Kor. Turfgrass Sci., 11(2), 89~95, 1997

Mineral Distribution of Soil at Different Depth in a Fairway Slope

B. J. Choi, Y. H. Ju* and H. Park**

Kongju National University, Suwon Rural Development Administration,*

*Korea Ginseng and Tobacco Research Institute***

훼어웨이 경사의 토양 깊이별 무기성분 분포

최병주 · 주영희* · 밝훈**

공주대학교 · 수원 농촌진흥청* · 한국인삼연초연구원**

ABSTRACT

Soil chemical properties were investigated to elucidate vertical movement of mineral nutrients in a fairway slope of 27 year-old golf course. Soil samples were taken at every 10cm depth to 40cm on 4 sites 20m apart each along two parallel lines 60m apart on the slope(15°) in August. According to the similarity of vertical distribution pattern they could be classified into 6 distinctive groups(magnesium, nitrate, phosphorus, ammonium, manganese and copper) and the slope tended to affect the vertical movement of minerals. The contents of Ca and Mg increased with depth while NO_3-N and Zn decreased and correlated positively. Soil pH showed significant positive correlation with depth, Ca and Mg. Phosphorus content was highest in 10~20cm depth and decreased resulting in relatively high content in 30~40cm depth of the bottom site of slope. Iron distribution pattern was similar to phosphorus. Potassium and NH_4 showed various(irregular) patterns. Mn was highest in the deep layer at the lower sites of slope but it was reverse at the upper sites and negatively correlated with Fe. Cu content incresed with depth and heighest in 20~30cm depth. Electroconductivity showed significant positive correlation with NO_3-N. Magnesium, calcium and copper seem to be prone to defficiency due to fast leaching, and nitrate and phosphorus prone to excess problem. Preventive measures on acidification of surface soil should be taken.

Key words: Mineral distribution, Fairway slope, Ca, Mg, NO_3-N.

INTRODUCTION

A survey of mineral content of surface soil in most golf courses showed great variation among golf courses and suggested excess problem in many golf courses(Lee *et al.*, 1993). Recently physiological symptoms have frequently occurred at various golf courses even though the age of most golf courses are young. Most probable factors of physiological symptoms are due to minerals(Choi *et al.*, 1993b). For the proper nutrient management of lawn some pieces of information on vertical movement of minerals are necessary. Vertical distribution of minerals in golf courses was recorded only when soil profile characteristics was investigated in very limited number of golf courses(Choi *et al.*, 1993a, Choi *et al.*, 1995). In this paper we reported vertical'distribution of minerals in a 15° slope of fair way.

MATERIALS AND METHODS

1. Investigation site

A 15° slope of fairway was chosen in New Korea Country Club(27 year old), Kyonggi province. Soil characteristics are red yellow soil from granite and granite neiss and Osan series with sandy loam(Choi *et al.*, 1992).

2. Soil sampling

Eliminating thatch layer soils were taken every 10cm depth to 400cm at 4 sites 20m apart each along the two pararell lines 100m apart on slope. Soil samples were airdried and collected through 20 mesh sieve.

3. Soil analyses

Analyses followed the common chemical methods(NASTI, 1983). K, Ca, Mg, Fe, Mn, Cu and Zn were extracted with 1M ammonium acetate solution and determined by Atomic absorpton spectrometry. NH_4-N and NO_3-N were extracted with 2M KCl and determined by micro Kjeldahl method. Available phosphorus was determined by Lancaster method. EC and pH were done with distilwater filtrate(soil to water 1:5 W/V). Organic matter was by Turin method.

4. Distribution pattern similarity

Degree of pattern similarity of vertical distribution of soil factors were determined by the significance of linear correlation coefficient in one site or one line of slope.

RESULTS AND DISCUSSION

Soil chemical characteristics with depth at 4 sites of two sides 100m apart of a slope were shown in Table 1 and 2. By eyeballing content and vertical distribution pattern of a mineral are almost same in all sites. The correlation coefficients of vertical distribution between two factors at one site were shown in Table 3 and linear regression equations and correlation coefficients at one side of slope were shown in Table 4. Soil pH showed highly significant positive correlation with soil depth while NO_3 showed significant negative correlation indicating that distribution pattern is quite reverse between pH and NO_3. Ca and

Table 1. Mineral distribution with soil depth along the first side of fairway slope(15°) in New Korea C.C.

