



Agro-environmental Fertilization Guide

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Agro-environmental fertilization guide

Modalities of sampling and soil analysis

This section describes the sampling method and the contents of the soil sampling report as well as (aluminium and phosphorus) analysis methods and assessment of the soil phosphorus saturation percentage referred to in the *Regulation respecting the reduction of pollution from agricultural sources* (RRPAS).

1. Soil Sampling Method [1](#)

The use of mineral fertilizers, animal waste, farm compost and various other residual fertilizing materials accounts for a large part of expenditures relating to plant production. This is because of the need to improve crop yields and quality, the increase in the cost of mineral fertilizers and the increase in the cost of managing fertilizing materials in order to minimize the risk of soil and water contamination. From this point of view, it becomes important to add to the soil only the quantities of nutritional elements required to obtain optimum yield.

Agricultural producers must be knowledgeable about the soils they are cultivating. This means they must pay close attention to the nutritional elements present in these soils. Analysis of a representative sample of the various types of soil or the different fields being used will give them useful information allowing them to use fertilizing information more rationally.



1.1 Sampling Frequency

The soil analysis used to prepare an agro-environmental fertilization plan (AEFP) or taken during regular monitoring of the phosphorus content of the soil must be representative of the fertilizing content of the soil to be fertilized. It must always be less than five years old. However, following recourse to high phosphorus content fertilization, for example, using animal waste or farm compost according to the nitrogen requirement specified in the *Fertilization recommendation* published by the *Conseil des productions végétales du Québec inc.* (CPVQ inc.) (AGDEX 540, 2nd edition, 1996), analysis must be less than one year old. This is also the case when it is expected that fertilization since the last soil analysis has altered the maximum limit for application of phosphorus to which a field is subject.

For the frequency of sampling and analysis needed to carry out the regular monitoring of soil phosphorus content as required in the RRPAS, refer to the section dealing with this aspect.



1.2 Sampling Period

Preferably, sampling should always be carried out at the same time of year, whether at the beginning of the season, in June, or after harvest. It is however necessary to avoid waiting until the day before ploughing since the analysis may not be completed in time to permit fertilization or application of lime. By obtaining analysis results early enough, you will be able to order the limestone in time, spread it when appropriate and not unduly delay work or else have your AEF in time to carry out the first fertilization work of a crop year.



1.3 Preparation for the Taking of Samples

A person who has to carry out this task should always refer to the farm plan before going to the fields to take samples. He must identify them (on each container, give details regarding the field designation appearing in the farm plan). In this way, it will be easy to match the results with their source when the results of the analysis are available and use them when preparing the agro-environmental fertilization plan.



1.4 Nature of the Soil

When the soil is uniform in nature (same texture, same drainage, same topography) and when dealing with the same field, you can make one comprehensive sample from a minimum of 10 specimens taken from different parts of the field.

If there are variations in the nature of the soil, it may be desirable to take samples separately as you would with a different field. Such variations are sometimes marked by difference in colour or texture. It is preferable to take separate samples of sandy, silt or clay soils.



1.5 Sample Taking

Using a soil sampler or a spade and bucket, take a small amount of soil from a depth of 16.9 cm in mineral soil (soil with 30 per cent or less organic material) and at 20 cm in organic soil (soil with more than 30 per cent organic material). A minimum of 10 specimens should be collected at different points in a given field in a zigzag across it. For fields with an area greater than three hectares, the minimum number of samples should be increased to 15. Crop wastes and vegetation must be removed from the samples. The soil samples must be sufficient in number, and sampling sites so chosen as to obtain a representative value of the average phosphorus content of the arable layer of the field.

The soil collected must be well mixed with a trowel or other tool and placed in a container labelled with the number of the field. Avoid handling a sample with the hands and use only clean tools and containers.

Avoid taking samples or specimens:

- on fields fertilized less than one month before;

- on edges of fields;
- on elevated spots;
- on the banks of ditches or waterways;
- at places where animal waste, farm composts, residual fertilizing materials (paper plant sludge, etc.) or lime have accumulated;
- along roads where snow containing calcium or sodium salts has been dumped;
- along farm driveways;
- in places that are too wet (low spots).



1.6 Situations Requiring Special Attention

1.6.1 Crops That Have Received Band Fertilization

In a field where mineral fertilizer has been spread in bands, the soil must be sampled both on the bands and between them, then carefully mixed to reduce the effects of this type of fertilization.

1.6.2 Establishment of Deep-root Crops

In such cases, two samples must be taken :

- a surface sample as already described;
- a depth sample by collecting specimens at the 16.9 or 20 cm to 40 cm depth, labelling the container that it is a depth sample.



2. Field Soil Sampling Report

The sampling activity must be clearly described in a report detailing the procedure followed and, especially, the special features of the samples taken. It is important to know that field boundaries will sometimes be determined by the nature (composition) of the samples taken.

