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Agroquant®

Soil Laboratory 3 x N/pH
Nitrogen and pH (lime requirement)

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Bodenlabor 3 x N/pH
Stickstoff und pH (Kalkbedarf)

Compact laboratory with test strips, reagents, balance, timer and accessories for the determination of nitrate-, nitrite-, and ammonium-nitrogen as well as pH in soils, water, plants, animal feed, compost, solid and liquid manure

Kompaktlabor mit Teststäbchen, Reagenzien, Waage, Uhr und Zubehör zur Bestimmung von Nitrat-/Nitrit-/und Ammonium-Stickstoff und pH in Böden, Wasser, Pflanzen, Futtermitteln, Kompost, Mist und Gülle

Release / Ausgabedatum 06/2014

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1 On soil testing in general

Responsible ecologically-minded gardeners and farmers test their soil before they fertilize it. The correct pH value of soil is just as important as the nutrient content. It depends on this value whether the nutrients are actually available to the plants. With the right pH value, the soil life can thrive, which is important for healthy soil.

As a farmer you obtain larger crops, as a gardener or flower grower you obtain more beautiful plants, when you know the pH value of your soil and adjust it accordingly by addition of lime. Only a healthy lime status of the soil offers the guarantee that phosphorus, nitrogen and potash fertilizers or compost fully develop their action.

Periodic soil testing is therefore extremely important, in order to fertilize correctly.

2 Nitrogen, the important plant nutrient

Nitrogen plays a very special role in agriculture and gardening. To obtain the best yields and high-quality food, this nutrient must be made available to the plants in adequate quantities. A lack results in poor plant nutrition and corresponding reduction in yield. Overfertilization also results in poor quality products, pollution of the environment and unnecessary expense. It is therefore necessary to ascertain the nitrogen available (nitrate NO_3^- and ammonium NH_4^+) using the rapid method described below, prior to every fertilization with nitrogen (N). The quantity of fertilizer can then be correspondingly dosed or omitted altogether if an adequate concentration is available in the soil. The advantage of this method of testing lies in its flexibility. By measuring at the beginning of growth, the natural nitrate supply (mineralization) of the ground can be used. The more nitrate (NO_3^-) the soil has supplied, the smaller the amount of fertilization required. If strong rainfall displaces the nitrate to deeper layers of the ground which are not reached by the plants, an inadequate supply of nitrogen can be avoided with the aid of the Agroquant® nitrate determination and corresponding fertilization.

Useful immediate information on the mineralized nitrogen content (= N_{min} content) of the soil can be obtained by the farmer himself with the aid of the Agroquant® Soil Laboratory. The basis for this test is the MQuant™ Nitrate test strip, Cat. No. 110020. The way it works is similar to the well-known pH papers and indicator strips. According to the nitrate content, a specific color change takes place in the test zone of the strip. The intensity of coloration is compared with a color scale supplied with the test, the nitrate concentration being that given next to the scale color which most closely matches that of the reaction zone.

The measurement itself is very quick and easy to conduct. The results of the rapid tests give the N_{min} supply in the soil accurately enough and in most cases meet the requirements of everyday practice. The method is intended to provide a rapid on-the-spot guide and should be regarded as a complementary method to the exact N_{min} determination in the laboratory. The disadvantages of the laboratory method lie in organizational difficulties (transport of refrigerated soil samples), the partly long waiting times for the analysis results and the relatively high cost.

3 The Agroquant® Soil Laboratory

The Agroquant® Soil Laboratory is fully equipped to determine the contents of nitrate, nitrite and ammonium as well as the pH value in soil, compost, liquid manure and other commercial manures. The sampling tubes required for taking soil samples must be obtained separately (see chapter 18).

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The soil laboratory contains:

MQuant™ Nitrate Test, Cat. No. 110020

MQuant™ Ammonium Test, Cat. No. 110024

from MColortest™ Ammonium Test, Cat. No. 114657:
3 bottles of reagent NH_4-1
1 bottle of reagent NH_4-2 (with integrated blue microspoon)
1 bottle of reagent NH_4-3
1 color card

MColorpHast™ pH-indicator strips pH 2.0 - 9.0, Cat. No. 109584

1 scale

1 timer with an audible signal

3 beakers (for weighing and mixing of the soil samples with extraction solution)

1 graduated 100-ml beaker

1 red dosing spoon

1 package (100 pcs) round filters Ø150 mm

1 spoon

Agroquant® Extraction Reagent (potassium chloride for soil testing)

1 1-l bottle

3 The Agroquant® Soil Laboratory

The nitrate/nitrite determination is carried out with the MQuant™ Nitrate Test, Cat. No. 110020.

The ammonium determination in soil is conducted with the MColortest™ Ammonium Test, Cat. No. 114657, with color card. Ammonium in commercial fertilizers such as liquid manure is usually determined with the MQuant™ Ammonium Test, Cat. No. 110024.

The pH value (soil reaction) is determined with non-bleeding MColorpHast™ pH-indicator strips pH 2.0 - 9.0, Cat No. 109584.

Using the equipment and tests in the soil laboratory it is possible to determine very quickly how many kilograms of mineralized nitrogen in the form of nitrate and ammonium are present per hectare in each layer of soil. However, precise work is essential to obtaining valid results.

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4 Procedure "Nitrogen in the soil"

- Soil sampling using a sampling tube or a spade
- Mixing and weighing of the soil sample
- Preparation of a soil suspension
- Filtration of the soil suspension
- Determination of the different parameters (nitrate, nitrite, ammonium and pH value)

Normally the nitrogen determination of the topsoil (0 to 30 cm) including sampling takes about 20 minutes. If three layers of soil are to be analyzed, 60 to 70 minutes will be required. Heavy soils containing clay are more difficult to mix and suspend and therefore require somewhat more time.

4.1 Soil sampling

Different types of plant grow roots to different depths.

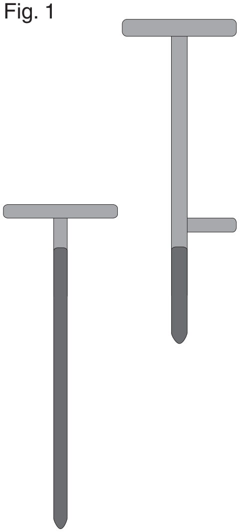
Soil samples should therefore be taken accordingly (Fig. 1).

It is important to investigate the layer of soil which is reached by the roots of the plant: in deep soils (a range of 0 - 90 cm) or shallow soils (a range of 60 cm or less). It has proven useful to divide the soil profile into 30 cm fractions. Separate analysis makes it possible to determine how the nitrogen is distributed in the soil, e.g. near the surface or deeper down.

