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Effects of Application of Compost Made from Citrus Skin and Starch Sludge on Potato Growth

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The experiment fields consisted of five plots as follows; 2, 4, and 8 tons · ha^{-1} citrus skin in combination with starch sludge and pig manure mixing compost (CSSP), 4 ton · ha^{-1} fermented pig manure compost (FPMC) treated plot, and untreated control. Plant height and stem diameter were significantly increased by CSSP. Most of all, average tuber weight and tuber yield per plant were significantly increased in 4 and 8 tons · ha^{-1} CSSP plots compared to the other plots. Marketable tuber (>50 g fresh weight) yield were superior in order of 4 and 8 tons · ha^{-1} CSSP plot, 4 tons · ha^{-1} FPMC plot, and 2 tons · ha^{-1} CSSP plot.

Key words : *sustainable agriculture, citrus skin, fermented pig manure compost, pellet type compost*

I. Introduction

Citrus, potato, and pig are representative agriculture and stock farm products produced in Jeju Province in Korea and their byproducts are considered as the pollutants aggravating the environmental pollution in Jeju. Potato production in Jeju Province is around 24% of Korea's total commercial production. Potato is the second most important crop nest to citrus. Its starch production determines to a large extent the price of potato in the market. Potato sludge is the main waste material after starch processing. The waste citrus skins have increased, with the processing of 100,000 tons of citrus annually (Yang et al., 2001). Jeju also has a hog farm complex, which, along with the disposal of starch sludge by the plants, produces a large amount of wastewater and aggravates ground water pollution. A large amount of composts have been used, although most composts are produced in exterior regions and transported to Jeju (Yang et

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al., 2001).

Thus, these experiments were conducted to estimate the effects of the citrus skin and starch sludge with pig manure mixing compost (CSSP) originated from Jeju region on the growth of spring-cropping potato in the volcanic ash soil of Jeju region, Korea.

Ⅱ. Materials and Methods

This study was conducted in the field of the Experimental Farm of Agriculture, Cheju National University (33° 27′20″N latitude, 277 m altitude) Jeju, Korea. The chemical properties of the topsoil (0 to 15cm) analyzed in this experiment are shown in Table 1. The field soil consists of dark-brown colored volcanic ash of silty loam and has a common fertility.

1. Plant material and compost application

Seed tubers of potato (*Solanum tuberosum* L. CV. Dejima) were planted in 70-cm rows with 20-cm spacing on March 3, 2003. At planting, all plots were fertilized with 1.2 tons · ha^{-1} of the complex fertilizer for potato ($N/P_2O_5/K_2O$, 10/10/14). Individual plots had four rows with 3 m long. The experimental was designed randomized complete block design with three replications. At 90 days after planting, two center 2m rows were harvested to determine potato yields. The treatments consisted of five plots: 2, 4, and 8 tons · ha-1 CSSP treated plots, 4 tons · ha^{-1} fermented pig manure compost (FPMC) treated plot, and untreated control(1.2 tons · ha^{-1} of the complex fertilizer for potato ($N/P_2O_5/K_2O$, 10/10/14)). CSSP was made by mixing agricultural byproducts; pig manure (50%, v/v), rape oil cake (20%, v/v, dry weight), citrus skin (15%, v/v, dry weight), potato starch sludge (10%, v/v), zeolite and lime (5%, v/v). The moisture contents of citrus skin and potato starch sludge were 80 and 65%, respectively. The mixture was left to ferment for 2 weeks. The compost was made into pellets, and left in storage to allow the compost to cure for 2 months. Chemical composition of some agricultural byproducts are shown in Tables 2 and 3. Main properties of FPMC (A local product from Samda Compost Co., Ltd., Jeju, Korea) were 70% pig manure and 30% sawdust. The certified properties of FPMC were 25% organic matter, 1.9% N, 1.6% P_2O_5, 1.2% K_2O, and 0.34% NaCl. Growth characteristics were determined 60 days after planting, and yield-related were determined 90 days after planting, in accordance with the examination guide of the Rural Development Administration (RDA, 1995), Korea. Chlorophyll content was measured with the use of a portable chlorophyll meter

(SPAD-502, Minolta Co., Japan), with ten replication.

