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SPATIAL AND TEMPORAL CHANGES OF SOIL ORGANIC CARBON AFTER IMPROPER APPLICATION OF FARMYARD MANURE – ON FARM STUDY

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Abstract

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Study of spatial and temporal variation of soil organic carbon depending on it distribution on field and in soil profile by drip irrigation on sandy soil. A network of sampling points was created using GPS equipment. Subsequent processing of obtained results using geostatistical methods was effectuated. Kriging maps with the distribution of organic carbon content were created. Immediately after manure application, in the abundantly fertilized part of the field, organic carbon content decreased down soil profile as follows 2.12%, 0.55% and 0.42% every 30 centimeters. Two years after a significant movement down soil profile of soil organic carbon was observed – 1.69%, 1.55% and 1.47% respectively. In a poorly fertilized part of the field organic carbon content did not changed.

Key words: Farmyard manure, quality of manure application, spatial variability, organic matter, soil profile, drip irrigation

Introduction

Applying dairy manure to agricultural fields increase crop yields, improves the water-holding capacity of the soil, and enhances soil fertility. However, when manures are applied to fields at high rates over a period of several years, nutrients can accumulate, P is causing eutrophication in drainage waterways; $N\text{-}NO_3$ provokes degradation of drinking water; nutrient toxicities in plants can occur; also nutrient deficiencies in plants is present (Moore and Ippolito, 2009). Farmers also, run the risk of violating Nitrate Directive of EC regulations designed to avoid these issues. Improper storing and application in field of manure could be a hazard for microbial pollution of soil and air (Kostadinova et al., 2014).

The residual effects of the manure and compost are important. Some benefit will be obtained in the second and third years following application. When manure and compost are used to fertilize crops, soil organic matter will increase over time. Continuous use of manure or compost can lead to high levels of residual N, P and other nutrients, which can potentially be transported to lakes and streams in runoff or leach and pollute the groundwater. Taking into account residual release of N in subsequent years should help to avoid excessive applications (Koehler et al., 2013). General rules of thumb for N are that organic N released during the second and third cropping years after initial application will be 50% and 25%, respectively, of that mineralized during the first cropping season (Rosen and Bierman, 2013).

Application of poultry manure at rate of 336 $kg\text{-}N.ha^{-1}$ gave high nutrient losses with subsurface drain water which contaminate the subsoil waters and surface water quality of rivers. Therefore, long-term applications at a rate of poultry manure of 168 $kg\text{-}N.ha^{-1}$ do not have lower negative impacts on subsurface drainage water quality and could be recom-

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mended as a good practice for poultry manure management (Nguyen, 2010).

The long-term manure applications resulted in increased levels of organic matter, N, P, salt and trace minerals in soil after manure application annually at 0, 30, 60, and 90 tons ha^{-1} under rainfed and 0, 60, 120, and 180 tons ha^{-1} under irrigated conditions.. This increased straw yield at all manure rates, but reduced grain yields at higher rates and affected crop quality. Increased nutrient levels also increase the potential for nutrient losses and surface and groundwater contamination. The soil enrichments were long-lasting and could pose environmental threats long after application has ceased (Hao and Benke, 2012).

Aims: Study of spatial and temporal variation of soil organic carbon on sandy soil depending on it distribution on field and in soil profile by drip irrigation.

Materials and Methods

The experiment was carried out in vegetable farm near Karlovo, Bulgaria on Alluvial Fluvisol in a field with tomatoes and drip irrigation. The soil is sandy - medium and coarse sand preponderate (Table 1). Nutrient contents is poor and organic matter content is very low (Table 2). A network of 15 sampling points, ever one in 0-30, 30-60 and 60-90 cm soil layers were created using Garmin GPS equipment. Subsequent processing of obtained results applying geostatistical methods was effectuated. Kriging maps with the distribution of organic carbon content were created. Geostatistical 1d analyses for a longitudinal transect of the field is made, too. Organic carbon was determined by Tyurin method (1966) in 2012 and in 2014. Geostatistical analyses were realized with GS+ software.

Results and Discussion

In 2012 the farmer tried to apply 20 tons farmyard manure in a field of about half hectare. Manure was stored in the end of the field ant the distribution was made by harrow. Most of the manure remains in 1/3–2/5 of the field (near the manure piles). Thus this part of the field obtained manure rate at least 120 $t.ha^{-1}$. Result of organic carbon increase in long-term farmyard application was presented by Parham et al. (2002) for 0–15 and 15–30 cm soil layers.

