ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 63 8 Number 1, 2015

http://dx.doi.org/10.11118/actaun201563010059

# COMPARATIVE STUDY OF MICROBIAL ACTIVITY AND CHEMICAL PROPERTIES OF SOIL BY IMPLEMENTING ANTI-EROSION MEASURE VERTICAL MULCHING WITH ORGANIC RESIDUES

Gergana Slavova Kuncheva[1]

[1] Laboratory of soil analysis and erosion research, ISS "Nikola Poushkarov"- Sofia, University of Ruse "Angel Kanchev"

## Abstract

KUNCHEVA GERGANA SLAVOVA. 2015. Comparative Study of Microbial Activity and Chemical Properties of Soil by Implementing Anti-erosion Measure Vertical Mulching with Organic Residues. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 63(1): 59–63.

Water soil erosion is a phenomenon in which soil particles are separated transported and translocated by the action of rain water. Removal of topsoil by water flow leads to a decrease of humus in the soil, deterioration of soil structure, compaction, and reduction of microbial activity.

Developed and tested have been number of methods and technologies for soil protection from the effects of water erosion. Such technology is vertical mulching, and straw or compost applied as mulching material.

This work is a study of the changes that occur in some soil chemical properties and soil microbiological activity, as a result in the implementation of anti-erosion measure vertical mulching with different mulching materials for growing corn and wheat grain on carbonate chernozem, on sloping agricultural lands.

Keywords: water erosion, microbiological activity of soil, compost, vertical mulching

## INTRODUCTION

Soil erosion is a physical phenomenon that separates and transports soil particles by wind, rain and irrigation water, under the influence of natural and anthropogenic processes. The average annual soil losses are estimated on 0.005 0.5 t/ha, depending on the slope under natural environmental conditions and from 50 to 500 t/ha – in terms of arable land [Rouseva *et al.*, 2010] .

Soil is one of the most important components of natural or agricultural ecosystems. Soil degradation processes result in low yield, reduced total biomass of flora and fauna, and reduced overall biodiversity of these ecosystems [Pimentel, D. and Kounang, N., 1998].

In recent years, the Experimental station for soil erosion control Ruse to IPAZR "Nikola Poushkarov" - Sofia, was developed a method of controlling water erosion by vertical mulching, and as mulching material were used straw or compost [Beloev, H., 2011; Dimitrov, P. *et al.*, 2004 ; Dimitrov, P. *et al.*, 2008]. This method is combined with minimal soil tillage (by excluding of primary treatment with plow and combining several technological operations) and is applied across the slope. The use of this system for the treatment of soil slope land contributes to soil protection and to prevent degradation processes (soil erosion, compaction, loss of organic matter and reduced microbiological activity) [Beloev, H., 2008].

The influence of organic matter on the imported properties of the soil depends on its amount and to the type [Voynova-Raykova, 1983].

Imported organic matter leads to increasing the microbial activity and to a change in the content of nutrients in the soil. Important in the evaluation of soil as a medium for the development of cultivated crops are the changes occurring in the levels of available nitrogen forms.

Studies of anti-erosion efficiency of the vertical mulching tended that, when imported straw in slots, it degrades more slowly than straw imported by plowing of the post-harvest residues.

The purpose of this study was to identify changes in microbial activity and some chemical properties of the soil by the use of different mulching materials (straw and compost) and applying them through vertical mulching for soil protection of sloping land against the effects of water erosion.

## MATERIALS AND METHODS

The study was conducted between 2012–2014, in the village of Trastenik, Ruse Region, in the experimental field of the Institute of Soil Science, agricultural technology and plant protection "Nikola Poushkarov " Sofia, on average eroded calcareous chernozem, with a slope of 5º (8.7%).

Field trials with maize for grain, were carried out. Minimal tillage was applied, combined with soil conservation method vertical mulching. It is implemented by a special machine, which forms on the surface of the soil in depth up to 0.40 m couple of slots filled with organic residues (straw and compost) in a band with a distance between the pair of slots 1.4 m and an interval between bands in the field 3 m. Presowing soil tillage, all soil treatments during vegetation and harvesting are carried out in direction perpendicular to the direction of the slope. Applied soil conservation methods have proven effective erosion control.

Soil samples for agrochemical and microbiological analyzes were taken from the very grooves and spaced 0.5 m from them in order to establish the influence of imported organic matter on the microbiological and chemical processes in the soil.

Saprophytic soil microflora (bacteria – spore-forming and non-spore, actinomycetes, fungi, oligotrophic bacteria, cellulose decomposers and nitrogen fixing microorganisms) was isolated and quantitatively accounted by the method of Koch on MPA (meat peptone agar) – bacteria, ammonia starch agar – for actinomycetes culture medium, medium of Capek – for fungi, diluted soil agar – for oligotrophic soil microflora, medium of Hutchinson for cellulose decomposers and medium of Eshbi for nitrogen-fixing bacteria.

