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Nutritional status in commercial currant fields

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The nutritional status on commercial currant fields was elucidated by advisory analytical data of 357 pairs of soil and leaf samples from commercial black, red and white currant fields in Southern and Middle Finland. The purpose was to investigate how nutrient concentrations in soil and leaves fitted in the recommended ranges, correlated with each other and to evaluate their usefulness in diagnosis of nutritional status. Soil pH(H_2O) and extractable nutrients (NO_3-N, P, K, Ca, Mg, B, Cu, Mn) and leaf nutrients (N, P, K, Ca, Mg, B) were analysed. The mean soil pH, P, K and Mn were in the recommended ranges. Over 50% of soil P and 60% of Mg results and the greatest part of Ca results passed below the lower recommended limits, but soil B and Cu were frequently over the upper recommended limits. The mean leaf N, P and K on all currants, Mg on black and red currants and Ca and B on black currant were within the recommended limits. The lower recommended limit of Mg was passed below in 74% of white currant leaf samples. Positive correlations were found between soil and leaf nutrient concentrations for P, Ca and Mg. The recommended lower soil analysis limits might possibly be too high for coarse soils, because low values of soil P, Mg and Ca were common. The nutrients also might not be evenly distributed in the sampled soil layer but might be accumulated in a thin surface soil layer because of repeated surface broadcasting of fertilizers.

Key words: black currants, leaf analysis, macro- and micronutrients, red currants, *Ribes nigrum*, *Ribes x pallidum*, soil pH, soil testing, white currants

Introduction

The chemical composition of a plant changes with nutrient supply, although the change is by no means commensurate with the variation in external supplies (Asher and Loneragan 1967, Spear et al. 1978). Soil analysis alone is not always a satisfactory guide to the fertilization of perennial plants like berry and fruit crops (Bould et al. 1960). Recommendations based on soil analysis assume that there is a direct relationship between the extractable nutrients in the soil and the uptake by plants. However, this relationship is affected by environmental factors like soil moisture. Therefore leaf analysis can be a more

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reliable tool in assessing the nutritional status and response to fertilizers and in giving information about the real uptake of nutrients. In Finland, leaf analysis has been used in the fertilization recommendations for currants since the 1970s. However, the values recommended for leaf nutrients have largely been based on the research done abroad. In addition, the studies have mainly concentrated on black currant (Ljones 1963, Bould 1964, 1969, Bjurman 1971, Bould and Parfitt 1972, Vang-Petersen 1973, Säkö and Laurinen 1979, Aaltonen and Dalman 1993, Niskanen et al. 1993, 1999, Kongsrud and Nes 1999, Aflatuni et al. 2001), and there are few studies on red and white currants (Vang-Petersen 1973, Ljones 1984, Aaltonen 1990, 1992, Aaltonen and Dalman 1993, Niskanen et al. 1993, 1994, 1999, Dierend et al. 1998, Rupp and Tränkle 2000). Therefore, recommendations for black currant (*Ribes nigrum* L.) have largely been applied also to red and white currants (*Ribes x pallidum* Otto & Dietr.).

Fluctuations in berry yields are major problems in commercial currant production (Voipio and Niskanen 1990, Niskanen and Matala 1991), and more knowledge is needed for solving the causes of low yields. More research is needed on the effects of fertilization on the berry yield and the applicability of soil and leaf analysis in the advisory work on fertilization (Niskanen 1989). Both environmental and economical viewpoints assume that fertilization must be as appropriate as possible. In practical cultivation, there have been problems in the interpretation and combination of soil and leaf analysis results, because they give sometimes contrary comprehensions of the nutritional status. When nutrient concentrations in leaves are within the recommended range, it has been difficult to use them as a basis for optimization of fertilization, because the values vary depending on the conditions. Because of these problems, leaf analysis has not been useful enough and has not met the needs of practical cultivation (Matala 1999). Therefore, the use of commercial analysis of leaf samples has decreased radically (Alainen 1999, personal communication).

The intention of this study was to elucidate the nutritional status on Finnish commercial currant fields, to compare leaf nutrient levels of different currant species, and to investigate how nutrient concentrations in soil and leaves fitted in the recommended ranges, correlated with each other and to evaluate their usefulness in diagnosis of nutritional status.

