State Research Organization for Plant Culture **Report No. 1062**

State Research Station Blangstedgaard (Dir. E. Poulsen)

The Nutritional State of Danish Fruit Orchards as Shown by Leaf Analysis

I. Apples 1963-66

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Summary

During 1963-66, leaf samples from 42 danish apple orchards were analyzed for N, P, K, Ca, Mg, B, and Mn. The level of the individual nutrient is found to be in agreement with results from many other countries. On the basis of these tests the state of nutrients can be described as quite satisfying, although there is some degree of excess nitrogen, potassium, and a deficiency of magnesium and boron.

The established sufficiency level for the single nutrient in other countries are found to be valid for danish apple orchards.

Introduction

In 1963 a cooperative project was established between State Research Station Blangstedgaard and advisors in D.E.F. (Danish Fruitgrowers Association) with the object of analyzing leaf samples from representative danish orchards. This data was used to determine the present nutritional state and the optimum range of each nutrient for danish conditions.

The research was initiated by Lic. Agro. Erik Poulsen who with Lic. Agro. P. Hansen led the collection of materials. The analysis and publication was carried out by Cand. Agro. O. Vang-Petersen.

Table 1. Nutritional State of Fruit Trees in Different Growing Areas

Bibl. no.	Growing Area	LEAF ANALYSIS, Part of Dry Matter						
		percent					ppm	
		N	P	K	Ca	Mg	B	Mn
28.	British Colombia	2.47	0.21	1.65	1.26	0.35	—	—
1.	Ontario	1.95	0.22	1.48	—	—	—	—
24.	Pennsylvania	2.45	0.15	1.15	1.35	0.25	40	66
2.	Several areas in U.S.A.	—	—	1.73	—	—	—	—
14.	Michigan	2.37	0.30	1.52	1.39	0.43	107	284
3.	Ohio	2.04	—	1.54	1.18	0.32	29	74
12.	Southeast England	2.80	0.21	1.41	0.85	0.22	—	—
21.	North Rhein	2.79	0.19	1.93	0.99	0.19	—	—
23.	Fyn-Sjaelland	2.41	0.21	1.69	0.71	0.19	—	—
9.	South Sweden	2.72	0.22	1.67	0.98	0.21		
16.	Norway	2.59	0.22	2.24	1.40	0.30	33	
25.	New Eng. & Pennsylvania	2.01	0.17	1.58	1.30	0.24	30	36
	average	2.42	0.21	1.63	1.14	0.28	—	—
	lowest value	1.95	0.15	1.15	0.71	0.19	—	—
	highest value	2.80	0.30	2.24	1.40	0.43	—	—

Similar research has been performed in other countries during the period 1950 to the mid 1960's, this data is shown in Table 1.

On the basis of the data in Table 1 and optimal levels proposed by other researchers (1, 4, 6, 8, 14, 24, 28) plus results from danish experiments (22), the following table has been constructed to characterize the nutritional state of apple orchards.

LEAF ANALYSIS, Part of Dry Matter. Apples

	% N	% P	% K	% Ca	% Mg	ppm B	ppm Mn
1. Deficient..	1.5-1.8	< 0.10	0.5-0.9	< 0.5	0.08-0.14	5-15	5-15
2. Low.....	1.8-2.0	0.10-0.18	0.9-1.2	0.5-0.7	0.14-0.20	15-25	15-25
3. Sufficient .	2.0-2.5	0.18-0.26	1.2-1.7	0.7-1.2	0.20-0.40	25-50	25-100
4. High.....	2.5-3.2	> 0.26	1.7-2.3	> 1.2	> 0.40	> 50	> 100
5. Excessive .	—	—	—	—	—	—	—

The terminology characterizing the results of leaf analysis is that described by *B. Ljones* (1966), and others.

1. *Deficiency:* Yield reduced very significantly. Outstanding deficiency symptoms. Increasing the leafs concentration of this element will bring a significant increase in quantity of yield and in some cases the quality.
2. *Low:* Deficiency symptoms not very apparent. Yield will increase slightly with increased concentration of this element.
3. *Sufficient:* Apperance normal. No effect on quantity or quality by increased concentration.
4. *High:* Supply plentiful. Often a reduction in quality. No actual poisoning symtoms.
5. *Excessive:* Decrease of both quantity and quality. Poisoning symptons can occur.

The optimal levels stated above were used in the evaluation of the leaf analysis.

Materials and Methods

Leaf samples were taken from representative fruit orchards four years in a row. These orchards were in north Sjaelland, south Sjaelland-Lolland-Falster, and Fyn and middle and south Jylland.

