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Soil testing and advice on plant feeding.

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Soil testing and advice on plant feeding

1. Taking Soil Samples

- a). The soil samples are taken till a depth of 30 cm. For fruit it may be important to know the chemical composition of the sub soil (30-60 cm).
- b). Each sample should be made up of at least twenty borings, fewer than this might not provide a representative sample.
- c). Borings should be taken systematically from all over the house. If the house has trenches for watering, samples should be taken in the trenches as well as in the walks.
- d). Samples from different houses should not be mixed.
- e). The size of a soil plot that can be represented by one sample, depends on the horizontal and vertical homogeneity of the ground.
- f). To get a characteristic sample one should make a vertical slice of even thickness, twenty fold, or twenty borings made with a soil drill of suitable length.

2. Summary of applied methods in soil testing

a. Glasshouse soils

Preliminary preparation. Each soil sample is thoroughly mixed; stones and branches, if any, are removed. Almost a kilogram of each sample is dried by means of heated air of 45°C, till it can be considered "air dry". All superfluous soil is cast away. The dried soil is grounded before it is ready for next tests.

Moisture content: 10 gram air dry soil is dried during 15 hours in a kiln at 110°C. Its loss in weight by evaporation is converted to determine the percentage of moisture left in the air dry sample concerned.

Organic matter content: the same sample, that was dried 15 hours at 110°C and weighed before, is heated afterwards at 600°C, during two hours. Its loss on ignition is converted into percentage of organic matter in the dry soil. Corrections for CaCO<sub>3</sub> and for water of crystallization are not performed.

Calcium Carbonate: 5 gram of air dry soil is treated with hydrochloric acid. The volume of liberated  $\text{CO}_2$  gas is measured and converted to evaluate the percentage of  $\text{CaCO}_3$  in the dry soil. Such a determination is known as "method of Scheibler".

pH-water: air dry soil <sup>and</sup> demineralised water are well stirred in a proportion of 1 (: ) 5 then left undisturbed during a night. This mixture is well stirred again and immediately afterwards measured by means of a pH meter, provided with a glass- and calomel electrode. The pH value is direct readable.

The next five measurements are executed in a watery extract, prepared as follows: air dry soil and demineralised water in a proportion of 1 (: ) 5 are mechanically shaken, during 15 minutes at room-temperature. The shaking bottles stay in a vertical position, while they are shaken in horizontal direction. The watery basic solution is ready after filtering through "Schut VF 215".

Chlorides: 25 milli-liter of the mentioned extract is titrated with  $\text{Hg}(\text{NO}_3)_2$  at a pH 2.0 - 3.5. Diphenyl carbazone and bromphenol-blue are added as indicator. The quantity of used titration liquid is converted into mgr. NaCl per 100 g of soil. This determination is described, among others, in "Normaalblad NEN 3130".

Electrical power conductivity: the conductivity is measured with a "Phillips conductivity meter" provided with a micro-electrode cell with a rubber sucker. The read value is calculated in mmho at  $18^\circ\text{C}$ , after correction on temperature and on electrode cell factor. The outcome is multiplied with an empirically fixed factor 0.44 to get the total salt content in gram per 100 g of dry soil.

Nitrogen: 25 ml of the watery extract and solutions of  $\text{FeSO}_4$ ,  $\text{AgSO}_4$  and NaOH are poured in a glass retort, which is fixed to a cooler. The content of a retort is boiled during half an hour, so all nitrogen is concentrated into ammonium-compounds, that is driven out as  $\text{NH}_3$  and fixed in boric acid. The quantity of  $\text{NH}_3$  is measured by titration with  $\text{H}_2\text{SO}_4$  and recalculated to known the N content in mg per 100 g of dry soil. This method is published by "Cotte and Kahane" in the "Bulletin de la Société chimique de France" 1946 : 542/4.

Phosphorus: the phosphorus content is measured with a colorimeter. Blue coloration develops from phosphate with molybdate, methol and ascorbic

acid. The measurements of color intensities are done with a colorimeter made by Kipp - Delft, type Engel. The found extinction value is recalculated (by comparison of a curve made with a progressive series of standard solutions) and given in mg  $P_2O_5$  per 100 g of dry soil. This modification of phosphorus measurements is described by Murphy and Riley in "Anal. chem. Act 1962: 27 - 31/6.

Potash: potash is measured with a flame photometer from Kipp - Delft. The found value is recalculated by means of a range of standard solutions to produce mg  $K_2O$  per 100 g of dry soil.

Next four measurements <sup>are</sup> realised in an "Extract of Morgan" that is prepared as follows: air dry soil and the extraction solution of Morgan (sodiumacetate-buffer, having a pH of 4.80) are vigorously shaken in a gr/ml proportion of 1 (: ) 2,5 during 30 minutes at room-temperature and finally filtered with paper "Schut V 257". Under "making a watery extract" the method of shaking is already described.