Reported are the mineral nitrogen, pH and conductivity of the soil solution with pH- meter equipped with pH – and conductive electrodes. In determining the pH in $H_2O$, in the soil, were used solutions 1:2.5 and for the compost 1:10.

As mulching material was used straw and compost waste product of mushroom production. The chemical composition of the applied composts is given on Tab. I.

## RESULTS

As a result of the analysis carried out it can be settled that the conductivity of the soil solution and the levels of ammonium and nitrate ions are highest in the compost that is in the slots, compared with the other samples (Tab. II).

The levels of inorganic nitrogen in the slots with straw are the lowest, in the slots with compost are the highest. The used compost is an organic material with high nitrogen and carbon content, which leads to a higher microbiological activity, higher conductivity, and higher levels of nutrients.

Upon introduction of a carbon source with low nitrogen content, such as wheat straw, are activated soil microbiological processes that lead to immobilization of available forms of nitrogen. This effect is clearly seen in the comparison of samples taken at a distance of the slots and the slots themselves. This trend is developing in the first few months after the introduction of the material because it is more pronounced in experiments with corn phase maximum growth. After the end of crop vegetation, nitrogen levels in the slots and the outside them are close in value, although the trend for immobilization of the nitrogen is observed again, but to a lesser extent.

Consequently the application of organic matter and by considerably higher humidity of the soil in the slots, there is a high microbiological activity.

I: *Chemical composition of used composts*

| Indexes, units | 2012 | 2013 | 2014 |
|---|---|---|---|
| $NH_4^+$, mg/kg | 1971.79 | 186.26 | 340.68 |
| $NO_3^-$, mg/kg | 753.80 | 99.46 | 2350.72 |
| Total N, % | 2.86 | 2.17 | 1.98 |
| Total C, % | 32.59 | 30.18 | 26.98 |
| C/N | 13.50 | 13.91 | 13.62 |
| pH, $H_2O$ | 6.78 | 6.90 | 7.96 |
| pH, KCl | 6.62 | 6.71 | 7.71 |
| EC, mS/cm | 10.14 | 7.37 | 5.91 |
| Available $P_2O_5$, % | 0.441 | 0.389 | 0.480 |
| Available $K_2O$, % | 0.996 | 0.287 | 0.251 |

II: *Chemical soil indexes, pH (pH units), EC (μS/cm), $NH_4^+$ (mg/kg), $NO_3^-$ (mg/kg), in two growth stages at two crops*

| | pH, $H_2O$ | EC | $NH_4^+$ | $NO_3^-$ | pH, $H_2O$ | EC | $NH_4^+$ | $NO_3^-$ |
|---|---|---|---|---|---|---|---|---|
| **In maximum growth stage, 2012** | | | | | **After harvesting, 2012** | | | |
| Slot with straw, M1 | 7.99 | 174.05 | 6.26 | 31.29 | 8.11 | 197.10 | 12.46 | 33.62 |
| 0.5 m from slot with straw, M2 | 7.99 | 216.00 | 10.73 | 36.81 | 8.14 | 212.00 | 15.68 | 31.36 |
| Slot with compost, M3 | 7.52 | 1092.00 | 31.39 | 106.74 | 8.08 | 327.00 | 39.41 | 53.06 |
| 0.5 m from slot with compost, M4 | 8.03 | 221.25 | 15.68 | 43.91 | 8.19 | 215.50 | 24.00 | 36.00 |
| **In maximum growth stage, 2013** | | | | | **After harvesting, 2013** | | | |
| Slot with straw | 7.74 | 109.7 | 22.70 | 22.70 | 8.21 | 211.25 | 12.80 | 13.00 |
| 0.5 m from slot with straw | 7.77 | 93.25 | 10.95 | 15.33 | 8.39 | 119.25 | 14.06 | 12.20 |
| Slot with compost | 7.35 | 3200.00 | 63.33 | 13.13 | 7.68 | 1870.00 | 61.75 | 22.61 |
| 0.5 m from slot with compost | 7.80 | 206.50 | 46.41 | 20.23 | 8.33 | 132.5 | 10.89 | 11.20 |
| **In maximum growth stage, 2014** | | | | | **After harvesting, 2014** | | | |
| Slot with straw | 7.81 | 184.60 | 38.49 | 4.50 | 8.01 | 160.8 | 23.69 | 10.10 |
| 0.5 m from slot with straw | 7.94 | 126.20 | 26.40 | 18.86 | 7.99 | 150.8 | 12.43 | 14.50 |
| Slot with compost | 7.56 | 1260.00 | 76.44 | 100.66 | 7.77 | 1302 | 40.30 | 75.34 |
| 0.5 m from slot with compost | 7.84 | 223.20 | 25.57 | 3.20 | 7.98 | 241.1 | 15.00 | 18.49 |

ANOVA for EC P = 0.000146; HSD[.05] = 784.93; HSD[.01] = 994.73; M1 vs M2 nonsignificant; M1 vs M3 $P < .01$; M1 vs M4 nonsignificant; M2 vs M3 $P < .01$; M2 vs M4 nonsignificant; M3 vs M4 $P < .01$.