Not all the samples collected could be used. For various reasons, mostly the lack of samples for one or more years, some of the testing areas fell away from the project, however 162 localities were represented for the full four year period. Except for boron and manganese, this report is based on a total of 648 analyses of each nutrient, 112 from north Sjaelland, 192 from south Sjaelland-Lolland-Falster, and 344 from Fyn, middle and south Jylland. The leaves were picked without petiole, from the middle third of the present years growth with about 100 leaves per sample, taken from at least 20 trees in the month of August.

The dry material of the leaves was analyzed for N, P, K, Ca, Mg, B and Mn. Total nitrogen (N) is measured by micro-Kjeldahl method, potassium (K) and calcium (Ca) by flame photometric, magnesium (Mg) complexometric, phosphorus (P) by vanadomolybdat method, boron (B) by a diantrimid method, and manganese (Mn) colorimetric. Samples from Sjaelland and Lolland-Falster were analyzed at Statens Planteavls-Laboratorium at Lyngby, Sjaelland. Samples from Fyn were analyzed at Blangstedgaard, Fyn, and those from Jylland were analyzed at Statens Planteavls-Laboratorium division at Vejle, Jylland. The major part of the statistical analysis was done at the Data Analytical Laboratorium at Lyngby, Sjaelland.

Results

The Individual Nutrients

Nitrogen

Variation of nitrogen in the leaf dry material has been very large, ranging from 1.21% to 4.09%. As shown in Table 2, the average content for the full period has been 2.75%. The single year averages deviate very little from each other. In relation to normal criteria for sufficient nitrogen

Picking of leafsample. Foto S. E. Vestergaard

content in leaf dry material, the levels shown have been high. Even in 1964 where the average is lowest, the nitrogen content is somewhat above the sufficiency level. The south Sjaelland-Lolland-Falster area had a somewhat higher nitrogen level than the Fyn-Jylland area (Table 3) presumally as a result of a stronger nitrogen fertilizer. The distribution of the collected samples on different intervals is shown in figure 1a for the single years and in figure 1f as the average of all years together.

The samples are very high in nitrogen as evidenced by 75.3 percent being above the sufficiency level, 21.6 percent being at the sufficiency level, and only 3.1 percent being under that level.

At the single location it is of interest to know the variation from year to year. The data in figure 2.a show how the single years sample varies from the average of the four years. Only 64 percent of the samples are within the average ± 0.2.

Phosphorus

Variations in the samples range from 0.09 to 0.45 percent P. For the full period the average content has been 0.23 percent (Table 2) which is satisfactory in relation to the sufficiency level. In some cases, the single years average shows some difference, but the fluctuation is so slight that it is not given any significance. The variation between the different growing areas is slight (Table 3) but south Sjaelland, Lolland and Falster has a somewhat lower content than the rest of the growing areas. For the four year period, 10.5 percent of the samples are above the sufficiency level, 76.5 percent are at that level, and 13.0 percent below the sufficiency level (figures 1b and 1f).

For a single locality, only 67 percent of the samples are within the average $\pm$ 0,02 (figure 2b).

Table 2

LEAF ANALYSIS. Total Sampling Area

	Average	Sampling Year				LSD_{95}	cV	sign.
	1963-66	1963	1964	1965	1966		%	
% N.....	2.75	2.79	2.61	2.67	2.90	0.06	9.5	***
% P.....	0.23	0.21	0.21	0.23	0.24	0.01	12.8	***
% K.....	1.63	1.55	1.54	1.52	1.72	0.06	15.6	***
% Ca.....	0.94	0.98	0.95	0.92	0.99	0.04	18.7	***
% Mg.....	0.21	0.21	0.21	0.20	0.22	0.01	19.4	***
* Bor ppm	19	—	15	17	25	4	52.6	***
** Mn ppm	108	—	98	117	—	—	125.9	N.S.

* 69 localities on Sjaelland, Lolland-F. ** 56 localities on South Sjaelland, Lolland-F.

Table 3

LEAF ANALYSIS, Part of Dry Matter

	North Sjaeland	South Sjaell. Loll.-Falster	Fyn South Jylland	LSD_{95}	Sign.
	percent				
% N.....	2.83	2.85	2.66	0.12	***
% P.....	0.23 ab	0.21 a	0.23 b	0.02[1])	***
% K.....	1.78	1.48	1.57	0.15	***
% Ca.....	0.95	1.04	0.93	0.11	**
% Mg.....	0.22	0.21	0.21	—	*

1. Means followed by different letters, the difference is significant.

Potassium

Potassium content ranged from 0.62 percent to 2.84 percent with an average of 1.63 percent (Table 2) which is in the upper part of the sufficiency level. In three of the four test years there is good agreement between the yearly averages while the fourth year has a higher potassium level. There is significant variation among the growing areas with north Sjaelland at a higher level than both south Sjaelland-Lolland-Falster and middle Fyn and south Jylland.

