Estimation of the soil nitric nitrogen concentration at plot scale
Impact of the sampling density on the result's precision

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Introduction

In the Walloon region of Belgium, the EEC 91/676 European Nitrates Directive is implemented through the Programme for Nitrogen Sustainable Management in Agriculture ("Programme de Gestion Durable de l'Azote en agriculture", P.G.D.A.). This P.G.D.A limits the application of organic N to 230 units on grasslands and to 115 units on crop lands. Moreover, farmers are obliged to provide N (organic and inorganic) to the crop taking account of the soil characteristics, the previous crop (and eventually catchcrop), …

Evidences of good N management at farm and plot scale are provided on the basis of the nitric nitrogen soil concentration (called "APL" for Azote Potentiellement Lessivable – Potentially Leachable Nitrogen) established in November at the beginning of the leaching period.

APL results for controlled fields are compared to reference values established every year by Gembloux Agro-Bio Tech and the Catholic University of Louvain in reference farms.

It appears crucial in that context that the assessment of both reference and control APL be realized upon a sound methodology and that sources of imprecision be properly quantified.

This study was conducted in order to evaluate the spatial variability of nitric nitrogen content at plot scale and consequent requirements regarding soil sampling.

Materiel and methods

The 8 hectares studied parcel is located in loamy region and presents Aba (loamy soil with good natural drainage) and Abp (loamy soil with good natural drainage without profile development) soils.

In a 270 x 180 meters primary grid, 70 soil cores were taken every 30 meters. In addition, 65 other soils cores were taken at 2, 5 or 15 meters of some of the 70 soil cores (fig. 1). Samples were taken for every layers of 30cm depth till 120cm.

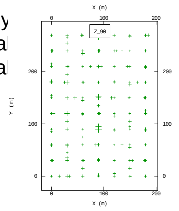

Figure 1: Sampling points on the field of Poucet

Nitric and ammonium nitrogen dosage were performed according to standardized procedures (ISO 14256-1).

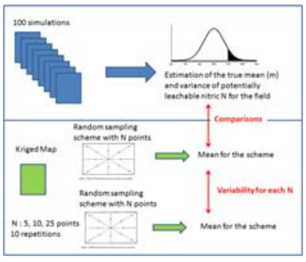

Figure 2: Methodology for interpretation of results

Results were analyzed upon geo-statistical analysis with ISATIS (fig. 2). First, the true values of mean APL content and variance of the field were estimated by conditional simulations.

Then, 30 different sampling schemes were applied on the kriging map. These schemes were all completely random and differed by location and number of points (5, 10 or 25).

Results and discussion

The results of soil sample characterization are summarized in table 1. The geostatistical analysis was performed on the 0-90cm only as it is the support used in the control. The histogram of raw data is given in figure 3.

The 0-90cm APL ranges between 55 and 282 kg/ha, with a mean of 106 which is a rather high level for Wallonia.

Table 1 : Summary statistics of nitric nitrogen measured on the 135 soil samples

	0-30cm	30-60cm	60-90cm	90-120cm	0-60cm	0-90cm	0-120cm
MIN	11,38	19,18	5,83	10,09	36,40	55,91	68,38
MAX	79,18	168,72	88,99	83,13	247,89	281,94	329,68
MEAN	30,20	44,34	31,62	27,49	74,54	106,16	133,65
MEDIAN	28,87	40,42	29,62	25,88	68,56	100,97	127,69
St. DEV	9,94	20,42	10,86	11,10	27,57	33,64	39,57
CV (%)	33	46	34	40	37	32	30
r (0-90cm)	0,77	0,92	0,67	0,42	0,96	1,00	0,97

The 30-60cm layer presents the highest levels of nitrogen but the four layers contribute significantly to the total APL measured in the first 120cm. Levels of variability are of the same magnitude around 35-40% of the mean.

Correlations are very highly significant between the 0-60, 0-90 and 0-120cm and these sums are mainly conditioned by the variation of the 30-60cm layer.

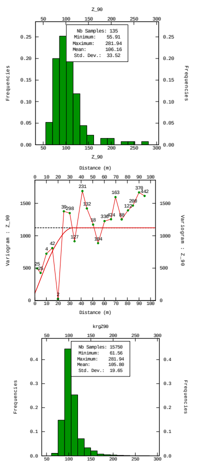

Figure 3: Histogram of raw data (up), semivariogram (middle) and histogram of kriged values (bottom)

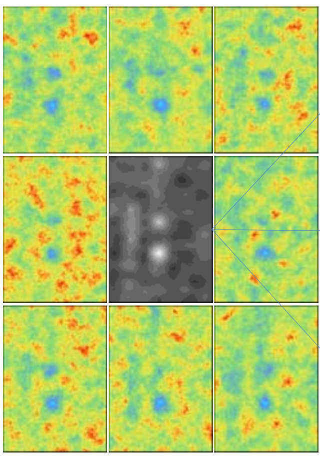

Figure 4: nine examples of simulations (on 100) surrounding the kriging estimate (grey scale).

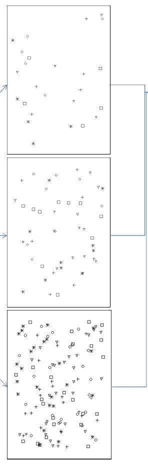

Figure 6: Examples of 5 random schemes with 5 (up), 10 (middle), and 25 (bottom) points each

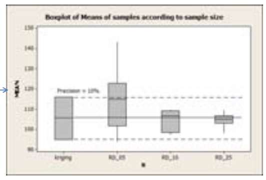

Figure 7: Performances of sampling schemes to predict the true mean of the parcel

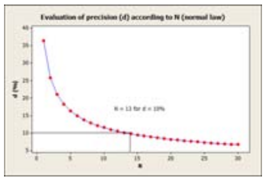

Figure 8: Relationship between theoretical number of sampling points needed to estimate the mean of the parcel and the relative precision.

A nugget+spherical model has been applied to the experimental variogram (fig. 3). The range of the model is circa 30m, meaning that the spatially-structured variation occurs at short distances compared to the size of the fields.

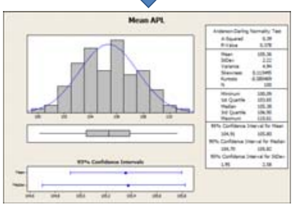

Figure 5: Graphical summary of the mean APL across the 100 simulations.

One hundred conditional simulations were realized and the field mean APL calculated (fig. 4 & 5). The true mean is assessed to be 105.4 kg/ha, which is very close to the mean of raw data (106,2) and kriging mean (105,6).

On every point of the field, the kriging estimate is equivalent to the mean of all the simulations and this map was used in order to test various sampling schemes (fig.6). A tolerance of 10% of precision was fixed as an acceptable limit.

When considering the mean values given by the 5-points samplings, we found that half of them were clearly outside the limits (fig. 7). Both 10-points and 25-points schemes were satisfactory. The more points the less differences between the schemes.

It is worthful to compare with the theoretical number of sampling points that should be needed given that level of precision and the variance of kriging estimates (fig. 8).

Our results appear rather optimistic regarding the performance of sampling with 10 to 15 points for almost 8 hectars. This is far less than what is usually recommended for fertility evaluation.

The question of the representativeness of the field and its spatial pattern of APL distribution is an important issue and we should multiply the examples in the near future in order to confirm these findings.