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THE EFFECT OF DIFFERENT TILLAGE SYSTEMS UPON SOME MICROORGANISMS

Svetoslava Kochovska, Yordanka Kartalska*

Agricultural University – Plovdiv

***E-mail: kartalska@gmail.com**

Abstract

The aim of this research was to establish the influence of two tillage systems: one without ploughing, and one with conventional tillage, upon soil microorganisms. The experiment was carried out on the farm of Brezovo, in two variants - control, with applied conventional tillage and a second variant – without ploughing, on an area of 200 dk for each variant. The soil type of the field is sandy - clay, with medium to high cation exchange capacity.

The nitrate nitrogen content was determined colometrically and spectrophotometrically for phosphorus and potassium. The ratio of carbon to nitrogen was measured twice - before sowing and during harvest time. The amount of total bacterial and fungal microflora, as well as the ratio of active bacteria and fungi was monitored. Based on the obtained results, it was found that the numbers of the total bacteria and fungi is higher in the variant without ploughing, compared to the control sample.
The same trend is maintained in the quantitative ratio of active fungi and bacteria. Reduced tillage systems create better conditions for the development of the studied groups of microorganisms, compared to conventional cultivation technologies.
Key words: tillage system, microbial biomass, roof crops

INTRODUCTION

Different tillage systems are important for the effective and sustainable management of agricultural ecosystems. The methods of soil cultivation affect its performance; they could worsen, stabilize or improve the soil fertility. In recent years, the interest in soil management and improving of soil productivity has grown significantly. One of the ways to achieve these goals is to replace conventional tillage with alternative cultivation techniques. They are defined as conservation agriculture, which includes non-tillage or reduced soil tillage systems. Reduced

tillage is used to preserve soil fertility and to minimize mechanical disturbances in the soil, erosion and agricultural production costs (Peigné et al. 2007, Alguacil et al. 2008, Ceja-Navarro et al. 2010). The applied technologies, together with water content, temperature and aeration of the soil influenced the intensity of all microbiological processes. (Feng et al., 2003; Han et al., 2007). Soil productivity is strongly influenced by soil microbial communities. Qualitative and quantitative changes in the population of soil microorganisms reflect changes in soil fertility (Sharma et al., 2010). The structure of a microbial community is characterized by its mass, abundance, and richness. According Wang et al. (2018) no-tillage cultivation has proved to increase the soil microbial community (Gouaerts et al. 2007). In many cases, both bacteria and fungi were more abundant under no-tillage than conventional tillage (Helgason et al. 2009). In no-tillage systems, fungi domination was frequently found, and the residue was mainly decomposed by the fungal community (Spedding et al. 2004, Gouaerts et al. 2007). Bacteria were generally considered to be the predominant decomposers of incorporated crop residues under conventional tillage (Nicolardot et al. 2007). The abundance and activity of microorganisms can lead to losses of nitrogen (N), changes in plant growth and development, to the rate of decomposition of organic carbon (C) in the soil, etc. This affects the mineralization of available nutrients and the efficiency of the nutrient cycle. The increased interest in reducing soil tillage techniques in the future is a good alternative to improve soil fertility, prevent soil erosion, reduce production costs, and maintain sustainable agro ecosystems. (De Vita et al., 2007).

The main goal of this research was to investigate the effect of conventional and reduced tillage technologies, upon changes of soil bacteria and fungi in sunflower.

MATERIALS AND METHODS

A field trail was conducted during the vegetation season 2019-2020 at a private farm near the town of Brezovo. The experiment was set up in two variants with conventional tillage and non -tillage, each with an area of 200 dk.

Variant 1: without tillage. For the weed control a total herbicide was applied at rate of 250ml/dk during autumn. A green fertilization was made with an oat composition 6 kg/dk and 0.5 kg/mustard seeds, applied at 4 cm depth. Before sowing, a total herbicide was applied in combination with liquid nitrogen fertilizer - UAN 38, and during sowing - NP 20/20 + 15 SO_3 fertilizer was used, at a rate of 15 kg/dk.

