mixed media of rice husk: rice husk ash: coconut coil: soil surface in a ratio of 1:1:1:1 (v/v) and placed in open field conditions. The application of fertilizers was divided into 4 times. Firstly, the fertilizers were added as basal fertilization and another 3 times after transplant (one-week interval). The 20 g of composts were applied on top the media of each plant and the chemical fertilizer were applied 2 g/plant.

Data collection and statistical analysis

Air temperature (℃) and relative humidity (%RH) were recorded every hour by a data logger (LogTag HAXO-8, LogTag Recorders Limited, New

Zealand). Data were collected from all planted. Plant height, plant width, leaf number per plant, and chlorophyll by using chlorophyll meter version SPAD-502 plus) were collected 4 times (1-week interval) and root length and fresh weight were collected at harvesting time. Collected data were analyzed by using Statistix 8 (V.2) developed by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The means were calculated and separated by (LSD) (P = 0.05).

Results

Weather and chemical properties of fertilizers

In the periods of transplanted in the field (October 2018), the maximum air temperature was 40.8 ℃ (day time) and the minimum was 19.4 ℃ (night time), with the monthly average 32.3 ℃. For the relative humidity throughout the experiment, the maximum, average, and minimum air relative humidity were 83.3, 80.1, and 52% RH, respectively (Figure 1). The chemical properties of four organic fertilizers are presented in Table 1. The average pH values of cow manure compost (CM), chicken manure compost (CHM), and goat manure compost (GM) were 6.61, 7.39, and 8.64, respectively. The EC of four manure composts (CM, CHM, GM and BF) proved higher than the standard (≤10 dS/m) were 26.2 dS/m, 28 dS/m, 14.8 dS/m and 15.05, respectively. The organic matter in CM showed a higher value than CHM and GM as 68.3%, 38.6%, and 62%, respectively. The carbon to nitrogen (C/N ratio) of CM, CHM, and GM was 28.1, 18.2, and 26.1, respectively. The chemical nutrients of four organic fertilizers were presented and different in both amounts of macronutrient (N, P, K) and micronutrients (Ca, Mg, Fe, Mn, Cu, Zn, B). In the chemical, fertilizer was contained macronutrient N, P, and K with amount 24%, 7%, and 7%, respectively. Among of four organic fertilizers (CM, CHM, GM and BF), CHM had the highest content of P (4.43 %), Ca (16.5 %), Mg (1.6 %), Fe (14,723 ppm), Mn (604 ppm), Cu (146 ppm), and Zn (569 ppm), but it was not detected B. The CM treatment was provided the highest amount of N (2.43 %) and K (2.25 %) and GM had highest on B (61.9%). Liquid organic fertilizer had lower nutrient content than manure compost and less than the standard of organic fertilizer (Table 1).

Plant growth

The plant growths of three lettuces (green oak, frillice iceberg, and green cos) during four weeks after transplanting (Figure 2). The response of plant growth to different fertilizers can be divided into two groups the first

group showed rapid growth on plant height, plant width, number of leaves, and SPAD unit when applied with chicken manure (CHM) and chemical fertilizer (CF) treatments. While, the second group showed slow growth in which the plant was applied by using cow manure compost (CM), goat manure compost (GM), liquid organic fertilizer (BF), and without fertilizer (NF).

