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Changes of Physico-chemical Soil Properties, Major Soil Nutrient Contents, and Weed Vegetation in Paddy Fields during Fallow Period

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휴경답에서의 토양의 이화학적 특성, 주요 영양분 및 잡초종의 변화

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Abstract : Changes in physico-chemical properties and major nutrient contents were investigated in the soil of paddy fields during fallow period.

Weed vegetation change in the fallow paddy fields was also examined. As the fallow period became longer, organic matter content in the paddy soil has gradually increased. Soil pH of the paddy fields has not changed until three years of fallow period and thereafter slightly increased. Cation exchange capacity of the paddy soil, and exchangeable N, K, Ca and Mg contents in the soil tended to decrease until three years of fallow period and then increase with the prolonged fallow period. As the fallow period became longer, available P_2O_5 content in the paddy soil has continuously decreased. Available SiO_2 content in the paddy soil has not changed until three years of fallow period and thereafter increased. The vegetation in the fallow paddy fields have mostly been occupied by the weeds of the Gramineae, Cyperaceae, and Compositae. As the fallow period became longer, the weeds of the Polygonaceae and Juncaceae have increased, whereas the weeds of the Leguminosae, Commelinaceae, Pontederiaceae, and Onagraceae have gradually disappeared. However, the weeds of the Gramineae and Cyperaceae have always been dominant in the paddy fields during the fallow paddy period.

Key words : fallow paddy field, Dominant weeds, physico-chemical soil property, soil nutrients, weed vegetation

Introduction

Arable paddy fields in Korea have gradually been reduced by increased industrialization and urbanization. Particularly, paddy fields having low productivity and high difficulties in mechanization have rapidly been changed to fallow fields. Increase of the fallow paddy fields reduces total rice production, and causes changes of soil environment and weed vegetation in the fields[2,6].

In addition, much effort and expenses should be necessary when the fallow paddy fields are being converted to arable fields.

Since fallow paddy fields have not been provided with irrigated water, fertilizers, and cultivation practices, physico-chemical soil properties and soil nutrient contents in the fields have greatly been changed. Furthermore, weed vegetation in the fields has also been changed[1,3]. Weeds having higher competitive ability in the fields under the fallow condition become dominant.

Weeds from other arable or unarable lands adjacent to the paddy fields have also infested and thereby caused weed vegetation change[1,2].

In the present study, changes of physico-chemical properties and major nutrient contents were examined in the soil of paddy fields with different fallow periods. Weed vegetation change was also monitored to characterize dominant weeds in the paddy fields and to predict the future vegetation change. This information will be

useful when the conversion of fallow paddy fields to arable fields is needed.

Materials and Methods

Determination of physico-chemical soil properties

Fallow paddy fields were selected from nine different areas in Naju, Hwasoon, and Seungju counties of the southeastern part of Korea. Surface soil samples (1 to 15 cm from the top) were separately collected from the paddy fields of different fallow periods (1, 3, and 5 years). Following the samples were dried in air and then sieved through 2-mm mesh, their physico-chemical properties were analyzed. Organic matter (OM) contents were determined according to the method of Tyurin[8]. Soil pH was measured by using a pH meter, after the soil samples were suspended with 5 volumes of distilled water. After subsequential extraction, distillation, and titration of the soil samples, cation exchange capacities (CEC) of the samples were determined as before[8].

The dry sieved soil samples as above were also used for analyzing major nutrients. Total N content was measured by the Kjeldahl method[5].

Available phosphorus (P_2O_5) content was determined by the method of Lancaster[8]. K, Ca, and Mg contents extracted by in ammonium acetate were analyzed by using an atomic absorption spectrometer[8]. Available SiO_2 content extracted by in sodium acetate(pH 4.0) was colorimetrically determined according to the standard method[8]. The nine areas of the fallow paddy fields examined were classified based on their physico-chemical soil properties and major soil nutrient contents by using the minimum variance clustering method[4].

Table 1. Physico-chemical soil properties of paddy fields with different fallow periods.

