レタス収量と土壌理化学性に及ぼすフイルタケーキ施用の効果(農芸化学科)

Effects of Filter-cake Incorporation on Yields of a Vegetable and Soil Characteristics*

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Summary

The obiectives were to test the effects of filter-cake on lettuce yields and soil characteristics. A dark-red soil was mixed with filter-cake at the rates of 0, 75, 150 and 300 g per kg of soil by fresh weight basis and used a potting medium. Lettuce was grown for 62 days on it.

The yields of lettuce as fresh foliage increased significantly by the treatments, but the dry matter of foliage and especially roots declined with an increase in filter-cake incorporation.

The soil was found to improve chemical properties by the treatments in general. The oxidation-reduction potential (Eh) of the soil was below 400 mv in many of the treated pots. No changes were recognized in the concentration of active ferrous and exchangeable manganese. Easily reducible manganese tended to decrease by the treatments in contrast with the rise of soil pH.

From the present experiment, implied were too high a rate of filter-cake incorporation would give vegetable roots unfavorable effects caused by lowered soil Eh and undetected factors.

Introduction

Organic matter gives many preferable effects to soil fertility as being discussed elsewhere. Farmers really appreciate the importance of organic matter in growing crops especially with Okinawan soils, which are very low in humus contents under humid and warm circumstances [4]. They, however, are generally reluctant to apply compost or farmyard manure for it is rather costly nowadays to make and transport it.

Filter-cake, one of the by-products from the sugar factory, is easily obtainable and its incorporation to the soil is becoming popular among the farmers. Data about filter-cake incorporation have been obtained scarcely in Okinawa. The objectives of this paper were to test the effects of filter-cake on vegetable using lettuce (*Lectu-*

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ca sativa L; Culti. Great Lakes) and on soil characteristics in a series of the studies on filter-cake incorporation.

Materials and Methods

1. Filter-cake

Filter-cake was obtained in May, 1978 from the heap in the yard of the Dai-ichi Seito Sugar Factory where the press method with the mill roller was applied to yields cane juice, and stored below 8°C until the experiment started. Some inclusion of baggasse and ash from the boiler furnace was observed in the filter-cake heap. The chemical composition of filter-cake was analyzed and shown in Table 1.

Table 1. Chemical composition of the filter-cake

Constituent	Concentration
Fresh material	
	%
Moisture	18.0
Dry matter	82.0
Total	100.0
Dry matter	
	%
Ash	32.80
Total C	38.69
Organic C	38.00
Inorganic C	0.69
Total N	2.46
〃 P_2O_5	1.70
〃 K_2O	0.76
〃 CaO	4.70
〃 MgO	0.97
〃 Na_2O	0.03
〃 SiO_2	17.08
	ppm
〃 Fe	9,070
〃 Mn	694
〃 Cu	67
〃 Zn	254

2. Soil

A dark-red soil was brought into a vinyl roofed green-house from the surface (0−15 cm) of the University Farm No. 15, air-dried, sieved through a wire screen with 5 mm openings, and used for the pot experiment. Soil analysis was carried out on fine earth (< 2 mm) and its physical and chemical properties were as shown in Table 2.

Table 2. Physical and chemical properties of the soil used for the pot experiment

pH		CEC	Exchangeable base				Base	Total	Total	Avail.	Texture
(H_2O)	(KCl)		Ca	Mg	K	Na	satu.	C	N	P_2O_5	
		me/100g	me/100g				%	%	%	mg/100g	
5.2	4.4	16.9	9.2	1.5	0.3	0.2	66.3	0.24	0.02	0.1	HC*

*Heavy clay with 0.7, 33.4, 18.2 and 47.7% of coarse sand(2.0-0.2 mm), fine sand (0.2-0.02 mm), silt(0.02-0.002 mm) and clay (<0.002 mm), respectively.

3. Treatment and growing of lettuce

The air-dried soil was mixed with filter-cake at the rates of 0,75,150 and 300 g per kg of soil by fresh weight basis. The additions of filter-cake were equivalent to 0,1.35, 2.7 and 5.4% of the soil by dry weight basis, respectively. To the soil, also added were 100 mg of N as ammonium sulfate and 230 mg of P_2O_5 and 150 mg of K_2O as potassium dihydrogen phosphate in 10 ml solution per kg soil for the bassal dressing. Another 100 mg of N was topdressed during the growth of lettuce.

The soil 1 kg each was placed in vinyl lined cans of 11 cm in diameter and 15cm in depth after the respective treatments which were replicated four times. Each of lettuce seedlings, prepared for 20 days on peatmoss discs was transplanted onto the pots which were completely randomized in the arrangement, and grown for 62 days from Dec. 29, 1978 in the vinyl roofed green-house. Water was given to the pots to keep soil moisture at 20 to 25%, and nitrogen only was topdressed in solution on February 6, 1979.

