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SPATIAL VARIABILITY OF TOTAL NITROGEN IN THE SURFACE HORIZON AT THE PRODUCTION FIELD SCALE

ZMIENNOŚĆ PRZESTRZENNA ZAWARTOŚCI AZOTU OGÓŁEM W POZIOMIE POWIERZCHNIOWYM W SKALI POLA PRODUKCYJNEGO

Abstract: Soil total nitrogen does not come under so great temporal changes as its mineral forms, but it could be spatially differentiated. Spatial variability of total nitrogen could occur in the region scale as well as in the microscale that is to say within production field scale. For agricultural practice very important is to know spatial variability of its nitrogen form in the field scale since it could be very important to optimization of fertilization. That is why the objective of this study was to estimate total nitrogen spatial variability in the field scale. To this end 16.5 hectare field after winter wheat cultivation was chosen and soil samples from 47 individual points were collected in spring every 50 m. Total nitrogen was determined by Kjeldahl method. On the basis of total N content results empirical variograms were drawn with SURFER 8.0 software. On the ground of variograms, mathematical models and raster maps illustrating the distribution of investigated total nitrogen content in the field scale were drown. Basic statistic calculations were done with the use of STATISTICA 8.0 software. Results showed differentiated concentration of total nitrogen content in the humic horizon of investigated soil (0.78–1.11 $g \cdot kg^{-1}$). Small differentiation of determined nitrogen could be confirmed by low standard deviation (0.078) and low correlation coefficients (8.44 %). Geostatistical analysis proved that surface layer nitrogen did not occur full dispersion what was confirmed by nugget effect amounting 0.001 $(g/kg)^2$ with the sill variance accounted for 0.006 $(g/kg)^2$. The large range of 212 m evidenced that the correlation between total nitrogen content is bigger than distances between samples points. Proper adjustment of models (spherical and nugget effect) was confirmed also by the variance calculated (0.006 $[g/kg]^2$), similar to sill variance defined on the ground of those models.

Keywords: spatial variability, total nitrogen, production field, surface horizon

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Soil fertility, among others, is determined by organic matter content [1, 2], which except for many functions is the reservoir of biogenic components for plants. One of them is nitrogen which accounts for 0.02–0.40 % of the topsoil [3]. Nitrogen occurs there mainly in organic compounds and only about 10 % constitutes mineral forms [4]. Organic forms of nitrogen become available for plants during organic matter decomposition processes. Nowadays, when well-balanced and ecological agricultural is promoted, not only qualification of the specific biocomponent content (ie total nitrogen) but also its spatial variability in the field scale is important [5].

It is even more significant in the context of more and more widely popular precision agriculture, in which one of the important elements is a practical consideration of a variability occurring in the area of the very specific arable field. That is why it is necessary to evaluate, at least preliminary, changeability of specific soil parameters and transfer these data to an applicable measure, such as precision sampling and the magnitude of the indicated classes.

Therefore, the objective of this study was to evaluate the spatial variability of total nitrogen at the production field scale. Moreover, an attempt to mark the distance between sampling points for total nitrogen variability determination has been done.

Material and methods

The research was conducted on the 16.5 hectare field under cultivation localized near the Lobdowo village (Cuiavia-Pomerania province). The field was covered by Alfisols classified to IIIa and IVa classes according to soil classification (land-capability taxation). Most of the surface of the research area was classified as a fine sandy loam according to PN 04033 except for a small area, which was covered by surface layer classified as a fine sand. Ranges and mean values of basic parameters of research area are shown in Table 1.

Table 1

Ranges and means of some properties of the investigated area

Parameter	C-org	Clay fraction	pH	CEC
	$g \cdot kg^{-1}$		1 M KCl	$mmol(+) \cdot kg^{-1}$
Min. – Max Mean	8.16 – 15.15 11.66	6 – 15 9.3	5.13 – 7.1 6.12*	4.93 – 11.50 7.15

* Geometric mean.

The field under study was prepared for corn cultivation with winter wheat as the forecrop. Farmyard manure was applied at the dose 30 $Mg \cdot ha^{-1}$, while nitrogen fertilization as urea (330 $kg \cdot ha^{-1}$) was used in autumn. In spring, before sowing of corn, soil samples were collected from 47 points of the soil surface layer. Sampling points were localized by the Magellan GPS system and distributed every 50 m (Fig. 1). Each soil sample accounted for the mean value of 20 individual samplings done by the Egner sampling device. Soil samples were dried and passed through a 2 mm

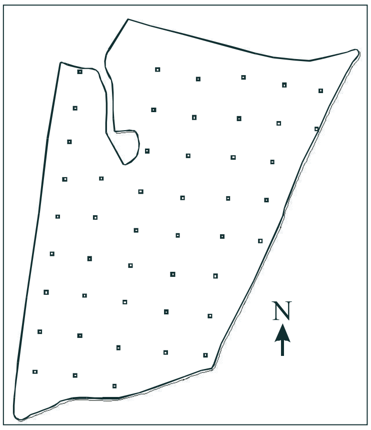

Fig. 1. Localization of sampling points on the research field

sieve. The fraction below 2 mm was analyzed for granulometric composition by a standard Cassagrande method as modified by Proszynski, pH in 1 M KCl, organic carbon content by volumetric method with 0.4 M $K_2Cr_2O_7$ and total nitrogen by Kjeldahl method.