Fallow period (year)	OM (g/kg)	pH (1:5)	CEC (cmol$^+$/100 g)
1	2.87±0.170	5.32±0.100	8.19±1.691
3	3.20±0.082	5.33±0.065	6.32±0.523
5	4.03±0.205	5.55±0.110	8.31±0.557

* Figures represent mean ± standard deviation of triplicates.

Weed vegetation change in fallow paddy fields

Weeds grown in 1 x 1 m sections of the above fallow paddy fields were separately collected and identified. The weeds were counted individually and their fresh weights were measured. In addition, weed distribution rates depending on the fallow period were calculated. All experiments for each measurement were triplicated in three different paddy fields of the same fallow period.

Results and Discussion

Physico-chemical soil properties of fallow paddy fields

Physico-chemical soil properties were compared in fallow paddy fields with different fallow periods with respect to OM, pH, and CEC. OM content in the paddy soil has gradually increased, as the fallow period became longer (Table 1). This is probably due to the increased decomposition of pre-existing plant residues. Soil pH of the paddy fields has not changed until three years of fallow period and thereafter slightly increased with the prolonged fallow period (Table 1). On the other hand, CEC of the paddy soil tended to decrease until three years of fallow period and then increase with the prolonged fallow period (Table 1).

Major soil nutrient contents in fallow paddy fields

Total N content in the soil of the fallow paddy fields has decreased until three years of fallow period and then increased with the prolonged fallow period (Table 2). Similar tendency was observed in K, Ca, and Mg contents in the paddy soil. As the fallow period became longer, P_2O_5 content in the paddy soil has continuously decreased by approximately 50% in two years (Table 2). SiO_2 content in the paddy soil has not changed until three years of fallow period and thereafter increased by approximately 40% with the prolonged fallow period (Table 2).

Levels of major soil nutrients examined except N and P_2O_5 were all higher in five-year-fallow paddy fields than those in one-year-fallow paddy fields. These results suggest that soil fertility in the paddy fields has been improved with the prolonged fallow period, confirming the previous report[6].The nine areas of the fallow paddy fields examined were grouped based on their physico-chemical soil

Table 2. Major soil nutrient contents in paddy fields with different fallow periods.

Fallow period (year)	N (%)	P_2O_5 (mg/100g)	K	Ca	Mg	SiO_2 (mg/100g)
			(cmol$^+$/kg)			
1	0.17±0.017	63.3±8.99	0.17±0.128	1.88±0.897	0.59±0.304	38.3±8.65
3	0.09±0.008	38.0±1.63	0.09±0.029	1.05±0.332	0.32±0.136	39.3±2.62
5	0.16±0.012	16.7±9.03	0.17±0.051	2.25±0.694	1.35±0.390	50.7±9.96

properties and major soil nutrient contents by using disimilarity indices. They could be classified into three distinct groups; group I for three-year-fallow, group II for one-year-fallow, and group III for five-year-fallow paddy fields (Fig. 1).

At the first year fallow period, vegetation in the paddy fields was mostly occupied by the weeds of the Gramineae, Cyperaceae, Leguminosae, Commelinaceae, and Pontederiaceae (Fig. 2). The weeds of the Gramineae and Cyperaceae have always been dominant in the paddy fields during the fallow period. As the fallow period became longer, the weeds of the Leguminosae, Commelinaceae, Pontederiaceae, and Onagraceae have gradually disappeared, whereas the weeds of the Polygonaceae, Compositae, and Juncaceae tended to increase (Fig. 2). Among them, Leersia japonica, Bidens frondosa, Juncus effusus, and Aneilema keisak were found to be the most dominant weed species (data not shown). With the prolonged fallow period, perennial weeds, upland weeds, and annual grasses have generally become dominant in the fallow paddy fields. These results might be due to the fact that no irrigation and cultivation have given to the fallow paddy fields. No irrigation to the fallow paddy fields caused upland weeds to have flourished[3]. No cultivation might have led to an increased abundance of annual grasses which readily establish near the soil surface and which have relatively short periods of dormancy[3,7,9]. On the contrary, annual broadleaf weeds have greatly decreased since they require deep soil disturbance to bring buried seeds to the soil surface. Since perennial weeds are not easily controlled by herbicides and cultivation, the dominant weeds found in the fallow paddy fields will cause a serious problem when the fallow paddy fields are being converted to arable fields[1].