Magnesium, Manganese, Iron and Aluminium: these cations are measured colorimetric. The applied working method and the used type of colorimeter are described under "Phosphorus". The extinction values are recalculated till: parts per million in the extract. The essential colours are produced: to measure the Mg-content with/titan-yellow, to know the Mn-content through oxydation into permanganate, for the iron-content with orthofenantroline and for the aluminium-content with aluminon. Last mentioned the methods four measurements are described, among others in the "Netherlands journal of Agricultural Science" 9, 1961, 2-16 by Schuffelen, Prof. dr. A.C. and collaborators.

The extractions and measurements are all executed in twofold, by different persons. The needed apparatus is also in duplo available. The two outcomes are checked by means of statistically found standards. Not fitting figures are investigated another time.

#### b. ===== Potting soils:

The methods of determination are identic with those for glasshouse soil. The extraction-liquids are applied in an other proportion: 1 (: ) 10 on behalf of pH-water.

The watery extract is made from air dry soil and demineralised water in a proportion 1 (: ) 25; and the Morgan extract 1 (: ) 10.

3. Possibilities of analysing soil samples on behalf of practical growers and interpretation of its analysis figures
- a. Complete analysis: this includes: Organic matter, Calcium carbonate, pH, Iron, Aluminium, chlorides, Total salt content (power-conductivity), Nitrogen, Phosphate, Potash, Magnesium and Manganese. Samples for this type of analysing are taken before the start of a new crop .. or when there were taken never soil samples before.
- b. Soil analysing for topdressing: in this case only chlorides, conductivity, Nitrogen, Phosphate and Potash are analysed. It is special used during the culture of crops as tomato, cucumber, carnation and rose.
- c. Determination of lime requirements: the growers become here the analysis of carbonates, pH, Iron- and Aluminium-level.
- d. Determination of the situation of soluble salts: herefore chlorides<sup>and</sup> conductivity levels are measured. This is specially done to know when the soil has to been washed out.
- e. Potting soil analysing: the same methods are applied for such a complete analysing, but while other proportions of the extract liquids are used. There is also another interpretation of its analyse-figures, in comparison to glasshouse soils.

#### Interpretation of the figures

Organic matter: the content is given in percentage of weight of the dry soil. It gives in the first place an indication of the capacity of the soil to hold water. This is important to interpret the salt- and nutrient/values of the soil. The organic-matter content can - only partly - give information about the structure of the soil. Sandy soils contain seldom more than 2 % of organic matter. In clay soils this content can go till 15 %. When the soil contains more than 30 % of organic matter, we call it "peat".

Calcium carbonate: this is also given in percentage of the dry soil. Young sea clay soils are often rich in calcium carbonate. From older sea clay soils it is washed out or removed by the plants. Diluvial sandy soils are poor in calcium carbonate. Alluvial sandy soils are, often rich in calcium-carbonate. Peat soils seldom contain much calcium carbonate.

pH: there is a very close relation between the pH and the calcium-carbonate content of the soil. When the pH is lower than the next values, chalk is given

sand	pH 6.3
sandy clay	" 6.5
clay	" 6.7
peat	" 5.0

Iron and Aluminium: the figures are given in p.p.m., after determination in the extract. In an acid soil and in a soil with bad permeability for water and air, high figures for Iron and Aluminium are often found. For mineral soils the figures for both elements should not be higher than: 2.0; for peaty soils: 6.0. More mobile Iron as well as Aluminium are often dangerous because: the soluble Phosphate will be fixated in the first place; secondly because the organic matter will get dehydrated in an irreversibel way.

Sodium chloride: this is given in mg per 100 g of dry soil. The water used for watering contains - especially in the west of the Netherlands - sometimes much sodium chloride. The tolerable limit for sodium chloride depends on the level of the organic matter content. According this if a soil contains more organic matter, it will retain more water per unit of weight. As a general rule we may apply that the sodium chloride content should not be higher than two times the organic <sup>matter</sup> content plus fifteen; or:

.. mg NaCl/100 g dry soil = 15 + 2 x .. % org. m.c. of dry soil.

Power conductivity: the total soluble salts content is given in percentage of the dry soil. Almost the same relation does apply to this item regarding the organic matter content as explained for sodium chloride. As a general rule for the admissible limit one can take: two times the organic matter content plus fifteen (however) divided by hundred now. A comparison of this standard <sup>with</sup> those of sodium chloride tells us, that the admissible limit of the conductivity is ten times higher than the admissible limit of Sodium chloride. The here mentioned standards are the average of the need of many crops. For advisory work one takes into account, for example, that lettuce is more sensitive for salt than tomatoes. The season is also important. For cucumbers is a higher salt content admissible in autumn and winter than in summer.