Material and methods

To study the nutritional status of commercial currant fields, soil testing and leaf macronutrient data provided by Soil Testing Service Ltd was investigated. During 1982–1991, soil and leaf samples were taken by growers after harvest at the end of August or at the beginning of September in commercial black, red and white currant fields located in Southern and Middle Finland. The total numbers of soil and leaf samples were 287, 51 and 19 for black, red and white currant fields, respectively. The samples were sent to Soil Testing Service Ltd for analysis. The cultivars were not always reported by the growers. However, ‘Red Dutch’, ‘Rondom’ and ‘White Dutch’ grew in some red and white currant fields, and the main black currant cultivar was ‘Öjebyn’.

According to the instructions (Soil Testing Service Ltd), soil samples should consist of 8–10 subsamples taken from the depth of about 0–20 cm and mixed thoroughly. The textural and humus content classes of soils were estimated by finger assessment. The pH and nitrate nitrogen were determined in soil-water suspension (1:2.5) after 12 hours standing. An ion-specific electrode was used for the measurement of the nitrate nitrogen. Before 1989, only nitrate nitrogen values higher than 10 mg l^{-1} soil were reported. Soil P, K, Ca and Mg were extracted by acid ammonium acetate (0.5 M acetic acid, 0.5 M ammonium acetate, pH 4.65, ratio 1:10 v/v, 1 h) (Vuorinen and Mäkitie 1955). Soil boron was extracted by hot water (Berger and Truog 1944)

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and copper and manganese by acid ammonium acetate-EDTA solution (Lakanen and Erviö 1971). Phosphorus was determined by a modification (Vuorinen and Mäkitie 1955) of molybdenum blue method, potassium and calcium by flame photometry, magnesium, copper and manganese by atomic absorption spectrophotometry and boron by plasma emission spectroscopy. The extraction method for soil copper and manganese was changed in 1986 and, differing from the other elements, only the results of the period 1986–1991 were included in the present study for these two nutrients. The results of manganese are given as pH-corrected values. The measured manganese concentrations (mg l^{-1} of soil) were multiplied by a coefficient which is dependent on soil pH (Sillanpää 1982).

The leaf samples consisted of 40–100 completely developed healthy leaf blades (about 100 g of fresh weight) of new shoots from all around the bushes. Air-dried leaf samples were ground and ashed at 550°C and the ash was dissolved in 2 M HCl. P, K, Ca, Mg and B in ash extracts were determined by plasma emission spectroscopy. Leaf N was determined by the Kjeldahl method.

Results

The samples collected from commercial currant fields during 1982–1991 consisted mainly of coarse mineral soils (Table 1). The greatest group consisted of sandy moraines of medium humus content. The mean soil pH was in the recommended range, but the values were under the lower limit in part of the soil samples (Table 2). The percentage of low pH values was highest for red currant fields. Nitrate N was below the range recommended for samples collected in autumn. The data on nitrate N was limited and included only samples from black currant fields where the

Table 1. Percentage of soil samples from currant fields of different textural and humus content classes during 1982–1991.

		% of currant fields		
		Black (n = 287)	Red (n = 51)	White (n = 19)
Textural class[1]	Clay, silt, loam	12	0	0
	Fine sand	21	10	21
	Sandy moraine	60	73	79
	No information	5	18	0
Humus content[2]	Low	6	4	16
	Medium	64	57	79
	Rich	21	22	5
	Very rich	1	0	0
	Mull	2	0	0
	No information	5	18	0

[1] Percentage of particle size fractions in textural classes:

Diameter, mm	Clay	Silt	Loam	Coarser soils
< 2	≥ 30	< 30	< 30	< 30
2–20		> 50	< 50	< 50
> 20			< 50	> 50

[2] Percentage of organic matter in humus content classes: < 3 low, 3–5.9 medium, 6–11.9 rich, 12–19.9 very rich, 20–40 mull
n = number of samples

Table 2. Soil pH(H_2O), extractable P, K, Ca, Mg and B (mg l^{-1} soil) in 1982–1991 and NO_3^--N (mg l^{-1}) in 1989–1991, copper (mg l^{-1}) and pH-corrected manganese in 1986–1991 and percentage of samples with values below (low values) and above (high values) the ranges recommended for currant fields.