Acknowledgments

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요 약

휴경답에서의 휴경년한에 따른 토양의 이화학적 특성과 주요 영양분의 변화 및 잡초종의 식생 변화를 조사하였다. 휴경년한이 경과할수록 휴경답 토양의 유기물 함량이 증가하였으며 pH는 휴경후 3년까지는 변화가 없었으나 이후로는 다소 증가하였다. 토양의 양이온치환용량 및 치환성 N. K. Ca. Mg의 함량은 휴경후 3년까지는 감소하였으나 휴경년한이 길어지면서 증가하였다. 유효 P_2O_5의 함량은 휴경년한이 길어지면서 지속적으로 감소한 반면 유효SiO_2의 함량은 3년까지는 변화가 없었으나 그이후로는 증가하였다. 휴경답에서의 잡초종 구성은 초기에는 화본과, 사초과 및 국화과가 주종을 이루었으며 휴경년한이 경과할수록 마디풀과와 골풀과의 잡초 발생이 증가하는 반면 콩과, 물옥잠과, 닭의장풀과, 바늘꽃과의 잡초 발생이 점차 감소하였다. 그러나 화본과와 사초과의 잡초종은 휴경년한의 경과와는 관계없이 항상 우점종으로 발생하였다. 일반적으로 휴경화가 진전될수록 일년생 잡초종에 비해 다년생 잡초종의 발생 비율이, 또한 논 잡초종에 비해 밭 잡초종의 발생 비율이 높아지는 경향이 뚜렷하였다.

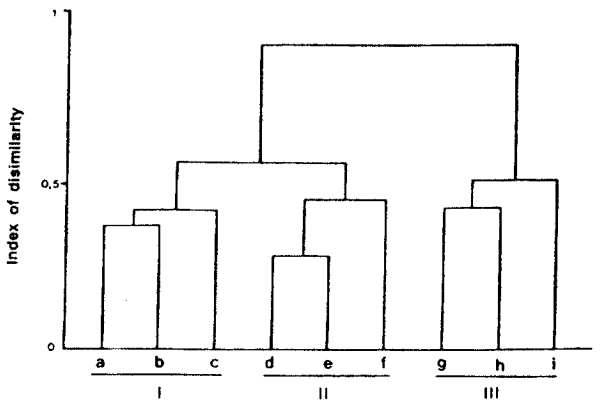

Fig. 1. Dendrogram of soil properties on nine areas (a to i) of paddy fields with different fallow periods.

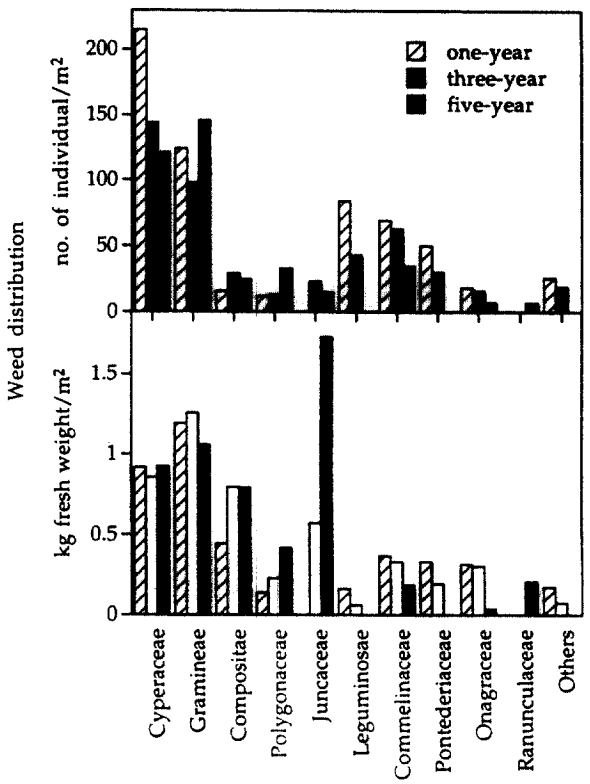

Fig. 2. Weed distribution in paddy fields with different fallow periods.