Site (m)	Depth (cm)	pH (1:5)	EC_5 (dS/m)	K	Ca	Mg	P_2O_5	Fe	Mn	Cu	Zn	NH_4	NO_3	OM (%)
				………				(me/kg)				………		
Top (0)	10	4.4	0.27	3.0	10.9	2.9	226	77	20	0.40	2.58	8.9	108	1.6
	20	4.8	0.10	2.2	12.7	2.6	538	89	10	0.50	1.68	7.9	36	2.1
	30	5.1	0.04	3.1	12.7	2.7	362	85	8	1.22	1.08	8.4	9.4	2.2
	40	5.3	0.08	2.6	13.2	3.6	67	22	12	0.92	1.26	5.9	7.1	0.9
Near top (20)	10	4.5	0.28	2.4	12.4	3.7	206	87	17	0.54	2.64	9.4	98	2.2
	20	5.2	0.08	2.1	14.1	2.9	348	94	5	0.58	1.20	8.9	35	2.1
	30	5.4	0.05	2.1	22.4	7.1	34	23	16	1.10	0.76	6.9	11	1.4
	40	5.7	0.05	2.0	27.6	8.9	6	8	14	0.32	0.46	3.4	3.1	0.9
Near bottom (40)	10	5.0	0.19	2.8	11.0	3.2	250	83	15	0.34	2.04	9.8	63	2.3
	20	5.1	0.07	2.6	11.2	3.2	324	104	9	1.20	1.56	8.5	20	2.0
	30	5.3	0.04	2.0	9.7	2.9	24	41	10	1.22	1.28	4.9	6.4	1.9
	40	5.3	0.04	2.1	13.2	4.0	9	28	22	1.10	1.32	3.0	3.5	1.4
Bottom (60)	10	4.1	0.31	2.6	9.6	2.8	340	81	14	0.58	2.46	5.9	60	1.9
	20	4.8	0.07	2.5	8.7	2.0	503	96	12	0.50	1.42	4.4	22	1.4
	30	5.2	0.07	4.7	31.7	7.6	76	72	26	1.22	1.34	6.4	34	0.7
	40	5.3	0.07	4.5	47.5	13.7	23	24	24	0.40	1.16	5.9	14	0.8

Table 2. Mineral distribution with soil depth along the second side of fairway slope(15°) in New Korea C.C.

Site (m)	Depth (cm)	pH (1:5)	EC_5 (dS/m)	K	Ca	Mg	P_2O_5	Fe	Mn	Cu	Zn	NH_4	NO_3	OM (%)
				………				(me/kg)				………		
Top (0)	10	5.0	0.20	2.1	11.6	3.3	164	75	19.0	0.28	2.78	14.8	61	1.3
	20	5.2	0.09	2.1	14.8	4.2	325	91	6.0	0.76	1.50	5.9	30	1.4
	30	5.3	0.08	2.2	14.1	4.3	219	89	8.4	1.06	1.34	4.9	34	1.8
	40	5.5	0.05	2.5	21.6	6.8	44	28	14.0	0.40	0.66	7.9	8.1	1.7
Near top (20)	10	4.8	0.18	2.1	12.3	3.3	208	92	24.0	0.78	2.72	11.8	69	1.6
	20	5.2	0.10	2.5	15.1	3.6	452	92	17.0	0.60	1.84	133	43	1.4
	30	5.3	0.06	2.2	14.9	4.0	271	91	9.7	0.90	0.94	16.8	32	1.0
	40	5.4	0.05	2.2	20.0	5.8	80	67	19.0	0.94	0.88	3.0	5.1	1.7
Near bottom (40)	10	5.0	0.14	2.2	8.3	2.3	174	86	16.5	0.52	1.86	7.9	41	1.1
	20	5.1	0.09	1.9	11.7	2.7	289	92	11.8	0.66	2.02	8.4	31	0.9
	30	5.3	0.06	3.4	13.6	3.5	178	83	18.8	1.54	1.16	10.8	8.6	1.8
	40	5.3	0.07	3.7	16.5	4.3	159	79	19.3	1.30	0.90	9.4	13	1.2
Bottom (60)	10	4.7	0.18	2.2	9.4	2.3	324	100	13.8	0.76	2.20	11.8	47	2.4
	20	5.1	0.11	3.2	10.0	3.7	343	103	5.5	0.80	1.34	6.4	31	1.7
	30	5.0	0.09	3.4	15.0	4.6	125	94	18.0	1.52	0.94	10.3	12	1.7
	40	5.0	0.09	3.4	17.6	5.2	149	95	26.0	1.23	0.90	7.4	14	1.3