Property[1]	Currant	n	Mean	SD	Range	Percentage of	
						low values	high values
pH	Black	287	6.3	0.4	5.3–7.4	27	14
	Red	51	6.2	0.4	5.2–7.0	39	14
	White	19	6.4	0.5	5.7–7.2	21	37
P	Black	287	22	17	1–106	59	14
	Red	51	26	21	4–95	51	22
	White	19	20	10	8–43	53	5
K	Black	287	187	80	20–562	32	6
	Red	51	195	92	40–380	35	8
	White	19	164	80	55–320	53	0
Mg	Black	287	198	88	40–690	61	4
	Red	51	168	65	50–395	78	0
	White	19	164	57	80–255	63	0
Ca	Black	287	1466	461	500–4100	91	3
	Red	51	1430	451	625–2525	86	0
	White	19	2005	1577	725–8000	74	16
B	Black	287	1.0	0.4	0.3–2.5	8	48
	Red	51	1.2	0.5	0.6–2.6	0	63
	White	19	1.6	0.6	0.6–2.8	0	90
Cu	Black	159	10.5	7.9	1.1–50.8	8	75
	Red	30	6.6	4.0	2.0–6.0	0	53
	White	17	11.7	6.4	1.8–25.6	6	88
Mn	Black	159	37	24	6–165	38	8
	Red	30	37	17	11–96	23	3
	White	17	55	72	20–330	18	12
NO_3^--N	Black	33	7.5	6.5	1.2–31.0		

[1] Ranges recommended for coarse mineral soils (Viljavuuspalvelu 1997): pH 6.1–6.5, P 20–40, K 150–350, Ca 2000–2600, Mg 200–400, B 0.6–0.9, Cu 2.7–5.0, NO_3^--N 30–50 mg l^{-1} soil, Mn-value 25–75

SD = standard deviation, n = number of samples

nitrate N concentration was ≤10 mg l^{-1} soil in 83% of samples. The means of soil P and K were in the recommended ranges. However, P, Mg and Ca values commonly fell below the recommended lower limits. Soil B and Cu were frequently over the upper recommendation limit. On the average, soil manganese was in the recommendation range. Low manganese values were most common on black currant fields.

The mean values of N, P and K in currant leaves were in the recommended ranges (Table 3). In black and white currant leaves, K level was good but N was below the recommended lower limit in one-fifth of the samples. High P values were most common in red currant leaves and high K values in black currant leaves. The mean Mg concentration in leaves of black and red currants were within the recommended range, low values being most common in white currant leaves. On average, Ca and B in black currant

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Table 3. N, P, K, Mg, Ca (g kg^{-1} of dry matter) and B (mg kg^{-1} of dry matter) in currant leaves 1982–1991 and percentage of samples with nutrient values below (low values) and over (high values) the recommendation range.

Nutrient[1]	Currant	n	Mean	SD	Range	Percentage of	
						low values	high values
N	Black	287	24.1	5.2	10.2–54.5	18	8
	Red	51	26.9	5.2	16.5–45.7	6	6
	White	19	24.9	4.5	16.9–31.2	21	0
P	Black	287	5.6	1.7	2.2–10.1	5	9
	Red	51	6.5	3.7	2.2–15.7	12	26
	White	19	5.1	1.4	3.1–8.1	0	5
K	Black	287	17.2	4.5	8.7–34.6	1	26
	Red	51	30.6	7.3	17.1–47.9	8	12
	White	19	31.7	3.2	25.8–35.9	0	0
Mg	Black	287	5.1	1.3	2.3–9.3	17	3
	Red	51	3.4	0.8	1.7–4.9	28	0
	White	19	2.8	0.7	1.7–4.0	74	0
Ca	Black	19	20.7	3.5	12.0–25.6		
	Red	6	31.0	2.6	27.8–35.6		
B	Black	40	34.3	10.2	19.5–82.0		
	Red	6	37.2	2.3	35.3–41.0		

[1] Recommendation ranges for nutrients in August (Viljavuuspalvelu 1997):

	N	P	K	Mg	Ca	B
Currant	g kg^{-1} of dry matter					mg kg^{-1} of dry matter
Black	20–30	3–8	10–20	4–8	20–30	20–60
Red, white	20–35	3–8	20–40	3–5	10–25	20–60

SD = standard deviation, n = number of samples

leaves were in the recommended range, although the number of analyses was low. The most remarkable distinction between nutrient levels in leaves of different currant species was a higher K level for red and white currants as compared with black currant. Mg was the only nutrient with higher values for black currant than for red and white currants. The other nutrient levels were higher for red currant than for black currant.