4 Procedure "Nitrogen in the soil"

4.1 Soil sampling

Fig. 1



Important soil layers for nitrate determination

Ground depth according to type of plant (e.g. cauliflower, 1st and 2nd layer), but only as deep as the rootage can take place in each case (e.g. compression zone).

			0 cm
e.g. endive, cabbage turnip, lettuce, garden radish			1st layer 30 cm
	e.g. cauliflower, chinese cabbage, round cabbage, spring spinach		2nd layer 60 cm
		e.g. grain, round cabbage (storage), corn, brussels sprout	3rd layer 90 cm

In order to obtain a representative soil sample, at least 16 samples must be taken with a suitable sampling tube (or a spade) per plot of land.

For seeding and planting, it is sufficient with all cultures to investigate the topsoil (0 - 30 cm). The soil samples can conveniently be taken with a small sampling tube (see Fig.1) and placed in a bucket. Only later when the roots of the plants have reached the 2nd or 3rd layers of soil, the large sampling tube (see Fig.1) is required. The different layers of soil (0 - 30 cm, 30 - 60 cm, 60 - 90 cm) must be collected in separate marked buckets.

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4 Procedure “Nitrogen in the soil”

4.2 Mixing and weighing of the soil sample

Thoroughly mix the soil samples from 0 - 30 cm, 30 - 60 cm, and 60 - 90 cm depth in separate buckets.

Fill each 100 g of soil sample, using the balance included in the soil laboratory, into separate beakers.

4.3 Preparation of the soil suspension

Add 100 ml of extraction solution to each soil sample and stir vigorously with the spoon for at least 2 minutes to prepare the soil suspension.

Preparation of the extraction solution

Fill 4 level red dosing spoons (included in the soil laboratory) of extraction reagent (potassium chloride) into the 1-l bottle.
Fill the bottle up to the neck with distilled water (approx. 1 l).
After dissolving the substance, the extraction solution can be used directly.

alternative: Instead of measuring a volume of extraction reagent with the red dosing spoon, 7 - 8 g can be weighed out using the balance.
Transfer this quantity to the 1-l bottle and fill up to the neck with distilled water or battery water (approx. 1 l).

4.4 Filtration of the soil sample

The soil suspension is filtered as followed:

A circular filter is folded twice and placed in the soil suspension in such way, that the filtration takes place from the outside to the inside.

Note:

This filtrate is suitable for measuring the nitrate, nitrite and ammonium contents as well as the pH value of the soil.

4 Procedure "Nitrogen in the soil"

4.5 Determination of the nitrate-nitrogen

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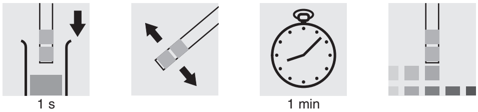
1. Immerse a MQuant™ nitrate test strip with both reaction zones in the filtrate of the soil suspension for 1 second.
   If the soil suspension filters too slowly, briefly press the test strip against the moist inner surface of the filter.
2. Fully wind up the timer and set the pointer to exactly 1 minute.
3. Shake off excess liquid from the strip and after 1 min (ring) determine with which color field on the label the color of the NO_3^- reaction zone coincides most exactly. Read off the corresponding result in mg/l NO_3^-.



The values given on the color scale, e.g. 100 mg/l NO_3^- are equivalent in this test to 100 kg of N per ha in the corresponding 30 cm layer of soil.

Adding the values for all three layers together gives the number of kg of N per ha in all the soil to a depth of 90 cm. This determination gives an approximate value for the N_{min} reserves in the soil.

4.6 Considering the water content of the soil

In order to obtain reliable results from the rapid test, the content of water in the soil should also be taken into account. As the aqueous phase becomes larger with an increasing proportion of water, the results obtained in practice tend to be too low. For this, the soil sample is dried under normal atmospheric conditions to determine the moisture content, for which the correction factor is given in Table 1. To this end, the soil sample is dried under normal atmospheric conditions to determine the moisture content, for which the correction factor is given in Table 1.

Where tests are carried out on the farm, the simpler estimation procedure can be used. Table 2 gives the correction factor to be added in percent for each type of soil and the estimated moisture in the soil. With sandy soils it may be necessary to add 16 % and with clay soils, up to 63 %.

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4 Procedure “Nitrogen in the soil”

4.6 Considering the water content of the soil

Table 1

Exact addition values after drying the soil to take into account the water content for the MQuant™ Nitrate Test																									
Soil water content in percent by weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Percentage to be added to the measured N content	2	4	6	8	11	13	15	17	20	23	25	27	30	33	35	38	41	44	47	50	53	56	60	63	67

Example:
If a value of 60 is measured and the soil moisture content is 12 %, it is necessary to add 27 %.
The value then increases to 60 x 1.27 = 76 kg N/ha.

Table 2

Estimated percentage to be added according to the type and water content of the soil taking the soil water content for the MQuant™ Nitrate Test into account

Soil moisture content		Add to the measured nitrate content for			
Content	Water capacity	Sand	Clay sand	Sandy clay	Clay, Loess
very dry	40 %	+ 8 %	+15 %	+17 %	+23 %
dry	55 %	+10 %	+20 %	+24 %	+33 %
medium moist	70 %	+12 %	+25 %	+31 %	+43 %
moist	85 %	+14 %	+30 %	+38 %	+53 %
very moist	100 %	+16 %	+35 %	+45 %	+63 %

Example:
A value of 60 for a clay sand which was tested after a heavy thunderstorm must be increased by about 30 %.
The corrected value is then, 60 x 1.30 = 78 kg N/ha.

As a rough guide it is sufficient to multiply the nitrate value read off the scale by 1.1 for **dry soils**, 1.3 for **normal soils** and 1.5 for **wet soils**.

Example:
If the color on the scale matching that of the test strip corresponds to 60 mg/l, the corrected value for normal soils is then 60 x 1.3 = 78 kg N/ha and 30 cm layer of soil.

4 Procedure “Nitrogen in the soil”

4.7 Determination of the nitrite-nitrogen

The nitrite-nitrogen is measured in the same way as the nitrate nitrogen.
Here, however, the color of the second, inner reaction zone is compared with the nitrate color scale.

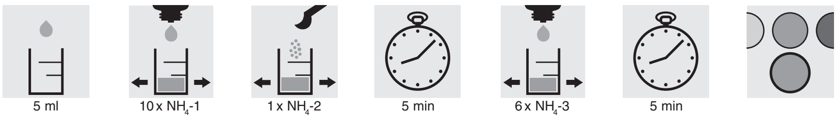
If the nitrite zone on the test strip is colored, this is a warning sign as healthy soils must not contain nitrite.

4.8 Determination of the ammonium-nitrogen

The soil suspension is prepared according to 4.1 - 4.4. Instead of the extraction solution, distilled water can be used.

