Liquid Fertilizer Effects of Four Different Anaerobic Digestion Effluents on Japanese mustard spinach (*Brassica rapa*)

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INTRODUCTION and OBJECTIVE

Anaerobic digestion effluent (ADE) is a by-product remained after fermentation processes of organic materials for methane production. The utilization of ADE for agronomic benefits has recently been recognized as a means of reducing volume of organic wastes. Since ADE contains significant amounts of NH_4-N, it can serve as a quick-releasing liquid fertilizer. However, different feedstocks yield ADE of different chemical properties, therefore it is difficult to standardize ADE as reliable and stable alternative materials to fertilizers.

In this study, a 2-year bioassay experiment was performed, as objective, to evaluate effects of different ADE derived from 4 different organic materials, namely a mixture of cow manure and food waste (CMFW), Mediterranean mussel (*Mytilus galloprovincialis*; MM), western waterweed (*Elodea nuttallii*; WW), and Sennin algae (*Potamogeton maackianus*; SA) as liquid fertilizer on the growth of Japanese mustard spinach (*Brassica rapa*) grown on a one type (subsurface) of Andosol in the first year, and two different types (subsurface and surface) of Andosols in the second year. In addition, pruned branches (PB) were mixed with soil for the second year experiment to evaluate the reduction of nutrient leaching.

MATERIALS and METHODS

The experimental treatments were no amendments applied (control), chemical fertilizer (140-120-120 N-P_2O_5-K_2O kg ha^{-1}; CF), and all 4 ADEs for the first year (Sep 9-Nov 3, 2011), and control, CF, PB, CMFW, CMFW+PB, SA, and SA+PBCF for the second year (Jul 18-Aug 17, 2012). All ADE was applied at 14 g N m^{-2} in 1 L pots. After the harvest, pH, NH_4-N, NO_3-N, biomass C in the soil, and dry weight (DW) of the spinach were analyzed.

Table 1. Soil chemical characteristics

	Subsurface Andosol	Surface Andosol
pH	7.27	6.83
T-N (g kg^{-1})	0.51	2.72
T-P (g kg^{-1})	0.32	0.65
T-K (g kg^{-1})	0.58	0.73

Subsurface Andosol

Surface Andosol

Table 2. Anaerobic digestion effluents chemical characteristics

	CMFW	MM	WW	SA
pH	8.11	7.76	8.06	7.98
T-N (mg L^{-1})	3235	2309	2151	1120
NH_4-N (mg L^{-1})	1357 (42%)†	595 (26%)	1154 (54%)	855 (76%)
T-P (mg L^{-1})	862	63	810	712
T-K (mg L^{-1})	2786	118	279	222

