Effect of composts of animal wastes on forage yield and chemical compositions of pangolagrass and soil fertility [1]

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Abstract

The objectives of this study were to determine the effect of animal composts of animal wastes on forage yield and chemical composition of pangolagrass (*Digitaria decumbens*) and soil fertility. Pangolagrass pasture received 9 treatments (annual application per ha), CK: no fertilizer, CF_1: chemical fertilizer N : P_2O_5 : K_2O = 200 : 72 : 75 kg/ha, CF_2: twice of CF_1, CA_1: compost of cow dung containing N 600 kg/ha, CA_2: twice of CA_1, HO_1: compost of pig wastes containing N 600 kg/ha, HO_2: twice of HO_1, CH_1: compost of chicken droppings containing N 600 kg/ha, CH_2: twice of CH_1. Pangolagrass applied with CH_1, CH_2 and CA_2 produced the highest dry matter yield. The highest crude protein (CP) contents of pangolagrass were observed for the treatments of HO_2, CA_2, CH_2 and CF_2. The treatments applied with more composts had higher CP contents. The contents of P, K and Cu in the plants increased with the compost application. The ratios of K/(Ca + Mg) in pangolagrass for treatments CH_1 and CH_2 were markedly higher than those of the other treatments. The uptakes of minerals in pangolagrass applied with composts were higher than those applied with chemical fertilizers. More compost application had higher uptake of minerals in the plant. The pH values, electric conductivity, the contents of organic matter, N, available P and K, extractable Ca, Mg, Cu, and Zn increased in soil after compost application except Cu contents for CH_1 and CH_2. Higher content of Cu in soil applied with compost of pig wastes and higher contents of Zn in soil applied with all composts were observed.

Key words ： *Digitaria decumbens*, Compost, Forage yield, Chemical composition, Soil fertility.

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Introduction

Animal wastes produced from livestock raising have considerably increased and caused pollution to environment in Taiwan. Meanwhile, physical and chemical properties of farmland are deteriorated and soil fertility is lower due to the application of chemical fertilizers for a long period of time. This leads to decrease in productivity of soil.

Pangolagrass (*Digitaria decumbens*) is one of the major forage species grown in Taiwan (COA, 2003). It is planted and harvested to make hay and haylage by mechanical operation. It is the biggest trade item among the domestic forage species. The soil of pangolagrass pasture has higher bulk density because of the compacting force of machines on the pasture for a long time (Hsieh *et al.*, 2003; Stone and Ekwue, 1993). It might affect root growth and forage yield of pangolagrass. Lu and Hsu (2004) reported that the apparent N recoveries (ANR) of the compost utilized by pangolagrass were 10-28%. Hsu *et al.* (2004) showed that ANRs of pangolagrass were changed with the application rates of N, locations and growth seasons. The objectives of this study were to determine the effect of composts of animal wastes on forage yield and chemical compositions of pangolagrass and soil fertility.

Materials and Methods

A field of pangolagrass pasture established for 6 years was used in the experiment. A randomized complete block design with 3 replications was used. The plot areas were 5×5 m^2. The treatments were as follows (annual application per hectare):

1. CK: No fertilizer applied.
2. CF_1: Chemical fertilizer N : P_2O_5 : K_2O = 200 : 72 : 75 kg.
3. CF_2: Twice of CF_1.
4. CA_1: Compost of cow dung, 35.3 Mg containing about N 600 kg.
5. CA_2: Twice of CA_1.
6. HO_1: Compost of pig wastes, 15.3 Mg containing about N 600 kg.
7. HO_2: Twice of HO_1.
8. CH_1: Compost of chicken droppings, 27.3 Mg containing about N 600 kg.
9. CH_2: Twice of CH_1.

All the composts were completely fermented by the research farm of Livestock Research Institute, Council of Agriculture, Hsinhua, Tainan, Taiwan. The plants were harvested four times yearly. Thus, the animal composts were divided into four times applied in the plots one week after each cutting. For chemical fertilizer, all P_2O_5, 1/2 K_2O and 1/4 N were applied as basic dressing during planting or early spring each year. The rests of N fertilizer were divided into the other 3 applications and the other 1/2 K_2O were applied after the 3rd cutting. The experiment was started on April 9, 1997 and ended on October 16, 2001.

On harvest, the plant height and the fresh weight were measured. The subsamples were taken to put in the oven at 70℃ for 48 hours to determine the dry matter. The oven-dry samples were used to determine the contents of N, P, K, Ca, Mg, Cu and Zn. The pH values and the chemical compositions of total N, P, K and Cu of composts of cattle, hog and chicken wastes were also determined. Soil samples were taken yearly from the plots to do the soil analysis. The pH values, electric conductivity (EC) and the contents of total N, available P, K, Ca and Mg and extractable Cu and Zn in soil were determined.