Ammonium determination with MColortest™, Cat. No. 114657:

1. Transfer 5 ml of the filtrate to the test tube with the syringe.
2. Add 10 drops of reagent NH_4-1 and mix.
3. Add 1 level blue microspoon (in the cap of the NH_4-2 bottle) of reagent NH_4-2, close the tube, and shake **vigorously until the reagent is completely dissolved**.
4. Leave to stand for 5 minutes (use the timer).
5. Add 6 drops of reagent NH_4-3 and mix.
6. Leave to stand for 5 minutes (use the timer).
7. Place the test vessel on the white area next to the color zones of the color card and determine with which field of the scale the color of the measurement solution - viewed from above - coincides most exactly.
   Read off the result in mg/l NH_4^+ from the color card.



The values given next to the color scale e.g. 3 mg/l NH_4^+, are equivalent to mg of ammonium per kg of naturally moist soil.

If the value found lies above 10 mg/l NH_4^+, the filtrate must be diluted.
Transfer only 1 ml of filtrate to the test tube with the syringe and make up to the 5-ml mark with extraction solution. Multiply the value read off the scale by the dilution factor 5.

4 Procedure "Nitrogen in the soil"

4.8 Determination of the ammonium-nitrogen in the soil

Note regarding the N_{min} method

As the N_{min} method measures the nitrogen content per ha in a 30 cm layer of soil, the value read off the color scale (if necessary adjusted by a dilution factor) must be multiplied by a factor of 3.
This conversion is based on an average soil density of 1.2 to 1.5 kg/dm^3.

Example:
A value of 1.0 mg/l NH_4^+ is read off the color scale. This value must be multiplied by a factor of 3. Thus, the soil contains 3 kg of ammonium-nitrogen (NH_4-N) per ha and 30 cm layer of soil.

4.9 Evaluation of the results

The results of this rapid test are used in the same way as the exact results provided by the soil sampling institutes.
Prior to cultivation, the nutrients available in the soil can be determined.
After harvesting, the amount of nitrogen removed from the soil can be determined.

The principle of the N_{min} method is illustrated below using winter wheat as an example:

Target value in the spring (= quantity of N required for maximum yield):	120 kg N/ha
minus	
N_{min} supply (measured in February at a depth of 0 - 90 cm):	-70 kg N/ha
required spring N fertilization:	50 kg N/ha

If the required 50 kg of N/ha are supplemented with mineral fertilization, the soil is brought up to 120 kg N/ha and thus reaches the target value for the N concentration, which ensures the maximum yield for winter wheat.

The N_{min} method measures kg of mineral nitrogen per ha in the entire layer of soil available to the roots, i. e. also in the deep soil (with plants having roots reaching to a depth of 90 cm in deep soils divided into 3 layers each of 30 cm).

As this mineral nitrogen is used by the plant in the same way as fertilizer nitrogen, it can fully be taken into account to the fertilization:

$$N_{min} \text{ reserve} = NO_3\text{-N} + NH_4\text{-N}$$

5 Simplified N_{min} method

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The content of mineral nitrogen in the soil is only of interest for the crop in the layers in which there are roots. This means that the depth of soil to be taken into account in nitrogen measurements depends on the type of crop. Before taking soil samples, it is therefore necessary to determine the soil depth in question.

To obtain comparable results, scientists have established soil layers of 0 - 30 cm, 30 - 60 cm and 60 - 90 cm depth. In seeding and planting for instance, only the first layer of soil (0 - 30 cm) is of interest. For later fertilization, the second and possibly even the third layer soil must be tested depending on the type of crop and soil.

Usually sampling the first (0 - 30 cm) and second (30 - 60 cm) layers of soil with a sampling tube does not present any severe difficulties. However, sampling the third layer (60 - 90 cm) usually is more problematic.
With cereals, maize, sugarbeet, brussels sprouts, head cabbage etc., it is necessary to take into account the third layer (60 - 90 cm) but trials by KOCH have shown that as a rule a simplified method can be used:

1. Investigation of the 1st layer (0 - 30 cm):		a kg/ha N
2. Investigation of the 2nd layer (30 - 60 cm):		b kg/ha N
3. Addition:	(a+b) =	c kg/ha N

If the N_{min} values of the first and second layers are added (= c) and doubled (= 2c), an approximation of the N_{min} potential for all three layers (0 - 90 cm) is obtained, including the correction for water content. This simplified method has been found useful in practice. The error range is usually less than ± 30 kg N/ha.

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6 Procedure “Nitrogen in liquid manure, stable manure, and compost”

Since the mid 1960's, considerations of efficiency in particular have led to a change-over from semi-liquid stable manure to the use of liquid manure in almost all fodder cultivation and processing farms. In modern livestock farming with large herds, which are sometimes no longer free ranging, animal excrement is produced in such large quantities that it becomes a waste product.

Various methods for treating animal excrement such as deodorization, disinfection, volume reduction, improvement of the storage and transport characteristics, as well as the degradation or removal of different constituents are already available or in development.

If liquid manure is spread at the right time and in the right quantities for the requirements of the plants, the effects of its nutrients can be compared to those of mineral fertilizers and measured in terms of these.

Usual dosages of liquid manure provide large quantities of nitrogen in absolute terms. Thus, for instance, 50 cm^3 of liquid cattle manure contain approximately 200 kg of total nitrogen. Depending on the animal species, 50 - 70 % of this total nitrogen is present as ammonium. As with the nitrogen in mineral fertilizers, this can be directly absorbed by the plant.

The ammonium nitrogen in the liquid manure is either absorbed directly by the crops or, depending on the soil temperature and moisture, converted by micro-organisms in the soil to nitrate (NO_3^-) within 2 - 3 weeks.

Nitrate can also be directly absorbed by the roots. It is then available in the same form of nitrogen as most nitrogen-containing mineral fertilizers.

The farm manager can determine the specific nutrient content of the liquid manure himself by testing with the MQuant™ Ammonium Test, Cat. No. 110024.

Prior to taking a sample, the contents of the manure pit must be very thoroughly mixed (homogenized). The time at which the samples are taken also influences the nutrient contents. Only repeated tests on the liquid manure provide the farm manager with average values which are specific to his liquid manure.

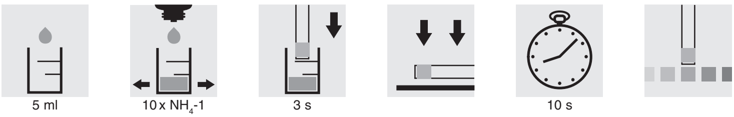
Repeated tests of the liquid manure are therefore absolutely essential as the nutrient content of liquid manure is subject to considerable fluctuation. Apart from the animal species and the age of the animals, the fodder in particular has a great influence.