The field referred to is the one specified in section 3 of the *Regulation respecting the reduction of pollution from agricultural sources* (RRPAS).

Thus, after samples are taken of the soil in one or more fields, a report must be prepared containing the following information:

- name of the person who carried out the sampling;
- date of the sampling;
- number of fields sampled according to the farm plan and identification number given to each sample;
- location of the soil sampling points;
- depth of sampling;
- number of specimens making up a sample;
- crop grown;
- all particular information relating to one or more fields sampled on the same date.



3. Soil Analysis Methods

Determination of Aluminium and Phosphorus Available in the Soil Using the Mehlich III Method²

3.1 Introduction

The Mehlich III method was developed by Mehlich (1984) as a method to extract various nutritional elements present in the soil. The Mehlich III extract solution is composed of 0.2 M CH₃COOH, 0.25 M NH₄NO₃, 0.015 M NH₄F, 0.013 M HNO₃ and 0.001 M EDTA. This method is used at present to determine the phosphorus (P) available to plants for Québec's mineral and organic soils (Tran and Giroux, 1989; Tran *et al.*, 1990).

The Mehlich III method also makes it possible to extract the following exchangeable mineral elements: potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na). It is also used in the determination of the following trace elements: aluminium (Al), copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe).



3.2 Equipment and Reagents

1. Rotary agitator
2. Erlenmeyer flasks, 125 mL
3. Filter funnels
4. Filter paper (Whatman[®] No. 42)
5. Disposable plastic flasks
6. Spectrophotometer for conventional colorimetry at 535 nm for Al and 882 nm for P or Technicon automated analyser for P or atomic absorption spectrometer or inductive plasma spectrometer
7. Mehlich III extract solution (0.2 M CH₃COOH + 0.25 M NH₄NO₃ + 0.015 M NH₄F + 0.013 M HNO₃ + 0.001 M EDTA)
 - a. Mehlich III mother solution: (1.5 M NH₄F + 0.1 M EDTA). Dissolve 55.56 g of ammonium fluoride (NH₄F) in 600 mL of distilled water. Add 29.23 g of ethylenediaminetetraacetic acid (EDTA) (p.m. 292.24) to this mixture, dissolve, top up to 1 L with distilled water, shake well and store in a plastic flask.
 - b. In a large plastic container, place about 8 L of distilled water, add 200.1 g of ammonium nitrate (NH₄NO₃), 100 mL of Mehlich III mother-solution, 115 mL of acetic acid (CH₃COOH), 82 mL of nitric acid (HNO₃) 10% v/v (10 mL of 70% concentrated HNO₃ in 100 mL of distilled water), dissolve, top up to 10 L with distilled water and shake well.
 - c. Store in a plastic container
8. Solutions for the manual determination of phosphorus
 - a. Solution A: Dissolve 12 g of ammonium molybdate [(NH₄)₆ Mo₇O₂₄ X 4 H₂O] in 250 mL of distilled water. In a 100 mL flask, dissolve 0.2908 g of antimony potassium tartrate [K(SbO)C₄H₄O₆ X ½ H₂O] in 80 mL of water. Transfer these two solutions into a 2 L volumetric flask containing 1000 mL of 2.5 M sulphuric acid (H₂SO₄) (141 mL of

- concentrated H_2SO_4 per litre), top up to 2 L with distilled water, shake well and store away from the light at 4°C .
- b. Solution B: Dissolve 1.056 g of ascorbic acid ($\text{C}_6\text{H}_8\text{O}_6$) in 200 mL of solution A. Prepare this solution daily.
 - c. Standard solutions of P: Use certified solutions of P or prepare a solution of 100 mg L^{-1} of P by dissolving 0.4393 g of monobasic potassium phosphate (KH_2PO_4) in 1 L of distilled water. Prepare standard solutions of 0, 2, 4, 6, 8 and 10 mg L^{-1} of P in the diluted Mehlich III extract solution.

The phosphorus concentration in the Mehlich III extract solution may be determined by other calorimetric methods, such as Bray-1 or Bray-2.

9. Solutions for the automated determination of phosphorus using the Technicon apparatus, according to modified industrial method no 94-70W (Technicon Autoanalyzer II, 1973)
 - a. Antimony molybdate solutions: Dissolve 30 g of ammonium molybdate [$(\text{NH}_4)_6 \text{Mo}_7\text{O}_{24} \times 4 \text{H}_2\text{O}$] in 600 mL of water. Add 0.15 g of antimony potassium tartrate [$\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6 \times \frac{1}{2} \text{H}_2\text{O}$] and complete the volume to 1 L with distilled water.
 - b. 1 M sulphuric acid: Dilute 56 mL of sulphuric acid (concentrated H_2SO_4) in 400 mL of distilled water, cool the solution. Add 1 mL of Aerosolâ 22 agent and dilute to 1 L with distilled water. This solution must be prepared daily.
 - c. Ascorbic acid solution: Dissolve 12 g of ascorbic acid ($\text{C}_6\text{H}_8\text{O}_6$) in 200 mL of distilled water, add 1 mL of wetting agent Levor IV and mix well.
 - d. Standard solutions of phosphorus: See 8 c.
10. Solutions for the determination of aluminium by manual colorimetry
 - a. Eriochrome cyanine R.

