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Effect of Tillage Methods of Paddy Field on Yearly Changes of Rice Yield and Soil Properties

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논의 耕耘方法이 年次間 벼收量과 土壤特性에 미치는 影響

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ABSTRACT : Field experiment was carried out to investigate the annual changes of rice yield and soil properties. Hwaseongbyeo was cultivated by different tillage methods and fertilizer levels for 5 years in the paddy soil. Tilth efficiency of power tiller(PT) rotary plot was higher by 74.8%, but that of tractor tillage plot was lower by 59.0%. Water requirement in depth of no-tillage plots after rice transplanting was highest and also those of the early growing stage was higher than those of the middle growing stage. Rice yield of PT rotary plot by recommended fertilizer application was increased by 17% than that of no-tillage plot by conventional fertilizer application. By the rotary of PT and tractor, rice yield increased by 6~17% than those of no-tillage. In case of cultivating years, rice yield of 2nd year was highest, but that of 4th year was lowest. Soil bulk density and solid phase of no-tillage plot which took not tillage were highest than the other plots. The changes of soil chemical properties in the all treatments had not definite tendency.

Key words : Rice, Minimum tillage, NPK fertilizers, Application rates, Yields, Soil physico-chemical properties.

Recently the studies on decreasing labour hours for rice cultivation are processing vigorly[1,5]. Profits of tillage were easiness of rice transplanting and root activity in the early growing stage, introduced oxygen to subsoil deeply, erased the weeds. For these reasons tillage in the paddy fields was necessary before rice transplanting in days of old. But for deficiency labour and increasing of production cost, minimum tillage is spreading in farm areas. Study on the no-tillage cultivation and direct sowing cultivation which decrease agricultural labour and production cost were conducted from now on[6,7].

Labour hours for tillage before transplanting by machine in paddy fields under rice cropping system were 81~82 hours /ha. That hour was similiar to the hour for rice transplanting.

Especially optimum selection of tillage methods on the soil properties help saving the energy, labour and agricultural equipment

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which would increase the production cost.

To determine the criteria of minimum tillage, various crop managements must consider such as soil texture, water drainage, topography, aggregates degree, disperson degrees, water temperature, crop yield, decreasing working item and driving skill of agricultural equipments,crop residues of surface, irrigation water and weed controls[2,9,11].

This study was designed to investigate the annual changes of rice yield and soil properties under the different tillage methods and fertilizer levels by machine transplanting including no-tillage.

MATERIALS AND METHODS

Trial field was located at the Seodun dong, Suwon city. Soil series was Hwadong silty clay(Fine, mixed, mesic family of Aquic Hapludalfs). Hwaseongbyeo was cultivated from 1987 to 1991 by the same cultivation methods. Planting date was May 28 year by year and 26cm between rows and 15cm within rows were used by machine transplantor. Harvesting date was September 30 from year to year. Fertilizer level of conventional plots were N-P_2O_5-K_2O =120-90-110 kg/ha. Also those of recommended plots were applied by recommended fertilizer of ASI(Agricultural Science Institute). The amount of recommended fertilizer was decided by the result of soil analysis before experiment.

Physico-chemical properties of used soil were showned at Table 1. Those properties were similiar to other paddy soils, but phosphate content was lower than the other paddy fields.

Treatments were designed as follows : 1) No-tillage 2) Power tiller rotary 3) Tractor rotary, and two levels of fertilizer application which were conventional plots and recommended plots. Water requirement in depth was measured by hook gauge at ten o'clock a day during rice growing seasons. Soil bulk density and 3 phases were analyzed by Yamanaka tester and SR-Ⅱ penetrometer[4]. pH value was measured by pH meter. And organic matter content was analyzed by Tyurin method in ASI method. In addition, the other chemical composition were analyzed and measured apply with the conventional methods in soil laboratory. Also workability of agricultural tillage machines measured and calculated. Statistical data was calculated by SAS(Statistical Analysis System) package program.

RESULTS AND DISCUSSION

Workability of various tillage machines are showned in Table 2. Depth of tillage by power tiller and tractor were 12.0, 21.0cm respectively.

Fuel efficiency of power tiller and tractor by rotary were 58.1 and 41.1m^3/l respectively. Tilth efficiency of power tiller were higher than those of tractor.

