Effect of different fertilization practices on soil microbial activities and community structure in volcanic ash citrus orchard soil

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Abstract
This study was performed to evaluate effects of different fertilization practices on soil microbial activities and community structure using soil enzyme activities, PLFA contents in volcanic ash citrus orchard soil. Urease activity was high in NPK+Compost treatment, July. Dehydrogenase activity was higher in 1/2NPK+Compost (4.3 ug TPF /g 24 /h) than other treatments in May. β-glucosidase activity was higher in May than in September. That showed significant in between treatments and ordered NPK>1/2 NPK+Compost >NPK+Compost>Compost>3NPK>Control. Soil basal respiration rate decreased gradually and that was not different significantly between treatments. Total PLFA contents were higher in NPK+Compost than in compost. Distribution ratio of soil microbial groups by PLFA profiles as biomarker showed that bacteria and actinomycetes increased and both fungi and mycorrizae decreased in July relative to March. Principal component analysis of the microbial community by PLFA pattern showed that PLFA profiles from NPK and NPK+Compost plots were different at the 3NPK plot in March. Our result showed that composition change in microbial community were affected by a fertilization effect and seasonable factor.

Key Words
Volcanic ash soil, citrus, PLFA, urease, nicrobial community.

Introduction
Environmental factors such as soil type, temperature, and moisture, application of organic and inorganic fertilizers play an important role in microbial activity. Soil microbial activity was low as phosphate is converted to non-available fractions easily in volcanic ash soil. The more inorganic fertilizer applied for more production of citrus fruit, the more soil pH values became low and microbial activity was decreased by soil acidity. Soil microbial activity could be used efficiently to evaluate soil health and quality. This study evaluated the effect of long-term application of compost and inorganic fertilizer on soil microbial activity using several parameter including soil enzyme activities, soil basal respiration rate, microbial biomass, phospholipid fatty acids (PLFA)contents.

Methods
Fertilization management Citrus (*Citrus unshiu* Marc.) have been managed according to the application rate of fertilizers and compost for 13 years in Andisol volcanic ash soil. Experiment plots were composed of six treatments such as Control, Compost (20 ton/ha), NPK (280-400-280 kg/ha), 1/2NPK+Compost (140-200-140 kg/ha+20 ton/ha), NPK+Compost (280-400-280 kg/ha +20 ton/ha), 3NPK (840-1200-840 kg/ha). Compost was applied as matured cow manure compost in March. Nitrogen and potassium fertilizers were applied in March, May, and October, which were 40, 30, 30% of yearly application rate, respectively and phosphate fertilizer applied at one time in March. Besides of fertilization management followed conventional management. Soil samples were taken early in March, May, July, September, 2007. Soil samples after sieving were stored immediately at 4℃ for soil enzyme activities and biomass N and at -20℃ for PLFA until analysis.

Analysis Dehydrogenase activity was measured by triphenylformazan method (Rossel and Tarradellas, 1991). Urease (Tabatabai 1976) and β‐glucosidase (Garcia‐Gil *et al.* 2000) activities were measured by the THAM buffer method. Biomass N was measured by Ninhydrin method (Amato *et al.* 1988). PLFA analyzed with a GC-FID instrument after Bligh/Dyer first‐phase extraction (Bligh and Dyer, 1959). Soil respiration rate was measured at 3, 10, 30 days by the 0.1M NaOH absorption method (Cerhanova *et al.* 2006).

Results

Soil enzyme activities are shown in Table 1. Urease activity was higher in NPK+Compost than in control, but was not significantly in between treatments. Dehydrogenase activity was in the orders of 1/2NPK+Compost > Compost > NPK > NPK+Compos t> 3NPK > Control in May. β-glucosidase activity was higher in NPK (38.2) than in Control(17.5 ug PNP /g/h) in May. Results indicated that urease and dehydrogenase activities in volcanic ash soil were low and not significantly different according to application rate of fertilizer and compost. β-glucosidase activity in NPK was considered high as an effect of fallen leaves from the citrus. Total PLFA content was higher about 2 times in NPK+Compost (237.4) than in 3NPK (133.0 n mol /g) in May (Figure 1). This result considered as an effect of soil acidity because soil pH value was lower for higher application of fertilizer, 3NPK compared with NPK. Soil respiration rate was not significantly different in between treatments (Figure 2).

Table 1. Soil enzyme activities for different fertilization management practices.