Nitrogen contents of both plant and soil were determined according to Kjeldahl method. Crude protein (CP) in the plant was obtained by N × 6.25. The contents of P in the plant were determined by colorimetric method with molybdate blue method. Those of K, Ca, Mg, Cu and Zn in the plant were determined by atomic absorption spectrometry. The uptakes of N, P, K, Ca, Mg, Cu and Zn in the pangolagrass were calculated.

The methods used to determine chemical compositions in soil were as follows (Page *et al.*, 1982):

1. P: Extracted with Bray's No.1 method and determined by colorimetric method with molybdate blue method.
2. K, Ca and Mg: N-neutral NH_4OAC extraction method followed by atomic absorption spectrometry.
3. Cu, Zn: 0.1 N HCl extraction method followed by atomic absorption spectrometry.

Results and Discussion

The ANRs of pangolagrass decreased with increasing rates of N applied, ranged from 48.2% to 72.8% (Hsu *et al.*, 2004). However, the ANRs of the compost utilized by pangolagrass were 10-28% (Lu and Hsu, 2004). This study was designed to determine the effect of animal composts on forage yield and chemical compositions of pangolagrass compared to chemical fertilizer in a wide range. More animal composts were used in the experiment.

Compost of chicken droppings had the highest pH value and K content among the three composts (Table 1). However, compost of pig wastes had the highest contents of total N and extractable Cu. Compost of cow dung had the lowest contents of total N, P, K and Cu with pH value 6.94 between those of pig and chicken (Table 1).

Pangolagrass applied with treatments CA_2, CH_1 and CH_2 had the highest plant height, followed by HO_2, CA_1, HO_1, CF_2, CF_1 and CK (Table 2). Pangolagrass applied with CH_1, CH_2 and CA_2 produced the highest fresh and dry matter yields, followed by HO_2, CA_1, HO_1, CF_1, CF_2 and CK. This showed a similar trend as observed for plant height. Compost of chicken droppings expressed the highest effect on both plant height and forage yield, followed by composts of cow and pig wastes. In addition, the plots which received more composts produced higher forage yields. All the plots applied with composts produced higher forage yields than did those applied with chemical fertilizer. The plot received no fertilizer produced the lowest forage yield.

Table 1. The chemical compositions of animal composts of animal wastes

Compost	pH	Total N	P	K	Cu
		———	%	———	mg/kg
Cattle	6.94[§]	1.70	0.02	0.98	49.1
Hog	6.35	3.93	0.75	1.23	219.0
Chicken	8.22	2.22	0.70	3.33	69.0

[§]Data shown are averages of four analyses for composts of cattle and pig wastes and three analyses for compost of chicken droppings, respectively.

The highest CP contents in pangolagras's were observed for treatments HO_2, CA_2, CH_2 and CF_2. The treatment with more composts applied had more CP contents in the plant (Table 3). The plots which received treatments CA_2, CH_2, HO_2 and CH_1 had the highest amounts of N uptake. All the plots applied with composts had higher amounts of N uptake than those applied with chemical fertilizers (Table 4). The same results were reported in pangolagrass (Hsu *et al.*, 1999) and napiergrass (*Pennisetum purpureum*) (Hong *et al.*, 2000).

The P contents in pangolagrass were higher in those treatments with compost applied than those with chemical fertilizer and those without fertilizer (Table 3). No significant difference was observed for P contents in the plant among compost treatments. However, treatments CH_1, CH_2 and CA_2 had the highest amounts of P uptake followed by HO_2, CA_1 and HO_1. The plots received chemical fertilizer and no fertilizer showed the lowest P uptake (Table 4).

The plants applied with compost of chicken droppings had the highest K contents among treatments, followed by those applied with composts of cow and pig wastes. The plants applied with chemical fertilizer and those with no fertilizer had lower K contents (Table 3). K uptake showed the same trends as K contents in the plants. Treatments CH_2 and CH_1 had the highest K uptake, then followed by CA_2, HO_2, CA_1, HO_1, CF_2, CF_1 and CK. The plants receiving more composts had more K uptake (Table 4).

No significant differences were observed in Ca contents of pangolagrass among all the treatments except CK (Table 3). The highest Ca uptakes occurred in treatments CA_2, CH_1, CH_2 and HO_2, followed by HO_1, CA_1, CF_1, CF_2 and CK (Table 4).