Nitrogen: the Nitrogen-level of mineral soils is evaluated as follows

<u>Nitrogen figures</u>	<u>Classification</u>
0 - 3.0	low
3.1 - 6.0	moderately low
6.1 - 9.0	normal
9.1 - 12.0	moderately high
12.1 →	"just high till "high"

Just what counts for the sodium chloride content and the power conductivity, the figures for N must also be higher, when the organic matter content is higher, to promote the same satisfaction.

For 20 % organic matter is this two times the figure, for 30 % organic matter three times and so on.

Phosphorus: the  $P_2O_5$  content is given in mg. per 100 g of dry soil. This figure gives better information in the degree of solubility of the present phosphates, than that it indicates an exact quantity.

The valuation is as follows

<u>Phosphate figure</u>	<u>Classification</u>
0 - 2.0	low
2.1 - 4.0	moderately low
4.1 - 6.0	normal
6.1 - 8.0	moderately high
8.1 →	high

Potash:  $K_2O$  is also given in mg. per 100 g dry soil. For the potash valuation exists, the same relation regarding the organic matter content, as for nitrogen. The valuation is as follows

<u>Potash figure</u>	<u>Classification</u>
0 - 6.0	low
6.1 - 12.0	moderately low
12.1 - 18.0	normal
18.1 →	"moderate ly high" till high

Magnesium:  $MgO$  is given in ppm. In the Morgan extract is analysed the exchangeable magnesium. For this reason its figure must be higher according the capacity of the adsorption-complex of the soil. Normally the next values are given as admissible limits.

Sand	25
Sand rich in organic matter	50
Sandy clay	75
Clay	125
Heavy clay	150
Peat	200

As result of a bad structure, a bad root-system, a high potash content, or a low pH magnesium deficiency will become visible, in spite of an enough high magnesium content of the soil.

Manganese: MnO is given in ppm just like magnesium. It is measured in Morgan extract. Manganese deficiency is mostly not provoked by a direct deficiency of the element in the soil. A high pH, a bad water- and air movement in the soil and so on will often stimulate the symptoms. When the figure is 2.0 or higher, Magnesium deficiency will seldom be found under normal circumstances. When the soil is sterilised by steam, much manganese is liberated. It may give toxicity in lettuce and cucumber crops.

#### 4. Advice on plant feeding

The analyse-figures complete a number of informations, on each sample from the grower's questionnaire. These figures make the base for the prescription. In it are advised organic as well as inorganic fertilisers. In the next standards for lettuce and tomatoe all quantities are given as fertilizers.

<u>Lettuce</u>	Nitrogen figure	Advised kilograms Ammonium Nitrate-lime mixture per 100 m <sup>2</sup> (= $\frac{1}{40}$ of acre)
	0 - 3	10
	3.1 - 6	6
	6.1 - 9	3
	9.1 - 12	0
	Phosphate figure	Advised kilograms of triple super phosphate per 100 m <sup>2</sup>
	0 - 2	10
	2.1 - 4.0	7
	4.1 - 6.0	3
	6.1 - 8.0	0

Potash figure	Advised kilograms Potash-Magnesium sulphate per 100 m <sup>2</sup>
0 - 6.0	10
6.1 - 12.0	5
12.1 - 18	0

For control the soluble salts situation for lettuce, special mixed fertilizer-compounds are advised. Moreover magnesium sulphate is advised if necessary.

<u>Tomato</u>	Nitrogen figure	Advised kilograms of Ammonium nitrate-lime mixture per 100 m <sup>2</sup>
	0 - 3.0	15
	3.1 - 6.0	10
	6.1 - 9.0	5
	9.1 - 12.0	0

  

	Phosphorus figure	Advised kilograms of triple super phosphate per 100 m <sup>2</sup>
	0 - 2.0	8
	2.1 - 4.0	5
	4.1 - 6.0	3
	6.1 - 8.0	0

  

	Potash figure	Advised kilograms of Potash-Magnesium Sulphate per 100 m <sup>2</sup>
	0 - 6.0	30
	6.1 - 12.0	20
	12.1 - 18.0	10
	18.1 - 24	5

Dependent on the pH nitrogen is given as ammonium nitrate-lime mixture or as of sulphate-ammonium.

##### 5. Interpretation Analysis figures and Advices on Potting Soils

A difference is made between:

- Potting soil for propagating vegetable plants. Normally the plants stay for a short period (3-6 weeks) in this potting soil.
- Potting soil for flowers and ornamental plants: the plants stay during a longer period in this potting soil. The next example does apply to a vegetable potting soil.

<u>Organic matter</u>	content in %	classification
	< 15	low
	16 - 30	moderately low
	31 - 45	normal
	46 - 60	moderately high
	> 60	high

To have a higher organic matter content: frozen black peat, or white peat is added and mixed. To get a lower organic matter content sand is added.