Majority of fertilizers move with wetting front in drip

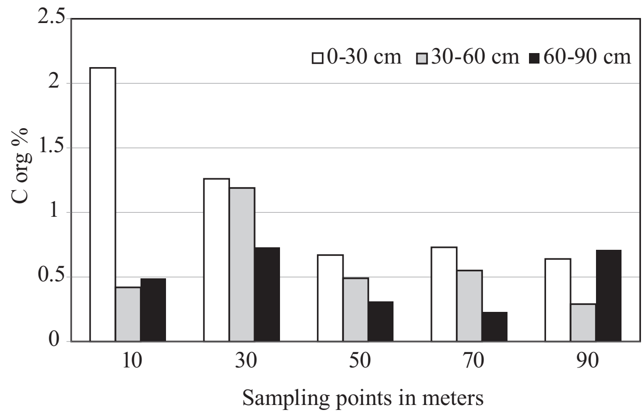

Fig. 1. Organic carbon content along tomatoes row and till 90 cm depth in the year of manure application

Table 1
Soil texture

Soil layer, cm	HCl treatment losses, %	Diameter limits, mm							
		1.00	1.00–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	< 0.001	<0.01
0–28	2.3	5.5	13.8	48.8	13.9	2.3	2,5	4.9	9.7
37–47	1.2	18.4	46.9	18.9	9.7	1.2	1,5	2.2	4.9
60–70	2.1	1.0	12.4	48.2	22.1	3.1	3.1	8.0	14.2
82–92	0.6	58.4	23.7	11.1	3.6	1.2	0.6	0.8	2.6
109–119	0.7	47.3	31.4	9.0	5.8	1.8	1.2	2.8	5.8

Table 2
Chemical characteristics

Soil layer, cm	Humus, %	N total, %	P_2O_5 total, %	$CaCO_3$, %	pH KCl
0–28	0.88	0.054	0.139	–	5.45
37–47	0.43	0.018	0.089	–	4.8
60–70	0.81	–	–	–	4.6
82–92	0.26	–	–	–	4.75
109–119	0.43	–	–	–	4.6

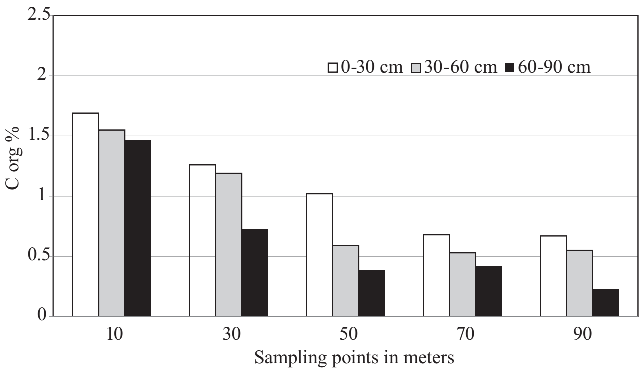

Fig. 2. Organic carbon content along tomatoes row and till 90 cm depth 3 years after manure application

irrigation. In our case, similar movement was found for organic carbon. In 2012 soil organic carbon in fertilized part of the field was 2.12% at 0–30 cm soil layer; 0.55% at 30–60 cm soil layer and 0.42% at 60–90 cm soil layer. In a poorly fertilized part organic carbon content was 0.67% at 0–30 cm soil layer; 0.55% at 30–60 cm soil layer and 0.38% at 60–90 cm soil layer (Figure 1). In 2014 soil organic carbon in fertilized part of the field was 1.69% at 0–30 cm soil layer; 1.55% at 30–60 cm soil layer and 1.47% at 60–90 cm soil layer. In a poorly fertilized part organic carbon content was 0.68% at 0–30 cm soil layer; 0.53% at 30–60 cm soil layer and 0.42% at 60–90 cm soil layer (Figure 2). For 3 years organic matter increased strongly even in the layer 60–90 cm in the heavily fertilized part of the field. This is due to very high manure rates and soils with extremely light texture – about 80% of sand.