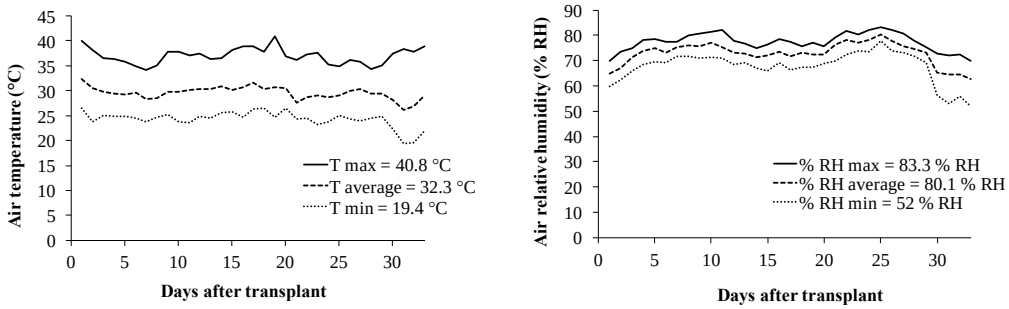

Figure 1. Maximum, average and minimum of air temperature and relative humidity during October to November 2018 in the field

Table 1. Chemical properties of chemical fertilizer, composted manures, liquid fertilizer, and standard nutrient elements

Fertilizers	CF	CM	CHM	GM	BF	SD
pH		6061	7.39	8.67	5.12	5.5-8.5
EC (ds/m)		26.2	28	14.8	15.05	≤ 10
Organic Matter (%)		68.3	38.6	62	4.13	> 30
C/N ratio		2831	18.2	26.1	-	≤ 20
N (%)	24	2.43	2.12	2.38	2,000 (ppm)	> 1
P (%)	7	2.13	4.43	0.075	25.27 (ppm)	> 0.5
K (%)	7	2.25	1.96	2.04	547.07 (ppm)	> 0.5
Ca (%)		3.41	16.5	2.58	167.66 (ppm)	-
Mg (%)		1.21	1.6	0.59	106.72 (ppm)	-
Fe (ppm)		2,890	14,723	5,239	4.55	-
Mn (ppm)		449	604	292	4.02	-
Cu (ppm)		105	146	30.2	0.29	-
Zn (ppm)		183	569	95.1	0.91	-
B (ppm)		36.2	-	61.9	0.2	-

Remark; CF (chemical fertilizer), CM (cow manure compost), CHM (chicken manure composted), GM (goat manure compost), BF (liquid organic fertilizer), and SD (organic standard of land development Department, Thailand)

Table 2. Plant growth of lettuces (green oak, frillice iceberg and green cos) grown under different types of fertilizers 28 days after transplant during October to November 2018