Variant 2: conventional tillage. The field was ploughed into 25cm depth during the autumn of 2019, followed by a double treatment of 4 cm at the spring. The fertilizers NP 20/20 and ammonium nitrate were applied at 15 kg/dk and 20kg/dk respectively, before the sowing of sunflowers.

In both variants, high oleic Clearfield hybrid, Talento, Syngenta selection sunflower was used. The hybrid has early flowering and a high yield potential, highly tolerant to lodging. This variety is suitable for intensive cultivation, medium early hybrid with a stem height of 160 cm, fat content- 48%, and oleic acid potential - 91%.

The seed rates for variant 1 was 6700 seeds/dk, and for variant 2 it was 5500 seeds /dк,. During the vegetation period, for weed control the applied herbicides were: Listego - 130 ml/da (40g /l imazamox) and Ordago SK - 110 ml/da (pendimethalin 400g/l), and Listego - 120ml/dк for variant 2.

The trial period included time with different average temperature and low quantity of precipitation, throughout the vegetation period (Table1).

Table 1. Weather conditions

	Period of report		Average Air TC°	Rainfall l/m²
1.	Before sowing		9.97	0.135
2.	Flower buds		20.37	0.245
3.	Harvest		24.67	0.011

Soil sampling and analysis

The soil samples were taken from 0-10 cm in depth, three times - before sowing, on phase flower buds - R4 and during harvest (Robinson, 1981). Soil texture composition was measured by near infra red method (see Table 2).

Table 2. Soil Texture and Property

Variant	Sand %	Silt %	Clay %	Available Water	Drainage Rate
1	21,04	42,25	36,71	Medium to Low	Slow
2	25,25	44,03	30,72	Medium to high	Medium to slow

The values of the soil reaction are measured according to the international standard ISO 10390. Nitrate nitrogen (NO3 - N) was determined by colometric analysis as a result of extraction with a solution of calcium sulphate. The phosphorus content was measured by the method of OLSEN, spectrophotometrically and the potassium content is determined by Inductive Plasma Analyzer (Table 3).

Microbiological analyses

Microorganisms were measured according to the dilution method and by planting on a selective nutrient media. Their quantity is represented as column forming units – (cfu) in 1g of soil.

Table 3. Available nutrition elements and pH

Variant	pH	Nitrate N mg/kg	Available Mg ppm	Available P и K ppm	
		NO_3-N	MgO	P_2O_5	K_2O
1	6.7	8.0	525	12	293
2	7,0	11,0	436	8	310

The analysis was performed in the Lancrop laboratory, Great Britain.

RESULTS AND DISCUSSION

Climatic conditions during the sunflower vegetation are one of the main factors determining the dynamics of the soil microflora. The average daily temperature is optimal and varies from 10ºC in March to 25ºC in August. The study period is characterized by a very low rainfall, ranging from 0.13 to 0.25 l/m^2, which reduces the moisture content of the soil and leads to permanent drought. Both variants are characterized by alluvial-meadow soil type, with sand content of 23.55% and 32.61% clay particles (Table 2). The percentage of alluvial particles determines the main properties of the soil related to its ability to retain water and nutrients, its drainage, its ability to warm and the risk of erosion. Due to the light mechanical composition and the low moisture content, these fields suffer from drought. The physicochemical parameters for the two variants are similar. One of the most important factors that have a direct impact on the soil microbial community is the soil reaction. It can affect abiotic factors such as the availability of carbon, nutrients, metal solubility, etc. In addition, soil pH can also control biotic factors such as the composition and amount of biomass of fungi and bacteria, both in agricultural and in forest soils. The data obtained from the analysis of the two variants show that the reaction of the medium is neutral with a slight range of variation (Table 3). This similarity in the reaction in the two variants minimizes the effect of the different tillage systems. Nitrate nitrogen and digestible phosphorus levels are low for both samples. Magnesium maintains very high levels, which can suppress the normal absorption of potassium, whose values are in the high range. These nutrient data show minimal differences between the two tests variants. The dynamics of development of total number of bacteria is present in Fig.1.