Positive correlations between leaf and soil nutrients were rather weak for P in black and red currant fields (Fig. 1). Values of correlation coefficients were rather low also for Mg of black currant and red currant (Fig. 2). A weak negative correlation was found between soil and leaf K in red currant fields (Fig. 3).

Discussion

The ranges recommended (Viljavuuspalvelu 1997) in Finland for macronutrient concentrations in currant leaves are wider and for nearly all nutrients higher than the optimum ranges for black currant leaves suggested in England (N 29–30, P 2.5–3.0, K 10–15, Mg 1.0–1.5 g kg^{-1} dry matter) (Bould 1964, 1969) and values recommended for all currants in Norway and Sweden (N 26–29, P 1.5–2.0, K 12–16, Ca 14–17 and Mg 2.5–3.5 g kg^{-1} dry matter) (Larsson and Svensson 1989).

In commercial currant fields, nutrient values below the recommended lower limits were more

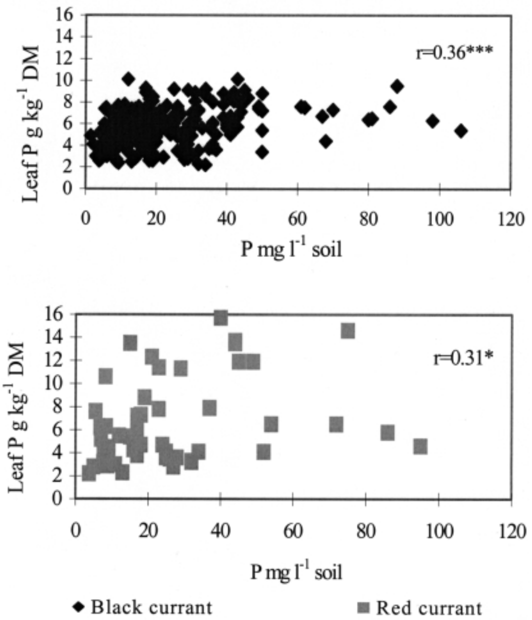

Fig. 1. Leaf versus soil P in black and red currant fields in 1982–1991 (significance: *** P = 0.001, * P = 0.05; black currant, n = 287, red currant, n = 51).

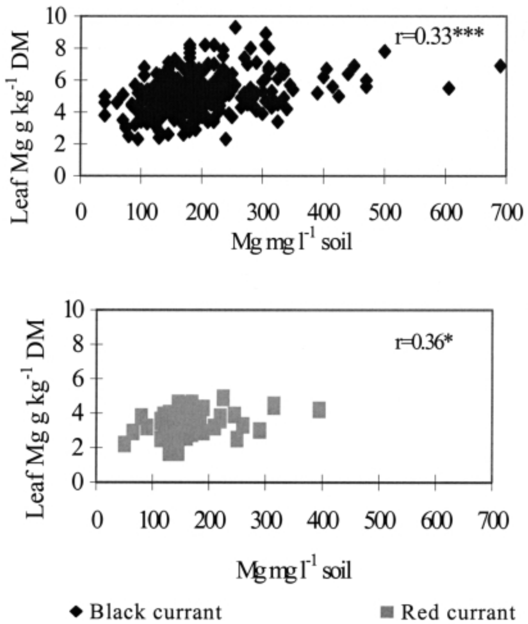

Fig. 2. Leaf versus soil Mg in black and red currant fields in 1982–1991 (significance: *** P = 0.001, * P = 0.05; black currant, n = 287, red currant, n = 51).