The total sample has 27.8 percent above the sufficiency level, 67.3 percent at that level and only 4.9 percent below the level (figures 1c and 1f). The deviation at each locality is shown in figure 2c where 66 percent of the samples are within the average ± 0.2.

Calcium

The calcium content ranges from 0.46 to 2.16 percent with a four year average of 0.94 percent (Table 2). There is little variation among the yearly average and while some differences of the individual samples exist, the deviations are slight. The variations among the different parts of the country (Table 3) are so small that they cannot be given special meaning. During the four year period, 19.2 percent of the samples were above the sufficiency level, 75.9 percent at that level and 4.9 percent below the sufficiency level (figures 1e and 1f). The variation at a single location is shown in figure 2d where 81 percent of the samples are within the average ± 0.2.

Magnesium

While evaluating the magnesium content of apple tree leaves it must be remembered that many orchards are sprayed systematically with magnesium during the growing season which strongly affects the leaf's content. The range of magnesium content was from 0.07 to 0.56 percent with a four year average of 0.21 percent. Deviations of any single year average from the four year average are too small to be of importance. The differences among the growing areas are also too small to be of any significance (Table 3).

During the four years, 2.4 percent of the samples were above the sufficiency level, 48.8 percent at that level and 48.8 percent below the sufficiency level (figures 1d and 1f). Finally the data from a single locality show 50 percent of the samples within the average ± 0.02 (figure 2e).

Boron

During the test period, boron content ranged from 10 to 40 p.p.m. with an average of 19 p.p.m. which is below the sufficiency level. Year to year variations are small (Table 2) though there are noticeable differences between 1964-1965, and 1966. Over the collection period, 85 percent of the samples have been above the sufficiency level and 15 percent of the samples at the sufficiency level. (192 samples total).

Manganese

The manganese samples are similar to magnesium in that manganese fertilizer is also sprayed either

