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Chemical Properties of Korean Orchard Soils in Main Apple, Pear, Grape and Peach Producing Area

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ABSTRACT

The aim of this study was to evaluate the chemical properties of orchard soils through which their soil fertilities were discriminated. Total 877 soil samples in major orchard area, *i.e.* from 239 apple, 369 pear, 168 grape, 101 peach orchards, were examed on the basis of temporary optimal range for each component.

The levels of fertility were ranged from 3.0 to 65.2 % compared to optimum fertility, suggesting that almost orchard soils contained inadequately soil components. The contents of chemical component have a tendency to decrease with soil depth gradually from surface to subsoil. This meaned that the contents of various components in subsoil could be estimated on the basis of analysis of surface soil, using the linearly fitted equations of the relationship between component in subsoil and in surface at least to which fertility were samely managed. Furthermore, even when only the content of components in 20cm depth surface soil was analyzed, it could be determined whether the amount of each component in the surface soil is surplus or deficient.

Key words : Orchard soil, Chemical propertis, Sub and surface soil.

Introduction

Total area of 4 orchards of apple, pear, graph and peach was 103,165 ha which is alloted about 57.3% of total orchard cultivation area. To make orchard integrated cultivating characteristics like climate, topography and fruit kinds should be considered enough because fruit tree is permanent and not able to move after transplanting. About 63% of orchards are distributed presently in narrow local valley, sloping hilly and mountainous area, in which are favorable for orchard cultivation due to be well-drained and escapable from freezing damage. In contrast, they are not easy to manage soil fertilization because of their barren and erosive characteristics in general.

Futhermore, orchard tree is deep-rooting and requires good soil physical properties like effective soil depth, infiltration and hardness to enhance yields (Kim, et al; 1989). It is required long time and much cost to improve soil physical properties of orchards cultivated, although soil physical characteristics might be improved by mechanical breaking or application of coarse organic matters inner deep depth. However, the growth characteristics like tree vigor, fruit quality and physiological disorder are decided by chemical properties of surface soil, and effective fertilizing

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management is very important in orchard cultivation (Oh, et al. 1986; Kenworthy et al., 1953).

Optimum rage of chemical properties for orchard is recomended as followings (Kim, at al., 1989) : pH 6.0~6.5, available phosphate 150 mg kg^{-1}, B 0.5 mg kg^{-1} and exchangeable K, Ca and Mg of 0.5, 9.0 and 2.0 $cmol^{+}$ kg^{-1}, respectively. But this range is changeable depending on climate, topography and tree type. In this study to establish the standard for fertilization management soil chemical properties were surveyed in apple, pear, graph and peach orchards on national scale.

Materials and Methods

1. Surveyed region selection

To determine soil chemical properties soil was sampled in the chief cultivating districts as the followings: 239 sites of apple orchard in Ahnsung and Yesan, 369 of pear in Ahnsung, 168 of graph in Kimpo, Taejon and Okchon, 101 of peach in Ichon, Umsung and Yeonki.

2. Soil sampling

Soil was collected separately on 4 depth of 0~20, 21~40, 41~60 and 61~80 cm. It was sampled in 13 apple orchards of 10 year Fuji species, 17 pear orchards of 20 year Shingo species, 82 graph orchards of 10 year Camberial species and 38 peach orchards of 10 year Mibaek species in the mid of July~the beginning of August.

3. Soil analysis

Soil chemical properties were determined as follows: pH (1:5 water extract), content of organic matter (Tyurin method), content of total nitrogen (micro-Kjeldahl digestion method), content of available P_2O_5 (Lancaster nethod), and contents of exchangeable Ca, Mg and K (1M NH_4-acetate pH 7), and available B (Curcurmin colouring method). Lime requirement was determined by ORD kit method, and sugar contents of fruits were checked by Brix sugar degree meter. The results were classified with low, medium and high depending on the contents of each component.

