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Liming materials — Guide to the determination of the lime requirement

ICS 65.080

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National foreword

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Liming materials - Guide to the determination of the lime requirement

Amendements minéraux basiques - Guide pour la détermination de la besoin en chaux

Calcium-/Magnesium-Bodenverbesserungsmittel - Leitlinie für die Bestimmung des Kalkbedarfs

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Foreword

This document (CEN/TS 15084:2006) has been prepared by Technical Committee CEN/TC 260 “Fertilizers and liming materials”, the secretariat of which is held by DIN.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this CEN Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Regular liming for regulation of the pH value of the soil has a long tradition in agriculture. Liming has a neutralizing effect on the natural acidification of the soil and thus serves the maintenance of soil fertility.

The desired effects of liming are mainly:

— **physical:** Increased structure stability of the flocculation and porosity of mineral soils, leading to better drainage, structure stability of the soil and improved aeration of the soil.

— **chemical:** Positive influence on solubility of macro- and some micro-nutrients, a reduction in the availability of aluminium and other toxic elements in the soil and avoid aluminium toxicity.

— **biological:** general support of active soil organisms.

Existing European Standards specify methods for assessing the value of liming materials. It is also necessary to establish the principles to be used when calculating the amount of liming material required.

Throughout Europe, wide national and regional variations in soil type, climate and types of farming prohibit the general use of detailed and specific recommendations. The principles set out in this standard should be used by experts at a local level to establish lime requirement.

1 Scope

This Technical Specification gives guidance on the parameters that should be taken into account in order to determine the lime requirement of agricultural soils.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12944-3:2001, *Fertilizers and liming materials — Vocabulary — Part 3: Terms relating to liming materials*

ISO 10390, *Soil quality — Determination of pH*

ISO 11259, *Soil quality — Simplified soil description*

ISO 11277, *Soil quality — Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation*

ISO 14235, *Soil quality — Determination of organic carbon by sulfochromic oxidation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12944-3:2001 and the following apply.

3.1
soil group
texture and organic matter to describe the cultivation characteristic of the soils (light, medium or heavy soils)

3.2
rainfall
water reaching the ground in the form of rain, snow and dew

3.3
pH class
defined pH range as determined by ISO 10390

3.4
target pH
soil pH to be achieved

3.5
basal liming
increase of soil pH from very low pH value to the target pH value with liming materials

3.6
improvement liming
recovery of soils from low pH value to a target pH value with liming materials

3.7
preservation liming
maintaining soil pH to the defined optimum pH value with liming materials

3.8
base saturation rate
proportion of calcium, magnesium, potassium and sodium of the total cation exchange capacity of the soil

NOTE The ratio expressed as a percentage: (Ca+Mg+K+Na expressed as *c*mol$^+$/kg) × 100/cation exchange capacity (expressed as *c*mol$^+$/kg).

3.9
crop rotation
sequence of agricultural crops on a field

3.10
soil cultivation
management of mechanical/physical soil treatment

3.11
lime loss
annual loss and consumption of neutralizing materials from the soil

4 Classification of soils

4.1 Basic scheme

Many chemical and most of the physical properties of agricultural soils depend on the clay fraction, organic matter content and pH. Therefore the clay content (fraction < 2 µm), the organic matter content and the actual and target pH are very important when establishing the lime requirement. A basic scheme for the classification of soils is given in Table 1.

Table 1 — Basic scheme for the classification of soils as specified in ISO 11259

Number	Typical group of soil general description	clay content[a] % (mass fraction)
1	sand	≤ 5
2	slightly loamy sand	> 5 to 12
3	heavy loamy sand	> 12 to 17
4	sandy silty loam	> 17 to 25
5	clayey loam, clay	> 25
6	peat	organic matter > 30 %
[a] a grain size < 0,002 mm in % mineral dry matter according to ISO 11277		

4.2 pH classes A to E

The pH classes A to E define the actual state of lime in the soil. This classification is the basis of determination of lime requirement within the specific system of national or regional standard. In this definition particular consideration is given to the aspects of soil fertility, soil structure, nutrients and the availability of other elements as well as general practical advice on liming (see Table 2).