Lettuce/ fertilizers[1/]	Plant height (cm)	Plant width (cm)	number of leaves	Leaf length (cm)	Leaf width (cm)	SPAD unit	Root length (cm)	Fresh weight (g/plant)
Green oak								
CM	19.22^{b}	7.25^{c}	9.11^{c}	5.31^{c}	3.81^{b}	9.49^{b}	11.64^{c}	3.71^{c}
CHM	29.50^{a}	21.58^{b}	20.83^{b}	11.64^{b}	11.02^{a}	17.28^{a}	16.25^{a}	80.32^{b}
GM	16.42^{c}	5.20^{d}	8.08^{cd}	3.87^{d}	2.52^{c}	8.40^{bc}	10.78^{cd}	2.28^{c}
BF	14.67^{c}	3.83^{e}	6.22^{d}	3.48^{de}	1.63^{c}	7.48^{c}	10.00^{cd}	1.67^{c}
CF	30.27^{a}	25.35^{a}	26.66^{a}	12.47^{a}	12.03^{a}	18.97^{a}	13.43^{b}	126.23^{a}
NF	14.39^{c}	4.29 ^{de}	6.79^{d}	3.05^{e}	2.07^{c}	8.73^{bc}	9.04^{d}	1.24^{c}
Means	20.75	11.25	12.95	6.64	5.51	11.72	11.86	35.91
F-test	**	**	**	**	**	**	**	**
C.V. (%)	14.54	14.85	22.77	14.52	27.08	24.2	21.83	53.05
Frillice iceberg								
CM	6.83^{b}	6.99^{b}	5.17^{b}	5.64^{b}	4.57^{c}	16.30^{b}	13.13^{c}	5.41^{b}
CHM	11.63^{a}	18.25^{a}	8.50^{a}	11.31^{a}	10.02^{b}	30.24^{a}	19.93^{a}	63.58^{a}
GM	6.07^{b}	5.22^{c}	4.22^{c}	4.86^{c}	3.57^{d}	11.04^{c}	12.21^{cd}	3.03^{b}
BF	4.27^{c}	3.40^{d}	3.50^{d}	3.44^{e}	2.55^{e}	7.76^{c}	11.42^{cd}	1.36^{b}
CF	11.91^{a}	18.66^{a}	8.76^{a}	11.75^{a}	10.70^{a}	27.80^{a}	17.33^{b}	57.65^{a}
NF	4.21^{c}	3.23^{d}	4.00^{cd}	4.06^{d}	3.09^{de}	10.57^{c}	11.12^{d}	1.26^{b}
Means	7.49	9.29	5.69	6.84	5.75	17.29	14.19	22.05
F-test	**	**	**	**	**	**	**	**
C.V.%	17.94	19.64	22.77	14.52	27.08	24.2	21.83	53.05
Green cos								
CM	21.72^{c}	7.83^{b}	10.67^{b}	6.94^{c}	2.97^{b}	25.02^{b}	12.81^{b}	9.08^{c}
CHM	32.39^{b}	23.81^{a}	28.17^{a}	15.39^{b}	7.61^{a}	34.37^{a}	13.06^{b}	123.50^{b}
GM	18.78^{d}	5.00^{c}	6.83^{c}	5.27^{d}	2.09^{c}	18.84^{c}	11.92^{b}	4.87^{c}
BF	14.30^{e}	3.40^{c}	5.65^{c}	3.53^{e}	1.74^{cd}	14.91^{d}	8.72^{c}	1.49^{c}
CF	35.72^{a}	22.63^{a}	30.02^{a}	16.21^{a}	7.48^{a}	34.55^{a}	15.19^{a}	162.59^{a}
NF	14.76^{e}	3.43^{c}	5.73^{c}	3.92^{e}	1.44^{d}	15.95^{d}	9.37^{c}	1.98^{c}
Means	22.94	11.02	14.51	8.54	3.89	23.94	11.84	50.58
F-test	**	**	**	**	**	**	**	**
C.V.%	17.17	25.73	26.88	13.38	21.39	13.35	25.66	29.05

[1/] CF (chemical fertilizer), CM (composted cow manure), CHM (composted chicken manure), GM (composted goat manure), BF (liquid organic fertilizer), and SD (standard nutrient element).

Plant height was significantly influenced by the treatments in three lettuce types (Table 2). Organic treatments CHM resulted in significantly higher plant height with CF in the second to fourth week after transplants (Table 2, Figure 2). The plant height values of other organic treatments (CM, GM and BF) did not significant differently than the without fertilizer control (NF) treatment. The plant height values in CHM treatment of green oak was

29.50 cm, frillice iceberg was 11.63 cm and green cos was 32.39 cm (Table 2; Figure 2C).