Table 2. Effect of composts on agronomic traits and forage yields of pangolagrass

Treatment	Plant height[§]	Dry matter percent[§]	Fresh weight	Dry weight
	cm	%	Mg/ha/year	
CK[#]	50.7[f*]	32.8[a]	38.1[d]	12.6[e]
CF_1	61.0[e]	31.3[b]	54.9[c]	16.9[cde]
CF_2	64.3[de]	29.6[c]	53.3[c]	15.6[de]
CA_1	69.5[c]	28.4[d]	68.8[bc]	19.4[bcd]
CA_2	78.9[a]	26.4[e]	91.8[a]	24.1[ab]
HO_1	67.2[cd]	28.8[cd]	63.4[c]	18.0[cd]
HO_2	73.9[b]	26.8[e]	80.2[ab]	21.3[bc]
CH_1	75.5[ab]	27.9[d]	94.0[a]	26.3[a]
CH_2	77.3[ab]	26.3[e]	93.4[a]	24.1[ab]

[#]CK: no fertilizer; CF_1: chemical fertilizer N : P_2O_5 : K_2O=200 : 72 : 75 kg/ha; CF_2: twice of CF_1; CA_1: compost of cow dung containing N 600 kg/ha; CA_2: twice of CA_1; HO_1: compost of pig waste containing N 600 kg/ha; HO_2: twice of HO_1; CH_1: compost of chicken dropping containing N 600 kg/ha; CH_2: twice of CH_1.

[§]Data shown are averages of 5 years.

[*]Means with the same letter in the same column are not significantly different at 5% level by multiple range test.

Table 3. Effect of composts on chemical compositions of pangolagrass[§]

Treatment	Crude protein	P	K	Ca	Mg	Cu	Zn	K/(Ca+Mg)
	%							
CK[#]	5.64[f*]	0.48[d]	1.25[fg]	0.24[b]	0.26[b]	7.94[e]	53.9[bc]	2.71[b]
CF_1	6.63[e]	0.51[bcd]	1.12[g]	0.31[a]	0.26[b]	8.76[de]	59.7[abc]	2.57[b]
CF_2	8.18[abc]	0.50[cd]	1.50[ef]	0.29[ab]	0.28[b]	9.36[cd]	48.0[c]	3.99[b]
CA_1	7.35[cde]	0.54[abc]	1.68[de]	0.28[ab]	0.25[b]	10.49[abc]	64.5[ab]	2.75[b]
CA_2	8.45[ab]	0.55[a]	1.99[c]	0.30[ab]	0.26[b]	10.12[abc]	54.3[bc]	2.74[b]
HO_1	7.62[bcd]	0.56[b]	1.54[def]	0.32[a]	0.33[a]	10.76[ab]	71.3[a]	2.05[b]
HO_2	8.76[a]	0.55[a]	1.83[cd]	0.32[a]	0.34[a]	9.66[bcd]	70.6[a]	2.38[b]
CH_1	6.85[de]	0.55[a]	2.55[b]	0.28[ab]	0.17[c]	10.27[abc]	48.0[c]	6.57[a]
CH_2	8.17[abc]	0.53[abc]	3.08[a]	0.28[ab]	0.19[c]	11.25[a]	57.4[bc]	7.65[a]

[#]As shown in Table 2.
[§]Data shown are averages of 5 years.
[*]Means with the same letter in the same column are not significantly different at 5% level by multiple range test.

Table 4. Effect of composts on mineral uptakes of pangolagrass[§]

Treatment	N	P	K	Ca	Mg	Cu	Zn
	kg/ha					g/ha	
CK[#]	29.8[d]	16.0[d]	41.7[f]	8.1[e]	8.5[e]	25.8[d]	177.7[d]
CF_1	47.2[c]	22.0[cd]	51.0[ef]	14.1[cd]	12.3[cd]	38.7[c]	265.7[c]
CF_2	53.8[bc]	20.4[cd]	62.3[def]	12.2[d]	11.7[de]	38.2[c]	197.4[d]
CA_1	60.7[b]	26.8[bc]	87.5[cd]	14.3[cd]	12.7[cd]	52.2[b]	335.3[b]
CA_2	86.7[a]	33.3[ab]	129.1[b]	19.1[a]	17.0[ab]	62.2[a]	346.6[ab]
HO_1	58.2[bc]	26.3[bc]	73.2[de]	15.3[bc]	15.3[bc]	50.9[b]	340.4[ab]
HO_2	79.2[a]	30.0[b]	104.2[bc]	17.7[ab]	18.6[a]	52.8[b]	396.4[a]
CH_1	76.0[a]	37.4[a]	179.4[a]	18.6[a]	11.6[de]	68.5[a]	331.9[b]
CH_2	83.8[a]	33.3[ab]	198.3[a]	17.7[ab]	11.7[de]	69.3[a]	372.2[ab]

[#]As shown in Table 2.
[§]Data shown are averages of 5 years.
[*]Means with the same letter in the same column are not significantly different at 5% level by multiple range test.