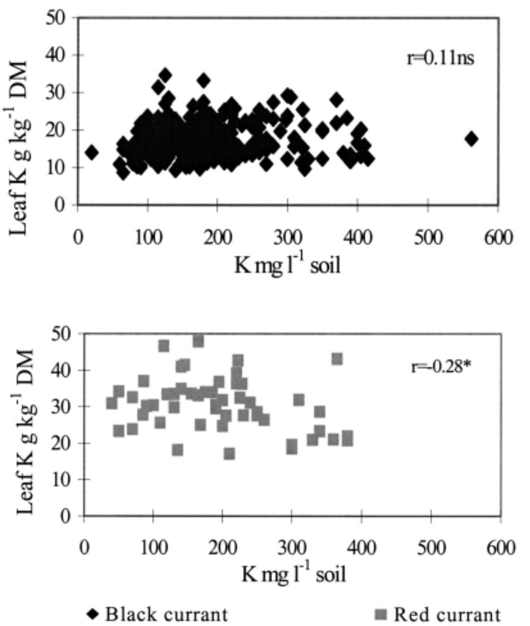

Fig. 3. Leaf versus soil K in black and red currant fields in 1982–1991 (significance: * P = 0.05, ns = not significant; black currant, n = 287, red currant, n = 51).

common in soils than in leaves. The fact that soil P, Mg and Ca values commonly fell below the recommended lower limits may reflect the great proportion of coarse soils with rather small nutrient sorption capacity. Furthermore, the pH was below the recommended lower limit in some of the soil samples. With decreasing pH the extractability of soil P by acid ammonium acetate decreases (Hartikainen 1989) and the pH-dependent part of cation exchange capacity diminishes (Mäntylahti and Niskanen 1986). This latter fact is revealed by positive correlation between pH and extractable Ca and Mg representing primarily the exchangeable cation fraction (Niskanen and Jaakkola 1985). In regard to Mg, low values in soil were reflected by low values in the leaves of red and white currants.

Soil and leaf analysis partially gave conflicting impressions of the nutritional status of currant fields. Although the nutritional status was satisfactory according to the soil analysis, the leaf concentrations were low. For example, in

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commercial fields K in black currant leaves tended to decrease in August although the soil K was satisfactory (Niskanen 2001). In this case it was possible that high Ca decreased the uptake of K. Antagonism between the K and Ca uptakes of black currant was also found in the study of Ljones (1963). The weak negative correlation between soil and leaf K in commercial red currant fields might be related to this connection. Rather weak positive correlations were found only in the cases of P and Mg. In a Norwegian field experiment on black currant, positive correlations between soil and leaf nutrients were found for P, K, Mg and Ca (Ljones 1963). In field experiments on black and red currants carried out by Aaltonen and Dalman (1993), the values of linear correlation coefficients between nutrients in the currant leaves and in the soil were mostly low. Leaf nutrient concentrations were only slightly dependent on soil nutrients also in Finnish commercial apple orchards (Dris et al. 1997, Dris and Niskanen 1998) and strawberry fields (Niskanen and Dris 2002). When the soil nutritional status is at least satisfactory, the poor correlation between nutrient concentrations in soil and in leaf dry matter is obvious and can be due to many factors affecting the availability and uptake of nutrients, e.g. weather conditions, soil moisture and nutrient levels, competition between nutrients in plant uptake, efficiency of shoot growth, amount of yield and incidence of pests. Also the soil and leaf sampling, its timing and how properly it is done, has an effect on how representative the results are. The data from commercial currant fields included material which was analyzed during a period of ten years. Differences in field management and weather conditions during growing seasons could cause variation in the data. Additional variation might be caused by differences in leaf nutrient composition between cultivars. Leaf Ca has been analyzed only seldom, the data from red and white currant fields was limited and there might be variation in the sampling methods used in different farms. As compared with the results of a single field experiment, different growth conditions and soil characteristics cause more variation in the analysis results of a material collected from many commercial fields. There seemed to be, however, no great differences in the average macronutrient composition of black currant leaves between commercial cultivations and pot and field experiments (Niskanen 2001).

The recommended lower soil analysis limits might be too high for coarse soils, because low values of soil P, Mg and Ca were rather common. It is also possible that nutrient concentrations are not evenly distributed in the sampled soil layer. In order to avoid of breaking the shallow root systems, soil tillage is lacking in perennial crop fields. It has been shown on black currant (Coker 1958) that under nontilled soil the level of root activity is greatest from 5–10 cm deep, if the surface soil moisture conditions are favorable. In fruit and berry fields the common practice has been to broadcast fertilizers on the soil surface. Therefore, nutrients accumulated in a thin surface soil layer from where the absorption of nutrients by roots has largely taken place. In this case, nutritional status might be satisfactory according to the leaf analysis but according to the soil analysis nutrient levels might be low because in soil sampling higher nutrient concentrations of the thin surface layer have been diluted to a larger sampled soil volume.