4. Determination of lettuce yields

The lettuce was harvested by cutting the stem near the soil surface on March 1, 1979, when the lettuce was about a third in head formation. The roots were collected as much as possible after the soil was dumped from the pots and loosened by fingers.

The fresh foliage and roots of lettuce were weighed immediately after harvesting and then dried at 70°C for their dry weight determination.

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5. Soil analysis

A portion of the soil, still moist after separating the roots, was used for the determination of oxidation-reduction potential (Eh) and active ferrous ion. The soil Eh was measured with a platinum electrode Eh meter by the method of Nishigaki et al.[2] and converted for the values at pH 6, which were expressed as Eh_6 in the data. The active ferrous ion was extracted with 1 M acetate buffer solution(pH3.0), and determined by the light absorbance at 525 mμ with a spectrophotometer after developing color with 0.2 % dipyridyl acid [2].

The rest of the soil was air-dried and used for chemical analysis. The soil before and after the pot experiment was analyzed by commonly adopted methods [2]; namely, the pH was determined by a glass electrode pH meter on the 1 : 2.5 soil suspension, and the CEC (cation exchange capacity) and exchangeable bases by saturation and extraction with neutral normal ammonium acetate. The carbon was determined by a wet combustion method using cromic acid-sulfuric acid mixture as oxidizer, nitrogen by the Kjeldhal method, the available phosphate by the Truog method, and the soil texture by the pipet method.

Results and Discussion

1. Yields of lettuce

The yields of lettuce as fresh foliage were significantly affected by the filter-cake incorporation as shown in Fig. 1. The statistical difference in the yields among the treatments were prooved by the analysis of variance and the least signigicant difference(L.s.d.) was 10. 1 g at the 5 % level. But the yields appeared to be asymptotic with the increasing rates of filter-cake.

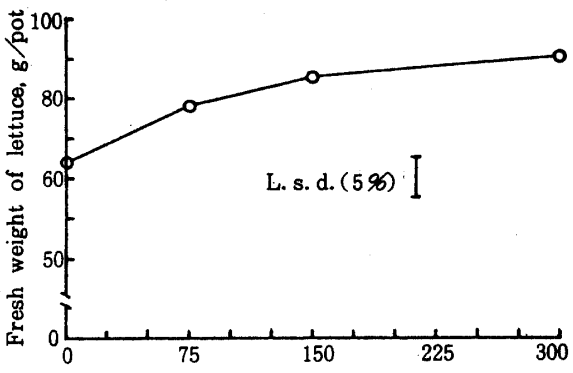

Fig. 1. Effects of filter-cake incorporation on the fresh weight of lettuce

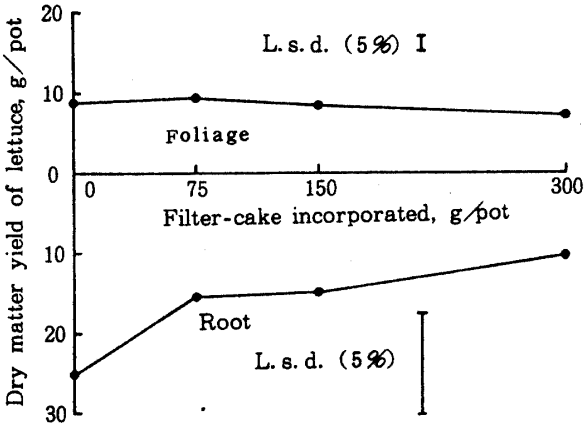

Fig. 2. Effects of filter-cake incorporation on the dry matter yield of lettuce

Both the foliage and roots, however, were found to decline in the dry matter with an increase in incorporated filter-cake as shown in Fig.2. A similar tendency was reported by Asghar and Kanehiro[1] who grew sugarcane on the soil to which sugarcane trash was applied up to 10 % by dry weight. The decline was slighter with the foliage than the roots in the present case. This may mean that the fresh foliage produced with the quantities of filter-cake applied had fresh-looking and better quality as the green than that with lesser applications. The roots, of which delline was rather drastic, may have recieved unfavorable effects from the treatments. It was not clear as to the cause of withholding development of proliferous roots, but one of the causes was probably due to the soil Eh which became low to some extent in the treated pots as discussed later. In any case, the findings with the yield curve which was asymptotic and with the decline of the dry weight of roots would be considered to imply that root deterioration would become severe if much of filter-cake was incorporated specifically in the pot culture and lead to the poor growth of lettuce foliage.