Liquid manure is an organic manure in which the ratio of the main nutrients ($N : P_2O_5 : K_2O$) varies greatly according to the animal species. Dairy cattle manure is rich in potash, manure from beef cattle farms contains more phosphate but less potash than dairy cattle manure, pig and fowl manure contain large quantities of nitrogen and phosphate but little potash.

6 Procedure “Nitrogen in liquid manure, stable manure, and compost”

6.1 Measurement of the ammonium-nitrogen in liquid manure with the MQuant™ Ammonium Test, Cat. No. 110024

1. Very thoroughly mix (homogenize) the liquid manure.
2. Weigh 30 g of liquid manure into a beaker.
3. Prepare an extract by adding 120 ml of extraction solution (see chapter 4.3) and stirring thoroughly (at least 2 minutes). Alternatively, distilled water can be used.
4. After stirring, immerse a round filter in the extract (filtration from the outside to the inside).
5. With the syringe, transfer 5 ml of the filtrate to the test vessel.
6. Add 10 drops of reagent NH_4-1 and swirl.
7. Dip the MQuant™ Ammonium test strip for **3 seconds** in the solution. The reaction zone should be fully covered.
8. Allow excess liquid to run off via the long edge of the strip onto an absorbent paper towel and **after 10 sec** determine with which color field on the label the color of the reaction zone coincides most exactly.
   Read off the corresponding result in mg/l NH_4^+.



By multiplying the value on the color scale by a factor of 5, you get approximately the ammonium-nitrogen (NH_4-N) in g/m^3 of liquid manure.

Example:
A value of 200 mg/l of NH_4^+ is read off the color scale. This factor must be multiplied by 5 to give approximately 1.000 g of ammonium-nitrogen (NH_4-N) per m^3 of liquid manure. With a liquid manure tank of 4 m^3 capacity, 4 kg of pure ammonium-nitrogen will therefore be applied.
This form of nitrogen (NH_4-N) is immediately available to the plant

6 Procedure "Nitrogen in liquid manure, stable manure, and compost"

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6.1 Measurement of the ammonium-nitrogen in liquid manure with the MQuant™ Ammonium Test, Cat. No. 110024

Note:
If the value determined is over 400 mg/l NH_4^+, the filtrate must be diluted accordingly. In such cases, transfer only 1 ml of the filtrate to the test vessel with the syringe and make up to the 5-ml mark with extraction solution. Subsequently multiply the value read off the color scale by the dilution factor of 25.
If any difficulty is experienced in filtering the liquid manure slurry (30 g liquid manure + 120 ml extraction solution), allow the slurry to settle for approximately 2 to 3 minutes, decant 5 ml or transfer with the syringe into the test vessel.
The subsequent ammonium determination is then as described above (point 6 to 8).

6.2 Measurement of ammonium-nitrogen in stable manure with the MQuant™ Ammonium Test, Cat. No. 110024

The ammonium-nitrogen in stable manure is measured in the same way as ammonium-nitrogen in liquid manure (see chapter 6.1).

By multiplying the value on the color scale by a factor of 4, this gives approximately the ammonium-nitrogen (NH_4-N) in g per ton of stable manure.

Example:
A value of 100 mg/l NH_4^+ is read off the color scale. Multiply this value by 4 to give the content of ammonium nitrogen (NH_4-N) in g per ton of stable manure. In this case the value is 400 g NH_4-N per ton of stable manure.
If 5 t of this stable manure is applied with a manure spreader, the soil will receive 2 kg of pure nitrogen.
This nitrogen is immediately available to the plant in the form of ammonium-nitrogen (NH_4-N).

6 Procedure “Nitrogen in liquid manure, stable manure, and compost”

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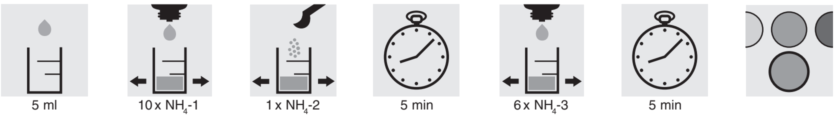
6.3 Measurement of the ammonium-nitrogen in compost with the MColortest™ Ammonium Test, Cat. No. 114657

1. Thoroughly mix the sample of compost. Sort out large lumps and stones.
2. Weigh 50 g of compost into a beaker.
3. Prepare an extract by adding 100 ml of extraction solution (see chapter 4.3) and stirring thoroughly (at least 2 minutes). Alternatively, distilled water can be used.
4. After stirring, immerse a round filter in the extract (filtration from the outside to the inside).
5. With the syringe, transfer 5 ml of the filtrate to the test vessel.
6. Add 10 drops of reagent NH_4-1 and mix.
7. Add 1 level blue microspoon (in the cap of the NH_4-2 bottle) of reagent NH_4-2, close the test vessel und shake **vigorously until the reagent is completely dissolved**.
8. Leave to stand for 5 minutes (use timer).
9. Add 6 drops of reagent NH_4-3 and mix.
10. Leave to stand for 5 minutes (use timer).
11. Place the test vessel on the white area next to the color zones of the color card and determine with which field of the scale the color of the measurement solution - viewed from above - coincides most exactly.
    Read off the result in mg/l NH_4^+ from the color card.



By multiplying the value on the color scale by a factor of 2, this gives approximately the amount of ammonium-nitrogen (NH_4-N) in g per ton of compost.

Example:
A value of 1 mg/l NH_4^+ is read off the color scale. Multiplication by the factor of 2 gives 2 g of nitrogen in the ammonium form (NH_4-N) per ton of compost.
If, for instance, 2 tons of compost have been spread, the total mass of compost contains 4 g of pure nitrogen (NH_4-N).

If values of 5 mg/l of NH_4^+ and over are indicated on the scale, the compost is rotten. Such a compost heap must be turned and aerated immediately.

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7 Plant analysis

7.1 The influence of nitrogen fertilization

Plants are capable of so-called luxury consumption, if they are oversupplied with nutrients. Under these conditions, the plants show no symptoms either of lack or excess of nutrition. However, the intake of nutrients is unnecessarily high and this frequently reduces the yield and quality of agricultural products.

In most plants, luxury consumption of the nutrient, nitrogen, leads to reduced yields and loss of starch. The stability, flavor, processing qualities, survival of storage and transport as well as the value of the crop can also suffer serious damage (KOCH 1982).

7.2 The assessment of the nutrient status of plants

Plant analysis provides information on the nitrogen nutrient status of plants. It can therefore be used to determine incorrect nutrition and the amount of fertilizer required.