† Percentage to T-N

Table 3. Pruned branches characteristics

T-C (g kg^{-1})	366
T-N (g kg^{-1})	6.5
C/N	56

RESULTS

First year results

Control | CF | CMFW | MM | WW | SA

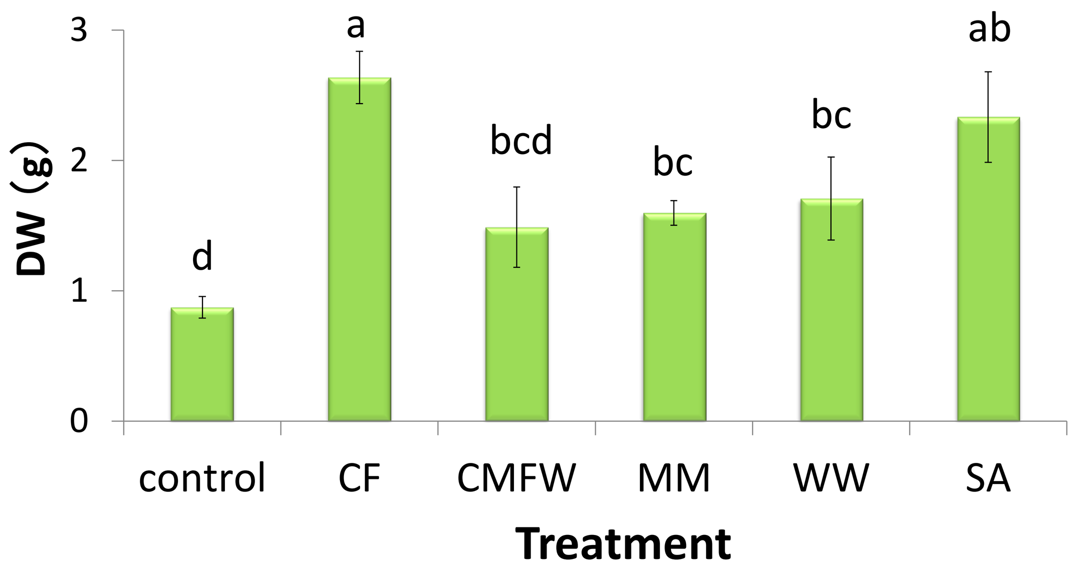

Fig.1. Dry weight of the spinach after the harvest

Table 4. Soil chemical characteristics after the harvest (first year)

	pH	NH_4-N (mg kg^{-1})	NO_3-N (mg kg^{-1})
Control	6.63 (c)†	0.9 (c)	0.8 (b)
CF	6.47 (d)	1.5 (abc)	1.7 (a)
CMFW	6.77 (a)	2.3 (a)	1.3 (ab)
MM	6.69 (b)	1.4 (bc)	2.0 (a)
WW	6.67 (b)	1.2 (bc)	1.8 (a)
SA	6.67 (b)	1.7 (ab)	1.6 (ab)

† Values followed by different letters in a column are significantly different at p=0.05 (Tukey).

- **pH, NH_4-N, NO_3-N and DW of all ADE-applied treatments increased compared to those of control.**
- **DW with MM, WW, and SA treatments were significantly greater than that of control.**
- **DW with SA treatment was highest likely because SA contained the highest percentage of NH_4-N to T-N.**