The results were evaluated with the use of classical statistical methods (STATISTICA v. 8.0 software) calculating arithmetic (AM) and geometric (GM) means, median (Me) standard deviation (SD), coefficient of variation (CV%), as well as skewness (Sw), kurtosis (K) and variance. Geostatistical calculations were done with the use SURFER 8.0 of Golden Software and they included empirical semivariograms graphs and theoretical mathematical model of variograms. On the ground of semivariograms raster maps illustrating the spatial variance of determined total nitrogen were drawn. The method of point kriging was adapted to the date estimation [6].

Results and discussion

The analyses showed that total nitrogen content in the surface horizon of the investigated production field disclosed a small spatial variability. Total nitrogen concentrations in the surface layer ranged 0.775–1.110 $g \cdot kg^{-1}$, with mean value 0.924 $g \cdot kg^{-1}$ (Table 2). The mentioned values fit in the range obtained in the surface area of the Cuiavia-Pomerania region soils [7]. However, comparison of mean value of total nitrogen content determined in the investigated area showed that it was lower about 0.746 $g \cdot kg^{-1}$ than the mean value obtained for soils of the region whereas mean total nitrogen value calculated for the investigated field was lower about 0.506 $g \cdot kg^{-1}$ than the amount determined in soils samples collected from the field located at the Sepopolska Plain [8].

A small variability of N-total obtained for the analyzed soil was confirmed by a low standard deviation value (0.078 $g \cdot kg^{-1}$) and coefficient of variation (8.4%) (Table 1).

Field spatial variability of total nitrogen content was lower than that of organic carbon, what was shown by a higher CV value (14.9 %) (data not shown). Similar values of arithmetic and geometric means as well as similar to normal total N distribution (K = 0.158) (Table 2) gave evidence for the lack of values differed from the mean. Total nitrogen content distribution showed a small right-sited asymmetry, what indicated that a large part of the results were lower than the mean and was confirmed by the median value lower than the mean (Table 2). According to the results reported by Cambardella et al [9] and Stenger et al [10] the occurrence of asymmetry in total N distribution is typical.

Table 2

Some statistical and geostatistical parameters of total nitrogen content

Parameter	Total nitrogen
n	47
Min.	0.775 $g \cdot kg^{-1}$
Max	1.11 $g \cdot kg^{-1}$
Arithmetic mean (AM)	0.924 $g \cdot kg^{-1}$
Geometrical mean (GM)	0.921 $g \cdot kg^{-1}$
Median	0.920 $g \cdot kg^{-1}$
Standard deviation (SD)	0.078 $g \cdot kg^{-1}$
Coefficient of variation (CV%)	8.4 %
Skewness	0.395
Kurtosis	0.158
Variance	0.006
Model	spherical, nugget effect
Nugget variance (C_0)	0.001 $(g \cdot kg^{-1})^2$
Total sill variance Cw = (C_0 + C)	0.006 $(g \cdot kg^{-1})^2$
Nugget effect (C_0 / (C_0 + C)) · 100	16.7 %
Range m	212 m

A theoretical mathematical model was designed to show a small N-total spatial variability on the basis of empirical semivariograms and small values of total sill variance (0.006 $[g \cdot kg^{-1}]^2$) were obtained. The sill variance contained the nugget variance as well, which amounted for N-total (0.001 $[g \cdot kg^{-1}]^2$) (Fig. 2). It accounted for 16.7 % of total sill variance (Table 2) and was caused by the occurrence of short-range influence variability due to the existence of microstructures in the spatial distribution (ie organic matter centers). The nugget effect was confirmed by Cambardella et al [9] and Stenger et al [10]. The range of semivariogram, defined as a distance of correlations between neighbouring sampling points [11], for investigated area amounted 212 m (Fig. 2). The raster maps drawn on the basis of calculated semivariograms showed that most of the surface layer of the investigated field contained from 0.9 to 1.0 $g \cdot kg^{-1}$ N total. Only small areas near the east and south-west border of the field had lower total nitrogen content (Fig. 3).

