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Effects of Organic Fertilizer Applications on Soil Properties and the Development of Chinese Cabbage (*Braccica campestris*) in the Alpine Regions of Korea

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강원도 고랭지 채소 재배지에 시비한 유기물이 토양과 배추의 성장에 미치는 영향

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광범위하게 집중적으로 채소 재배에 이용되고 있는 강원도 태백산맥 지역의 고랭지를 대상으로 유기물 시용이 토양의 비옥도를 비롯한 화학적 성질에 미치는 영향을 조사했다. 또한 이런 조건에서 재배되는 배추의 생장과 수확량, 그리고 품질을 평가했다. 토양에 첨가한 많은 양의 돈분과 톱밥, 계분과 톱밥, 계분, 퇴비 등의 유기물질과 화학비료가 토양 유기물 함량에는 결과적으로 거의 영향을 미치지 못했다. 토양의 pH에도 마찬가지로 별 영향이 없었다. 그러나 K와 함께 Fe와 Mn의 함량은 감소한 반면 Ca와 Mg의 함량은 증가했으며 특히 유효 P_2O_5는 대단히 많은 양이 축적되는 것을 발견하였다. 배추의 양분 함량을 내엽과 외엽으로 구분하여 분석한 결과 일반적으로 외엽의 영양소 함량이 내엽보다 많았으며 토양에 첨가한 유기물질의 종류간에는 별 차이가 없었다. 수확량에도 첨가한 유기물질의 종류가 뚜렷한 차이를 나타내게 하지 않았으며 병충해에 의한 피해는 관찰되지 않았다.

요약어 : 고냉지 토양, 유기물질, 비옥도, 배추

I. Introduction

The Northeastern region of South Korea was such a remote rural country that in spite of its

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rich mineral resources only very little agricultural importance was known to the general public. Until early 1960's shifting cultivation for corn and potatoes was a conventional and widely practiced agricultural business. Rugged terrain of mountainous landscape and steep slopes with cool summer and cold winter climate has been a natural barrier for any economic development in general, and agriculture of a large scale in particular. In recent decades, however, the rapid expansion of networks of road coupled with the convenience of various transportation means has been transforming this region from once an inaccessible country to the place where any one can come and enjoy its natural beauty of landscape and a variety of sports and recreation. Agricultural bushiness also gets benefit from these social and economic changes and development. Improvement of living standard and ever increasing demand of food of good quality as well as quantity has been closely related with increasing demand of fruits and vegetables. This region with high altitude and cool summer climate provides favorable growth conditions for vegetable crops. Chinese radish and Chinese cabbage are the two major crops most widely planted in the field of this area (NIHA, 2002; Kangwon Do, 1995; Lee et al., 1973). In addition to these, cash crops such as carrot, tomato, edible wild plants, pimiento, and a number of exotic cultivars are those that give farmers ample opportunity for a fair income (MAF, 2006; Lee, 1998). Of the total area of the field utilized for agriculture about 72% is steep and hilly with a slope of 7% or more (NIHA, 1996). Frequent hazard of soil erosion and the loss of plant nutrients are some of serious problems (NIHA, 1996).

Organic substances of various origins and resources have been added to soils of this area in order to be effective for soil conservation and improvement of fertility, which eventually enhance stable production of vegetable crops of good quality. In the present experiment, common compost, mixture of sawdust and piggery waste, poultry waste, mixture of poultry waste and sawdust were added to the soil.

Ⅱ. Materials and Methods

1. Soil and organic substances

A representative alpine soil of this area was selected for this research. As shown in Table 1, its chemical characteristics were assessed by standard methods (NIAST, 1998). Ordinary farm compost has been routinely applied to soil. Piggery waste and poultry waste are the major organic materials very common and easily obtainable in a rural country of Korea. It is not

unusual for farm livestock wastes to have an excess of water which makes it troublesome to handle. Sawdust has been for a long time as an absorbent of water in such a waste along with chemical fertilizers which help microbial decomposition of the organic substances. Four different formulae of organic materials were prepared for this experiment as shown in Table 2. Addition of them to the soil was done at the time of transplantation. Chemical compositions of the formulae without NPK added are tabulated in Table 3. The contents of P_2O_5 and K_2O of sawdust and piggery waste mixture were enormously higher than those of the others. And the mixture of poultry waste and sawdust exhibited the highest C/N of 40.