Dissolve 0.750 g of eriochrome cyanine R in 200 mL of demineralized water. Add 25 g NaCl, 25 g NH_4NO_3 and 2 mL concentrated HNO_3 . Top up to 1 litre with demineralized water.

- b. Ammonium acetate - acetic acid buffer.

Dissolve 320 g ammonium acetate in 500 mL demineralized water. Add 5 mL of chilled acetic acid and top up to 1 litre with demineralized water.

- c. Ascorbic acid.
2% aqueous solution
- d. Standard solutions of aluminium.

Prepare a range of standard solutions: 0, 0.80, 1.60, 2.40, 3.20 and 4.00 ppm of Al prepared in a Mehlich-III solution diluted to 1/100 with demineralized water.

11. Solutions for the determination of aluminium using atomic absorption
 - a. Solution of ionic suppresser and interference suppresser (0.06% CsCl + 0.2% LaCl_3): dissolve 3.16 g of caesium chloride (CsCl) in 100 mL of

lanthane chloride (LaCl_3 10%).

- b. Standard solution: according to the instrument used and the concentrations desired, prepare a range of standard solutions for the calibration of the aluminium.



3.3 Procedure

1. Extraction

- a. Weigh 3 g or measure 3 mL of 2 mm sifted soil in 125 mL Erlenmeyer flasks. For organic soils, a volume of 3 mL soil is recommended.
- b. Add 30 mL Mehlich III extract solution (soil: solution ratio of 1:10).
- c. Agitate immediately for five minutes in a rotary agitator ($120 \text{ revolutions min}^{-1}$).
- d. Filter through Whatman No. 42 paper filter and collect the filtrate in plastic flasks. Carry out the analyses as quickly as possible.

2. Determination of phosphorus by the manual colorimetry method

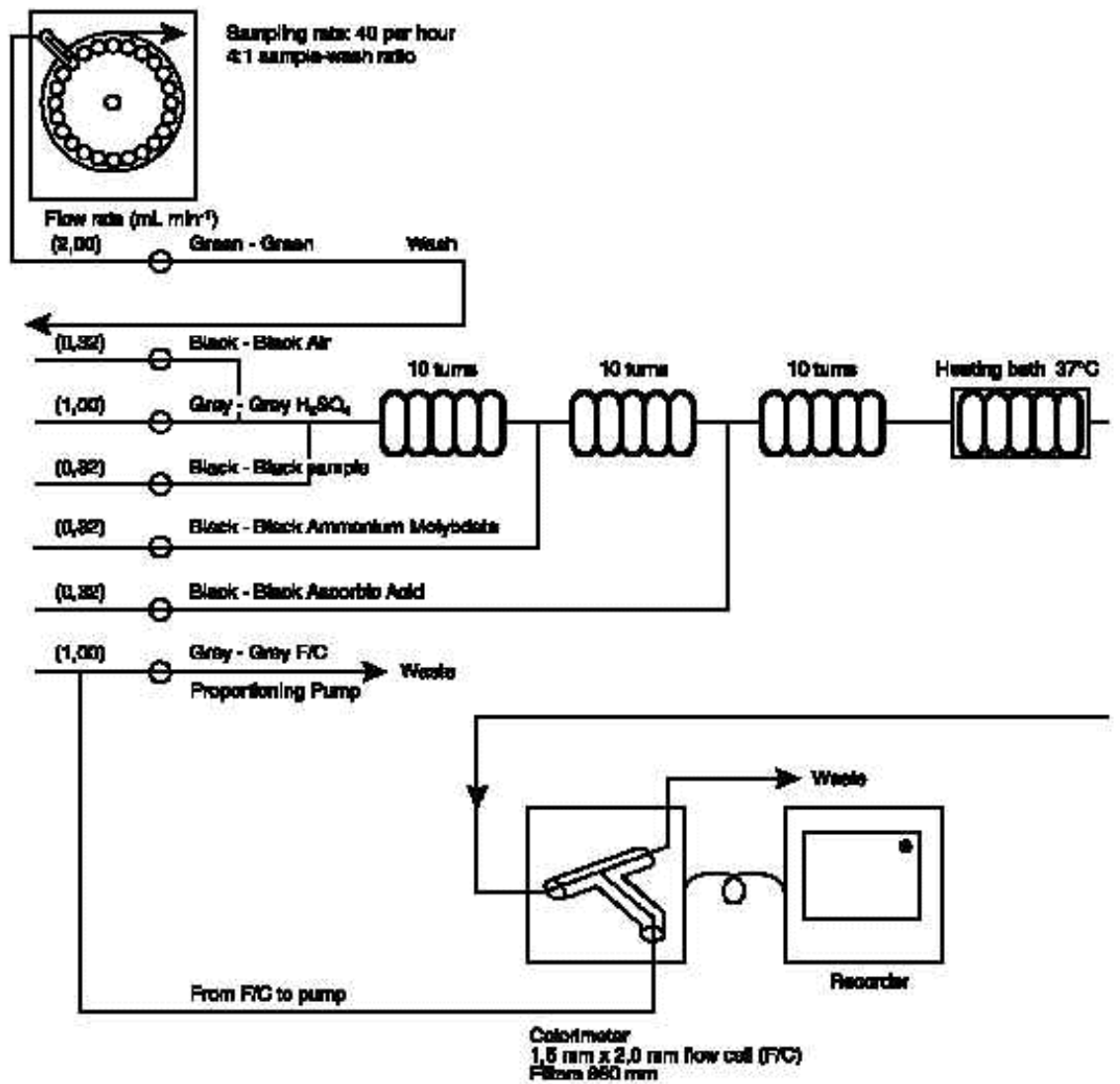
- a. Pipette 2 mL of clear filtrate into a 25 mL volumetric flask.
- b. Add 15 mL of distilled water and 4 mL of solution B, dilute to 25 mL with distilled water and mix well.
- c. After 10 minutes of colour development, measure absorbency at 882 nm.

