METHOD OF SOIL SAMPLING BASED ON CIRCULAR PROBE APPARATUS

Mesic, I. Sestak, I. Kisic, Z. Zgorelec, A. Jurisic

Milan Mesic, PhD, Full Professor, Ivana Sestak, PhD, Assistant Professor, Ivica Kisic, PhD, Full Professor, Zeljka Zgorelec, PhD, Assistant Professor, Aleksandra Jurisic, PhD, Assistant.
Department of General Agronomy, University of Zagreb, Zagreb, Croatia.
Corresponding author: Milan Mesic, Svetosimunska c. 25, 10000 Zagreb, Croatia; phone: 0038512393956; e-mail: mmesic@agr.hr.

ABSTRACT:*Conventional soil sampling usually implemented in Croatia considers sample weight of 2 kg per 4-5 ha area, which means that representative sample in relation to soil mass up to 30 cm depth is presented through the ratio 1:10000000. New sampling method changes the ratio to 1:625000, thus increasing amount of sampled soil 16 times with assumption that such sample better describes investigated area. Moreover, new soil sampling probe can be used for precision farming purposes where the central point of the probe ring is positioned with precision of ±1 cm and represented with 4, 8 or 16 samples taken in 50 cm radius from the center. Soil probe prototype was tested on agricultural land of 4 ha area with total number of 200 samples. To justify application of new constructed probe, this study gives results of geostatistical analysis of spatial variability in soil pH values up to 30 cm depth.*
KEYWORDS. *CIRCULAR SOIL PROBE APPARATUS, GRID SAMPLING, PH, PRECISE SOIL SAMPLING*

INTRODUCTION

The key to efficient and effective site-specific management is an understanding of the spatial and temporal variability in yield generating factors and environmental conditions (Slater, 2000). Soil sampling is the first step in generating field-specific information on which to base agricultural input decisions. In the past, farm fields where managed as single units and managers required estimates of average conditions for soil attributes for the whole field. Precision management requires an understanding of variability within the field, and hence sampling is needed to estimate attributes at a finer scale than whole-field average. The objective of this study was to evaluate potential of new precision soil sampling method for increasing representativeness of soil attributes at specific location.

PREREQUISITES AND MEANS FOR SOLVING THE PROBLEM

LOCATION AND RESEARCH CONDITIONS

Research was conducted on experimental field located within drained cropland in Western Pannonian subregion of Croatia (45°33´N, 16°31´E) (Figure 1). The soil type of trial site is drained distric Stagnosol. Terrain is flat with average altitude 97.2 m. Soil is acid in first two horizons, but pH increases with depth according to carbonates accumulation. Lowered soil pH values on nitrogen (N) fertilization treatments are in some extent result of the long-term mineral N fertilization.

SOLUTION OF THE EXAMINED PROBLEM

EXPERIMENTAL DESIGN

Experimental field is a part of a 15 years long research of influence of mineral N fertilization on nitrogen use efficiency, crop yield and nitrate leaching within a framework of scientific project "Nitrogen fertilization acceptable for environment" (funded by Ministry of Science, Education and Sports). Semi-automatic circular tractor soil probe prototype (PCT-HR2011-000021) (Figure 2) was tested after winter wheat harvest (20th July, 2010) on field experiment area of 4 ha with total number of 200 samples (regular grid: 15 x 15 m) covering 10 different fertilization treatments with 4 replication plots (Figure 1). Dimension of each trial treatment is 30 x 130 m including blank space, and 26 x 26 m for replication parcel.

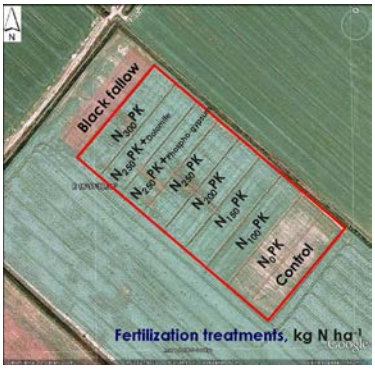

Figure 1. *Field experiment with 10 nitrogen fertilization treatments*

MACHINE DESIGN

The invention refers to a circular probe assembly with a rotational mechanism, where simultaneous soil sampling by means of 2 single probes at least and 16 at most is made possible in 1 m diameter to make 1 average sample (Figure 2). Present invention includes a sample collection container, intended for simultaneous taking of an average soil sample and tracing the soil fertility maps. The rotary probe assembly is attached to the tractor's hydraulic leverage and linked with the support of the whole rotary probe assembly. Further, the rotary probe assembly incorporates the main hydraulic cylinder and the oil container and oil pump. The container is lifted and lowered by means of the hydraulic cylinder. The perimeter of the container has up to 16 orifices for fixing the single probes, whereby simultaneous soil sampling up to max. 60 cm depth is made possible. Vibration facilitates the forcing of more single probes into the ground, as well as efficient discharging of soil samples from the single probes over the opened part into the container. Depending on the sampling technique, in one working day up to 70 average samples can be taken with the operation of 4 active single probes on the machine and with 6 sticks, which makes 1 average sample (sample density is 1 sample per 5 ha), or up to 400 average samples (sample density is 16 samples per 1 ha). The coring time (up and down) is 15 to 20 seconds per 30 cm length of the single probe.