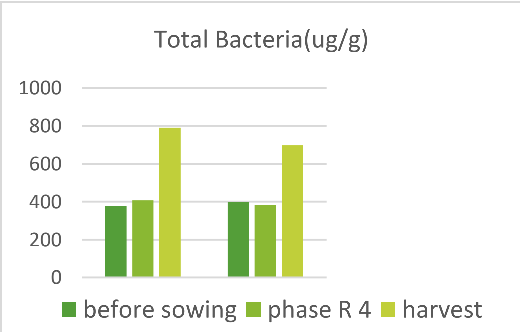


Fig.1. Number of total bacteria

It can be seen that their quantity is relatively constant for the first two periods of the study. There was a delay in their development, which is probably due to the permanent drought, due to the scarce amount of rainfall in May, June, and July. At the end of vegetation there is an increase in the population of bacteria. Positive changes are observed in the last phase of the development of the culture, as with the arable technology the number of bacteria reaches 790 ug/g, compared to variant 2, where an amount of 698 ug/g is reported.

It was found that the C:N ratio affects the rate of mineralization of organic matter in the soil. Our research shows that in Variant 1 this ratio is 11:1, and in Variant 2, respectively 10:1. These insignificant differences are probably an explanation for the close values of the studied microorganisms and the yield obtained. The results, obtained for the development of active bacteria are presented in Fig. 2.

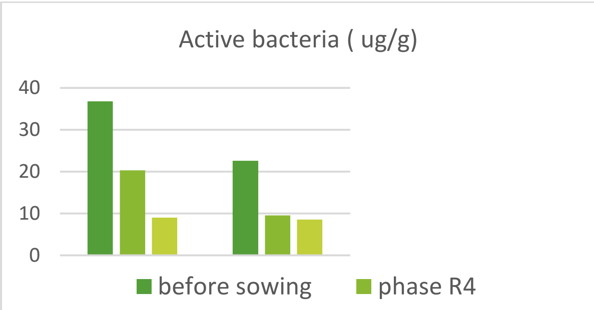
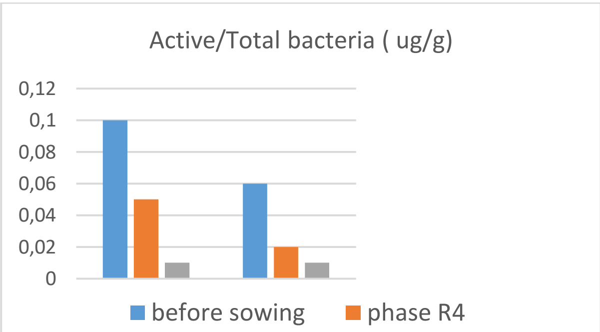


Fig.2. Number of active bacteria

Fig. 3. presents the results in the dynamics of development of active to total bacteria. Higher levels of bacterial activity lead to an increase in beneficial bacterial populations. In Variant 2, a ratio below the optimal range is observed, which shows that anaerobic species predominate in the soil, while in Variant 1 these levels are lower.



Fig, 3. Active to total bacteria ration

Several authors report that the rate of decomposition of organic matter by soil microscopic fungi decreases after the application of nitrogen fertilizers (van Groenigen et al., 2007). The presence of organic substances with a high C/N ratio stimulates the participation of fungi in the mineralization of substances. The dynamics in the development of a total number of microscopic fungi is presented in Fig. 4. The rate of fungal development in both variants is insignificant, especially during the last two reporting periods. To a large extent, it remains strongly inhibited by the lack of moisture in the soil.