<u>Calcium carbonate</u>	content in %	classification
	< 0,5	low
	0,6 - 1.0	moderately low
	1,1 - 2.0	normal
	2,1 - 3,0	moderately high
	3.1 - 5.0	high
	> 5.1 →	very high

When the calcium carbonate content is too low, one should mix lime or magnesium lime in quantities till 5 kg per m<sup>3</sup>.

<u>pH water</u>	figure	classification
	< 3.9	very low
	4.0 - 4.7	low
	4.8 - 5.5	moderately low
	5.6 - 6.3	normal
	6.4 - 7.1	moderately high
	< 7.2 →	high

When the pH is too high some peat is mixed.

<u>Iron and Aluminium</u>	figure	classification
	< 2.0	favourable low
	2.1 - 4.0	almost low
	4.1 - 6.0	high
	6.1 - 8.0	very high
	> 8.0	exceptional high

Too high figures for iron and aluminium indicate mostly a bad aeration of the organic matter. If the soil is too bad than it must be disapproved without more. A bad soil might improve when organic matter of a good quality is mixed.

<u>Sodium chloride</u>	figure	classification
	$2\frac{1}{2}$ x org. matter cont.	favourable low
	$2\frac{1}{2}$ x o.m.c. + 1 till 5 x o.m.c.	almost low
	5 x o.m.c. + 1 " $7\frac{1}{2}$ x o.m.c.	high
	$7\frac{1}{2}$ x o.m.c. + 1 " 10 x o.m.c.	very high
	10 x o.m.c. and more	far too high
<u>Power conductivity</u>	figure	classification
	$< \frac{2 \text{ x o.m.c.}}{100}$	favourable low
	$\frac{2 \text{ x o.m.c.} + 1}{100}$ till $\frac{3\frac{1}{2} \text{ x o.m.c.}}{100}$	almost low
	$\frac{3\frac{1}{2} \text{ x o.m.c.} + 1}{100}$ " $\frac{5 \text{ x o.m.c.}}{100}$	moderately high
	$\frac{5 \text{ x o.m.c.} + 1}{100}$ " $\frac{6\frac{1}{2} \text{ x o.m.c.}}{100}$	high
	$\frac{6\frac{1}{2} \text{ x o.m.c.}}{100}$ and more	far too high

When the sodium chloride content and the power conductivity are too high organic matter (like frozen black peat or white peat) are advised.

<u>Nitrogen and Potash</u>	N and K figure	classification
	$< \frac{1}{2}$ x o.m.c.	low
	$\frac{1}{2}$ x o.m.c. + 1 till 1 x o.m.c.	moderately low
	1 x o.m.c. + 1 " $1\frac{1}{2}$ x o.m.c.	normal
	$1\frac{1}{2}$ x o.m.c. + 1 " 2 x o.m.c.	moderately high
	2 x o.m.c. + 1 " $2\frac{1}{2}$ x o.m.c.	high
	$> 2\frac{1}{2}$ x o.m.c. + 1	very high

When the figures for nitrogen are too high, the potting soil must be washed out. It is also possible to mix it with peat. When these figures are too low, these nutrients can be added and mixed as well in inorganic as in organic form.

<u>Phosphorus</u>	figure	classification
	$< 20$	low
	21 - 40	moderately low
	41 - 60	normal
	61 - 80	more than normal
	81 - 100	much
	$> 101$	very much

High phosphorus contents do not give any trouble for propagation plants. When the phosphorus figure is too low triple super phosphate is mixed in quantities till 1 kg per m<sup>3</sup>.

Magnesium: for the evaluation of the magnesium figure, the potting soils are graduated according to its different organic matter contents.

o.m.c. 20 - 40	o.m.c. 41 - 60	o.m.c. 61 - 80	o.m.c. 81	classification
< 30	< 40	< 50	< 60	low
31 - 60	41 - 80	51 - 100	61 - 120	moderately low
61 - 90	81 - 120	101 - 150	121 - 180	normal
91 - 120	121 - 160	151 - 200	181 - 240	moderately high
> 121	> 161	> 201	> 241	high

High magnesium figures do not give any trouble. When the magnesium figures are low, magnesium sulphate is mixed.

<u>Manganese</u>	figure	classification
	1.0	low
	1.1 - 5.0	normal
	5.1	high

Mixing of compounds containing minor elements like "Sporumix" and mixing of organic matter, make rise the manganese content. Manganese figures which are too low are not often found in these humic mixtures. When the manganese content is too high, it can be immobilized <sup>by</sup> mixing lime.

## 6. Plantanalysis

This is done only for internal information. Plantanalysis is not done for practical purposes. As far as plantanalysis is done one follows the methods of "complete analysis" (see 3a).

Naaldwijk, 14<sup>th</sup> July 1967.