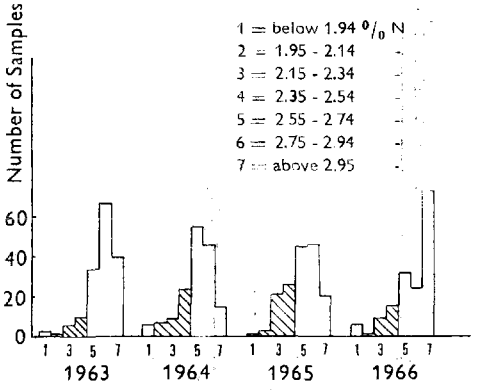

Fig. 1a. Nitrogen

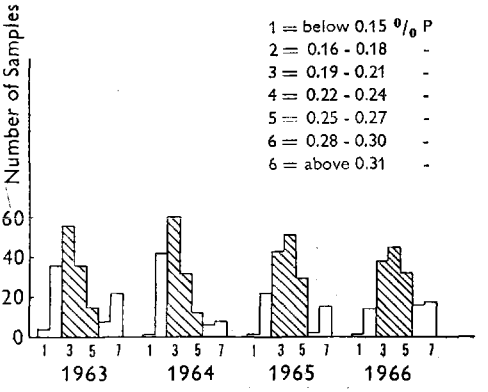

Fig. 1b. Phosphorus

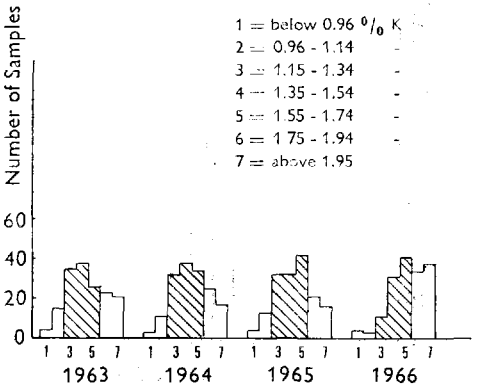

Fig. 1c. Potassium

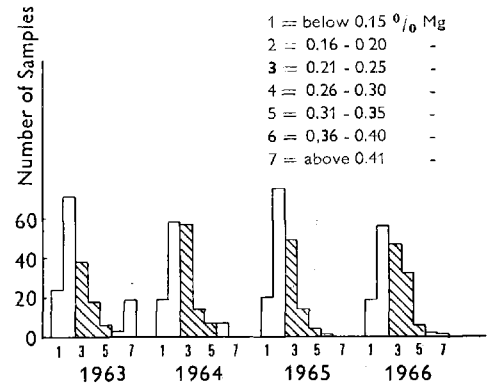

Fig. 1d. Magnesium

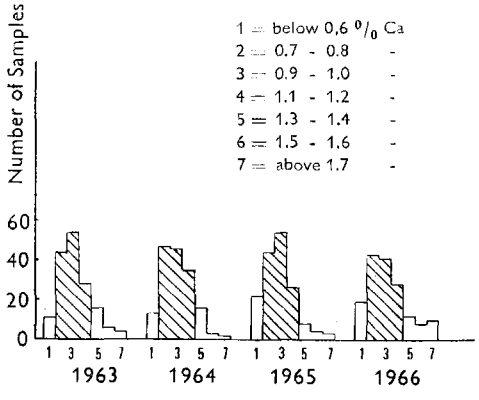

Fig. 1e. Calcium

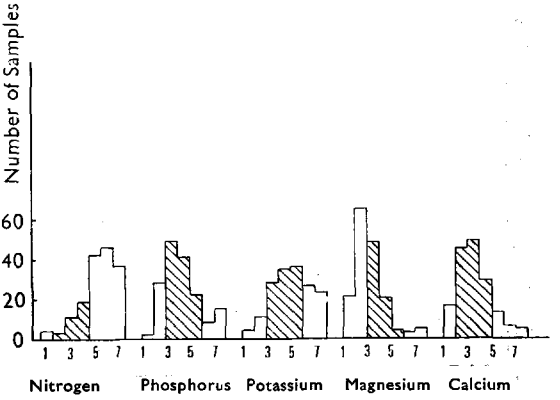

Fig. 1f. 1963-1966. All nutrients. Average

Figure 1a-f. Destribution of leaf samples according to nutrient content. Hatching shows terms of sufficiency for concerning nutrients.