Mg followed the distribution pattern of pH. Significant positive correlation between pH and Ca was observed in surface soils(Choi *et al.*, 1993b; Lee, 1994) and soil profiles(Choi *et al.*, 1993a) of golf courses. The same phenomenon between pH and Mg was observed in surface soils(Lee, 1994). Similarity among pH, Ca and Mg in vertical distribution was found firstly in this time. Major factor for the distribution similarity of Ca, Mg and pH was not easy to find. Mobility of minerals in soil column by irrigation water was in the decreasing order of Cl, NH_4-N, K, Mg, Ca and P(Ryu *et al.*, 1991). In Table 1 and 2 the low mobile minerals, Mg, Ca, P, appeared to be high mobile ones until 40cm depth investigated. Vertical distribution depends on application, irrigation, absorption and chemical change. NO_3 should be a high mobile one as Cl but it is least mobile according to only distribution pattern. NO_3 may easily change in lower layers. In a grass land experiment urea application increased NO_3 than NH_4 in soil profile and NO_3 decreased until 60cm depth and increased gradually with soil depth until 100cm(Yun and Yoo, 1991). Since urea is only used for nitrogen fertilizer in most golf courses high NH_4 content will be estab-

Table 3. Similarity of mineral distribution in soil depth of a fairway slope

Site	pH-depth	NO_3-depth	pH-Ca	pH-Mg	P-Fe	Mn-Fe	EC-NO_3	NO_3-Zn	NH_4-K
1st line									
0	0.9891**	−0.9024*	0.9260*	0.5097	0.8585	−0.0781	0.9794**	0.9849**	0.4391
20	0.9621**	−0.9266*	0.8787	0.7576	0.9516**	−0.4541	0.9803**	0.9985***	0.7420
40	0.9467*	−0.9026*	0.1499	0.3060	0.9923***	−0.4097	0.9971***	0.9912***	0.9369*
60	0.9481*	−0.8096^N	0.8115	0.7529	0.8328	−0.6909	0.9125*	0.9412*	0.7052
2nd line									
0	0.9923***	−0.9200*	0.9230*	0.9380*	0.9114*	−0.4731	0.9483*	0.9815**	−0.2173
20	0.8474	−0.9885**	0.7516	0.6164	0.7503	−0.1441	0.8121*	0.9208*	0.1466
40	0.9467*	−0.8990	0.9256*	0.9270*	0.9013*	−0.9394	0.9434*	0.8861	0.7629
60	0.5963	−0.9224*	0.3788	0.7173	0.9747**	−0.8706	0.9417*	0.9750**	−0.7204

*, **, *** : significant at p=0.1, 0.05 and 0.01 respectively in simple correlation

Table 4. Vertical distribution pattern similarity of minerals in a fairway slope

Side	Linear regression	Correlation coefficient(r, n=16)	Significance(p)
1	pH = 0.0298 Dep + 4.2975	0.8260	0.001
2	pH = 0.0195 Dep + 4.600	0.6433	0.01
1	pH = 0.1852 Ca + 0.47204	0.4693	0.1
2	pH = 0.4870 Ca + 0.43978	0.5086	0.05
1	pH = 0.6503 Mg + 0.47323	0.4927	0.1
2	pH = 1.4458 Mg + 0.45065	0.4870	0.1
1	P_2O_5 = 4.6937 Fe − 88.9616	0.8497	0.001
2	P_2O_5 = 3.9921 Fe − 119.5838	0.6552	0.01
1	NO_3 = −2.3903 Dep + 92.9125	−0.8366	0.001
2	NO_3 = −1.4523 Dep + 66.3125	−0.8758	0.001
1	EC = 0.0026 NO_3 + 0.0280	0.9062	0.001
2	EC = 0.0020 NO_3 + 0.0435	0.8406	0.001
1	Zn = 0.0170 NO_3 + 0.9501	0.8968	0.001
2	Zn = 0.0288 NO_3 + 0.5984	0.9076	0.001
1	Mn = −0.0679 Fe + 18.9251	−0.3715	NS
2	Mn = −0.0417 Fe + 18.9641	−0.1234	NS