Second year results

Plant

SA+PB
SA
CMFW+PB
CMFW
PB
CF
Control

Subsurface Andosol | Surface Andosol

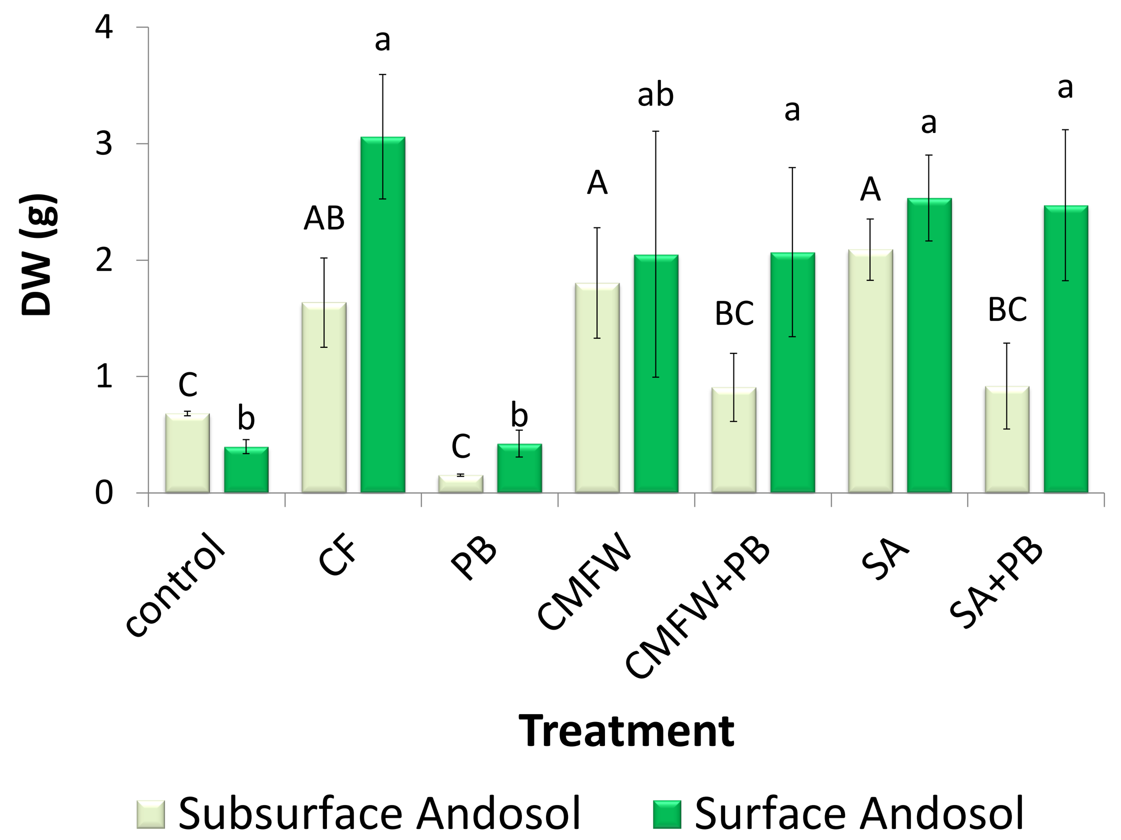

Fig.2. Dry weight of the spinach after the harvest

Soil pH, N, and biomass C

Table 5. Soil chemical characteristics after the harvest (second year)

	Subsurface Andosol				Surface Andosol			
	pH	NH_4-N mg kg^{-1}	NO_3-N mg kg^{-1}	Biomass C mg kg^{-1}	pH	NH_4-N mg kg^{-1}	NO_3-N mg kg^{-1}	Biomass C mg kg^{-1}
Control	6.63 (b)	1.2 (b)	0.3 (b)	187 (b)	6.66 (cd)	7.6 (ab)	0.9 (b)	266 (b)
CF	6.62 (b)	4.6 (a)	1.4 (a)	278 (b)	6.59 (d)	10.5 (a)	4.0 (a)	321 (b)
PB	6.80 (a)	1.2 (b)	0.5 (b)	550 (a)	6.85 (bc)	5.4 (b)	1.4 (b)	556 (a)
CMFW	6.89 (a)	2.8 (ab)	1.0 (ab)	193 (b)	6.82 (bc)	8.4 (ab)	2.5 (ab)	223 (b)
CMFW+PB	6.89 (a)	3.5 (a)	1.1 (ab)	641 (a)	7.04 (a)	4.9 (b)	1.0 (b)	563 (a)
SA	6.89 (a)	4.2 (a)	1.0 (ab)	166 (b)	6.91 (ab)	8.2 (ab)	0.8 (b)	244 (b)
SA+PB	6.91 (a)	4.1 (a)	1.1 (ab)	561 (a)	7.05 (a)	5.7 (ab)	0.5 (b)	510 (a)

- **All ADE treatments showed increased and comparable DW compared to control and CF, respectively.**
  → ADE may have potential as liquid fertilizer to supply N.
- **PB only treatment showed the lowest DW, and ADEs mixed with PB showed decreased DW compared to those with ADEs without PB, respectively, on especially subsurface Andosol.**
  → Plant and microbes may compete for soil nutrients.
- **Soil NH_4-N and NO_3-N after the harvest showed different tendencies by ADE application in two different soils. → Different soil characteristics may affect N dynamics in soil.**
- **ADE had a little effect on soil biomass C. → Increased biomass C was caused by PB application.**

CONCLUSION

- **All ADE tested increased soil pH, NH_4-N, NO_3-N, and spinach DW over control, showing potential as liquid fertilizer.**
- **ADE with higher content of NH_4-N or its percentage to TN may have higher potential to be used as valuable liquid fertilizer.**
- **Mixing ADE and PB increased soil biomass C but decreased DW compared to ADE only.**

Need to be evaluated in the future…

ADE with different feedstock, different soil types, different plants, soil nutrient and biomass C changes over time, negative environmental effects by ADE application, and etc.