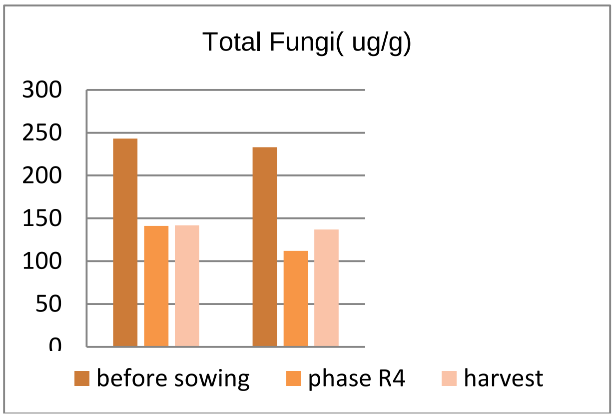


Fig.4. Number of total fungi

Active fungi are involved in the breakdown of complex carbon compounds, maintain soil structure and retain nutrients in the soil, making them available for uptake by plants. In the non-arable variant, the amount of active fungi during the first period is the largest, which is probably due to the used cover culture and the higher carbon to nitrogen ratio (Fig.5). In Variant 2, the values of the fungal microflora are low for the whole period of the study.

A number of studies show that tillage affects the biomass ratio of fungi and bacteria. In most cases, bacteria dominate conventional tillage, while fungi dominate No-till systems. This is suggested to be due to the direct contact between bacteria and substrate in conventional tillage, which stimulates bacterial growth (Beare et al., 1997). During this tillage, the hyphae of the fungus are torn and they can be suppressed in their growth.

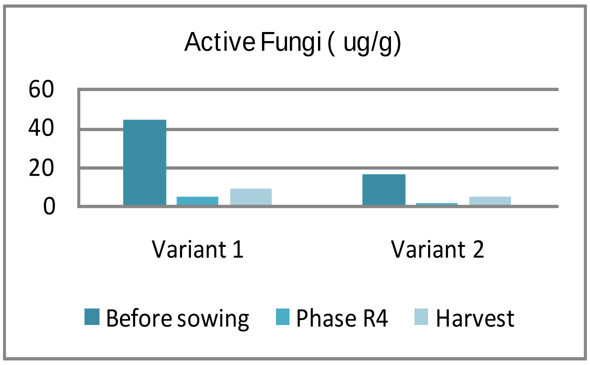


Fig.5. Number of active fungi

Higher ratios of fungi to bacteria are indicative of a more sustainable agro-ecosystem with a lower environmental impact, in which the decomposition of organic matter and the mineralization of nitrogen dominate in the supply of nutrients to plants. The obtained results (Fig.6.) show insignificant dominance of bacteria over microscopic fungi, which show the joint influence of abiotic and biotic factors on the quantitative changes of the soil fungal and bacterial microflora.

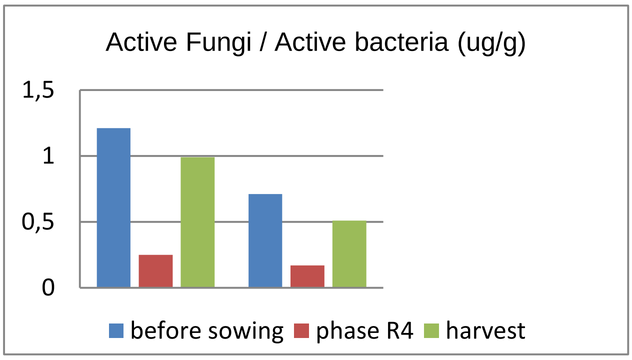


Fig.6. Numbers of active fungi to active bacteria

CONCLUSIONS

Based on the study, it was found that non-arable technology increases the amount of both the total and active number of bacteria and fungi, compared to arable technology.

The obtained data confirm the information that the reduction of tillage leads to an increase in the amount of microorganisms in the soil and does not reduce the yield.

The effect of the applied technology on the development of microorganisms in sunflower is positive.

REFERENCES

Alguacil, M.M., Lumini E., Roldán A., Salinas-García J.R., Bonfante P., Bianciotto V., 2008. The impact of tillage practices on arbuscular mycorrhizal fungal diversity in subtropical crops. Ecological Applications, *18*: 527–536.