3. Determination of phosphorus by the automated method (Technicon Autoanalyzer)

- a. Start up the various modules of the Technicon automated analyser at least 30 minutes ahead of time.
- b. Place each tube in its respective reagent (see diagram in Figure 1). Let it pump for 20 minutes to balance the system.
- c. Adjust the base line using the Mehlich III extract solution and the maximum absorbency level of the recorder using the standard solution containing the highest phosphorus concentration.
- d. Place the standard solutions and soil filtrates on the sampler and start it up. Use distilled water with a few drops of Levor IV wetting agent as washing solution.

Figure 1.

**Operating Diagram for Assaying Phosphorus
Available in the Soil Using the Mehlich III
Method Using the Technicon Automated Analyser.**



4. Determination of aluminium by manual colorimetry.

- Pipette 1 mL filtrate into a 100 mL graduated flask. Top up to the mark with demineralized water.
- Remove 1 mL filtrate diluted to 1/100 (or to standard) in a colorimetry tube.
- Add 2.4 mL demineralized water.
- Add 0.5 mL eriochrome cyanine R solution
- Add 1.0 mL ammonium acetate - acetic acid buffer.
- Add 0.1 mL 2% ascorbic acid. The stage c to f reagents may be mixed in advance in the following manner: 48 mL demineralized water, 10 mL eriochrome cyanine R solution, 20 mL ammonium acetate-acetic acid buffer and 2 mL 2% ascorbic acid. Remove 4.0 mL of the reagent mixture and continue to step g.
- Shake well to homogenize and let stand for 20 minutes.
- Read spectrophotometer absorbency at 535 nm.
- If the concentration is too high, dilute the filtrate to 1/100 and repeat stages b to h taking dilution into account in the final calculation.

5. Determination of aluminium by atomic absorption

- a. The (Mehlich-III) soil extracts are titrated by conventional atomic absorption in the presence of an ionic suppresser and an interference suppresser combined (0.06% caesium chloride + 0.2% lanthane chloride, reagent No. 6) at a rate of 1 mL per 50 mL of diluted extract.
- b. To avoid any simultaneous precipitation of CsCl and LaCl₃ in the presence of Mehlich-III extract, it is preferable to dilute in demineralized water. Dilution in water also decreases the concentration of dissolved salts deposited at the surface of the burner.

Example of 1/10 dilution:

- 5 mL soil extract;
- 1 mL suppresser solution;
- complete with water to 50 mL.

- c. Standard solutions are also diluted in aqueous medium.

6. Determination of aluminium and phosphorus by the inductive plasma spectrometry method

The (Mehlich III) soil extracts may be titrated directly by plasma emission without adding internal standard or interference suppresser. The instrumental parameters and optical characteristics of the plasma emission spectrometer are different from one instrument to another and must be calibrated accordingly. The aluminium present in the soil extract may produce interference affecting the phosphorus channel. It is advisable that a correction factor be integrated, if necessary. In the case of soils rich in organic material (% M.O. > 5), phosphorus contents titrated by plasma emission may be higher than those titrated by colorimetry. However, this difference will not markedly affect the fertility class of the analysed soil.

References

Mehlich, A., 1984. Mehlich-3 soil test extractant: a modification of Mehlich-2 extractant. *Comm. Soil Sci. Plant Anal.* 15: 1409-1416.