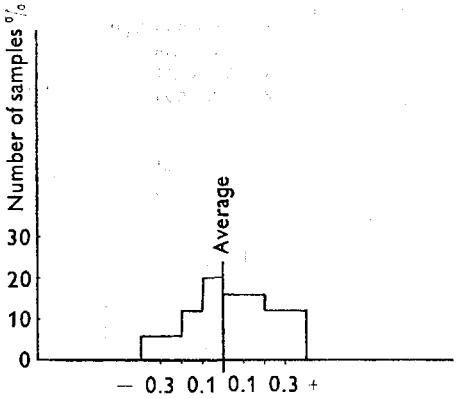

Fig. 2a. Nitrogen

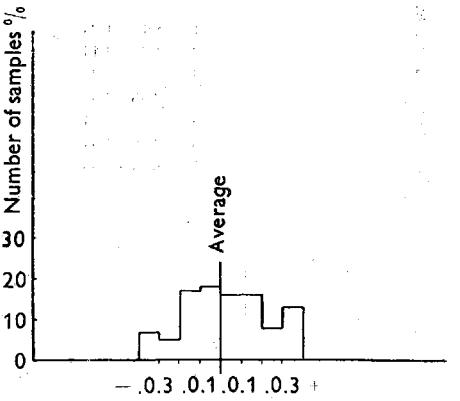

Fig. 2b Phosphorus

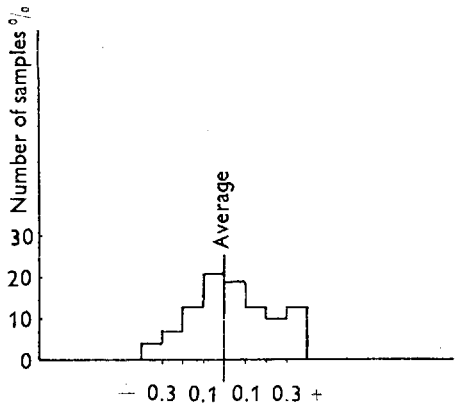

Fig. 2c. Potassium

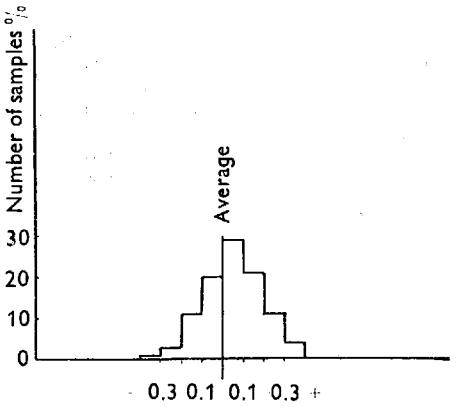

Fig. 2d. Calcium

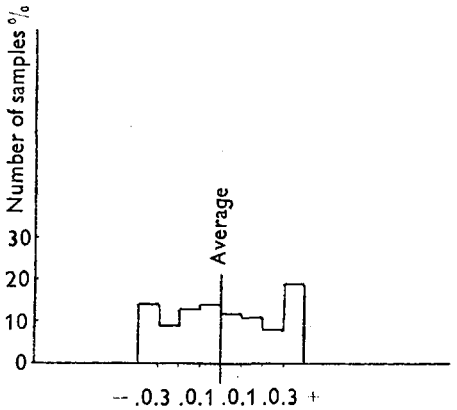

Fig. 2e. Magnesium

Figure 2a-e. Distribution of the leafsamples in the single year proportional to average 1963-66 for concerning locality.

directly with manganese fertilizer or with fungicides containing manganese. When an unusually large variation is found, 11 p.p.m. to 586 p.p.m. in this case, it must be presumed to be due to this situation. The average for the collection period was 108 p.p.m. Mn. which is a little higher than the sufficiency level. Of the 136 samples, 20 percent were above the sufficiency level, 52 percent at, and 28 percent below the sufficiency level.

Table 4. Interactions Between Different Nutrients

		r	sign.
% N — % Mg	y = 2.48+0.01 x	0.203	***
% K — % Ca	y = 1.89÷0.32 x	÷0.266	***
% K — % P	y = 1.18+0.02 x	0.244	***
% K — % Mg	y = 1.91÷0.02 x	÷0.252	***
% Ca — % P	y = 1.10÷0.01 x	÷0.102	*
% Ca — % Mg	y = 0.64+0.02 x	0.307	***

Interaction

Nutrients Mutual Relationship

The extent to which the content of one nutrient affects the content of the other nutrients is shown in Table 4. There is a noticeable correlation as pairs between several of the nutrients, however a meaningful co-variation can only be proven for potassium-calcium and calcium-magnesium.

Table 5. LEAF ANALYSIS, Percent of Dry Matter

	N	P	K	Ca	Mg
Cox Orange.....	2.85	0.23	1.66	0.78	.20
Ingrid Marie.....	2.83	0.24	1.51	0.95	.23
Golden Del.....	2.60	0.20	1.74	1.18	.20
LSD_{95}.....	.06	—	.06	.05	—

Cultivar Variations

In the samples collected there were a large number of varieties of which Cox Orange, Ingrid Marie, and Golden Delicious were the major portion (approximately 530 samples). Table 5 shows the results of analysis for these three varities. Golden Delicious differs from the other two by a lower nitrogen content and a significantly higher calcium content while both Cox Orange and Golden Delicious have a higher potassium content than Ingrid Marie.

Table 6. LEAF ANALYSIS, Percent of Dry Matter

soil type	N	P	K*	Ca	Mg
Heavy.....	2.71	0.23	1.56a	0.92	0.20
Medium heavy...	2.76	0.22	1.54a	0.97	0.21
Light.....	2.85	0.21	1.81b	0.96	0.22
SIGN.....	***	—	***	—	—

*) Means followed by different letters, the difference is significant.

Soil Type

A tabulation of the material for various soil types is shown in Table 6. Nitrogen is found in ever rising content with decreasing degree of soil heaviness. Potassium also has higher content in the light soils than in the heavy and medium heavy soils. Phosphorus, calcium and manganese are not affected by soil type.

Discussion

Results of tests similar to that of this report are shown in Table 1. For comparison purposes, the results of this report are shown in Table 7 with the averages of norwegian, swedish, german and english results. Agreement is very good, comparison of the range of data is also in good agreement.

Table 7. LEAF ANALYSIS, Percent of Dry Matter

	N	P	K	Ca	Mg
average:					
9,12,16 and 21	2.72	0.21	1.81	1.06	0.21
» of danish samples.....	2.75	0.23	1.63	0.94	0.21

For nitrogen, *Kenworthy* (1950) has found 1.69 percent and *Reinken* (1969) 4.25 percent as outer limits. The high average for the danish orchards must be seen in the light of the common practice of using some nitrogen fertilizer in spite of test results showing no advantage, as long as clean soil plus cover crop is the preferred method of cultivation.

In later analysis, *Smith* (1968) found lower N content, possibly as a result of instruction to practice wholly or partly on the basis of present knowledge and of a more widespread use of nitrogen consuming grass strips as cover-crop.

Holland (1965) and *Beattie* (1950) have each found on the basis of materials from 30 and 29 orchards respectively that the spread is nearly equal to those found here.

For phosphorus *Reinken* (1969) found 0.13 percent P and Kenworthy (1950) 0.75 percent P as the lower and higher values respectively. On the whole, danish orchards compare very well to the sufficiency level. In view of the fact that phosphorus fertilizing is used very little, it is noteworthy that only 13 percent of the samples are below the sufficiency level.