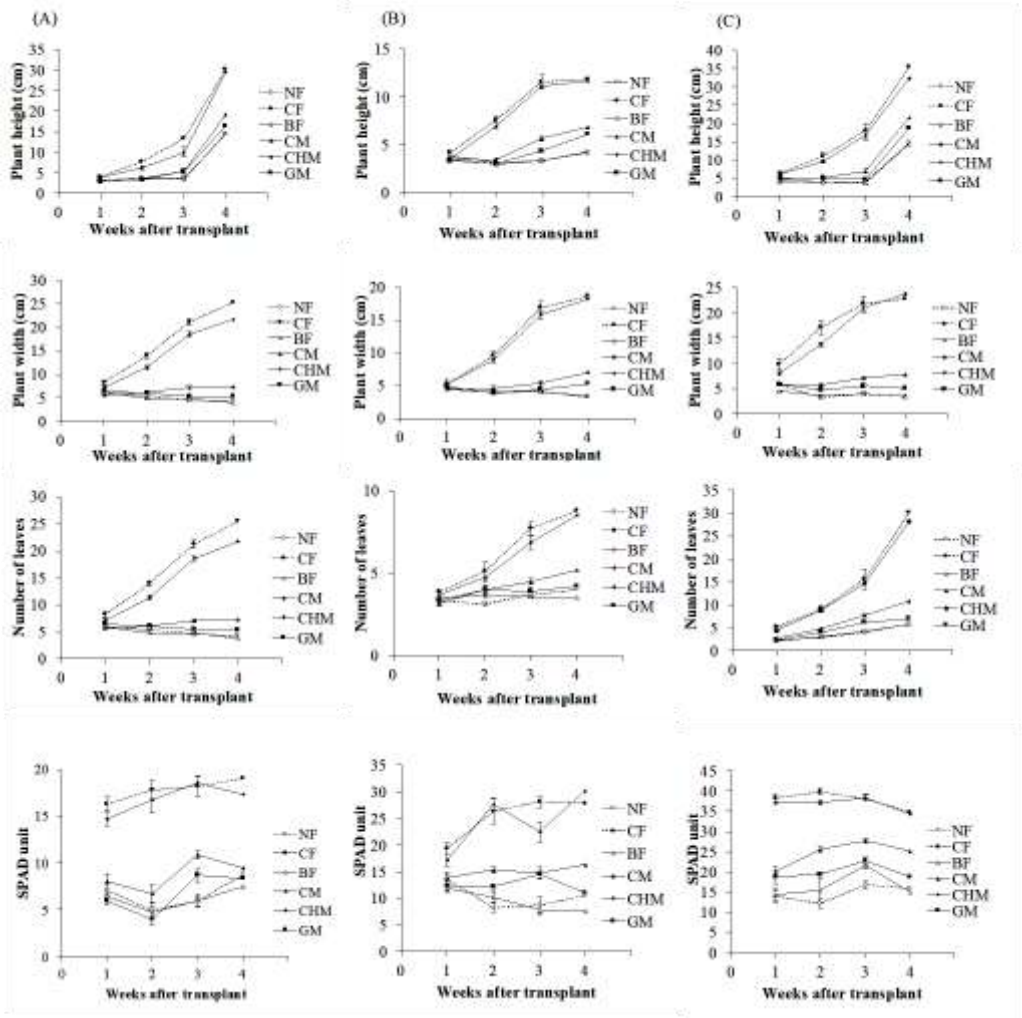

Figure 2. Plant height, plant width, number of leaves, and SPAD unit during four weeks after transplanting of lettuces, green oak (A), frillice iceberg (B), and green cos (C) grown under different types of fertilizers. CF=chemical fertilizer, CHM=chicken manure compost, CM=cow manure, GM=goat manure compost, BF=liquid organic fertilizer, and NF= without fertilizer

The differences between treatments for plant width were also found significant at the second to fourth week after transplants (Figure 2). The plant width was greater with organic treatments CHM than CM, GM and BF treatments. However, the plant width in CHM treatment did not exceed than CF