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Tran, T.S. et M. Giroux, 1989. Évaluation de la méthode Mehlich-III pour déterminer les éléments nutritifs (P, K, Ca, Mg, Na) des sols du Québec. *Agrisol* 2: 27-33.

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4. Soil Phosphorus Saturation Percentage

With respect to fertilization, at present there is a problem of water quality related to poor management of phosphorus from all sources. In the RRPAS, the limitation on the use of phosphate fertilizers is established on the basis of two parameters, soil phosphorus content and saturation percentage. The phosphorus content of the soil indicates the level of soil fertility. The soil phosphorus saturation percentage shows the proportion of soil fixation sites already occupied by this element. This latter parameter is related to the phosphorus fixation capacity of the soil, which is defined as the power of a soil to hold a given quantity of phosphorus. These two parameters provide an indication of the environmental risk that the presence of phosphorus represents.

In Québec, soil phosphorus content is measured using Mehlich III extract. It is one of a number of highly effective extracts that make it possible to measure the phosphorus fixation capacity of the soil. Under our soil conditions, the studies carried out by Giroux and Tran (1996) show that there is a very good relationship between the aluminium content extracted with the Mehlich III solution and soil phosphorus fixation capacity. Both of these values are regularly provided in the soil analysis reports.

Giroux and Tran (1996) also demonstrate the value of two indications of phosphorus saturation of the soil: the Mehlich III P / Mehlich III Al ratio and the Mehlich III P / phosphorus fixation capacity ratio. They obtained a strong relationship between these two indexes. Thus, the fixation capacity makes it possible to easily determine the saturation percentage and, from a practical point of view, this means that we have a reliable agro-environmental diagnostic tool based on the data provided by the soil analysis bulletin.

As we have just seen, the soil phosphorus saturation percentage is the ratio between the soil phosphorus content and aluminium content in a field, both extracted by Mehlich III solution. This value is calculated in the following manner:

$$\left[\frac{\text{M-3}^3 \text{ phosphorus content (kg P/ha)}}{\text{M-3 aluminium content (mg Al/kg soil)}} \times 2.24 \right] \times 100$$

Reference

Giroux, M. et T.S. Tran, 1996. Critères agronomiques et environnementaux liés à la disponibilité, la solubilité et la saturation en phosphore des sols agricoles du Québec. *Agrosol* 9 (2): 51-57.



1

Adapted from : CPVQ, 1980. *Analyse de sol. Prélèvement d'un échantillon de sol* [Soil analysis. Soil sampling]. Conseil des productions végétales du Québec. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec. 8 pages.

2 **Translated and adapted from:**

Tran, T.S. et R.R. Simard, 1993. Mehlich-III-extractable elements. Pages 43-49, Chapter 6, in : *Soil sampling and methods of analysis*. M.R. Carter (ed.) for the Canadian Society of Soil Science. Lewis Publishers, Boca Raton (Florida).

Tran, T.S. et al., 1997. Détermination de P, K, Ca, Mg, Na et des oligo-éléments disponibles du sol par la méthode Mehlich-3. 9 pages in : *Méthodes d'analyse des sols, des fumiers et des tissus végétaux*. Conseil des productions végétales du Québec inc. Publication V9706. AGDEX 533.

³M-3 : Mehlich III extract

⁴Transformation factor : mg Al/kg in soil in kg Al/ha on a depth of 16.9 cm of soil



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Agro-environmental fertilization guide

Assessment of the Phosphorus Content in the Harvested Portion of Crops

Under the *Regulation respecting the reduction of pollution from agricultural sources* (RRPAS), the phosphorus sample from the harvested portion of the crop serves as a basis for determining the amount of phosphorus that may be contributed by animal waste and farm compost within an agro-environmental fertilization plan (AEFP). This value is obtained by multiplying the amount of phosphorus in one tonne of the harvested portion of a crop, obtained from the table appearing on the following page, by the yield for this crop. This assessment must be based on the yields obtained by the agricultural operation concerned according to the data provided by the RAAQ (the Québec agricultural insurance board).

However, it may happen that an agricultural operation does not use the insurance products offered by the RAAQ or a crop is not covered by an insurance program offered by this organization. In such cases, the person who has to prepare an AEFP for such an operation must determine the crop yield of the agricultural operation according to the methods elaborated by the RAAQ for this purpose.