Results and Discussions

1. Chemical properties of soils

Table 2 shows chemical properties of top soils collected from main cultivating areas of 4 fruits.

Comparing with the optimum chemical range which was established from the results of soil diagnosis by RDA during 1960s~1980s (RDA, 1994) and the diagnosis standard of Japan (1989), chemical properties were different with depending on tree species and districts. Of them available phosphate was exclusively accumulated, and exchangeable potassium was exceeded over the optimum range. But organic matters were contained insufficient entirely. Soil pH, the rates of exchangeable Ca, Mg and Mg, K, and available B were distributed within the optimum range.

Soil organic matters were continuously dropped from 13g kg^{-1} in 1960s to 10 g kg^{-1} in 1980s which was caused by the difficulties of compost preparation and the misunderstand to their function in soil. That is, organic matters might be estimated with simple function to supply a nutrient (Shin, et al; 1988). In a previous study soil phosphate and potassium were increased with crop cultivation by chemical fertilizer amendments (Park, et al, 1994).

Table 1. Numbers of soil sample collecxted from the planted area of orchards

Orchard	Samples site	No. of farmers field	Age of tree	Cultivar
Apple	Anseong, Yesan	239	10	Fuji
Pear	Anseong	369	20	Sinko
Grape	Kimpo, Taejeon, Okcheon	168	10	Cambelly
Peach	Incheon, Umseong, Yeongi	101	10	Miback

Table 2. Chemical properties in orchard soils of 4 fruit ultivating districts

Orchard	Region	pH (1:5)	OM (g kg^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex.(cmol$^+$ kg^{-1})			Ca/Mg	Mg/K	Av.B (mg kg^{-1})
					K	Ca	Mg			
Apple	Anseong	6.4	20	395	0.6	5.2	1.4	3.7	2.2	0.40
	Yesan	5.8	22	423	0.80	6.2	1.5	4.4	1.8	-
	Mean	6.1	21	410	0.73	5.7	1.4	4.1	2.0	-
Pear	Anseong	6.0	22	466	0.77	4.3	1.2	3.6	1.6	0.51
Grape	Kimpo	5.4	13	239	0.58	5.3	1.5	3.5	2.6	-
	Taejeon	5.4	20	464	0.54	4.4	0.9	4.9	1.7	-
	Okcheon	5.1	13	286	0.35	3.0	0.8	3.8	2.3	-
	Mean	5.3	15	321	0.48	4.1	1.1	3.7	2.3	-
Peach	Incheon	5.7	24	368	0.53	4.1	0.6	6.8	1.1	-
	Umseong	5.3	18	248	0.56	3.5	0.9	3.9	1.6	-
	Yeongi	5.7	19	456	0.71	2.9	0.8	3.6	1.1	-
	Mean	5.4	20	357	0.60	3.5	0.8	4.4	1.3	-
Optimum level		6.0~6.5	25~35	200~300	0.3~0.6	5~6	1.2~2.0	3~5	)2	0.4~0.6

In general, orchards have the good adaptability to soil and climate condition. In particular, grape has the strong resistance to cold and drought. Though it showed the differences among the species, orchard is suitable in fertile soil on the range of sandy loam~clay loam, deep effective depth of soil and the well-drained soil (Oh, et al., 1986).

Especially, pear root is elongated to 90cm of soil depth. It is good for pear to cultivate in soils over 100cm of effective depth and, at least, the effective depth is required to minimum 61~80cm.

2. Distribution of chemical properties with soil depth.

Table 3 shows chemical properties of orchard soils with different depths. Essential nutrients like organic matter, phosphate, potassium and calcium were distributed in the surface soils and decreased with deepening soil depth. The facts that nutrient contents became lower with depth, chemical fertilizer might be applied to the subssoil layers for cultivating deep root orchard.