In **fruit farming**, leaf analysis provides a check on the nitrogeb supply. Combined with other data such as the type of soil, proportion of ground cleared with herbicide between the trees, organic fertilization including leaf fertilization, the amount of fruit on the tree, and the variety, the leave analysis is also used to determine the amount of manure needed for the following year. The concentration of total N is measured in leaves from the middle of one-year-old shoots in July/August. The ideal ranges for some fruits are given below:

apples (primarily eating quality)	2.20 - 2.40 % N
apples (primarily high yield)	2.40 - 2.60 % N
sweet cherries	2.70 - 2.90 % N
sour cherries	2.90 - 3.10 % N

Cereal crops:
To decide on the amount and timing of late fertilization, it is necessary to measure the nitrate content in the base of the stem between the shoots and the ears, using the MQuant™ Nitrate Test, Cat. No. 110020. This test measures the N supply of the plant which comprises:

- The N_{min} reserve in the soil in spring
- N-fertilization up to the time of measurement
- subsequent N supply (net mineralization) of the soil between spring and the time of measurement.

7 Plant analysis

7.3 Nitrate determination in plants

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Here, too, the same MQuant™ Nitrate Test, Cat. No. 110020, can be used as was used to analyze the soil.
The handling for the determination of the nitrate content in plants is simple:

Cut through the plant material,
moisten a test strip against the cut surface,
wait 1 minute, and
compare the intensity of coloration with the color scale supplied.
The value read off is in units of mg nitrate/kg plant material.

The so-called plant sap method can also be used for all types of plant.
Cut up several plant samples and press the material in a household press (e.g. a garlic or onion press).
Measure the nitrate concentration in the sap using MQuant™ Nitrate Test.
The result is given in mg nitrate per kg plant material.

If the vegetable material is strongly colored (e.g. beet-root) the juice must be diluted (e.g.1+9) in order to extensively eliminate the natural coloration. The nitrate value read off must then be multiplied by the dilution factor (in this case 10).

If the vegetable material has a high nitrate content, the juice must be diluted accordingly.

Example:
Press the juice from a plant sample and
transfer 0.25 ml to a 25 ml volumetric flask with a micropipette.
Fill the volumetric flask up to the mark with distilled water.
Measure the nitrate concentration with the MQuant™ Nitrate Test, Cat. No. 110020, and multiply the result by the dilution factor 100. This gives the nitrate concentration in mg nitrate per kg plant material.

However, it is necessary to consistently test certain unmistakable parts of the plant at a certain state in their growth.

The range of possible nitrate contents is extremely wide:
Asparagus juice and chicory shoots contain almost no nitrate, while field/lettuce leaves can contain up to 5000 mg of NO_3^-/kg of plant material.

8 The purpose of the nitrogen determination

The nitrogen supply in the soil depends on a large number of factors. It can vary considerably from place to place. In extreme cases the optimum N supply of the crop can be provided either exclusively by nitrogen fertilization or exclusively from the soil. As a rule, a lesser or greater proportion of the nitrogen requirement must be met by fertilization.

With nitrogen fertilization, the farmer or gardener should not rely solely on his experience but should rather take advantage of the available analytical aids (soil and plant analyses).

The rapid method presented here for the measurement of the nitrogen supply in the soil enables valuable scientific results to be put to use in everyday practice. With the rapid test, the farmer has an aid which allows him to fertilize more accurately.

This has proved to give greater yields - often with reduced nitrogen fertilization - as well as reduced nitrogen losses through soil erosion. The purpose of this analytical method is to provide the plants with nitrogen according to their needs, which is an important precondition for high yields and satisfactory quality of the produce. The method also contributes to meet the requirements of environmental protection.

9 The nitrogen requirements of various agricultural plants

9.1 Normal nitrogen requirement for outdoor vegetables

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The prerequisite here is that the nutrient content of the soil meets the target values.

The nitrogen quantities given (target values) refer to depleted soils.
N_{min} supplies must be taken into account.

Vegetable	Nitrogen demand (N) kg/ha
Asparagus	150
Beetroot	160
Black salsify	160
Brussels sprout	300
Bush beans	140
Carrots	200
Cauliflower	300
Celery	200
Chicory	80
Chinese cabbage	220
Chives	200
Cucumbers	200
Endives	120
Fennel (tuberaus)	180
Field lettuce	120
Head cabbage	300
Kale	180
Kohlrabi	180
Leek	220
Lettuce	120
Maize (sweet corn)	150
Onions	180
Parsley	160
Peas	80
Pieplant	200
Radishes (red)	80
Radishes (white)	200
Spinach	220
Tomatoes	250
Zucchetti	200

en

9 The nitrogen requirements of various agricultural plants

9.1 Normal nitrogen requirement for outdoor vegetables

It may be necessary to adjust these values to local requirements.
Outdoor factors include: humus supply, the use of stable manure, the distance between plants, duration of growth, type of soil and expected yield.

$$\text{Conversion in kg/a} = \frac{\text{Measured value [kg/ha]}}{100}$$

9.2 Normal nutrient requirement for glasshouse vegetables

The prerequisite here is that the nutrient content of the soil meets the target values.

The nitrogen quantities given (target values) refer to depleted soils.
N_{min} supplies must be taken into account.

Vegetable	Nitrogen demand (N) kg/ha
Aubergines (4 months)	300
Bush beans	140
Carrots	100
Cauliflower	250
Celery (for bunches)	100
Chinese cabbage	220
Cucumbers	400
Endives	120
Field lettuce	120
Kohlrabi	180
Leek (for bunches)	140
Lettuce	120
Paprika (4 months)	300
Parsley	160
Radishes (red)	80
Radishes (white)	200
Runner beans	240
Spinach	180
Tomatoes (7 trusses)	300

9 The nitrogen requirements of various agricultural plants

9.2 Normal nutrient requirement for glasshouse vegetables

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It may be necessary to adjust the values given according to local conditions. Factors in the glasshouse include: the humus supply, the use of stable manure, the distance between plants, the duration of growth, the type of soil and the method of irrigation.

$$\text{Conversion in kg/a} = \frac{\text{Measured value [kg/ha]}}{100}$$

9.3 Average nitrogen requirement in g/100 plants and week

Vegetable	Nitrogen demand (N)
Aubergines	100
Cucumbers	230
Paprika	300
Runner beans	30
Tomatoes	100

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9 The nitrogen requirements of various agricultural plants

9.4 Nitrogen requirement of plant crops

Crop	Yield dt/ha	Nitrogen demand (N) kg/ha
Winter wheat	60 - 80	180 - 240
Winter barley	50 - 70	110 - 150
Rye	50 - 60	120 - 150
Oats	50 - 60	120 - 150
Sugarbeet	400 - 600	200 - 270
Potatoes (late)	300 - 500	150 - 250
White cabbage (late)	700	300
White cabbage (early)	300	120
Cauliflower	500	300
Spring spinach	300	150
Bush beans	120	100
Celery	300	180
Leek	400	140
Lettuce	300	70
Apples	wood increment + leaves + fruits	60 - 80

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10 Analysis of nitrate-nitrogen in the fodder

With the aid of the MQuant™ Nitrate Test, Cat. No. 110020, it is possible to rapidly determine with adequate accuracy the nitrate quantities in the fodder rations.
This is quite straight forward and inexpensive.
The following are some of the materials which may be analyzed:
grass and rape samples, young green cereal (e. g. green oats or rye), sunflower/pea/bean mixture etc.