Table 1. The chemical properties of the selected soil (Imog, coarse loamy, mixed, mesic Dystric Eutrochrepts) in the mountainous region of Kangwon province.

pH	OM†	Available P_2O_5	K^+	Ca^{2+}	Mg^{2+}	Fe^{2+}	Mn^{2+}
(1:5)	%	mg kg^{-1}	$cmol_{(+)}$ kg^{-1}			mg kg^{-1}	
5.7	3.2	801	1.20	3.00	0.71	54.1	21.0

†OM stands for organic matter.

Table 2. Organic materials and application rates.

Organic materials and NPK	Application rate
Chemical NPK	N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}
Sawdust (S)+Piggery waste (Pi)+NPK	30Mg ha^{-1}+ N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}
Poultry waste (Po)+NPK	5,000kg ha^{-1} + N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}
Po+S+NPK	5,000kg ha^{-1} + N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}
Compost+NPK	15Mg ha^{-1} + N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}

Table 3. Chemical compositions of organic materials.

Organic materials	Moisture content	Total N	Total C	P_2O_5	K_2O	CaO	MgO	C/N
	%							
Compost	31.1	0.90	12.8	0.54	0.67	0.90	0.62	14
Sawdust (S) + Piggery waste (Pi)	48.1	1.19	28.0	1.90	2.26	1.24	1.24	24

Organic materials	Moisture content	Total N	Total C	P_2O_5	K_2O	CaO	MgO	C/N
Poultry waste (Po)	47.9	1.23	20.5	0.54	0.64	1.39	1.39	17
Po + S	42.2	0.92	36.7	0.36	0.40	0.98	0.50	40

Ⅲ. Results and Discussion

1. Changes of organic matter content in the soil

There were two patterns of soil organic matter content in the transitional period between 15 days after transplant and harvesting (Fig. 1). On the 15th day after transplant, the organic matter contents of the soil fertilized with mixtures of sawdust and piggery waste or compost were 4.8% or 3.5%, respectively, then decreased afterwards. In the mean time, however, addition of poultry waste or the mixture of poultry waste and sawdust had little effect on the organic matter content of the soil, which might be the consequence of rapid decomposition by soil organisms.

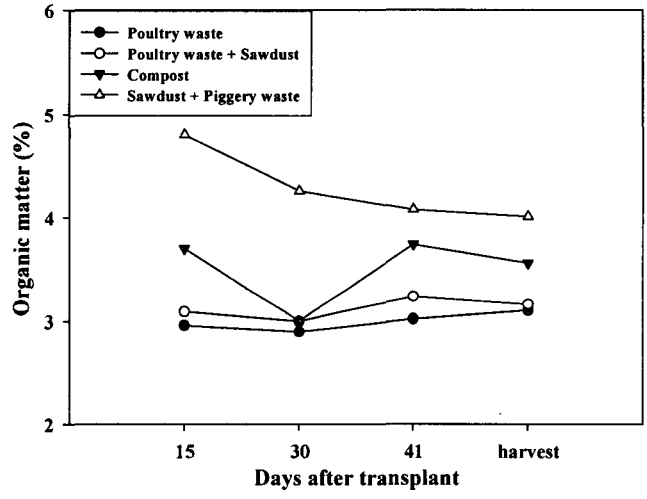

Fig. 1. Seasonal variation of soil organic matter contents.

2. Changes in soil chemical properties

A significant build-up of available P_2O_5 was observed when organic materials were applied to

the soil (Table 4). The highest accumulation of P_2O_5 occurred with the application of the mixture of sawdust and piggery waste product as shown in Table 4. Cool climate, soil acidity, and soil aluminum and iron might have some effect on the immobilization of P_2O_5. Concentrations of other plant nutrient elements such as K, Ca, Mg, Fe, and Mn decreased as result of the absorption by the vegetable crop.

Table 4. Chemical properties of the soil at the harvest time.