control treatment. On the other hand CM, GM and BF organic fertilizers did not differ with NF. In the final days the value of plant width treated with CHM of green oak, frillice iceberg and green cos were 21.58 cm, 18.25 cm and 23.81 cm, respectively. Numbers of leaves per plant of the three lettuce types grown under the different organic fertilizers are presented in Table 2. The results showed that number of lettuce leave per plant were significantly affected by the organic treatment ($P \leq 0.01$). The highest values obtained from the CHM treatment in all lettuce types as green oak was 20.83 leaves, frillice iceberg was 8.50 leaves and green cos was 28.17 leaves (Table 2). All treatments had a significant influenced on leaf length at the final day (4 weeks after transplant). CHM treatment resulted highest values among organic treatment, while the BF treatment did not differ with NF control treatment. Leaf width also showed significantly different among organic fertilizer treatments at $P \leq 0.01$, CHM treatment gave the highest value than other organic fertilizers. The SPAD chlorophyll unit was significantly influenced by the different treatment at the first week after transplant (Figure 2), the CHM and CF treatment gave similarity values. CHM treatment produced SPAD unit of green oak (17.28 unit), Frillice iceberg (30.24 unit) and green cos (34.37 unit). The root length at the last week (harvesting time) of three lettuce types was significantly different in different organic fertilizer treatments. The maximum root length was recorded in CHM treatment in green oak was 16.25 cm, frillice iceberg was 19.93 cm and green cos was 13.06 cm, however two lettuces (green oak and frillice iceberg) showed higher than CF treatment. The plant fresh weight (PFW was measured as indicators of economic yield of lettuce. The fresh weight was significant influenced by the treatment in all lettuce types (Table 2). Organic treatment CHM resulted in significantly higher plant fresh weight than other organic fertilizers. The fresh weight values of green oak, frillice iceberg and green cos were 80.32 g, 63.50 g and 123.50 g, respectively.

Discussion

The four organic fertilizers CM (cow manure compost), CHM (chicken manure composted), GM (goat manure compost), BF (liquid organic fertilizer) showed differences among nutrition and effects of plant growth. The chicken manure gave the highest nutrition, while BF gave the lowest nutrition. Moore *et al.* (1995) reported that the nutrition in organic fertilizers depend on the kind of animal, feed, and cultural system. In this study, we used chicken manure from egg production farm, which feeds by protein supplements such as soybean oil meal, mineral supplements, and vitamin supplements, while cow manure and goat manure were fed the diets by mainly containing the protein supplements and rice straw. Therefore, the chicken manure compost was highest nutrient

value for macronutrient (P), and micronutrients (Ca, Fe, Mn, Cu, and Zn), which was higher than the standard of organic fertilizer of organic standard of land development Department, Thailand similar to the research of Irshad *et al*. (2013) and Bassyouni (2016) who found that the chicken manure contained more macronutrients (N, P and K) than others manures. In our experiment, the manure composts were fermented for 30 days after mixing the raw material, among the organic fertilizers cow and goat manure composts showed C/N ratio higher than the organic standards, it is possible that both manure composts did not mature, because of their C/N ratio higher than 30:1 ratio. Therefore, the manures are slow-fermented and showed immature manure compost. Thus, the manure from cow and goat should be extent fermented time from 60 to 90 days (Bernal *et al*., 2009) for fermentation or until the C/N ratio decreased lower than 20. On the other hand, we found that the growth of three lettuces under cow, goat manure composts and liquid organic fertilizers were exhibited slowly growing up similar to without fertilizer. This indicated that the nutrition from those organic fertilizers supplied were not enough for plant requirements. In addition the high C/N ratio (more than 20/1) caused immobilizations of N, which directly affects plant growth and yield (Chaves *et al*., 2005).

In addition, the pH of manure composts ranged between 6.5 and 8.0 were considered as an optimum condition of composting, except for goat manure showed slightly higher than standard organic fertilizer (Vakili *et al*., 2012). EC values of three manure composts were exceeded to limit standard (10 µS/m), which is considered as a toxic to plant if applied with higher doses (Soumare *et al*., 2002). In this experiment, we divided the application of fertilizers to the lettuce plants for four times to prevent the toxic from salt. However, the liquid organic fertilizer used in this experiment contained small amounts of total nitrogen, P and K, which was lower than the organic standard of land development Department, Thailand, therefore the plant growth is could not grow up. However, it contained the micronutrients similar report of Phibunwatthanawong and Riddech (2019), who found the liquid organic fertilizer contained micronutrient and supplement nutrients, microorganisms, IAA (hormone), which are promoting the growth of the plant. There the results from this work suggested that the chicken manure compost is the most response and suitable fertilizer for lettuces.

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