Potassium is one of the key nutrients for fruit trees, so fruitgrowers have been diligent in fertilizing with potassium. It is not surprising that many samples are above the sufficiency level, even though the contrast is not as great as with nitrogen. *Batjer* (1938) has found 0.49 percent K and *Reinken* (1969) 3.22 percent as the lowest and highest value in their tests. The variations in the danish orchards agree with these results. The reason that north Sjaelland has higher potassium content in the leaves cannot be explained on the basis of present knowledge, however, a difference in soil type (lighter) and in fertilizer practice seems most likely.

The variation for calcium, magnesium, boron, and manganese are equal to what has been found in earlier tests (3, 13, 21, 28). Even though the same fertilizer is not used from year to year in each locality, the major part of the localities can be seen to be fertilized equally in the sampled years. The fact that in spite of equal fertilization there is a noticeable difference among the years for all nutrients (except Mn) is attributed to alternate fruit bearing (7, 11, 15, 18) and the climate. *Poulsen* and *Hansen* (20) report a great temperature and precipitation variation in the soil nitrate producing ability. The higher level of nutrients in 1966 could have been caused by a very early winter with permanent frost by November 10. 1965 which reduced the natural washout of nitrogen especially, and to some degree that of potassium.

Equivalent yearly variations have been found by Whitfield (1965), *Smith* et al. (1952), and *Holland* (1965) who report that variations between years are greater than the variations between the orchards in a single year. The established variety difference is in agreement with observations made by *P. Hansen* (1965) and *N. Smith* (1968) among others.

Conclusion

On the basis of collected leaf samples from apple trees in a number of danish fruit orchards it has been established that the level of the single nutrients in a leaf analysis closely resembles what has been found in Norway, Sweden, Germany, England, and U.S.A.

During the collection period 1963-66, the apple trees have been oversupplied with nitrogen and potassium sufficient supplied with phosphorus, calcium, and manganese, and undersupplied with magnesium and boron.

The sufficiency levels which have been established on the basis of tests in foreign countries seem adequate for danish situation as far as the areas range and level is concerned and the present test results give no basis for change.

The nutrient content varies from year to year for a single locality, possibly due to climate and yield variations. This uncertainty with single samples representing average situations is quite large in relation to the range of the sufficiency levels.

Nutrient status in danish apple orchards can be described as quite satisfying especially since fertilizing technical development after the sampling period (1963-66) has resulted in better possibilities for regulating the trees supply.

Resumé

Ernæringstilstand i danske frugtplantager belyst ved bladanalyser. I. Æbler 1963-66.

I årene 1963-66 er indsamlet bladprøver i 42 danske frugtplantager til analysering for N, P, K, Ca, Mg, B og Mn. Niveau af de enkelte næringsstoffer er fundet at være i god overensstemmelse med, hvad der tidligere er fundet i en række andre lande. På grundlag af det foreliggende materiale kan ernæringstilstanden betegnes som ret tilfredsstillende, idet der i nogen grad er tale om overforsyning med kvælstof og kalium og underforsyning med magnesium og bor. De stipulerede