10.1 Sample pretreatment

The sample pretreatment is based closely on the directions of the agricultural research and testing stations. It consists of the following steps:

1. Chop up the plant material (scissors, knife) to a size of approx. 1 cm.
   Ensure that all parts of the plant are distributed as evenly as possible in the sample, as the nitrate content near the ground is particularly high.
2. Weigh 50 g of the chopped sample of vegetable matter using the balance in the Agroquant® Soil Laboratory and blend in an electric mixer or meat mincer.
3. Quantitatively transfer the product as well as any liquid to a measuring beaker (wash remains in the mixer into the beaker using 150 to 250 ml of distilled water) and make up the measuring vessel to exactly 500 ml with distilled water.
4. Thoroughly stir the sample material for 5 minutes.

10.2 Determination procedure

1. Leave the suspension to settle and then dip for 1 second a test strip of the MQuant™ Nitrate Test in the supernatant solution.
   If necessary, filter the sample material. The nitrate content is then measured corresponding in the filtrate.
2. Shake off excess liquid from the strip and after 1 min determine with which color field on the label the color of the NO_3^- reaction zone coincides most exactly. Read off the corresponding result in mg/l NO_3^-.
   Each strip also features a second reaction zone **(alert zone)**, the color of which changes in the presence of nitrite ions.
3. Calculation of the nitrate content in the plant:

   $$\text{mg } NO_3^-\text{/g of fresh vegetable material} = \frac{\text{mg/l}}{100}$$

   Conversion to the dry substance:

   mg NO_3^-/g fresh substance x 5 or 6

   (5 for normal grass: dry substance content approx. 20 %,
   6 for young grass: dry substance content approx. 16 - 17 %).

11 Nitrogen in the form of nitrate, nitrite and ammonium in drinking and well water

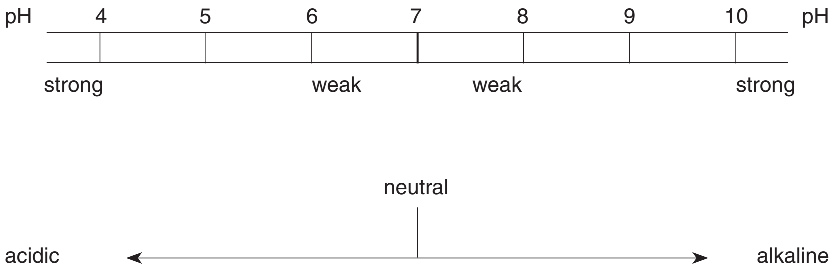
It is always important to regularly check the nitrate, nitrite and ammonium content in drinking and well water if the farm has its own water supply.

If the nitrate value regularly exceeds 50 mg/l constantly, the cause should be urgently investigated. In drinking water under no circumstances ammonium or nitrite should be detected with the tests provided in the soil laboratory.

12 pH value (soil reaction)

12.1 pH value ranges

Soils are classified as strongly acidic, acidic, weakly acidic, neutral and alkaline according to their lime content. Science has introduced the concept "pH value" (soil reaction) for this. If soil tested with the kit reacts neutrally, it will have a pH value of 7, while values over 7 indicate alkaline soil and below 7, acidic soil.



12 pH value (soil reaction)

12.2 The significance of the pH value and the lime content for the soil

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An important requirement for good friability and structure of the soil is a correct lime content, also referred to as "soil reaction". Lime is an indispensable nutrient for plants. However, it is equally necessary for maintaining healthy and fertile soil. Nevertheless, lime requirements differ: sandy soils require less, clay soils require more. This is explained by the effect lime has on the friability: together with the soil humus, the lime ensures that the very fine loose particles of soil remain bonded together in a friable aggregate. The aggregate is then interwoven by very fine threads of algae and fungi, making the soil even more resistant to destructive influences, e.g. erosion by cloudbursts. The heavy clay soils are particularly susceptible to this. They require more lime than a sandy soil as the many very fine particles of clay require more binding material (consisting of lime and humus) to hold them together than the coarser sand grains. Most crop plants do not stand a strongly acidic soil but thrive better in the weakly acidic range. As an excess of lime is undesirable in a light sandy soil (such soils become too "hot and dry"), it is better to keep them in the weakly acidic range, e.g. at a pH of about 6. The more clay the soil contains, on the other hand, the more readily lime can be added up to pH 7.5.

12.3 The significance of the pH value for plant growth

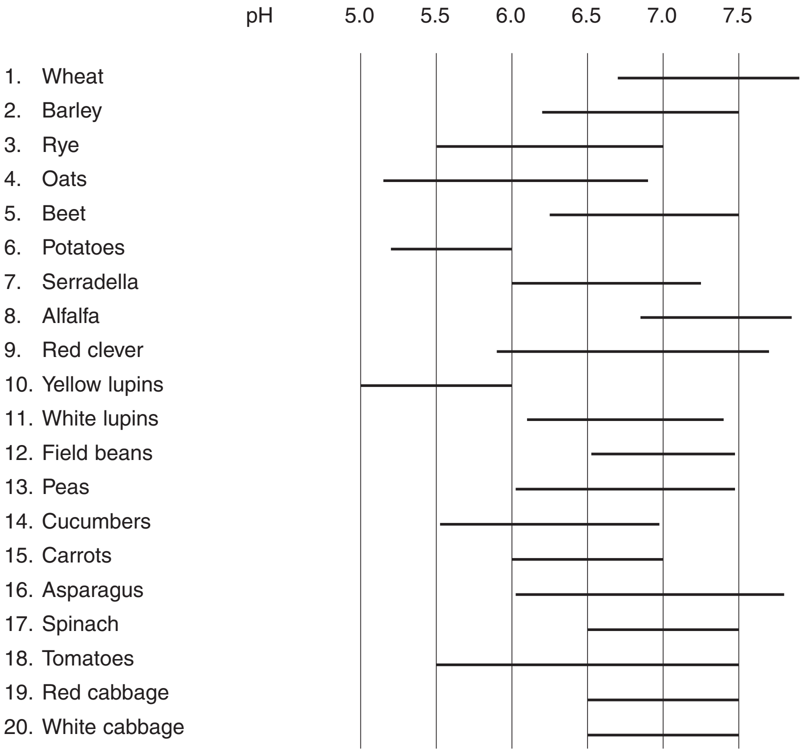
Plant growth as well as biological processes are very much dependent on the acidity of the soil (pH value). Different plants have a different optimum pH at which they thrive best, though it must be pointed out that under otherwise favorable conditions, such as with a good humus status, it is possible to counteract an unfavorable pH.