Crop phosphorus content according to different parts of the plant¹

Crop	Part of plant	Humidity (%)	Quantity of phosphorus sampled ² (kg P/tonne)
Oats	Grain	14	4.0
	Straw	D.M.	1.0
Wheat	Grain	14	4.0
	Straw	D.M.	1.0
Barley	Grain	14	4.0
	Straw	D.M.	1.0
Grain corn	Grain	15	3.0
	Stem and leaf	D.M.	1.3
Silage corn	Whole plant (above-ground portion)	D.M.	2.5

Rye	Grain Straw	14 D.M.	3.2 1.0
Grain hay less than 40 % legume	Whole plant (above-ground portion)	D.M.	2.5
Legume hay more than 40 % legume	Whole plant (above-ground portion)	D.M.	3.0
Potatoes	Tubers Tops (before topping)	80 D.M.	0.5 1.8
Soya	Beans Tops	10 D.M.	6.0 2.5
Canola	Grain Whole plant (flowering)	10 D.M.	7.0 2.9
Colza fodder	Whole plant (after flowering)	D.M.	3.2

¹ Samples from "*Fertilization Recommendations*" (AGDEX 540, 2nd edition) published by the *Conseil des productions végétales du Québec inc.*

² The quantity of phosphorus sampled is expressed per tonne harvested for the percentage of humidity indicated or on a dry matter basis (D.M.).



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Agro-environmental fertilization guide

Monitoring of Phosphorus Required in an Agro-Environmental Fertilization Plan

This section describes three elements that must appear in the agro-environmental fertilization plan specified in the *Regulation respecting the reduction of pollution from agricultural sources* (RRPAS). These are the calculation of expected changes in soil phosphorus content and saturation percentage, regular monitoring of these readings, and determination of phosphorus reception or surplus capacity in an agricultural operation.



1. Calculation of Expected Changes in Soil Phosphorus Content and Saturation Percentage

1.1 Changes in Soil Phosphorus Content

It is known that a contribution of phosphorus beyond that contained in the harvested portion of a crop leads to an enriching of the soil content of that element. Since the nitrogen and phosphorus content of animal waste does not generally correspond to the quantities of nitrogen and phosphorus taken up by the various crops and since the quantity of phosphorus necessary to meet the crop needs is generally less than the amount of nitrogen that is needed, the quantity of manure spread to meet all or a large part of the nitrogen needs of the crops has the effect of producing a relatively large increase in the phosphorus content of the soil. This may also be true in cases where phosphated mineral fertilizers are used in addition to contributions of animal waste or beyond the crop needs. This situation will deteriorate even more with frequent repetition.

In fields whose soil is classified as "poor" or "average" in phosphorus, a controlled enrichment is desirable to achieve quality yields. However, in fields whose soil is classified "good," "rich" or "exceedingly rich," excessive enriching is harmful to the maintenance of surface waters quality, especially when the saturation level exceeds 10 per cent (Giroux and Tran, 1996).

Although, on the one hand, the lawful requirements as to the quantities of phosphorus that may be spread on a soil and a given crop become stricter over time and, on the other hand, it is not always easy to quickly make the necessary adjustments for certain agricultural operations, it is foreseeable that over a certain period (short and medium terms), operations have to fertilize beyond the desirable quantities. In such situations, the speed of soil enrichment and the consequences of reducing relatively quickly the quantities of phosphorus spread on the fields must nonetheless be assessed. This information makes it possible to adopt the fertilization procedure best adapted to the situation of the agricultural operation in question.

In consulting various research studies carried out in Québec, Giroux *et al.* (1996) found that it is necessary to add from two to five kg P/ha to crop samples to increase the Mehlich III phosphorus content of a soil by 1 kg P/ha. For his part, Beaudet (1996) estimated long-term changes in the phosphorus content of the soil of a silage corn crop following fertilization with liquid pig manure. He also established that it was necessary to practice fertilization exceeding the crop sample by 3.5 kg P/ha to increase the soil phosphorus content by 1 kg P/ha. In another case, Tran *et al.* (1996) show that each 3.6 kg P/ha contributed exceeding silage corn crop samples in the form of liquid pig manure on a Neubois silt loam produces an additional 1 kg P/ha in soil content. Similarly, they recorded an increase of 1 kg P/ha on a Le Bras silt loam for each 3.8 kg P/ha spread in the form of cattle manure exceeding the samples from a silage corn crop. Finally, Gangbazo *et al.* (1998) obtained on a Coaticook silt loam an increase of 1 kg P/ha for each 2.8 kg P/ha contributed exceeding the phosphorus samples from a silage corn crop as well as an increase of 1 kg P/ha for each 10 kg P/ha exceeding the samples for a meadow. These authors also noted that a contribution of 2.8 kg P/ha and 1.4 kg P/ha less than the phosphorus samples respectively for a silage corn and meadow crop led to a reduction of 1 kg P/ha of soil.

When such fertilization is expected, the fertility level may be assessed by adding to the initial soil phosphorus content (according to soil analysis), the enrichment value obtained following excess fertilization in relation to the crop sample for each season involved. This excess is determined by assessing the phosphorus contributed by the fertilizing materials used, from which the crop sample must be subtracted, and applying the conversion factor given in the studies cited above or obtained on the farm. The crop sample is calculated by multiplying the yield of this crop, obtained by the operation involved in accordance with RAAQ data, by the sample of a ton of the harvested crop (kg P/ tonne harvested according to values given in the *Assessment of the Phosphorus Sample in the Harvested Portion of Crops* section of this Guide).