Table 8. LEAF ANALYSIS, Percent of Dry Matter 1963-66

Growing Area		Locality	N	P	K	Mg	Ca
North Sjaelland	1	Poul Frederiksen, Lillevang, Roskilde	2.76	0.24	1.54	0.19	1.07
	2	C. P. Frohn, Kattinge, Roskilde	2.91	0.27	1.47	0.23	1.15
	3	E. Sørensen, Lundtorph, Tikøb	2.61	0.19	2.12	0.15	0.87
	4	Haregabsgården, Græsted	2.85	0.23	1.96	0.14	0.95
	5	Herman Jensen, Hønsinge	2.48	0.24	1.94	0.20	0.86
	6	H. Beier, Kobbelgården, Jægerspris	2.91	0.21	1.84	0.32	1.01
	7	Maglemose Frugtplantage, Vedbæk	3.23	0.24	1.64	0.16	0.98
	8	Kettinge Frugtplantage, Hørsholm	2.69	0.23	1.99	0.20	0.70
	9	Askhavegård, Hastrup, Gadstrup	2.69	0.32	1.56	0.24	1.12
	10	N. P. Nielsen, Tissø, Jørslev Sj.	2.80	0.18	1.96	0.19	0.94
	11	Krogelund Frugtplantage, Kvistgård	2.72	0.22	1.99	0.20	0.82
	12	Holmehus Frugtplantage, Kvistgård	2.91	0.23	1.74	0.25	0.76
South Sjaelland	13	P. Nielsen, Guldborghave, Guldborg	2.76	0.21	1.53	0.23	1.17
Lolland-Falster	14	La Cour, Poppelgården, Nakskov	2.80	0.21	1.24	0.26	1.15
	15	P. Glarbo, Lollands Frgtpl. Frejlev	2.85	0.23	1.46	0.14	0.77
	16	K. Jensen, Erdrup, Boelslunde	2.91	0.21	1.62	0.23	0.88
	17	H. Hansen, Guldborgland, Guldborg	2.63	0.20	1.34	0.21	1.21
	18	E. Lolle, Killerup, Saxkøbing	2.99	0.21	1.54	0.21	1.17
	19	M. Tønnesen, Nr. Alslev	2.94	0.19	1.42	0.22	1.08
	20	P. Schilling, Frejlev, Kettinge	2.61	0.22	1.45	0.19	1.05
	21	P. Jensen, Karrebæksminde	2.96	0.23	1.73	0.19	0.92
Funen	22	E. Haugaard, Farstrup	2.73	0.22	1.59	0.23	0.92
	23	J. Nordenbæk, Emmelev, Otterup	3.06	0.22	1.84	0.22	1.15
	24	A. Gjaldbæk, Horsebæk, Otterup	2.90	0.23	1.60	0.22	0.91
	25	L. Mortensen, Kauslunde	2.98	0.27	1.66	0.21	0.68
	26	Th. Jensen, Bogø, Otterup	2.85	0.20	1.62	0.19	1.02
	27	J. Øbroe, Kauslunde	2.78	0.23	1.56	0.19	0.90
Jutland	28	Christiansen, Søborg, Glud, Horsens	2.52	0.18	1.65	0.23	0.83
	29	Klejsgård Frgtpl. Klejs, Juelsminde	2.66	0.23	1.77	0.16	1.00
	30	A. S. Daugård Strands Frgtpl. Daugård	2.09	0.33	1.76	0.16	0.91
	31	I. Hansen, Sottruptræer Vester Sottrup	2.83	0.21	1.41	0.20	0.84
	32	Niels Bang Jacobsen, Daugård	2.48	0.32	1.77	0.16	0.68
	33	Jens Carlo Jensen, Skablund, Hundslund	2.64	0.20	1.61	0.18	0.84
	34	Jessen, Calvinsvej 36, Fredericia	2.39	0.29	1.69	0.19	0.67
	35	Johansen, Alpedalen, Kolding	2.59	0.20	1.74	0.20	0.80
	36	P. B. Jørgensen, Stensballe, Horsens	2.45	0.22	1.57	0.20	0.95
	37	Rasmus Knudsen, Årøsund	2.57	0.19	1.21	0.22	0.98
	38	Svend Korsholm, Åkjær, Bjært	2.70	0.23	1.42	0.22	1.03
	39	Chr. Christiansen, Elmose, Malling	2.56	0.19	1.50	0.21	0.78
	40	Trappergårdens Frgtpl. Strdh. Kolding	2.92	0.23	1.87	0.21	0.87
	41	P. G. Olsen, Erritsø, Fredericia	2.73	0.26	1.43	0.28	0.84
	42	Lauritsminde Frugtplantage, Varmark	2.90	0.24	1.31	0.25	1.23
Average		All Orchards	2.75	0.23	1.63	0.21	0.94

optimalområder for de enkelte næringsstoffer findes at gælde for danske æbleplantager på linie med, hvad der er tilfældet i andre lande.