Figure 2. *Soil sampling with a new semi-automatic circular tractor soil probe (Patent pending: international application No. PCT/HR2011/000021).*

Safety emphasis

According to the current status of the patent presented in terms of upgrading the soil probe mechanism for sample homogenization and precise GPS incorporation into the system, personal safety is still under consideration. Currently, only 2 operators are needed for the work with the assembly. Further automation of the system may improve safety due to the less direct contact with hydraulic components.

RESULTS AND DISCUSSIONS

Grid sampling was applied to give detailed insight of true within-field spatial variability of soil attributes after years of different N fertilization. Each sampling location was precisely defined using GPS (Trimble GNSS R8). The point sampling scheme was circular line sampling of 0.5 m radius around the grid node representing sampling site of the 16-samples soil composite. To justify application of new constructed probe, this study gives results of analysis of spatial variability in soil pH values up to 30 cm depth mapped using ArcView geographic information system (GIS) (ESRI, 2006). Soil pH was measured in 1:2.5 (w/v) soil suspension in 1 M KCl (Table 1, Figure 3).

Table 1. *Descriptive statistics of soil pH values measured.*

Variable	N	Mean	Variance	Min	Max	CV (%)
pH	200	4.40	0.93	3.31	6.91	21.8

N, number of observations; CV, coefficient of variation.

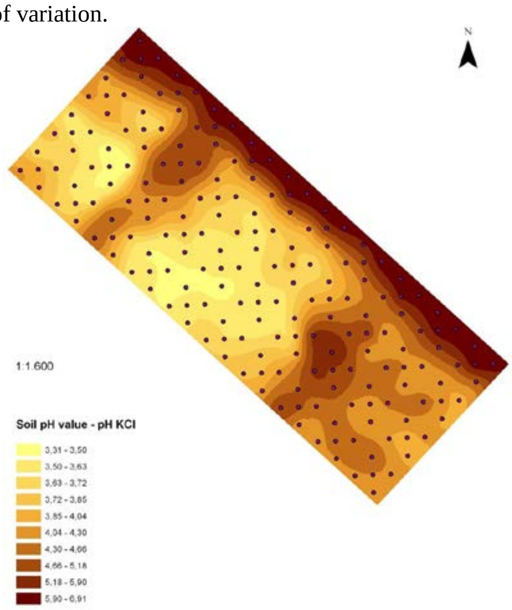

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Figure 3. *Soil pH map generated by ordinary kriging based on 200 soil samples*

Soil pH may vary dramatically over very small distances, but it was found to be strongly spatially dependent due to the low nugget-to-sill ratio as explained by Farooque et al. (2012). Concentrations and amounts of fertilizers may cause sizeable pH variations within the space of a few centimeters to a few meters (Brady and Weil, 2010). Other factors, such as drainage, may cause pH to vary considerably over large distances (hundreds of meters), often ranging over two or more pH units within a few hectares.

The selected grid locations have covered the experiment spatial variation in N fertilization amounts while simultaneously maximizing the spatial uniformity of the sampling design over the study area. Increase in sampling density frequently resulted in a more accurate soil pH maps which showed strong spatial structure within given range where sequence of changes in pH values was influenced by increased N rates, lime materials on treatment with 250 kg N per hectare, effect of parent material on treatment with 100 kg N per hectare and canal deposit on northeastern side of the field. Detailed insight in soil pH spatial variability in this case was feasible only by applying fast and reliable intensive sampling method. Changes in a soil pH values over the period of 1996 – 2010 are presented in a figure 4.

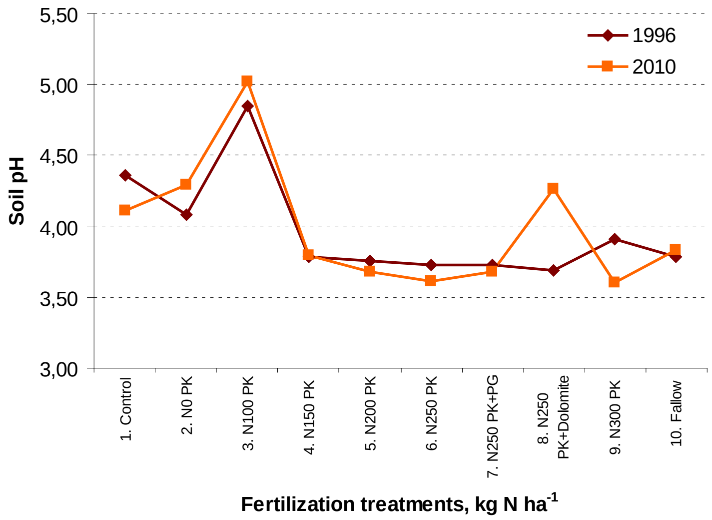

Figure 4. Changes in soil pH under the influence of 10 fertilization treatments in period 1996-2010

It is obvious that higher amounts of mineral nitrogen had an adverse effect to the soil pH.

CONCLUSIONS

Using new soil sampling method for soil survey provides a solution for quantifying spatial variability of soil properties, in this case, the change of the soil pH after 15 years.
Higher amount of minerals nitrogen applied in a field trial lowered the initial soil pH.

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