Bayhan, Y. Kayisoglu, B. Gonulol, E. Yalcin, H. and Sungur, N., 2006. Possibilities of direct drilling and reduced tillage in second crop silage corn. Soil Tillage Res. 88: 1-7.

Beare, M.H, 1997. Fungal and bacterial pathways of organic matter decomposition and nitrogen mineralization in arable soils. p. 37–70.InL. Brussaard and R. Ferrera-Cerrato (ed.) Soil ecology in sustainable agricultural systems. Lewis Publishers, Boca Raton, FL

Ceja-Navarro J.A., Rivera-Orduna F.N., Patino Zuniga L., Vila-Sanjurjo A., Crossa J., Govaerts B., Dendooven L., 2010. Phy-logenetic and multivariate analyses to determine the effects of different tillage and residue management practices on soil Bacterial communities. Applied and Environmental Microbiology, *76*: 3685–3691

Gouaerts B., Mezzalama M., Unno Y., Sayre K.D., Luna-Guido M., Vanherck K., Dendoouen L., Deckers J.,2007: Influence of tillage, residue management, and crop rotation on soil microbial biomass and catabolic diversity. Applied Soil Ecology, 37: 18–30.

De Vita, P. Di Paolo, E. Fecondo, G. Di Fonzo, N. and Pisante, M., 2007. No-tillage and conventional tillage effects on durum wheat yield, grain quality and soil moisture content in southern Italy. Soil Tillage Res. 92: 69-78.

Feng,Y.,A.C. Motta, D. W. Reeves, C. H. Burmester, E. van Santen, and J. A. Osborne, 2003. "Soil microbial communities under conventional-till and no-till continuous cotton systems," Soil Biology & Biochemistry, vol. 35, no. 12, pp. 1693–170.

Gencsoylu, I.and Yalcin, I., 2007. Advantages of different tillage systems and their effects on the economically important pest, Thrip tabaci Lind. and Aphis gossypii Glov. in cotton fields. J. Agronomy and crop science190: 381-388.

Han, Y.,Du,J., Li, J., and Li, M.,2019. Quantification of the organic acids in hawthorn wine: a comparison of two HPLC methods. *Molecules* 24:2150.

Hatfield, J.L., Allmaras, R.R., Rehn, G.W., and Lowery, B., 1998. Ridge tillage for corn and soybean production: Environmental quality impacts. Soil Tillage Res. 48: 145-154.

Nicolardot B., Bouziri L., Bastian F., Ranjard L., 2007. A microcosm experiment to evaluate the influence of location and quality of plant residues on residue decomposition and genetic structure of soil microbial communities. Soil Biology and Biochemistry, 39: 1631–1644.

Peigné J., Ball B.C., Roger-Estrade J., David C. 2007. Is conservation tillage suitable for organic farming? A review. Soil Use and Management, *23*: 129–144.

Robinson, R.G., Miler, G.F., 1981. Sunflower Phenology- Variety and Date of Planting Effects on Day and Growing Degree-day Summations.

Sharma, SK, Ramesh A, Sharma MP, Joshi OP, Govaerts B, Steenwerth KL, Karlen D. L., 2010. Microbial community structure and diversity as indicators for evaluating soil quality. In E Lichtfouse, ed, Biodiversity, Biofuels, Agroforestry and Conservation Agriculture, Vol 5. Springer, Dordrecht, The Netherlands, pp 317–358

Spedding T.A., Hamel C., Mehuys G.R., Madramootoo C.A., 2004: Soil microbial dynamics in maize-growing soil under different tillage and residue management systems. Soil Biology and Biochemistry, 36: 499–512.

Van Groenigen, 2007. Abundance, production and stabilization of microbial biomass under conventional and reduced tillage

Wang, B, Adachi Y, Sugiyama S., 2018. Soil productivity and structure of bacterial and fungal communities in unfertilized arable soil. PloS ONE 13(9):

Yalcin, H. and Cakir, E., 2006. Tillage effects and energy efficiencies of subsoiling and direct seeding in light soil on yield of second crop corn for silage in western Turkey. Soil Tillage Res.90: 250-255.