The final phosphorus content of the soil is determined from the following data:

beginning soil content + [(contributions - sample) × conversion factor] = final content.

Here is an example:

Let us assume a clay soil growing grain with a grain yield assessed according to the RAAQ as 6800 kg/ha and a moisture rate of 15 per cent. The analysis of the soil from this field carried out with the Mehlich III extract shows quantities of 132 kg P/ha, 156 kg K/ha and 1128 mg Al/kg.

According to the *Fertilization Recommendations of the Conseil des Productions Végétales du Québec* [Québec plant production council] Inc. (AGDEX 540, 2nd edition, 1996), this crop needs 150 kg N/ha, 40 kg P₂O₅/ha and 75 kg K₂O/ha.

The field is fertilized at seeding time with mineral fertilizers at the rate of 30 kg N/ha in the form of NH₄NO₃ and post-emergence with liquid manure from a pig breeding operation containing 3.0 kg N/m³, 2.8 kg P₂O₅/m³ and 1.5 kg K₂O/m³ sprayed and incorporated in less than one week.

Following the fertilization with 30 kg N/ha in the form of NH₄NO₃, the needs of the crop are therefore 120 kg N/ha, 40 kg P₂O₅/ha, 75 kg K₂O/ha.

Considering the fertilization modes adopted (type of manure, when spread, etc.), efficiency coefficient and loss factors that apply to this situation, the available nitrogen content of the liquid manure used is obtained as follows:

$$3.0 \text{ kg N/ha} \times 0.6 \times 1.4 \times 1.0 = 1.3 \text{ kg N}_{\text{available}}/\text{m}^3$$

When fertilization is carried out according to the crop's nitrogen requirement, this represents a quantity of:

$$120 \text{ kg N/ha} \div 1.3 \text{ kg N}_{\text{available}}/\text{m}^3 = 92 \text{ m}^3/\text{ha}$$

This quantity corresponds to a phosphorus contribution of:

$$92 \text{ m}^3/\text{ha} \times 2.8 \text{ kg P}_2\text{O}_5/\text{m}^3 = 258 \text{ kg P}_2\text{O}_5$$

This type of fertilization furnishes excess phosphorus assessed as follows:

$$\text{Contribution} - \text{Sample} = \text{Excess}$$

Since 2.29 kg P₂O₅ corresponds to 1 kg P, this excess corresponds to:

$$258 \text{ kg P}_2\text{O}_5/\text{ha} - (6.8 \text{ t/ha} \times 3 \text{ kg P/t} \times 2.29) = 211 \text{ kg P}_2\text{O}_5/\text{ha}$$

For the purposes of this exercise, it was assumed that a corn crop fertilized in excess of the samples at the rate of 3.5 kg P/ha enriches the soil by 1 kg P/ha. This fertilization contributes to the phosphorus enrichment of the soil in the following manner:

$$[211 \div (2.29 \times 3.5)] \text{ kg P/ha} = 26 \text{ kg P/ha}$$

Consequently, it will have the effect of increasing the fertility of the soil to the following level:

$$\text{Initial level} + \text{Excess} = \text{Level attained}$$

$$132 \text{ kg P/ha} + 26 \text{ kg P/ha} = 158 \text{ kg P/ha}$$

To anticipate the long-term phosphorus content of the soil in this field, any assessment must take into account the fertilization used for each of the seasons preceding the sampling date. Thus, the former fertilization practice repeated for five years will lead to a phosphorus level of 262 kg P/ha, which increases environmental risk.



1.2 Changes in Soil Phosphorus Saturation Percentage

The soil phosphorus saturation percentage provides information on the level of phosphorus availability but also the level of environmental risk this element presents to water quality. In addition to leading to an increase in the phosphorus content of the soil, over-fertilization thus also has the effect of increasing the soil

phosphorus saturation percentage. So, when a soil holds 1128 mg Al/kg soil and 132 kg P/ha extracted with Mehlich III solution and is fertilized in such a way that its content reaches 262 kg P/ha, the soil saturation percentage it represents therefore increases by 5.3 to 10.6 per cent. A field may therefore change from a favourable agronomic situation to a risky environmental situation without necessarily guaranteeing better agronomic performances.

Changes in soil phosphorus saturation percentage may be calculated using the following equation:

$$[\text{M-3 phosphorus content (kg P/ha)} / \text{M-3 aluminium content (mg Al/kg soil)} \times 2.2] \times 100$$

Here is an example:

Let us assume the same field as in the previous example whose beginning soil phosphorus content is 132 kg P/ha and aluminium content 1128 mg Al/kg soil extracted with Mehlich III solution and presenting a phosphorus content of 165 kg P/ha after fertilization with liquid manure from a pigs breeding operation.