2. Chemical properties of the soil

General chemical properties of the soil were found to be much improved by the filter-cake incorporation as shown in Table 3. This would indicate that the elements contained in filter-cake became a good source of soil nutrients. And noteworthy was a rise in the CEC along with the amounts of filter-cake applied. Organic matter of filter-cake was considered to become a good source of soil charge. Contribution of organic matter to the soil charge is stated elsewhere with good intensions. In addition, the filter-cake incorporation brought about a kind of liming effects, which was called as effects of "self-liming" by Asghar and Kanehiro[1], as seen in the rise of soil pH with the treated pots. All of these effects seemed to be reflected to the yields of lettuce. Consequenty filter-cake can be regarded satisfactory material to supply nutrients to the soil as well as organic matter, if its incorporation is done

Table 3. Chemical properties of the soil after the pot experiment

Filter-cake incorporated	pH (H_2O)	CEC	Exchangable base				Base satu.	Total C	Total N	Avail. P_2O_5
			Ca	Mg	K	Na				
g/pot		me/100g	me/100g				%	%	%	mg/100g
0	5.45a	17.19a	9.63a	2.47a	2.02a	0.11a	82.9a	0.39a	0.076a	3.5a
75	5.85b	18.34a	10.60a	2.88a	2.25a	0.33a	87.5a	0.62a	0.101a	6.1ab
150	6.18c	29.35b	15.01b	4.32b	2.88b	0.71a	78.1a	0.99b	0.136b	10.8b
300	6.60d	33.03c	18.13c	5.35c	3.94c	2.18b	89.7a	1.25b	0.171b	23.0c

Means followed by same letters are not significantly different from each other.

in pertinent quantities.

3. Eh, active ferrous and manganese of the soil

The Eh, active ferrous, and exchangeable and easily reducible manganese were determined on the soil after the experiment and the results were shown in Table 4.

Table 4. The En and concentrations of active ferrous and manganese in the soil after the pot experiment

Filter-cake incroporated	Eh_6	Active Fe^{++}	Mn*	
			Exchangeable	Easily reducible
g/pot	mv	ppm	ppm	
0	467 a#	19 a	7	772
75	386 b	19 a	8	754
150	417 b	21 a	7	711
300	385 b	22 a	8	626

*Determined on composite samples. # Means followed by same letters are not significantly different from each other.

As a general tendency soil oxygen is consumed by microorganisms in the process of decomposition of organic matter applied to the soil. And this my result in a decrease in the soil Eh, if the incorporation of organic matter is too much for the supply of oxygen. Upland soils are considered to show 400 mv or higher as the value of the Eh. Divalent manganess is formed prior to ferrous ion formation as the soil Eh decreases[5]. In paddy soil, Mn^{2+} formation occurs below 500 to 600 mv and Fe^{2+} below 300 to 500 mv of the Eh and accompanied is vigorous evolution of ammonium and carbon dioxide according to Takai[6]. Root injury of upland crops is to occur with the low En as well as with ferrous and manganese ions probably below these levels of the En.

The soil Eh in the present experiment declined below 400 mv in many of the treated pots. Consequently, it was probable that the lowered soil Eh in the filter-cake treated pots caused some injury to the lettuce roots.

Neither active ferrous nor exchangeable manganese changed noticiably in the concentration by the treatments. Easily reducible manganese tended to decrease with the quantity of filter-cake incorporated. The soil pH which was raised by the treatment (Table 3) was considered effective enough to control these ions.

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レタス収量と土壌理化学性に及ぼすフイルタケーキ施用の効果

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要約

レタス（*Lectuca sativa* L；Culti. Great Lakes）の収量と土壌理化学性に及ぼすフィルタケーキ施用の効果をポット試験により調べた。土壌は琉球大学附属農場の暗赤色土壌を用い，土壌1kg（ポット）当たり第一製糖（株）提供のフイルタケーキを現物重で0, 75, 150, 300gずつ混合処理（4連）し，レタス苗1本ずつを植付け62日間（1989年12月29日～1979年3月1日）ビニールハウス内で栽培した。

レタスの収量についてみると，フイルタケーキの施用により茎葉生重は有意に増加したが，茎葉及び根の乾物重は逆に減少した。

栽培後の土壌を分析した結果フイルタケーキ施用量の増加に伴ない，pH，CEC，置換性塩基含量，窒素含量，炭素含量，有効態リン酸含量など一般化学性及び養分状態が良くなる傾向にあった。

土壌Ehは処理区では400mv以下に低下しているものが多かった。活性二価鉄や置換性マンガン濃度には変化がなく，易還元性マンガンはフイルタケーキ施用量の増加に伴ない減少する傾向が見られた。

この試験からフイルタケーキの過剰施用は土壌Ehその他不明の原因によりレタス根の生育阻害が起こり，ひいてはそれが茎葉の収量低下につながる可能性のあることが示唆された。

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