The economic and environmental benefits of grid soil sampling and precision nutrient application are not limited to crop producers with access to variable rate manure and fertilizer technology. Grid soil sampling can be used to guide conventional manure application in a way that can optimize the economic value of manure as a fertilizer replacement, produce more uniform yields, and reduce phosphorus in runoff to surface water. Livestock farms often have fields where manure was not applied uniformly in the past, resulting in areas with very high soil test P and K levels and other areas with low values. This can be a problem both for crop yields in low testing areas and unnecessary application of nutrients in high testing areas. Grid soil sampling provides a map of soil test values that can be used to target manure application, increasing its economic value. Targeting manure application can gradually reduce soil test values in the excessively high areas, reducing P in runoff and nitrates leaching in underground waters (Les Everett, 2012).

Spatial variability of organic carbon content in the field and vertical spatial variability in the 1d transect of a tomatoes row gives better view on the organic matter distribu-

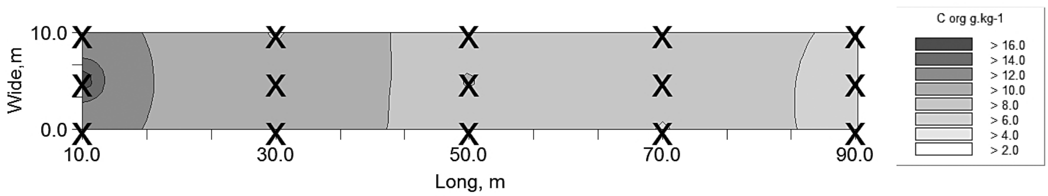

Fig. 3. Spatial variability of organic carbon content in the tomatoes field after improper manure application

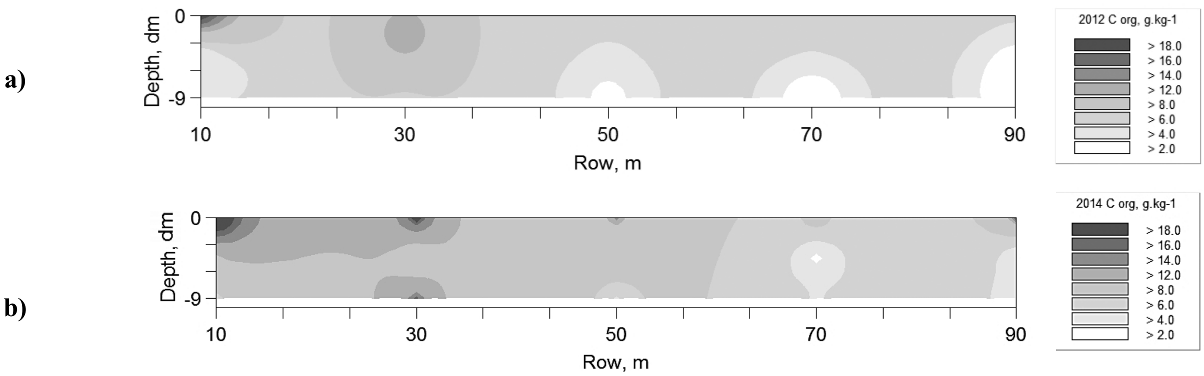

Fig. 4. Vertical spatial variability of organic carbon content in the transect of a tomatoes row after manure application (a) and 3 years later (b) – 100 m long by 0.9 m deep

tion. Kriging map is one of best way for presentation of exact spatial variability of nutrients in soil. Kriging method permits to obtain results with high precision between sampling points. In our case it will be a base for improving rates and quality of farmyard manure distribution in field. Surface spatial variability (Figure 3) shows the manure distribution on the field. Highest content is observed from 0 to about 40–45 meters. After the 50^{th} meter soil organic matter content increase is not so important. Similar changes are observed in soil profile in the year of manure application (Figure 4a). Organic carbon content changes are more important 3 years later (Figure 4 b), similar as results presented in Figure 2.

Conclusions

Large amounts of organic fertilizers could provoke transfer of organic matter and pollution in deep soil layers on sandy soils.

Soil organic carbon in fertilized part of the field changed from 0.42% to 1.47% in 60–90 cm soil layer for 3 years.

Improper fertilization could provoke serious damages in the environment.

In our case the fertilized part is more than 100 m from the river bank and pollution is not so important.

Precise rates of organic fertilizers must be applied with right technique and approach.

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