Table 2 — Definition of pH classes for the supply of lime as well as liming recommendations

pH class soil state of lime	Description of status and target	Requirement of liming materials and fertilizers
A very low	Status: Extreme restriction of soil structure and nutrient availability, very high lime requirement, significant losses of yield of almost all crops up to total loss of yield, extreme increase in plant availability of elements which become increasingly harmful as their plant availability increases at low pH Target: Achievement of targeted, optimal soil reaction; Liming has the highest priority above all other fertilizing and cultivating measures	Basal liming
B low	Status: Optimal conditions for soil structure and nutrient availability are not yet achieved, high lime requirement, still significant losses of yield with crops with a high lime demand, still high plant availability of elements which become increasingly harmful as their plant availability increases at low pH Target: Achievement of targeted, optimal soil reaction; liming within crop rotation, preferably prior to crops with a high lime requirement	Improvement liming
C optimum	Status: Optimal condition for soil structure and nutrient availability is given, low liming requirement, low respectively no increased yield by liming, but stable yield on this pH value Target: Preservation of lime condition by appropriate liming of crops with a high lime demand during crop rotation. The annual proton production has to be neutralized by preservation liming	Preservation liming
D high	Status: Lime supply is higher than targeted, no lime requirement Target: Slow decrease of soil reaction by refrain from liming	No liming
E very high	Status: Soil reaction is much higher than targeted and may have a negative influence on nutrient availability Target: Refrain from any liming	No liming

NOTE In some instances, the application of liming materials to improve soil structure will take precedence over soil pH status when assessing lime requirement.

5 General principles

The determination of the required amount of liming material shall consider the various parameters to establish a recommendation of tonnes of liming material per hectare (see Table 3).

Table 3 — Criteria, parameters and priorities for the lime requirement

Parameter	Units	Specification - Fraction	Priority for lime requirement	Remarks
Frequency of soil analysis	year	3 to 4	* * *	-
Initial pH	-	-	* * *	to be used for determination
Target pH	-	-	* * *	to be used for determination
Clay content	%	0 to 5 5 to 12 12 to 17 17 to 25 25	* * *	to be used for determination
Organic matter (Determined according to ISO 14235)	%	-	* * *	to be used for determination
Rainfall	mm/year	< 500 500 to 800 > 800	* * *	should be used for determination
Crops	-	-	* *	-
Crop rotation system and crop removal	-	-	* *	-
Cation saturation rate	%	< 20 20 to 50 50 to 80 > 80	* *	may be used for determination instead of pH
Soil fineness	mm	< 2	* *	-
Aluminium content	$cmol^+/kg$	Free, toxic aluminium species	* *	valid for recommen-dation
Exchange capacity	$cmol^+/kg$	-	*	-
Acidifying fertilizers Base equivalent of fertilizer applied	CaO equivalent per 100 kg fertilizer -	Calculation dependent upon fertilizer application rate -	*	should be used for determination

* low
* * medium
* * * high

6 Preservation liming

As defined in Table 2, the annual lime consumption losses need to be compensated by preservation liming. This can be carried out annually or in cycles of several years. The period depends on the crop rotation system, the depth of soil cultivation and the amount of annual rainfall. Usually the cycle is 3 years (see Tables 4, 5 and 6).

Where soil analysis is not available, an estimate of the lime requirement may be made by using the annual lime losses shown in Table 6.

Table 4 — General scheme for the classification of pH values in soils in pH class C (targeted/optimal pH range) as well as requirement for preservation liming during crop rotation (kg *NV*/ha)

Arable Land

Parameter			**Organic matter content** % (mass fraction)				
Soil group	**Soil**	**pH class** pH_{KCl}	**<4**	**4,1 to 8,0**	**8,1 to 15,0**	**15,1 to 30,0**	**>30**
1	Sand	pH class C kg *NV*/ha	5,4 to 5,8 600	5,0 to 5,4 500	4,7 to 5,1 400	4,3 to 4,7 300	-
2	Slightly loamy sand	pH class C kg *NV*/ha	5,8 to 6,3 1 200	5,4 to 5,9 900	5,0 to 5,5 800	4,6 to 5,1 400	-
3	Heavy loamy sand	pH class C kg *NV*/ha	6,1 to 6,7 1 400	5,6 to 6,2 1 200	5,2 to 5,8 1 000	4,8 to 5,4 500	-
4	Sandy silty loam	pH class C kg *NV*/ha	6,3 to 7,0[a] 1 700	5,8 to 6,5 1 500	5,4 to 6,1 1 300	5,0 to 5,7 600	-
5	Clayey loam clay	pH class C kg *NV*/ha	6,4 to 7,2[a] 2 000	5,9 to 6,7 1 800	5,5 to 6,3 1 600	5,1 to 5,9 700	-
6	Peat	pH class C kg *NV*/ha	-	-	-	-	4,3 to 4,7 300

[a] in the case of free carbonates (free lime) no preservation liming

Table 5 — Basic scheme for the classification of pH values in soils in pH class C (targeted/optimal pH range) as well as requirement for preservation liming (kg *NV*/ha)