High values of soil B and Cu were common in currant fields. This can be attributable to the use of compound fertilizers including micronutrients. The repeated surface broadcasting of these fertilizers might have caused enrichment of B and Cu in the soil surface layer at a detrimentally high level, because these elements are liable to be tightly bound in soil. High Cu and B levels in soil have been commonly found also in strawberry fields (Kukkonen and Uosukainen 1999, Niskanen and Dris 2002). It is considered that low strawberry yields might be partially caused by high soil B concentration. In currant fields it might be also necessary to reconsider the amount of B and Cu fertilization.

High soil P values were found in a part of currant fields. In nontilled soil, broadcasted P is bound to 1–2 cm thick surface layer and the soluble P concentration of this layer increases and may lead to higher loss of P by surface runoff and drainage water (Turtola and Jaakkola 1995, Turtola and Kemppainen 1998, Turtola and Yli-Halla 1999). This risk is very possible, because currants are often cultivated on coarse mineral soils and slope fields. The recommended soil P range for currant fields is rather high as compared the present recommendations for cultivation of cereal and other agricultural crops (Yli-Halla et al. 2001). It might be necessary to adjust recommendations for soil P also in currant fields. Furthermore, it could be reasonable to replace surface broadcasting of fertilizers by other fertilization methods like placement fertilization (Niskanen et al. 1999) and fertigation (Kongsrud and Nes 1999) for improvement of the use of nutrients and for prevention of nutrient losses by surface runoff and drainage water.

According to the soil analysis results low Ca, Mg, K and P values were common in currant fields but leaf analysis results were mostly in recommended ranges and did not indicate frequent nutrient deficiences in currant fields. Because the use of commercial analysis of leaf samples has decreased radically, the fertilization has been based only on soil analysis results. Then low soil nutrient values have led to high fertilization recommendations and possibly to use of superfluous high fertilizer doses.

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SELOSTUS

Herukkaviljelmien ravinnetila

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Musta-, puna- ja valkoherukkaviljelmien ravinnetilan määrittämiseksi koottiin Viljavuuspalvelu Oy:n marjasarja-analyysien tuloksia vuosilta 1982–1991. Aineisto käsitti maa-analyysin (pH, NO_3-N, P, K, Ca, Mg, B, Cu, Mn) ja herukan lehtien ravinnepitoisuudet (N, P, K, Ca, Mg, B) yhteensä 357 viljelmältä Etelä- ja Keski-Suomesta. Aineistosta selvitettiin, oliko maan ja lehtien ravinnepitoisuuksien välillä yhteyttä, ja kuinka hyvin ravinnepitoisuudet vastasivat suositusarvoja sekä kuvasivat viljelmien ravinnetilaa.

Maanäytteiden keskimääräinen pH sekä fosforin ja kaliumin pitoisuudet ja pH-korjattu mangaani olivat suositusten mukaisia. Suurimmassa osassa maanäytteistä kalsiumin pitoisuus, yli 60 % näytteistä magnesiumin pitoisuus ja yli 50 % näytteistä fosforin pitoisuus alitti suosituksen, mutta boorin ja kuparin pitoisuudet ylittivät usein suosituksen. Lehtien keskimääräiset typen, fosforin ja kaliumin pitoisuudet kaikilla herukoilla, magnesiumin pitoisuus musta- ja punaherukoilla sekä kalsiumin ja boorin pitoisuudet mustaherukalla olivat suositusten mukaisia. Valkoherukalla 74 % lehtinäytteistä magnesiumpitoisuus alitti suosituksen. Lehtien ja maan fosforin, kalsiumin ja magnesiumin pitoisuuksien välillä oli melko heikko yhteys. Vaikka ravinnetila oli lehtianalyysin perusteella hyvä, maan fosforin, magnesiumin ja kalsiumin pitoisuudet olivat usein pieniä. Tämä viittaa siihen, että karkeilla kivennäismailla maa-analyysin ravinnesuositusten alaraja on liian korkea. Maa-analyysin pienet ravinnepitoisuudet saattavat johtua myös ravinteiden epätasaisesta jakautumisesta ja laimenemisesta maanäytteessä, koska pintalannoituksen ja muokkaamattomuuden vuoksi ravinteet ovat kertyneet aivan maan pintakerrokseen.