SAMPLING STRATEGY FOR MINERAL NITROGEN IN A GREENHOUSE SOIL

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Introduction

Greenhouse crops typically have a high net economic added value, whereby suboptimal cultivation conditions have repercussions on the economic return. Especially mineral nitrogen (N_{min}), being the most important macro-nutrient, is required in a sufficient amount and uniform spatial distribution, as crop responses to variability in mineral nitrogen exert their effect on both yield and quality (Roberson, 2000). As the natural N-supplying process, i.e. mineralization from soil organic matter, seldom provides enough nitrogen for economic crop production, fertilizers are necessary to make up the deficiency. Quantitative studies on the availability of soil N to plants (N-fertilizer advices) require best estimates of mean mineral N concentrations and a measure of the reliability of those estimates. Therefore, bulking is practiced to minimize the variability that exists over short distances between soil cores collected in a sample area (Wollenhaupt et al., 1997). Although it was stated already 40 years ago that a mere concern with the quantity of nitrogen is not sufficient for optimum plant production (Harmsen and Kolenbrander, 1965), the uniform management of N across fields with variable soil and plant N relations remains common practice. As greenhouse soils are expected to have a low spatial variability because only mineral fertilizer are applied and, on the contrary to e.g. grazed pastures and arable land, neither excreta nor organic amendments introduce supplementary variability (Bogaert et al., 2000) only a limited number of investigations have been performed concerning the spatial variability and its effect on sampling strategy for mineral nitrogen in greenhouse soils. The aim of this investigation was to calculate the number of soil samples necessary to obtain an acceptable mean value for this nutrient constituent. Classical statistical analysis of the data was performed to accomplish this objective.

Material and methods

The field experiments were carried out in a greenhouse with a total area of 1890 m^2 (42m × 45m) located at Gits, West-Flanders, Belgium. The field has been permanently glass-covered since 1963 and the rotation scheme ever since fixed at 3 × butterhead lettuce (October till May), followed by a summer cultivation of tomatoes. For the last 10 years, the different crops have been fertilized according to an N_{min}-fertilizer advice.

Soil sampling

To investigate the variability of the NH_4^+-N and NO_3^--N content in the experimental field, 300 soil samples were taken using a regular grid with a sampling distance of 3 m. Two small grids with a sampling distance of 0.5 m were added (Figure 1).

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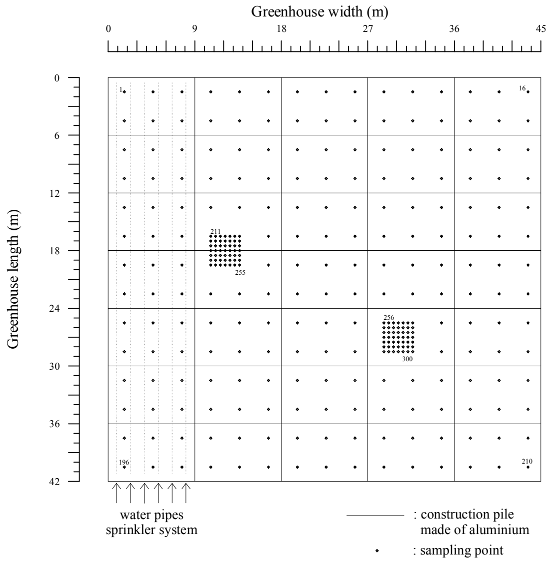

Figure 1. Sampling grid for the determination of soil N_{min} (figures indicate sample number)

Soil sampling was carried out in spring just after a harvest of lettuce and before fertilizing and planting a new butterhead lettuce crop. Soil samples were taken at 2 depths: 0-30 cm and 30-60 cm. At each sampling point a boring was carried out by means of an auger (∅ 3 cm) and stored in the freezer till analysis. At the same time, undisturbed soil samples of the two layers were taken in order to determine the soil bulk density, which was on average 1.18 ± 0.04 g cm^{-3} for the 0-30 cm layer and 1.44 ± 0.07 g cm^{-3} for the 30-60 cm layer.

Determination of soil mineral nitrogen

After thawing and grinding the fresh soil, 30 g moist soil was mixed with 60 ml of a 1 N KCl solution. Then the 1:2 soil:solution (w:v) was shaken for 1 h, using a reciprocating shaker, and filtered. The KCl extracts were measured colorimetrically by a continuous flow auto-analyzing system, determining at the same time the NO_3^--N and NH_4^+-N concentration. The results are expressed on a dry weight basis (105°C).

Statistical analysis

Means, variances and standard deviations were estimated by applying conventional statistical methods. The coefficient of variation (CV) was used for purpose of expressing variability on a relative basis. The number of samples needed to obtain a mean value of a given parameter with a given precision and confidence level was calculated by (Cline, 1944):

$$N = [(CV/d)t_l]^2 \quad (1)$$

where d is the allowable error (%) and t_l is the value of the two-tailed Student's t with indefinite degree of freedom at the desired level l.