The treatments applied with compost of pig wastes had higher contents of Mg in the plant and those applied with compost of chicken droppings had lower contents of Mg in the plant. The Mg contents in the plant for the other treatments were not significantly different (Table 3) from each other. The highest amounts of Mg uptake occurred in treatments HO_2 and CA_2. Both CH_1 and CH_2 had the lowest Mg uptake (Table 4).

The ratios of K/(Ca + Mg) in the plant for all the treatments were higher than 2.2 except HO_1, especially the plots receiving compost of chicken droppings (Table 3). Animal performance would be affected if the animals were put on the pasture treated with the ratio of K/(Ca + Mg) higher than 2.2 (Hsu, 1987). It indicated that compost of chicken droppings was not suitable for applying in the pasture prepared for grazing animal.

The Cu contents of pangolagrass applied with composts were higher than those applied with chemical fertilizer and those with no fertilizer (Table 3). Cu uptakes in pangolagrass were the highest in treatments CH_2, CH_1 and CA_2, followed by HO_2, CA_1, HO_1, CF_1, CF_2 and CK (Table 4). The Zn contents of pangolagrass were the highest in treatments HO_1, HO_2 and CA_1 (Table 3). The amounts of Zn uptake in pangolagrass were the highest in treatments HO_2, CH_2, CA_2, and HO_1, then followed by CA_1, CH_1, CF_1, CF_2 and CK (Table 4).

The chemical compositions in soil of pangolagrass pasture after applying the composts for 5 years were shown in Table 5. The pH values of soil applied with composts increased significantly as compared with those applied with chemical fertilizer and those with no fertilizer. The pH values of soil applied with compost of chicken droppings were the highest, followed by those applied with cattle manure, then with

Table 5. Effect of composts on chemical compositions in soil of pangolagrass pasture[§]

Treatment	pH	Electric conductivity	Organic matter	N	P	K	Ca	Mg	Cu	Zn
		dS/m	—— % ——		———— mg/kg ————					
CK[#]	4.99^{d*}	0.077^{d}	2.26^{e}	0.053^{f}	13.5^{e}	73.3^{c}	351.3^{e}	66.8^{ef}	2.05^{de}	8.71^{d}
CF_1	4.65^{e}	0.113^{bcd}	2.47^{de}	0.062^{ef}	30.2^{e}	69.2^{c}	295.3^{e}	26.7^{f}	1.32^{efg}	7.59^{d}
CF_2	4.55^{e}	0.103^{cd}	2.54^{de}	0.051^{f}	70.9^{e}	76.2^{c}	275.0^{e}	22.9^{f}	0.97^{fg}	7.69^{d}
CA_1	6.10^{b}	0.153^{bc}	3.42^{bc}	0.092^{de}	224.7^{d}	81.2^{c}	920.1^{d}	181.6^{cd}	2.43^{cd}	23.0^{c}
CA_2	6.13^{b}	0.293^{a}	5.57^{a}	0.176^{a}	371.8^{c}	122.0^{c}	1237.1^{c}	256.6^{c}	3.74^{ab}	47.38^{a}
HO_1	5.66^{c}	0.167^{b}	3.13^{cd}	0.082^{def}	322.1^{c}	75.3^{c}	832.7^{d}	141.6^{de}	3.22^{bc}	31.43^{b}
HO_2	5.70^{c}	0.260^{a}	3.75^{bc}	0.104^{cd}	479.6^{b}	94.3^{c}	936.6^{d}	164.6^{d}	4.48^{a}	49.17^{a}
CH_1	7.49^{a}	0.257^{a}	3.42^{bc}	0.129^{bc}	464.1^{b}	248.8^{b}	2114.2^{b}	620.3^{b}	1.56^{def}	33.26^{b}
CH_2	7.58^{a}	0.293^{a}	4.05^{b}	0.153^{ab}	759.1^{a}	460.2^{a}	2445.4^{a}	848.2^{a}	0.47^{g}	45.97^{a}

[#]As shown in Table 2.
[§]Data shown are the analyses of the last soil somples.
[*]Means with the same letter in the same column are not significantly different at 5% level by multiple range test.

compost of pig waste. Those applied with chemical fertilizer decreased significantly. The more chemical fertilizers were applied, the lower pH values in soil were obtained. The results confirmed that compost application could prevent soil acidifying.