The table below shows the optimum soil-pH values for the different crop plants.

12 pH value (soil reaction)

12.3 The significance of the pH value for plant growth

Optimum pH values for crop plants



The pH value indicates whether the soil is suitable for the cultivation of certain crops or not. The pH value also indicates whether the soil requires lime or not. For this reason it is not worth attempting to adjust the pH value to a particular level, e.g. the neutral point.
Instead, different pH ranges have been found for the different types of soil and the plants normally grown in these, above which lime no longer needs to be added; for in general only such plants are planted in light soils which are relatively insensitive to the lime status and which thrive best in acidic or slightly acidic soil e.g. lupins, potatoes, rye etc. By contrast, it is preferable to plant crops such as beet, wheat, barley, etc. in heavier soils, which are sensitive to the pH value and demand adequate lime content in the soil.

12 pH value (soil reaction)

12.3 The significance of the pH value for plant growth

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According to the guidelines of the Association of German Agricultural Testing and Research Stations (VDLUFA), lime must be added if the pH value falls below the optimum:

Soil type	Ideal pH value	Recommended maximum liming dt CaO/ha and year	Annual maintainance liming dt CaO/ha
Sandy soils	5.5	10	2
Loamy sandy soils	6.0	15	2
Sandy loamy soils	6.5	20	3
Loam and clay soils	6.9	50	5

An annual replenishment of lime can be omitted if the ideal pH value is significantly exceeded.

Agricultural or horticultural soils contain sufficient lime if they have the following pH values:

Soil type	pH value
Clay and loamy soils	6.5 - 7.5
Sandy loamy soils	6.0 - 6.5
Loamy sandy soils	approx. 6.0
Sandy soils	5.5 - 6.0
Sandy soils with high humus content	4.5 - 5.5
Peat soils	4.0 - 4.5

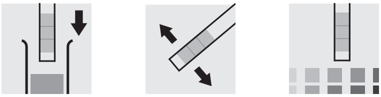
Note:

If your pH measurements give values of pH = 4 or lower, you should absolutely consult your agricultural adviser. A precise laboratory analysis of soil samples of your problem field can then be used to work out recommendations for improving the quality of your soil.

12 pH value (soil reaction)

12.4 Measurement of the pH value

1. Take an indicator strip pH 2.0 - 9.0 and dip or hook it for at least 3 minutes in the soil suspension filtrate (see chapter 4.5 "Measuring the nitrate-nitrogen"). To hook the strip in the filtrate fold the upper end to form a hook.
2. Remove the indicator strip, shake off excess solution and determine the pH value by comparison with the color scale.
   If all three colors on the test strip approximately match the color scale, the pH value (soil reaction) can be read off the scale.



12.5 pH simple test

To obtain a **rough** idea of the soil reaction (pH value), the pH indicator strips can be used as follows:
Press a pH indicator strip against the naturally-moist ground for at least 2 minutes. Dry or roughly structured soils can be moistened with a small amount of water. The colors on the pH indicator strip are compared with the color chart supplied and the pH value is read off.

If the reaction zones of the indicator test strip are covered with soil, they can be briefly rinsed with distilled water or extraction solution without significantly changing the pH value.

alternatively: Use the MColorpHast™ pH-indicator strips pH 2.0 - 9.0, special indicator for pH measurement in turbid solutions (suspensions), Cat. No. 109502. The reaction zones can be compared with the transparent strip on the back.

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12 pH value (soil reaction)

12.6 Estimation of the lime requirement

In accordance with the guidelines of the German Agricultural Testing and Research Stations (LUFA), soils can be divided into certain pH ranges:

pH (KCl suspension)	Assessment
below 4.0	extremely acidic
4.0 - 4.5	strongly acidic
4.6 - 5.5	acidic
5.6 - 6.5	weakly acidic
6.6 - 7.2	neutral
above 7.2	alkaline

Classification of the soils into lime requirement classes according to type of soil and pH value:

Class	Requirement	pH value for light soils	medium soils	heavy soils
III	strong lime requirement	below 4,9	below 5,5	below 5,7
II	lime requirement	5,0 - 5,7	5,6 - 6,3	5,8 - 6,9
I	decent lime requirement	above 5,7	above 6,3	above 6,0

Agricultural or garden soils falling under class 1 can be regarded as adequately provided with lime.

Recommended lime fertilization for different types of soil in kg CaO/100 m² or dt CaO/ha:

Class of lime requirement	Light soils	Medium soils	Heavy soils
III (annually)	5 - 10	10 - 20	20 - 40
II (annually)	3 - 5	5 - 10	10 - 20
	only maintenance lime fertilization		
I	3 - 5 every 2 years	6 - 12 every 3 years	15 - 20 every 4 years

13 Additional research options

The extensive range of rapid & ready to use tests makes it possible to determine a large number of additional parameters in the soil, plants, food and water (see e.g. catalog "Water and Food Analytics" or www.analytical-test-kits.com).

Thus, for instance, it is possible to determine e.g. phosphate, potassium, calcium, magnesium and boron in appropriate soil solutions, both semiquantitatively and fully quantitatively.

Also of interest is the determination of ascorbic acid (Vitamin C) in plants and food as well as the determination of chloride in soil and plants.

Ascorbic acid (Vitamin C) plays a similar role in plant cells as it plays in human organs. It is an antioxidant, an "antistress factor" so that its proportion in cell sap is a measure of the resistance in stress situations, e.g. a lengthy transport. A large number of trials have shown that increased nitrogen fertilization has an adverse effect on the Vitamin C content in plants. With increasing doses of nitrogen, the Vitamin C content in the potato can drop by as much as 50 %. This partly explains the greater sensitivity of overfertilized plants.

The transfer of salt from roads to farming land and the subsequent contamination of the ground water is undesirable both from the agricultural and from the hydrological point of view.

13.1 Determination of ascorbic acid (Vitamin C) in plants

The measurement of the Vitamin C content in plants can also be rapidly and simply conducted with the aid of the MQuant™ Ascorbic Acid Test, Cat. No. 110023. The Ascorbic Acid Test is used in the same manner as the Nitrate Test (see capter 7.3 "Nitrate determination in plants").

The result is given in mg ascorbic acid (Vitamin C) per kg of plant material.

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13 Additional research options

13.2 Determination of chloride (common salt) in the soil

1. Mix the soil sample thoroughly and
   weigh 100 g into a beaker using the balance included in the Agroquant® Soil Laboratory.
2. To prepare a soil suspension, add 100 ml of distilled water to the soil sample and stir vigorously with a spoon.
3. A circular filter is folded twice and placed in the soil suspension in such way, that the filtration takes place from the outside to the inside.
4. Using the plastic syringe, withdraw 5 ml of the filtrate and determine the chloride content with the MColortest™ Chloride Test (Cat. No. 111106).
   This test kit contains a titrating pipette graduated in steps of 2 mg/l.