Treatment	pH	OM†	Available P_2O_5	K^+	Ca^{2+}	Mg^{2+}	Fe^{2+}	Mn^{2+}
	(1:5)	%	mg kg^{-1}	$cmol_{(+)}$ kg^{-1}			mg kg^{-1}	
Chemical NPK†	5.2	3.4	1,407	0.62	2.76	2.76	52	19
Sawdust (S) + Piggery waste (Pi) + NPK	5.7	3.9	2,042	1.19	3.45	3.45	37	12
Poultry waste (Po) + NPK	5.5	3.1	1,392	0.68	2.97	2.97	44	8
Po + S + NPK	5.4	3.2	1,600	0.57	3.00	3.00	44	14
Compost + NPK	5.5	3.2	1,271	0.59	2.81	2.81	46	10

†NPK : $N-P_2O_5-K_2O = 320-200-270 kg\ ha^{-1}$

3. Contents of nutrients in the plant parts

The contents of nutrient elements of the cabbage were analyzed in two parts, inner leaves and outer leaves, because the edible part is as a matter of fact the former. The outer leaves are usually discarded. Total N was found higher in inner leaves of the crop grown with chemical NPK and ordinary compost application (Table 5). The highest level of total N was in inner

Table 5. Nutrient contents of Chinese cabbage harvested.

Treatment	Total N		P_2O_5		K_2O		CaO		MgO	
	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf
	%									
Chemical NPK†	3.40	3.32	1.82	2.05	3.93	7.27	0.28	1.05	0.42	0.58
Sawdust (S) + Piggery waste (Pi) + NPK	2.80	3.22	1.97	2.21	5.27	8.80	0.29	1.16	0.39	0.53
Poultry waste (Po) + NPK	2.23	3.18	1.93	2.17	4.00	7.10	0.32	1.08	0.39	0.45

Treatment	Total N		P_2O_5		K_2O		CaO		MgO	
	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf	Inner leaf	Outer leaf
Po + S + NPK	3.42	3.57	1.90	2.09	4.10	6.30	0.30	1.08	0.40	0.46
Compost + NPK	4.13	3.56	1.94	2.01	4.47	7.80	0.33	1.30	0.38	0.50

†NPK : N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}

leaves of the crop with conventional farm compost applied. In general, contents of other nutrients such as P_2O_5, K_2O, CaO, and MgO were higher in outer leaves regardless of organic substances applied. There were no significant differences among organic materials treated plots when a given nutrient was considered, although K_2O level was exceptionally high in outer leaves of the crop grown with the mixture of sawdust and piggery waste.

4. Yield components of Chinese cabbage

As shown in Table 6, the highest yield of Chinese cabbage was achieved with the application of the mixture of sawdust and piggery waste. Fertilization with mixture of poultry waste and sawdust or of ordinary compost did not produced as good yield as other treatments, but there

Table 6. Yield components of Chinese cabbage.

Treatment	Weight	Diameter	Height	Dw/Fw§	Yield	Yield index¶
	kg $plant^{-1}$	cm	cm	%	kg ha^{-1}	
Chemical NPK†	1.74	17.1	26.1	5.21	80,590	100
Sawdust (S) + Piggery waste (Pi) + NPK	2.16	16.6	26.4	5.16	83,530	104
Poultry waste (Po) + NPK	1.88	15.3	25.0	5.10	83,210	91
Po + S + NPK	2.03	16.7	25.5	5.20	80,880	100
Compost + NPK	1.96	16.2	25.6	5.20	77,060	96
LSD‡	0.49	1.43	1.67	0.46	14,260	

†NPK : N - P_2O_5 - K_2O = 320 - 200 - 270kg ha^{-1}

‡LSD stands for least standard deviation at $P<0.05$.

§Dw/Fw (%) = (Dry weight of cabbage / Fresh weight of cabbage)×100 Root

¶Yield index = (average yield from each fertilizer / urea)×100

were no statistical significant differences among all the treatments. It seemed that there was no need of any work for pest control, because no injury or damage caused by disease and insect was observed. The crop did not appear to have any experience of nutrient deficiency.

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