Table 1. Chemical properties of soil used for this experiment.

Item	pH (1:5)	Organic matter (%)	Available P_2O_5 ($mg \cdot kg^{-1}$)	Exchangeable cations ($cmol+kg^{-1}$)				EC
				K_2O	CaO	MgO	Na	($dS \cdot m^{-1}$)
Before Expt.[y]	5.20	4.23	108	0.69	6.14	2.01	0.20	1.20
After Expt.[z]	5.25	4.25	121	0.70	6.15	2.01	0.21	1.30

[y]Before complex fertilizer for potato and compost fertilizing.
[z]At 90 days after planting.

Table 2. Chemical composition of citrus skin, potato starch sludge, pig manure and rape oil cake before composting.

Material	T-N	P_2O_5	K_2O	CaO	MgO	NaCl
	%					
Citrus skin	0.7	0.18	1.2	1.3	1.0	0.02
Potato starch sludge	0.2	1.93	0.4	0.25	0.1	0.05
Pig manure	1.2	1.25	0.8	0.33	0.2	0.12
Rape oil cake	6.3	2.82	1.3	0.20	0.4	0.04

Table 3. Chemical properties of CSSP compost.

pH (1:5)	Moisture	Organic matter	T-N	P_2O_5	K_2O	CaO	MgO
	(%)						
6.8	28.0	32.0	2.5	2.8	1.8	5.7	1.5

2. Compost and statistical analysis

The chemical properties of the experimental soil and CSSP were analyzed as follows: pH and EC (1:5 water extraction), content of organic matter (Wakley and Black method; RDA, 1989), content of total nitrogen (micro-Kjeldahl digestion method), content of available P_2O_5 (Lancast method; NIAST, 2000), and contents of exchangeable Ca, Mg, K, and Na (1M NH_4-acetate pH 7). The data were statistically analyzed using PROC (ANOVA) of the SAS program (2000). The differences between the treatment means were compared with the use of Duncan's multiple range test (DMRT).

Ⅲ. Results and Discussion

1. Top growth characteristics

Plant height and stem diameter were significantly increased by CSSP. Chlorophyll content was significantly increased at 4 and 8 tons · ha^{-1} CSSP application plots (Table 4). Weon et al. (1999) reported that soil microbial flora and chemical properties were significantly vigorous by the application of pig manure compost.

Eastwood and Watts (1956) reported that photosynthetic activity was increased by compost application as well as the yield increased. Therefore the effects of treating CSSP and FPMC on top growth characteristics of potato cropping were more affirmative than untreates control.

Table 4. Effects of CSSP application on growth of spring-grown potato at 60 days after planting.

Treatment	Plant height (cm)	No. of stems per plant	Stem diameter (mm)	Chlorophyll[z]
Untreated control[v]	31.0 c[y]	3.09	9.2 b	38.8 b
4 ton · ha^{-1} FPMC[w]	36.2 ab	3.13	10.2 a	39.5 b
2 ton · ha^{-1} CSSP[x]	35.5 b	3.12	10.2 a	39.9 b
4 ton · ha^{-1} CSSP	38.1 a	3.18	10.6 a	41.7 a
8 ton · ha^{-1} CSSP	38.3 a	3.21	10.8 a	42.1 a

[v]1.2 tons · ha^{-1} of the complex fertilizer for potato ($N/P_2O_5/K_2O$, 10/10/14).
[w]Pig manure and saw dust (70:30, v/v).
[x]Compost using citrus skin and starch sludge.
[y]Mean separation within columns by DMRT at 5% level.
[z]SPAD value.
(1.2 tons · ha^{-1} of the complex fertilizer for potato ($N/P_2O_5/K_2O$, 10/10/14))

Table 5. Effects of CSSP application on yield of spring-cropping potato at 90 days after planting.