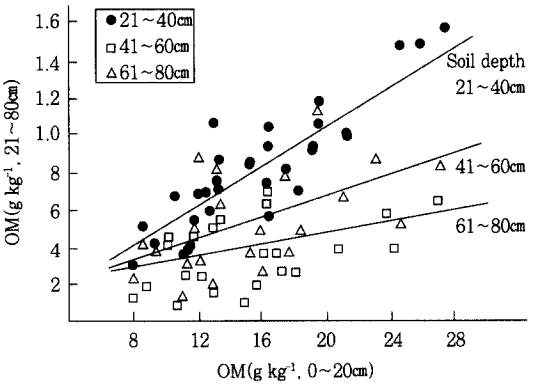
Table 3. Chemical properties in orchard soils with varing soil depths

Orchard	Depth (cm)	pH (1:5)	OM (g kg^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex.(cmol$^+$ kg^{-1})			Ca/Mg	Mg/K
					K	Ca	Mg		
Apple	0~20	6.2	18	423	0.71	5.4	2.0	2.7	2.8
	21~40	5.6	11	167	0.45	4.4	1.6	2.8	3.6
	41~60	5.2	6	115	0.33	3.5	1.6	2.2	6.7
	61~80	5.2	5	48	0.27	3.2	1.9	1.7	7.0
Pear	0~20	5.6	19	573	0.86	4.6	1.2	3.8	1.4
	21~40	5.4	9	244	0.70	3.8	1.0	3.8	1.4
	41~60	5.2	5	111	0.58	3.3	1.2	2.8	2.1
	61~80	5.2	5	55	0.47	3.1	1.6	1.9	3.4
Grape	0~20	5.2	17	358	0.50	4.0	1.1	3.6	2.2
	21~40	5.1	12	207	0.36	3.9	1.1	3.5	3.1
	41~60	5.1	10	91	0.29	4.0	1.4	2.9	4.8
Peach	0~20	5.4	20	357	0.60	3.5	0.8	4.4	1.3
	21~40	5.0	14	80	0.37	2.2	0.6	3.7	1.6
	41~60	5.0	9	27	0.21	1.9	0.8	2.4	3.8

3. Relationship of Chemical Properties in Surface and Subsurface Soils

It is very difficult to evaluate fertility of subsurface soil by sampling. To estimate indirectly chemical properties of subsurface soil and to manage effectively nutrients, the relationship between chemical properties of surface and subsurface soils were evaluated (Fig. 1). This is based on hypothesis that nutrients in surface soil may move to subsurface layer without cultivating condition.

Organic matter contents in top layer have the statical correlation with those in 21-40, 41-60 and 61-80 cm of subsoil layers. With the same methodology the relation of the following chemical components was calculated between surface layer (x) and subsoil (y) in table 4 : pH, available phosphate, exchangeable Ca, Mg and K and CEC. Chemical properties in subsurface below 20 cm may be estimated from those of surface soil by this correlated expression.



Regression equation
(y : OM in subsoil, x : OM in topsoil)
subsoil 21~40cm : y = -0.18 + 0.553x (r=0.773**)
41~60cm : y = 1.21 + 0.270x (r=0.525**)
61~80cm : y = 1.63 + 0.160x (r=0.394*)

Fig. 1. Relationship between contents of organic matter in subsoil and those in top soil.

4. Distribution characteristics of soil chemical properties in orchard

Table 5 shows the distribution ratios of soil chemical components to the optimum range of orchards. Each

Table 4. Relationship between the chemical properties of topsoil and those of subsoil