lished in surface soil just after application. When the lawn uptakes NH_4 soil becomes acidic due to released H^+ which will accelerate leaching of Ca and Mg. Mg, Ca and pH made the group of increasing pattern of vertical distribution. Mg and Ca content was very low provablly due to heavy leaching. This soil is prone to Mg and Ca defficiency. Meanwhile some of NH_4^+ moved down to next layer and affect in the same way. Since NH_4^+ is mobile(Ryu *et al.*, 1991) it was no great difference in soil profile(Table 1 and 2). Large amount of NH_4 seemed to turn into nitrate especially in surface soil.

Distribution pattern of NH_4 was a little similar to K(Table 3). But no significant similarity was shown in a line of slope(Table 4). Distribution pattern of K and NH_4 was different in each site(Table 1 and 2) indicating irregular(zigzag or mixed) pattern. Thus K and NH_4 made the group of mixed pattern. Since K is applied as fertilizer and fast mover it is likely to take part in leaching Ca and Mg by ion exchange and rapidly move down below 40cm depth. Distribution of organic matter was similar to NH_4.

Electroconductivity(EC_5) of soil followed NO_3 pattern in vertical distribution in each site and a line of slope(Table 3 and 4). EC was positively correlated with total nitrogen(TN) content of surface soils in golf courses(Choi *et al.*, 1993b). In this case NO_3 might account for most part of TN. In the present investigation NO_3 was more dominant than NH_4 especially in surface layer as shown in Table 1 and 2. Zn followed NO_3 pattern. Thus NO_3, EC and Zn made the group of decreasing pattern.

Distribution of available phosphorus in soil depth was unique, highest in the second layer and then decreased(Table 1 and 2). Phosphorus was the least movile mineral(Ryu *et al.*, 1991) but at bottom site of the 2nd lines of slope relatively large content appeared in the 3rd or 4th layer(Table 2). Phosphorus and Fe had similar pattern of distribution in each site(Table 3) and on the both line of slope(Table 4). It may indicate that available P may with iron. P and Fe made the group of middle-high pattern of distribution.

Mn content was highest(19.3~26mg/kg) in 4th layer(30~40cm) at the lower sites(3rd and 4th) but it was reverse at the upper sites, 1st and 2nd(19.7~24mg/kg cm). Mn showed a reverse pattern of Fe in each site(Table 3) but not significant in the line of slope(Table 4). But Mn had it's own pattern, the middle-low type. From some point in the

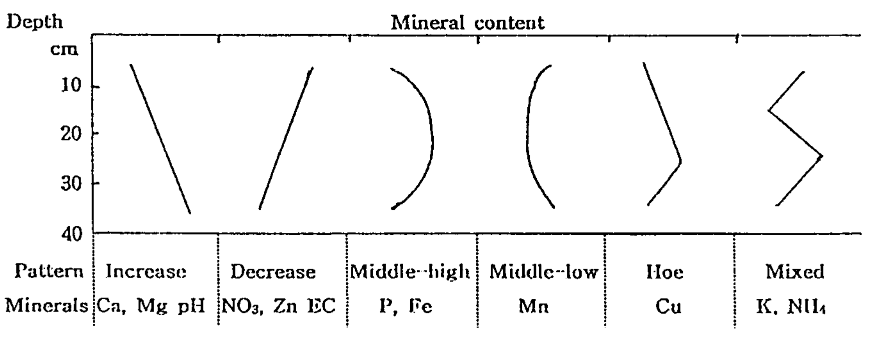

Fig. 1. Schematic drawing of distribution patterns of minerals in a fairway slope.

middle layer unknown factors seemed to accelerate Mn leaching. Copper content increased gradually and highest in 3rd layer(20~30cm) and then decreased in the final layer. Cu had it's own distribution pattern, the hoe type. Vertical distribution patterns of minerals were schematically shown in Fig. 1.