Table 1. Physico-chemical properties of experimental soil

Soil	Bulk density	Hardness	pH	OM	P_2O_5	SiO_2	Ex. cations(me/100g)			CEC
depth	(g/cc)	(mm)	(1:5)	(%)	-- (ppm)--		K	Ca	Mg	(me/100g)
Top	1.26	19.3	5.3	1.5	12	182	0.23	5.02	2.32	14.0
Sub	1.38	22.0	5.4	0.9	8	196	0.24	5.28	2.49	14.2

Table 2. Workability of various tillage methods and equipments

Item	Power tiller		Tractor	
	Tillage	Rotary	Tillage	Rotary
Depth of tillage(cm)	12.0	6.8	21.0	14.8
Workability(hr/ha)	15.2	8.0	2.8	3.2
Fuel efficiency(m^3/l)	57.3	58.1	63.7	41.1
Tilth efficiency(%)	64.6	74.8	59.0	72.6

Water requirement in depth of paddy field by different tillage methods showed in Fig. 1. Water requirement in depth of no-tillage plots was higher than the other plots. Because no-tillage method is necessary amount of water,in case of no-tillage cultivation, farmers must caution the water deficiency of the growth of rice in the paddy field.

In the early growing stage, water requirement in depth was increased, but in the middle growing stage that was decreased. This is due to the changes of climatic factors such as cloud and rainfall which occurred frequently for long time in the middle growing stage. Hur et al.[3] reported that water requirement in depth of sandy loam soil was higher than that of silty clay soil.

Table 3 indicate the annual changes of rice yield by different fertilizer levels and tillage methods. Average yield of rice was 6.17 ton/ha during 5 years. Increasing ratio were 6~17% under tillage treatments.

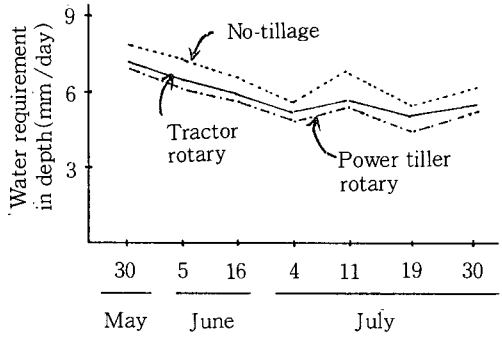

Fig. 1. Seasonal changes of water requirement in depth by different tillage methods.

That of PT rotary plot was higher by 17% than that of no-tillage plot under conventional fertilizer application, but in the recommended plots, tractor rotary plot was higher by 14% than that of no-tillage plot. Rice yield of the 2nd year was highest during experiment period.

Mineral contents of rice plant were analyzed(Table 4). The contents of T-N, P_2O_5,

Table 3. Annual changes of unhulled rice yield by different fertilizer levels and tillage methods(ton/ha)

Treatment	Fertilizer level	'87	'88	'89	'90	'91 year	Mean (Yield index)
No-tillage	Conventional	5.66	6.81	5.76	4.86	5.11	5.64(100)
	Recommended	5.88	7.05	6.78	5.26	5.92	6.18(109)
Power tiller rotary	Conventional	5.70	6.77	6.24	5.36	5.81	5.98(106)
	Recommended	5.90	6.91	7.50	6.36	6.26	6.59(117)
Tractor rotary	Conventional	5.80	6.88	6.67	5.88	6.00	6.25(111)
	Recommended	5.92	7.10	6.88	6.03	6.15	6.42(114)
Mean		5.81	6.92	6.64	5.63	5.88	6.17

Table 4. Mineral content of plant by different treatments

Treatment	Fertilizer level	T-N	P_2O_5	CaO	K_2O	MgO	Na_2O	SiO_2
		.....	.....	.....	(%)	.....	.....	.....
No-tillage	Conventional	0.48	0.60	0.32	1.53	0.23	0.08	5.2
	Recommended	0.53	0.57	0.32	1.54	0.22	0.08	5.3
Power tiller rotary	Conventional	0.40	0.43	0.26	1.41	0.18	0.06	5.1
	Recommended	0.41	0.43	0.33	1.53	0.17	0.06	5.3
Tractor rotary	Conventional	0.46	0.52	0.33	1.51	0.22	0.09	5.0
	Recommended	0.45	0.51	0.32	1.52	0.21	0.08	5.3

K_2O and MgO in the no-tillage plots were higher than the other plots. Also those of power tiller rotary plot were lowest than the other plots. Mineral contents of rice plant by different tillage methods had not definite tendency.

Soil physico-chemical properties in the topsoil at the harvesting stage were analyzed (Table 5). Bulk density of no-tillage plot were highest. These results were due to no tillage of the no-tillage plot before rice transplanting. Those of tractor rotary plots were lowest. Sato and Yumura[10] reported that the degree of soil compaction caused by tractor traffic was raised as soil moisture contents increased, and consequently volume weight increased and both air capacity and hydraulic conductivity decreased remarkly. But the degree of increased compaction would be decrease during rice growing seasons by long flooding.