Grassland

Parameter			**Organic matter content** % (mass fraction)		
Soil group	**Soil**	**pH class** pH_{KCl}	**≤ 15**	**15,1 to 30**	**> 30**
1	Sand	pH class C kg *NV*/ha	4,7 to 5,2 400	4,3 to 4,7 300	
2	Slightly loamy sand	pH class C kg *NV*/ha	5,2 to 5,7 500	4,6 to 5,1 300	
3	Heavy loamy sand	pH class C kg *NV*/ha	5,4 to 6,0 600	4,8 to 5,4 400	
4	Sandy silty loam	pH class C kg *NV*/ha	5,6 to 6,3 700	5,0 to 5,7 500	
5	Clayey loam - Clay	pH class C kg *NV*/ha	5,7 to 6,5 800	5,1 to 5,9 600	
6	Peat	pH class C kg *NV*/ha			4,3 -

Table 6 — Annual lime losses by neutralisation and leaching according to cultivation and rainfall in *NV* per hectare per year

Types		**Rainfall** mm/a		
Soil type	**Cultivation type**	Low < 600	Medium 600 to 750	High > 750
Light sandy soils	Arable land	300	400	500
Medium loamy silty soils		400	500	600
Heavy clay soils		500	600	700
Light sandy soils	Grassland	150	250	350
Medium loamy silty soils		200	300	400
Heavy clay soils		250	350	450

7 Basal and improvement liming

7.1 General

Only by field experiments using local or regional soil types and under local climatic conditions, can the figures for lime requirement be accurately verified.

NOTE From the farmer's point of view, the determination of lime requirement must consider, not only the scientific reasons for correct soil pH, but also the economics of the subsequent liming operation.

7.2 Source values to calculate an amount of lime

7.2.1 The initial and the target pH value of the soil

Use the results of field experiments carried out over many years with the most important crops and under various climatic conditions to establish the optimum soil pH, which will give the highest financial return after taking into consideration the cost of the liming operation.

The results are recorded in *NV* per hectare.

7.2.2 The initial and the target cation saturation rate of the adsorption complex in the soil

This type of calculation should be verified by field experiments.

7.2.3 Reaction of a soil sample with chemical reagents

The barium acetate buffer method or ammonium acetate method are laboratory analytical methods, which can be used to determine the lime requirement of agricultural soils.

NOTE See Bibliography [1], [2] and [3].

7.2.4 The optimum pH range of crops or crop rotation system

The position of the liming operation in the crop rotation programme is important. The special pH requirement of single crops or the average pH requirement of a complete crop rotation shall be considered when determining the *NV* per hectare to be applied.

7.2.5 Buffering capacity of soils

Buffering capacity of soils regarding pH shall be taken into account when determining the amount of liming material and required to reach the targeted pH. Clay content, organic matter or cation exchange capacity can provide an estimation of it. Lime requirement for basal or increase pH liming requires higher application rates in clay or organic soils, since the buffer capacity of which is higher in these soils. See also experimental approach in 7.2.3.

8 Determination and calculation

The lime requirement, R, is expressed as *NV* per hectare or kilograms per hectare of CaO-equivalent. The amount of product required, Q, is expressed in kilograms per hectare according to the following equation:

$$Q = \frac{R \times 100}{NV} \tag{1}$$

where

R is the requirement, in kilograms per hectare,

NV is the Neutralizing Value.

Recommendations for lime requirement should be given by trained personnel, and be based upon the guidelines principles and parameters set out in this document. The recommendations will vary according to regional and local circumstances.

When determining lime requirement, it is particularly important to know the Neutralizing Value (*NV*) of the fertilizer to be applied. *NV* is the principal indicator of the ability of a fertilizer to neutralize acidity.

Where very high rates of liming material are recommended, they should be divided. Table 7 shows the recommended maximum annual amount of *NV* equivalent to be applied depending upon soil type.

Table 7 — Maximum amounts of *NV* per year

Character of Soil Type	Amount of *NV* per ha
light sandy soils	3 000
medium loamy soils	6 000
heavy clayey soils	9 000

A simplified system of lime requirement may be used when soil analysis is not possible. In that case the schedule given in Table 5 shows the guideline figures:

9 Additional conditions to be considered

— The application rate of liming material required for arable land generally refers to soils with a 20 cm to 30 cm depth of almost stoneless (or with very few stones) soil, and surface soils and grassland soils up to 10 cm deep. If the soil is considerably more shallow and contains more stones, the required amount of lime may be reduced by 20 % to 40 %.

— The spreading of liming material within the crop rotation should coincide with the planting of crops with higher soil pH demands. This applies particularly to preservation liming.

— On soils with low clay content, the use of carbonate limes should be preferred (see Bibliography [4]).

— The soil pH value naturally fluctuates within certain limits, and is influenced by cultivation, weather and soil condition. The effectiveness of the liming operation, particularly following basal and increase liming, should be monitored by repeated soil analyses at shorter intervals (i. e. annually if required).

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[4] EN 14069, *Liming materials - Description and minimum requirements.*

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