   If graduations of 25 mg/l chloride are adequate, the MColortest™ Chloride Test, Cat. No. 111132, with dropper bottle can be used.

13.3 Determination of potassium in the soil

The MQuant™ Potassium Test, Cat. No. 117985 is a rapid screening test for checking whether the soil contains enough potassium.
If the potassium test strip indicates approx. 0 mg/l K^+, the soil contains too little potassium.
Soil containing the correct amount of potassium will give an indicated value of approx. 250 mg/l.
Soils indicating 450 mg/l and higher contain too much potassium.

Procedure:

1. Mix the soil sample thoroughly and
   weigh 100 g into a beaker using the balance included in the Agroquant® Soil Laboratory.
2. To prepare a soil suspension, add 100 ml of 0.0125 molar calcium chloride solution* and stir vigorously with the spoon for at least 2 minutes.
3. A circular filter is folded twice and placed in the soil suspension in such way, that the filtration takes place from the outside to the inside.
4. The potassium determination is carried out using the MQuant™ Potassium Test, Cat. No. 117985, in the resulting filtrate.

* Preparation of the 0.0125 molar calcium chloride solution:

Weigh approx. 2 g of calcium chloride dehydrate for analysis EMSURE® (Cat. No. 102382) using the balance. This amount is given into a 1 l bottle and it is filled to the neck with distilled water or battery water (approx. 1 l).

14 Literature

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15 Refill packs for the Agroquant® Soil Laboratory

Agroquant® Soil Laboratory for nitrogen, pH and lime requirement, Cat. No. 114602: Compact laboratory with test strips, reagents, balance, timer and accessories for the determination of nitrate-, nitrite-, and ammonium-nitrogen in soil, water, plants, fodder, compost, solid and liquid manure.

MQuant™ **Nitrate Test**, Cat. No. 110020, 100 determinations

MQuant™ **Ammonium Test**, Cat. No. 110024, 100 determinations

MColortest™ **Ammonium Test**, Cat. No. 114657, 50 determinations

MColorpHast™ **pH-indicator strips pH 2.0 - 9.0**, Cat. No. 109584, 100 determinations

Potassium chloride for analysis EMSURE®, Cat. No. 104936, for the preparation of the extraction solution

The filter paper contained in the compact laboratory can be obtained from laboratory or agricultural suppliers.

16 Ordering informationen

Cat. No.	Description	Measuring range
109502	**MColorpHast™ pH-indicator strips** pH 2.0 - 9.0, Special indicator for pH measurements in turbid solutions (supensions)	pH 2.0 - 9.0
110023	**MQuant™ Ascorbic Acid Test** Test strips with color card 100 determinations	0 - 2000 mg/l ascorbic acid
110083	**MQuant™ Calcium Test** Test strips with reagents and color card 60 determinations	0 - 100 mg/l Ca
111110	**MColortest™ Calcium Test** Test kit with titration pipette (graduation 2 mg/l) 100 determinations	2 - 200 mg/l Ca with 1 full pipette
111132	**MColortest™ Chloride Test** Test kit with dropping bottle (graduation 25 mg/l) 100 determinations at 150 mg/l Ca	

16 Ordering informationen

Cat. No.	Description	Measuring range
111106	**MColortest™ Chloride Test** Test kit with titration pipette (graduation 2 mg/l) 100 determinations	2 - 200 mg/l Cl^- with 1 full pipette
117895	**MColortest™ Potassium Test** Test strips with reagents and color card 100 determinations	0 - 1500 mg/l K
114661	**MColortest™ Phosphate Test** Test kit with color card in reclosable blister pack 100 determinations	0.25 - 3.0 mg/l PO_4^{3-} with 1 full pipette
109511	**Lead(II) acetate paper** Test paper on roll for determination of sulfide 3 x 4.8 m	

17 Suppliers of test kits

This tests are available through dealers in laboratory chemicals.
We shall be pleased to supply further details.

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18 Suppliers of sampling tubes

Sampling tubes can be borrowed or rented from agricultural institutes and authorities (e.g. the Ministry of Agriculture and Fisheries).

19 Short descriptions of the product lines

Agroquant®

Complete, ready-to-use reagent kits and portable laboratories for testing soil, water, plants, fodder, compost, solid and liquid manure.

MQuant® test strips

Test strips which are used as exploratory screening or preliminary tests, for the rapid semi-quantitative determination of ions and certain compounds starting from 1 mg/l in field or on-site tests or in formal laboratory analysis.

MColortest™ titrimetric and colorimetric methods

Reagent kits for testing drinking and industrial water as well as soil, plant and food extracts. The analyses are quick, reliable and simple to perform, requiring no materials other than those provided.
The MColortest™ titrimetric and colorimetric methods are based on titrimetric and colorimetric methods. The titration tests contain dropping bottles, precision droppers or titrating pipettes. The colorimetric determinations are performed using color scales or MColortestTM color-matching vessels.

MColortest™ with color-card comparator

Complete, ready-to-use reagent kits with integral color-card comparator.
An analysis system allowing the minutest concentrations to be measured in drinking water and aqueous extracts.

MColortest™ with color-disc comparator

Test kits with a color-disc comparator for testing by transmitted light, for the semi-quantitative determination of important constituents of water or aqueous extracts in higher concentration ranges.
The MColortest™ with color-disc comparator kits are especially suitable for water and aqueous solutions having slight intrinsic coloration or turbidity.

MColortest™ refill packs

For many MColortest™ kits economic refill packs are available.

19 Short descriptions of the product lines

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MColorpHast™ pH test strips and paper

With MColorpHast™ no instrument or sample pretreatment is necessary.
The pH tests provide convenient and fast brilliant and color-coded results.
Furthermore they can be used for all sample materials in environmental analytics as well as in in-process control in the industry.
Even extremely turbid liquids can be used without difficulty. Our special transparent test strips ensure clear and reliable measurement results - without sample pretreatment.

Reflectoquant® test kits

Reflectoquant® test strips evaluated reflectometric - simple handling of a quantitative measurement combined with the precision of instrumental analytics.

Spectroquant® test kits

Reagent kits for rapid photometric analysis of certain constituents of water and aqueous extracts.

Merck KGaA, 64271 Darmstadt, Germany,
Tel. +49(0)6151 72-2440
www.analytical-test-kits.com

EMD Millipore Corporation, 290 Concord Road,
Billerica, MA 01821, USA, Tel. +1-978-715-4321

Merck KGaA, 64271 Darmstadt, Germany,
Tel. +49(0)6151 72-2440
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