Effect of slope on mineral distribution was not clear but there was tendency to accelerate the movement along the slope. NO_3 showed the highest content in the 4th layers of the bottom site of both lines of slope(Table 1 and 2). Such phenomenon in one side of slope was shown in Mg, Ca, K, P, Zn, Cu and EC(Table 1 and 2). According to vertical distribution and content, the management criteria for each mineral could be established.

적 요

개관 27년인 골프장의 훼어웨이 경사에서 무기성분의 수직 이동을 구명하기 위하여 토양 화학성을 조사하였다. 8월에 15° 경사지에서 양편으로 60m 떨어진 경사선을 따라 한편에서 20m 거리로 4개소에서 10cm 깊이로 40cm 깊이까지 토양시료를 채취하였다. 수직분포 양상의 유사도에 따라 분포양상은 6개의 서로 다른 군으로(마그네슘, 질산태 질소, 인산, 암모니움, 망간, 동) 구분되었으며 경사는 수직분포에 영향을 주는 경향을 보였다. Ca과 Mg은 깊이에 따라 증가하였다. NO_3-N와 Zn은 깊이에 따라 감소하였으며 서로 정적 상관을 보였다. 토양 pH는 깊이, Ca, Mg와 유의미한 정적 상관을 보였다. 인산은 10~20cm에서 가장 높았고 그 이하에서 감소하였으며 30~40cm 깊이에서 비교적 높은 값을 보였다. 철의 분포는 인산과 유사하였다. K과 NH_4는 여러 가지 불규칙한 분포양상을 보였다. Mn은 경사의 아래쪽에서는 깊은 층에서 높았으나 높은 곳에서는 그 반대로 분포했고 Fe과는 부적 상관을 보였다. Cu는 깊이에 따라 증가하고 20~30cm에서 가장 높았다. EC는 NO_3-N와 유의미한 정적 상관을 보였다. Mg, Ca, Cu는 빠른 용탈로 인하여 부족되기 쉬우며 NO_3-N와 P은 과잉 문제가 되기 쉽다. 표토의 산성화 방지책도 강구되어야 한다.

REFERENCES

1. Choi, B. J., Y. H. Ju, J. S. Shim and B. N. Yoo. 1992. Classification and characteristics of soil in Korean golf courses, Korean J. Turfgrass Sci. 6: 113-119.
2. Choi, B. J., Y. H. Ju, J. S. Shim and B. N. Yoo. 1993a. Physico-chemical characteristics of soil profile of four golf courses in Kyonggi province, Korean J. Turfgrass Sci. 7: 55-60.
3. Choi, B. J., Y. H. Ju, J. S. Shim and H. Park. 1993b. Chemical characteristics of surface soils and mineral content of lawn in some golf courses in Kyonggi province, Korean J. Turfgrass Sci. 7: 129-135.
4. Choi, B. J., Y. H. Ju and J. S. Shim. 1995. Soil profile characteristics of golf courses located in southern region, Korean J. Turfgrass Sci. 9: 75-80.
5. Lee, J. J., S. T. Kim, S. G. Ham and I. S. Kim. 1993. Soil chemical characteristics of golf courses in Korea, Korean J. Turfgrass Sci. 7: 35.

6. Lee, I. S. 1994. Chemical characteristics of golf courses soils in Kyonggi province, Korean J. Turfgrass Sci. 8: 25-28.
7. National Agricultural Science and Technology Institute(NASTI). 1983. Soil and plant analysis.
8. Ryu, K. S., S. H. Yoo and K. C. Song. 1991. Movement of applied nutrients through soils by irrigation, J. Korean Soc. Soil Sci. Fert. 24(2): 102-108.
9. Yun, S. G. and S. H. Yoo. 1991. Seasonal changes in inorganic nitrogen content in the soil profile of urea-ferfilized grassland, J. Korean Soc. Soil Sci. Fert. 24(3): 171-176.