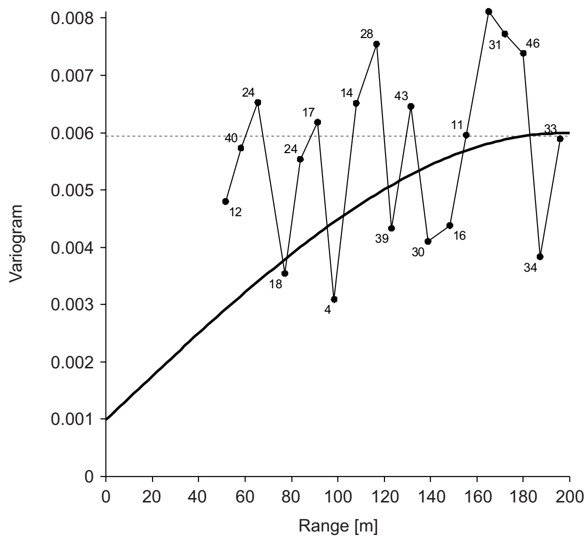

Fig. 2. Empirical semivariogram of total nitrogen content with estimated theoretical model

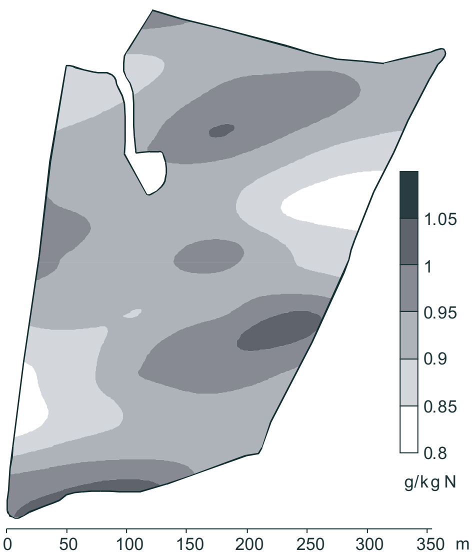

Fig. 3. Raster map of total nitrogen spatial variability

Conclusions

Total nitrogen content in the surface horizon of the investigated field showed small variability what was confirmed by the low coefficient of variation as well as low value of sill variance. It was caused by differentiated concentration of organic matter in the field under study.

Geostatistical analysis was confirmed by the micronested structure of total nitrogen concentration what corroborated with the nugget effect. A significant effect of autocorrelation between total nitrogen determined for specific sampling points allowed to increase the distance of soil sampling to 200 m.

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ZMIENNOŚĆ PRZESTRZENNA ZAWARTOŚCI AZOTU OGÓŁEM W POZIOMIE POWIERZCHNIOWYM W SKALI POLA PRODUKCYJNEGO

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Abstrakt: Azot ogółem w glebach nie podlega tak dużym zmianom w czasie jak jego formy mineralne, ale jego zawartość może być zróżnicowana przestrzennie. To zróżnicowanie może występować w makroskali np. regionu, jak i w mikroskali, czyli w obrębie pola produkcyjnego. Dla praktyki rolniczej szczególnie ważne jest poznanie zmienności tej formy azotu na obszarze pola, gdyż może to być pomocne przy optymalizacji nawożenia. Dlatego też celem niniejszej pracy było oszacowanie zmienności przestrzennej azotu ogółem w obrębie pola uprawnego. Do tego celu wytypowano pole po pszenicy ozimej o powierzchni 16,5 ha, z którego wiosną pobrano próbki z 47 punktów rozmieszczonych co 50 m. Azot ogółem oznaczono metodą Kjeldahla. Na podstawie otrzymanych wyników przy zastosowaniu programu SURFER 8.0 wykreślono wariogram empiryczny, który posłużył do stworzenia modelu i wykreślenia mapy rastrowej obrazującej rozkład badanej formy azotu w obrębie pola. Wykonano również obliczenia statystyczne przy użyciu programu STATISTIKA 8.0. Przeprowadzone badanie wykazały zróżnicowaną zawartość azotu ogółem w poziomie próchnicznym (0,78–1,11 $g \cdot kg^{-1}$). O niewielkim zróżnicowaniu analizowanego parametru może świadczyć mała wartość odchylenia standardowego (0,078) oraz mały współczynnik zmienności (8,44 %). Przeprowadza analiza geostatystyczna wykazała, że azot w poziomie powierzchniowym nie występuje w pełnym rozproszeniu, o czym świadczy występowanie efektu samorodka, który dla badanej cechy wynosił 0,001 $(g/kg)^2$ przy wariancji progowej wynoszącej 0,006 $(g/kg)^2$. Duży zasięg wynoszący 212 m świadczy o skorelowaniu zawartości azotu ogółem na odległości większe niż odległości między punktami pobierania próbek. Dobre dopasowanie modeli (sferycznego i efektu samorodka) potwierdza również wariancja obliczona 0,006 $(g/kg)^2$, która jest zbliżona do wariancji progowej odczytanej na podstawie tych modeli.

Słowa kluczowe: zmienność przestrzenna, azot ogółem, pole produkcyjne, poziom powierzchniowy