Soil properly	Depth(cm)	Regression equation (y:subsoil, x:topsoil)	r
pH(1:5)	21~40	y = 0.572 + 0.842x	0.820**
	41~60	y = 2.052 + 0.469x	0.608**
	61~80	y = 3.318 + 0.325x	0.476**
Av. P_2O_5 (mg kg^{-1})	21~40	y = 24.662 + 0.369x	0.713**
	41~60	y = 37.318 + 0.137x	0.449**
	61~80	y = 27.880 + 0.045x	0.372**
Ex.K(cmol$^+$ kg^{-1})	21~40	y = 0.130 + 0.582x	0.662**
	41~60	y = 0.180 + 0.369x	0.415**
	61~80	y = 0.285 + 0.133x	0.169NS
Ex.Mg(cmol$^+$ kg^{-1})	21~40	y = 0.951 + 0.613x	0.791**
	41~60	y = 2.336 + 0.204x	0.615**
	61~80	y = 2.900 + 0.048x	0.609**
CEC(cmol$^+$ kg^{-1})	21~40	y = 2.369 + 0.647x	0.676**
	41~60	y = 4.122 + 0.384x	0.457**
	61~80	y = 5.192 + 0.226x	0.332NS

Table 5. Distribution ratio of the sufficiency for the chemical properties in orchard soils (unit : %)

Orchard	Degree of sufficiency	pH (1:5)	OM (g kg^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex.(cmol$^+$ kg^{-1})			Ca/Mg	Mg/K	Av.B (mg kg^{-1})
					K	Ca	Mg			
Apple	Optimum	28.1	10.2	12.5	32.9	17.6	54.0	65.2	46.3	38.5
	Insuffic.	35.4	89.8	14.4	9.0	39.2	33.9	20.9	53.7	46.1
	Excess	36.5	0	73.1	58.1	43.2	12.1	13.9	0	15.4
Pear	Optimum	19.6	16.3	13.0	32.2	17.7	30.9	52.6	28.7	23.6
	Insuffic.	52.8	82.0	9.5	7.1	62.4	59.1	24.3	71.3	35.2
	Excess	27.6	1.7	77.5	60.7	19.9	10.0	23.1	0	41.2
Grape	Optimum	1.2	3.0	22.0	45.2	15.5	29.2	51.2	48.2	-
	Insuffic.	98.8	96.9	25.6	29.8	70.2	63.1	17.3	51.8	-
	Excess	0	0.1	52.4	25.0	14.3	7.7	31.5	0	-
Peach	Optimum	10.6	15.8	27.9	45.2	9.3	12.5	34.6	17.8	-
	Insuffic.	84.6	83.2	41.3	16.3	84.9	84.6	21.8	81.2	-
	Excess	4.8	1.0	30.8	38.5	5.8	2.9	43.6	-	-

chemical component was distributed from minimum 3.0% to maximum 65.2 % within the optimum range. Though it was somewhat different on species and tree kinds, more than 50% of surveyed orchards were distributed out of optimum range, which included insufficient and excess cases and needs to improve soil and fertilization system.

Chung et. al. (1994) and Hyeon, et al. (1994) reported that around 65% of apple and 54% of grape orchards were formed in undesirable physical condition of soil like texture, sloping degree, drainage condition, ground water level, and hard pan.

From this survey most of orchard was managed in the insufficient chemical condition like organic matters, exchangeable cations, Mg/K rate and available B. It is further needed that orchard should be managed effectively by integrated fertilization for improving fruit yields and maintaining good soil condition.

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우리나라 사과, 배, 포도 및 복숭아 주산지 토양의 화학적 특성

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주요 과수재배지 토양에 대한 화학적 특성을 파악하기 위하여 사과 239, 배 369, 포도 168, 복숭아 101, 합계 877포장에서 주간 중간지점의 토양을 채취분석하여 토양화학적 특성에 따라 토양비옥도를 구분하였다.

주요 과수 주산단지 토양화학성분의 적정수준 비율은 3.0~65.2%로서 대부분의 과수원이 부적지였으며 토양층위별 화학성분은 하층으로 내려 갈수록 일정하게 감소되는 경향을 보여 시비관리가 동일한 지역에서는 표층토 20㎝ 깊이의 토양 화학성분 함량만 알면 층토의 성분함량을 추정할 수 있으며 또한 과종별 표토의 토양화학성분함량의 과부족율을 추정할 수 있었다.

Key words : Orchard soil, Chemical propertis, Sub and surface soil.

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