The EC of soil applied with composts increased significantly. Higher EC was observed in the plots receiving more composts. All the contents of organic matter and minerals in soil applied with composts were higher than those applied with chemical fertilizer and those with no fertilizer (Table 5). Treatment CH_2 had the highest contents of P, K, Ca and Mg in soil, while CA_2 had the highest content of N and HO_2 had the highest content of Cu in soil. Treatments HO_2, CA_2 and CH_2 had the highest contents of Zn in soil. It might be caused by higher content of Cu observed in hog compost (Table 1). Treatment CH_2 had the highest Cu uptake (Table 4). It might cause the treatment to have the lowest Cu content in soil (Table 5).

Hong *et al.* (2000) indicated that forage yield of napiergrass increased with increasing amounts of composts of cattle and hog wastes applied. Meanwhile, the contents of CP, P, Ca, Mg, Cu and Zn in the plants and the contents of organic matter, total N, available P, exchangeable Ca and Mg, extractable Cu and Zn increased in soil after applying composts of cattle and hog wastes. Especially, both contents of Cu and Zn increased significantly in soil when hog compost rich in Cu and Zn was applied. The same results were also obtained in pangolagrass applied with composts of cattle and hog wastes (Hsu *et al.*, 1999). Hsu *et al.* (1999) showed that the application of compost could prevent acidifying in soil. It was further confirmed by this study. Hsieh *et al.* (1997a, b) showed that the application of composts of cattle and hog wastes in pangolagrass pasture increased the initial infiltration rate in soil. However, the bulk density, porosity and terminal infiltration rate of soil were not affected by broadcasting compost application.

McLaughlin *et al.* (2004) reported that the soil of the hay field received swine effluent spray had higher levels of nutrients and pH values than that with no swine effluent spray. They also indicated that replacing johnsongrass (*Sorghum halepense*) with bermudagrass (*Cynodon dactylon*) would increase annual dry matter yield and P uptake in the field.

Lu and Hsu (1994) demonstrated that the application of hog waste sludge on pangolagrass pasture could help adjust pH values in acid soil and increase soil fertility. Lu and Hsu (2000) further reported that hog waste sludge applied with chemical fertilizer could increase the apparent N recovery in the soil of pangolagrass pasture.

In conclusion, both forage yield and chemical compositions of pangolagrass increased with compost application. The compost could prevent acidifying in soil. The contents of organic matter and minerals in soil increased and soil fertility was improved after compost application. However, higher contents of Cu in soil with compost of pig wastes applied and higher contents of Zn in soil with all of the three composts applied were observed.

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禽畜堆肥對盤固草產量及化學成分與土壤地力之影響 [1]

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摘　　要

本研究的目的乃在探討禽畜堆肥對盤固草（*Digitaria decumbens*）產量及化學成分與土壤地力之影響。盤固草草地接受 9 種不同施肥處理（每公頃年施用量）： CK ：未施任何肥料； CF_1 ：施化肥 N ： P_2O_5 ： K_2O = 200 ： 72 ： 75 kg ； CF_2 ： 2 倍 CF_1 施用量； CA_1 ：牛糞堆肥含 N 600 kg ； CA_2 ： 2 倍 CA_1 施用量； HO_1 ：豬糞堆肥含 N 600 kg ； HO_2 ： 2 倍 HO_1 施用量； CH_1 ：雞糞堆肥含 N 600 kg ； CH_2 ： 2 倍 CH_1 施用量。施用 CH_1、CH_2 及 CA_2 等處理可得最高乾物產量，而 HO_2、CA_2、CH_2 及 CF_2 等處理植體中含有最高的粗蛋白質含量，施用堆肥越多，其粗蛋白質含量也越高，植體中 P、K 及 Cu 之含量隨堆肥之施用而增加，CH_1 及 CH_2 處理植體中 K/(Ca ＋ Mg)之比顯著高於其他處理。施用堆肥後植體中礦物元素之攝取量均比施化肥者為高，同時增加堆肥施用也會提高礦物元素之攝取量，除了 CH_1 及 CH_2 處理土壤中 Cu 含量外，土壤中 pH 值、電導度、有機質、N、P、K、Ca、Mg、 Cu 及 Zn 等含量均因施用堆肥而增加，施用豬糞堆肥者，土壤中 Cu 含量較高，而施用禽畜堆肥均會增加土壤中 Zn 含量。

關鍵詞：盤固草、堆肥、牧草產量、化學成分、土壤肥力。

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