Soil air phase of all treatments were ranged 2.4~8.1%. Nonoyama[8] reported that there was little difference in the distribution of the three physical phases. however, the

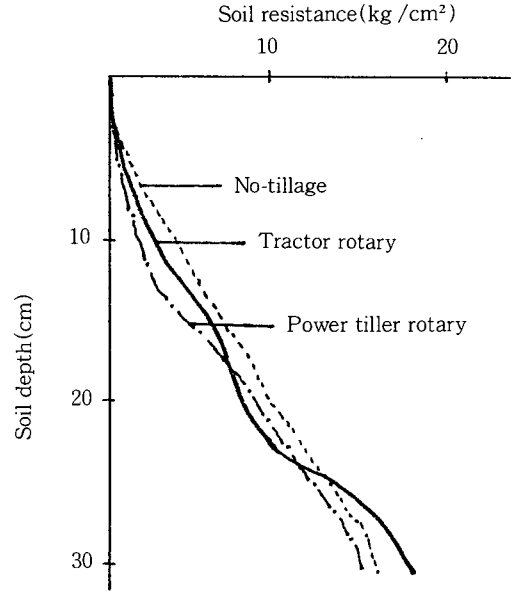

Fig. 2. Change of soil resistance by different tillage methods and soil depths.

Table 5. Physico-chemical properties of topsoil at the harvesting stage

Treatment	Fertilizer level	Bulk density (g /cc)	3 phase(%) Solid	Liquid	Air	pH (1:5)	OM (%)	CEC (me /10g)
No-tillage	Conventional	1.40	52.8	41.0	6.2	6.5	2.3	13.5
	Recommended	1.33	50.3	47.3	2.4	6.2	1.8	17.3
Power tiller rotary	Conventional	1.30	49.2	45.3	5.5	6.4	1.9	14.7
	Recommended	1.25	47.3	50.2	2.5	6.4	1.8	15.9
Tractor rotary	Conventional	1.22	46.1	47.4	6.5	6.6	2.1	12.7
	Recommended	1.22	45.0	46.9	8.1	6.5	2.3	13.1

Table 6. Correlation coefficient between rice yield and soil properties of topsoil

Bulk density	Solid	Liquid	Air	pH	OM	Ca	K	Mg	CEC
0.320*	0.320*	−0.461**	0.470**	0.332*	0.245	−0.634**	0.491**	−0.473**	−0.524**

*, ** : Significant at 5, 1% level respectively.

percentage of small clods to the total clods at the time of autumn plowing was lower in the plowed field than in the non-plowed field.

Soil pH of no-tillage plots were similiar to the other plots. Organic matter contents of power tiller rotary plots were lowest. Cation exchange capacity of all treatments had not taken definite tendency.

Fig. 2 showed the soil resistance by different tillage methods and depths. Soil resistance of no-tillage plots was strongest than the other plots, but that of tractor plot was weakest.

Terasawa[12] reported that in inorganic paddy field, as tilled paddy field shifts to no-tilled paddy field, the hardness of surface soil and plow sole is clearly increasing.

Table 6 indicate the relationship between rice yield and soil properties. Soil physico-chemical properties except organic matter content had highly correlated with rice yield. Especially calcium content was highest. In case of rice was cultivated continuously in the paddy field, soil chemical properties were highly contributed to the increasing of rice yield.

摘 要

논토양에서 耕耘方法과 施肥水準을 달리하여 화성벼를 5년간 同一圃場에서 재배했을 때 벼收量과 土壤特性 變化를 조사분석한 결과는 다음과 같다.

1. 機種別 耕耘效率은 경운기 로타리구가 74.8%로서 제일 높고 트랙타 경운구가 59.0%로서 가장 낮았다.
2. 벼 이앙후 무경운구의 減水深이 가장 많았으며 벼 생육중기보다는 생육초기에서 많았다.
3. 벼 收量은 무경운 관행시비에 비해 경운기 로타리 농토배양시비구가 가장 많은 17%가 增收되었고 경운처리를 하므로서 벼수량은 6~17% 증수되었다. 年次間에는 2年次에서 수량이 가장 많았고 4년차에서 가장 낮았다.
4. 경운하지 않은 무경운구의 容積密度와 固相率이 가장 높았으며 토양의 化學性 변화는 處理間에 일정한 경향이 없었다.

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