Table 3. Major weed species found in the fallow paddy fields.

Family name	Scientific name	Common name	Life form*
Cyperaceae	Eleocharis kuroguwai Ohwi	Water chestnut	G-D_5-R_5-t
	Cyperus difformis	Umbrella sedge	Ths-D_4-R_5-e
	Scirpus juncoides Roxb.	Japanese bulrush	H-D_3-R_3-t
	Cyperus serotinus Rottb.	Flatsedge	G-D_5-R_4-t
	Cyperus iria	Rice flatsedge	Ths-D_4-R_5-e
	Scirpus triqueter L.	Triangular bulrush	H-D_5-R_3-t
	Kyllinga brevifolia Rottb.	Green kyllinga	H-D_5-R_3-t
	Fimbristylis milliacea	Globe fringerush	G-D_5-R_5-t
Gramineae	Leersia japonica Makino	Japanese cutgrass	G-D_5-R1-t
	Echinochloa crus-galli	Barnyardgrass	Ths-D_4-R_5-e
	Panicum bisulcatum	Blackseed panicgrass	Ths-D_4-R_5-e
	Sacciolepis indica (L.) Chase	India cupscale	Ths-D_4-R_5-e
	Digitaria sanguinalis L.	Large crabgrass	Ths-D_1-R_{1-3}-e
	Setaria viridis L.	Green foxtail	Ths-D_1-R_5-e
Compositae	Bidens frondosa L.	Devils beggarticks	Ths-D_2-R_5-e
	Bidens tripartita L.	Bur beggarticks	Ths-D_2-R_5-e
	Eclipta prostrata L.	Eclipta	Ths-D_4-R_5-b
	Ixeris dentata L.	Nigana	Ths-D_1-R_3-r
Polygonaceae	Polygonum hydropiper L.	Smartweed	Ths-D_4-R_5-e
Leguminosae	Aeschynomene indica L.	Indian jointvetch	Ths-D_3-R_5-e
Juncaceae	Juncus effusus var. decipiens	Rush	G-D_5-R_3-t
Lythraceae	Rotala indica	Indian toothcup	Thw-D_3-R1-p
Commelinaceae	Aneilema keisak	Marsh dayflower	Ch-D_3-R2-p
Pontederiaceae	Monochoria vaginalis Presl	Monochoria	Ths-D_4-R_3-t
Scrophulariaceae	Lindernia procumbens	Falsepimpernel	Ths-D_3-R_3-b
Onagraceae	Ludwigia prostrata Roxb.	Waterprimrose	Ths-D_3-R_5-e
Labiatae	Acalypha australis L.	Copperleaf	Ths-D_4-R_3-e
Ranunculaceae	Ranunculus japonicus Thunb.	Buttercup	H-D_4-R_5-e

*Ch, chamaephyte; G, geophyte; H, hemicryptophyte; Ths, therophyte (summer annuals); Thw, therophyte (winter annuals); D1, disseminated widely by wind and water; D2, disseminated attaching with or eaten by aminals and man; D3, disseminated by mechanical propulsion of dehiscence; D4, having no special modification for dissemination; D5, not producing seeds; R1, widest rhizomatous growth; R2, moderate rhizomatous growth; R3, narrowest rhizomatous growth; R4, clonal growth by stolons and struck roots; R5, non-clonal growth (monophyte); b, branched form; e, erect form; p, procumbent form; r, rosette form; t, tussock form.

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