Treatments	Dehydrogenase				β-glucosidase			
	March	May	July	September	March	May	July	September
	------ ug TPF /g 24/h ------				------ ug PNP /g/h ------			
Control	3.2±0.4†	2.4±0.4b††	2.7±0.6	4.3±1.2	21.2±3.5c	17.5±3.1b	21.4±1.3	7.0±0.9
Compost	5.1±3.2	3.6±0.8ab	3.2±0.5	7.2±3.2	34.4±5.2ab	30.3±10.2ab	30.0±5.5	13.9±5.2
1/2NPK+Compost	5.5±1.9	4.3±0.2a	4.2±1.3	10.3±5.9	37.8±2.4a	32.1±2.5a	33.2±2.8	13.7±6.4
NPK	4.5±1.2	3.5±1.6ab	4.3±2.8	5.6±3.8	36.5±3.4a	38.2±12.8a	37.2±12.2	14.6±4.0
NPK+Compost	4.5±1.3	3.1±0.5ab	3.4±1.6	7.5±6.7	29.2±2.7b	30.4±5.4ab	37.3±11.9	10.3±4.1
3NPK	3.9±0.8	2.8±0.8ab	2.5±0.4	3.6±0.0	37.4±6.0a	27.0±6.0ab	30.7±6.0	14.4±4.9

†Mean ± Standard Deviation.
†† DMRT at p=0.05 level.

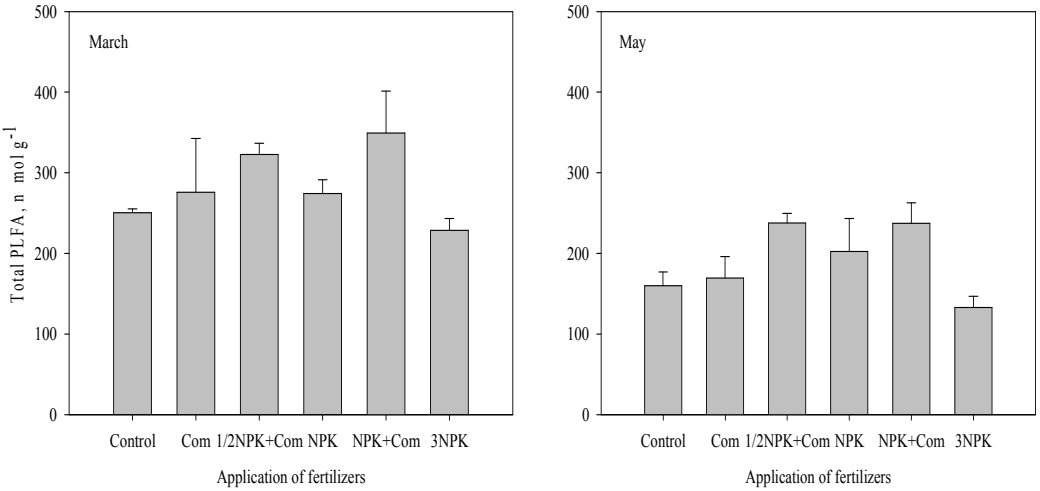

Figure 1. The amount of phospholipid fatty acid caused by different fertilization management practices.

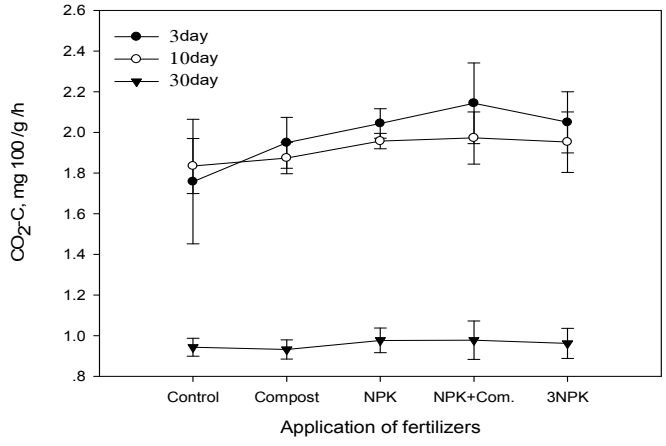

Figure 2. Soil respiration rate for different fertilization management practices for volcanic ash citrus orchard soil.

Conclusion

Urease and dehydrogenase activities in volcanic ash soil were low and not significantly different according to application rate of fertilizer and compost. β-glucosidase activity was higher in NPK (38.2) than in Control (17.5 ug PNP /g/h) soil in May. Soil basal respiration rate was not significantly different between treatments. Principal component analysis of microbial community by PLFA pattern showed that PLFA profiles from NPK and NPK+Compost plots were different at 3NPK plot in March. Our result showed that the microbial community was affected by fertilizer treatment effect and seasonal factors.

References

Bligh EG, Dyer WJ (1959) A rapid method for total lipid extraction and purification. *Can. J. Biochem. Physiol.* **37,** 911-917.

Dick RP (1992) A review: long-term effects of agricultural systems on soil biochemical and microbial parameters. *Agric. Ecosyst. Environ.* **40,** 25-36.

Hu C, Cao Z (2007) Size and activity of the soil microbial biomass and soil enzyme activity in long-term field experiments. *World J. Agri. Sci.* **3,** 63-70.

Marschner P, Kandeler E, Marschner B (2003) Structure and function of the soil microbial community in a long-term fertilizer experiment. *Soil Biol. Biochem.* **35** 453-461.

Rahman MH, Okubo A, Sugiyama S, Mayland HF (2008) Physical, chemical and microbiological properties of an Andisol as related to land use and tillage practice. *Soil Till. Res.* **101,** 10-19.