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References

1. *Archibald, J. A.* (1964). Weather effects on Leaf-Nutrient Composition of Fruit Crops. Plant Analysis and Fertilizer Problems IV, 1964, 1-8.
2. *Batjer, L. P.* and *J. R. Magness* (1938). Potassium content of Leaves from commercial apple orchards. Proc.Amer.Soc.Hort.Sci. 36, 197-201.
3. *Beattie, James M. & C. W. Ellenwood* (1950). A survey of the nutrient status of Ohio apple trees. Proc.Amer.Soc.Hort.Sci. 55, 47-50.
4. *Benson, N. R.* and *S. C. Vandecaveye* (1951). Soil fertility conditions in the apple orchards of North Central Washington. Bulletin No. 527, The State College of Washington.
5. *Bould, C., E. G. Bradfield* and *G. M. Clarke* (1960). Leaf analysis as a guide to the nutrition of fruit crops. I. general principles, sampling tecniques and analytical methods. J. Sci. Food Agric. 11, 229-42.
6. *Bould, C.* and *R. M. Jarrett* (1962). The effect of cover crops and NPK fertilizers on growth, crop yield and leaf nutrient status of young dessert apple trees. J. Hort. Sci. 37, 58-82.
7. *Cain, John C.*, and *Damon Boynton* (1948). Some effects of season, fruit crop and nitrogen fertilization on the mineral composition of McIntosh apple leaves. Proc. Amer. Soc.Hort.Sci. 51, 13-21.
8. *Dowd, Oscar J.* (1949). Observations on Boron Deficiency in Apples in Southwestern Michigan. Proc.Amer.Soc.Hort.Sci. 53, 23-25.
9. *Fernqvist, Ingvald* (1965) Tables: Leaf analyses of fruittrees and strawberry plants. Stencilprint, Department of Pomology, Agricultural College of Sweden. Institut for Frugt- og bærodling. Alnarp.
10. *Fernqvist, Ingvald* (1971). Bladanalyser från Gödslingsforsök i Skåne. Nordisk Jordbrugsforskning (1971), 1, 64-66.
11. *Hansen, P.* (1965). Æbleblades næringsstofindhold II. Afhængighed af grundstamme, sort, år, bæring og nedbør. Tidsskr. f. Planteavl 69, 305-313.
12. *Holland, D. A.* (1965). Variability in the chemical composition of leaf samples from commercial apple orchards. Rep. E. Malling Res.Sta. for 1965 (1966) 110-114.
13. *Kenworthy, A. L.* (1950). Nutrientelement composition of leaves from fruit trees. Proc.Amer.Soc. Hort.Sci. 55, 41-6.
14. *Kenworthy, A. L.* (1955). Leaf analysis as a grower service in Michigan. Quarterly Bulletin, The Michigan Agricultural Experiment Station, Michigan State College, East Lansing Vol. 37, 4 p. 486-488.
15. *Lamb, J. G. D., Golden, J. D.* and *Power, M.* (1959). Chemical composition of the shoot leaves of the apple Laxton's Superb, as affected by biennial bearing. J.Hort.Sci. 34, 193-98.
16. *Ljones, Bjarne* og *Braadlie* (1954). Innhaldet av plantenæringsemne i epleblad frå norske frukthagar. Forskn. og forsøk i landbr. 5, 115-140.
17. *Ljones, Bjarne* (1966). Ranges of the nutrient status of fruit trees and small fruits as evaluated by leaf analyses and yield records. Meld. Norges Landbr.Høgsk. 45, 12.
18. *Mason, A. C.* (1955). A note on differences in mineral content of apple leaves associated with fruiting and non-fruiting of biennial bearing trees. Rep. E. Malling Res.Sta. for 1954 (1955) 122-25.
19. *Mason, A. C.* and *A. B. Whitfield* (1958). A progress report on the mineral composition of leaves from selected apple orchards in the eastern counties of England. Rep. E. Malling Res.Sta. for 1958 (1959) 86-88.
20. *Poulsen, E.* og *Poul Hansen* (1962). Undersøgelser over jordens nitratindhold. Tidssk. f. Planteavl 65, 206-234.
21. *Reinken, G.* (1969). Mehrjahrige Ergebnisse und Erfahrungen mit Blattanalysen und Bodenuntersuchungen in Nordrheinischen Erwerbsobstbaubetrieben. Der Erwerbsobstbau 11, 27-30.
22. *Sandvad K*, og *H. M. Jepsen* (1967). Forsøg med kvælstofgødning til æbletræer under forskellige kulturforhold. Tidsskr. f. Planteavl 70, 76-90.
23. *Schmidt, N.* (1968). Bladanalyser. Erhvervsfrugtavleren *35*, 230-3.
24. *Smith, Cyril B. & George A. Taylor* (1952). Tentative optimum leaf concentrations of several elements for Alberta Peach and Stayman apple in Pennsylvania orchards. Proc.Amer.Soc.Hort.Sci. 60, 33-41.
25. *Walrath, E. K.* and *Rodger C. Smith* (1952). Survey of forty Apple orchards. Proc.Amer.Soc.Hort.Sci. 60, 22-32.

26. *Warren, C. Stiles* (1969). Nutritional status of Maine orchards after six years of leaf analysis service. Res.Life.Sci. 17 (1), 1-5.
27. *Whitfield, A. B.* (1965). The mineral composition of leaves from selected apple orchards in some south-eastern and eastern counties of England. Rep.E.Malling Res. Sta. for 1965, 146-147.
28. *Woodbridge, C. G., N. R. Benson* and *L. P. Batjer* (1961). Nutrition of fruit trees in the semiarid regions of the pacific northwest. Am.Inst. of Biol. Sci. publ. no. 8, 64-73.

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