Initially, the saturation percentage is :

$$[132 \text{ kg P/ha (1128 mg Al/kg soil} \times 2.2)] \times 100 = 5.3\%.$$

After one year of fertilization, the saturation percentage will be:

$$[158 \text{ kg P/ha (1128 mg Al/kg soil} \times 2.2)] \times 100 = 6.4\%.$$

After five years of fertilization, the saturation percentage will be:

$$[262 \text{ kg P/ha (128 Al/kg soil} \times 2.2)] \times 100 = 10.6\%.$$



1.3 Periods and Modalities

The agro-environmental fertilization plan (AEFP) must provide two former assessments for a period from the first crop year covered by the AEFP until the date the second phase of the phosphorus standard comes into effect. However, this period may not be less than five years. More specifically, values must be produced for the first crop year when the first phase and second phase standards come into effect. Once these dates are reached, the assessments must to be produced for a date ending a minimal period of five years.

Assessments must be prepared for each field of an agricultural operation.

The preparation of assessments must take into account expected fertilization and crop rotation. The conversion factor for the quantities of phosphorus introduced in excess of the samples to be used to carry out the assessments is 3.5 kg P/ha, to increase soil phosphorus content by 1 kg P/ha or any value that can be supported with data by the author of the AEFP (research work carried out in Québec or data from the agricultural operation involved).

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2. Regular Monitoring of Soil Phosphorus Content and Saturation Percentage

The only known way to monitor changes in soil phosphorus content and saturation percentage is to measure the phosphorus and aluminium content extracted using Mehlich III solution.

The objective of the regular monitoring set out in the *Regulation respecting the reduction of pollution from agricultural sources* is to measure real changes in soil phosphorus content and saturation percentage. This data will make it easier to plan optimum use of fertilizing materials by the agricultural operation involved or animal waste and farm compost to export or import.

Thus, if a field receives only mineral fertilizer, monitoring consists in taking a soil sample and measuring its phosphorus content at least once every three years. In other cases, it must be carried out at least once every two years.



3. Determination of Phosphorus Reception or Excess Capacity of an Agricultural Operation

Any agricultural operation fertilizing according to an agro-environmental fertilization plan (AEFP) and receiving animal waste or farm compost from one or more other operations must determine its phosphorus reception capacity according to the fertilization standards in effect. Similarly, any operation fertilizing according to an AEFP and not able to use all its waste or farm compost so as to comply with the quantities of nitrogen and phosphorus set out in the fertilization standard in effect must use a different method to determine the excess phosphorus it will have to dispose of. The present section aims at specifying the approach to be utilized in carrying out these two assessments as well as the period and modalities to achieve them.



3.1 Phosphorus Reception Capacity of an Agricultural Operation

The first stage in meeting this requirement consists in establishing, from the information appearing in the AEF, the quantities of phosphorus that may be spread on each field of the agricultural operation according to their phosphorus content and saturation percentage, their area, the crop grown and the fertilization standard specified in the AEF, which may not exceed the fertilization standard in effect. These quantities must then be totalled for all fields in the operation. The following stage consists in establishing the quantities of phosphorus from the operation's animal waste and farm compost.

Finally, the operation's phosphorus reception capacity must be determined by subtracting from the quantities which may be spread the animal waste and farm compost produced by the operation as already appraised.

$$\text{Reception capacity} = \text{quantity of P which may be spread} - \text{quantity of P contributed by animal waste and farm compost}$$



3.2 Phosphorus surplus of an agricultural operation

The present assessment is based on the same parameters as the assessment of the phosphorus reception capacity of an agricultural operation. However, the last stage in this assessment consists in determining the phosphorus surplus of a farm by subtracting from the contributions from its animal waste and farm compost the quantities that may be spread as already appraised.

$$\text{Surplus} = \text{quantity of P contributed by animal waste and farm compost} - \text{quantity of P which may be spread}$$



3.3 Period and Modalities

This requirement calls for the production of assessments at various times. Thus, in all cases, an assessment must be carried out for the first crop year covered by the AEF. The assessment must also deal with each year when the first and second phase of the fertilization standard come into effect. The assessment must always cover a minimal period of five annual crop years.

These assessments may be prepared taking into account the fertilization and rotation set out in the AEF, while considering the values obtained from the calculation of the foreseeable changes in the soil phosphorus content and saturation percentage that are themselves a function of the expected fertilizations and crop rotations.

[1](#) M-3 : Mehlich III

[2](#) Transformation factor: mg Al/kg in kg Al/ha over a depth of 16.9 cm of soil



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Fertilizing Materials

- Project notice according to sections 39 and 40 of the Regulation respecting agricultural operations - Form ([French](#), Word file, 357 Ko)
- Phosphorus Report - Form ([French](#), Word file, 308 Ko)
- [Interim Criteria for the Reclamation of Fertilizing Residuals](#)
(Land application, storing, composting, manufacture and use of soil mixes)
- [Agro-environmental Fertilization Guide](#)
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