Treatment	Average tuber weight per plant	Tuber yield per plant	Total tuber yield	Marketable tuber yieldz	Rate of marketable tubers
	(g)	(g)	(tons · ha^{-1})	(tons · ha^{-1})	(%)
Untreated control[v]	36.0 C[y]	262.6 c	17.6 c	10.9 c	61.8 b
4 ton · ha^{-1} FPMC[w]	38.4 b	288.7 ab	19.1 b	12.2 b	63.7 ab
2 ton · ha^{-1} CSSP[x]	38.6 b	281.0 bc	19.0 b	12.1 b	63.6 ab
4 ton · ha^{-1} CSSP	41.9 a	303.4 a	21.4 a	14.0 a	65.7 a
8 ton · ha^{-1} CSSP	42.0 a	304.9 a	21.4 a	14.1 a	65.8 a

[v]1.2 tons · ha^{-1} of the complex fertilizer for potato ($N/P_2O_5/K_2O$, 10/10/14).
[w]Compost using citrus skin and starch sludge.
[x]Pig manure and saw dust (70:30, v/v).
[y]Mean separation within columns by DMRT at 5% level.
[z]Tuber > 50g.

2. Yield characteristics

The average tuber weight per plant and tuber yield per plant were superior in order of 4 and 8 tons · ha^{-1} CSSP plot, 4 tons · ha^{-1} FPMC plot, 2 tons · ha^{-1} CSSP plot. For the total tuber yield, 4 and 8 tons · ha^{-1} CSSP plot were in better (21.4 tons) than others. Marketable tuber (larger than 50 g of tuber) yield was 14.0~14.1 tons in the 4 and 8 tons · ha^{-1} CSSP plot (the proportion of marketable tuber were 65.7~65.8%), 12.1~12.2 tons in the 2 tons · ha^{-1} CSSP plot and 4 tons · ha^{-1} FPMC plot (63.6~63.7%), and 10.9 tons in the untreated control (61.8%).

The relationship between the CSSP application rate and the marketable tuber yield was $y = -0.0791x^2 + 1.0602x + 10.725$ ($r^2 = 0.95$). According to the equation, the optimum application rate of CSSP showing a maximum marketable tuber yield in the volcanic ash soil of the Jeju region was around 6.7 tons · ha^{-1} (Fig. 1). In this study, CSSP applied to potato has a good influence for top growth by accelerating sprout elongation (Harris, 1978). In addition, composts improve the physical and chemical properties of soil, promoting the top and root growth of the cultivating crops as well as improving the yield potential and quality of the crops by increasing the activity of growth element and the compost efficiency in soil (Harada and Knoko, 1975).

In summary, the CSSP application at spring-cropping potato field in the Jeju region was found to have a positive effect on growth and yield characteristics.

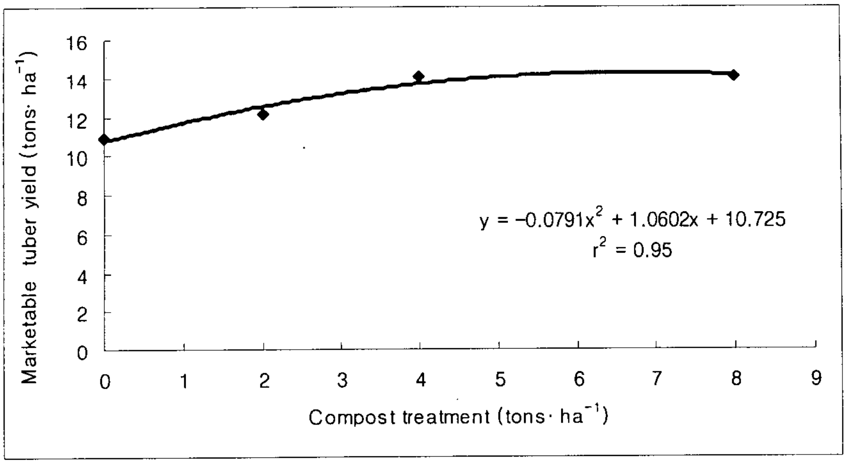

Fig. 1. The relationship between CSSP application rate and marketable tuber yield of potato at 90 days after planting.

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