For [$NH_4^+$] P = 0.0002; HSD[.05] = 20.47; HSD[.01] = 25.94; M1 vs M2 nonsignificant; M1 vs M3 $P < .01$; M1 vs M4 nonsignificant; M2 vs M3 $P < .01$; M2 vs M4 nonsignificant; M3 vs M4 $P < .01$.

For [$NO_3^-$] P = 0.009, HSD[.05] = 36.37; HSD[.01] = 46.09; M1 vs M2 nonsignificant; M1 vs M3 $P < .05$; M1 vs M4 nonsignificant; M2 vs M3 $P < .05$; M2 vs M4 nonsignificant; M3 vs M4 $P < .05$.

The largest number of bacteria have been reported in the slots with compost. The total number of bacteria in the samples taken from the slots is considerably greater than that in the samples taken at 0.5 m to them. Spore-forming bacteria are more abundant in mulching with straw. Their activity has been associated with the degradation of complex organic compounds.

The reported amounts of actinomycetes are significantly more at the slots in which compost has been applied in comparison with those in which straw has been used. The trend with fungi is opposite.

Oligotrophic bacteria are in larger amounts in slots mulched with straw. This relationship is reported in all observed periods.

Nitrogen-fixing activity is higher in the slots with straw. This is due to low levels of available nitrogen form the slots with high carbon source.

It is reported is very high cellulose decomposers activity in the samples taken from the slots with compost, as compared to those of the slots with the straw. This is the result of the input cellulose-decomposing organisms in the compost and higher levels of available nitrogen forms.

In the application of such vertical mulching anti erosion measure it has been founded that when using the straw as mulch material, it decomposes very slowly. This is probably due to the low nitrogen content in this material, which is unsuitable condition for active microbial activity.

In turn compost, carries many cellulose-decomposing microorganisms, and besides it is a material with high nitrogen content and organic substances in a varying extends of degradation, which further stimulates the microbial activity of the soil.

III: *Soil microbiological activity in CFU (colony forming units)* $10^6$/g dry soil*

| | Total number Saprophytic bacteria (1) | Spore-forming Bacteria (2) | Oligotrophic bacteria (3) | Actino Micetes (4) | Fungi (5) | Nitrogen-fixing bacteria (6) | Cellulose-decom-Posers (7) |
|---|---|---|---|---|---|---|---|
| **In maximum growth stage, 2012** | | | | | | | |
| Slot with compost, M1 | 27.65 | 6.11 | 4.71 | 0.92 | 0.0027 | 1.00 | 0.62 |
| 0.5 m from slot with compost, M2 | 10.11 | 8.24 | 8.78 | 0.94 | 0.0044 | 1.23 | 0.30 |
| Slot with straw, M3 | 19.60 | 12.03 | 17.69 | 2.52 | 0.0032 | 1.65 | 0.53 |
| 0.5 m from slot with straw, M4 | 9.54 | 5.64 | 4.49 | 0.55 | 0.0024 | 1.27 | 0.29 |
| **After harvesting, 2012** | | | | | | | |
| Slot with compost | 34.84 | 2.89 | 26.49 | 1.62 | 0.0019 | 2.50 | 0.32 |
| 0.5 m from slot with compost | 10.60 | 3.17 | 19.54 | 0.58 | 0.0018 | 2.00 | 0.25 |
| Slot with straw | 16.62 | 2.77 | 19.74 | 0.50 | 0.0011 | 3.20 | 0.27 |
| 0.5 m from slot with straw | 17.91 | 1.79 | 12.29 | 0.00 | 0.0038 | 1.90 | 0.25 |
| **In maximum growth stage, 2013** | | | | | | | |
| Slot with compost | 22.34 | 2.85 | 35.97 | 6.34 | 0.0028 | 10.00 | 4.73 |
| 0.5 m from slot with compost | 7.46 | 3.47 | 9.33 | 2.30 | 0.0045 | 10.80 | 1.26 |
| Slot with straw | 25.93 | 18.13 | 49.92 | 2.90 | 0.0040 | 19.30 | 0.56 |
| 0.5 m from slot with straw | 5.86 | 3.27 | 9.67 | 2.80 | 0.0053 | 8.80 | 0.30 |
| **After harvesting, 2013** | | | | | | | |
| Slot with compost | 72.00 | 10.23 | 41.00 | 3.00 | 0.0012 | 2.50 | 4.07 |
| 0.5 m from slot with compost | 32.00 | 5.10 | 20.33 | 0.60 | 0.0014 | 2.80 | 0.48 |
| Slot with straw | 44.00 | 11.07 | 45.00 | 0.63 | 0.0040 | 3.20 | 0.48 |
| 0.5 m from slot with straw | 17.66 | 1.70 | 11.33 | 0.60 | 0.0018 | 2.40 | 0.73 |
| **In maximum growth stage, 2014** | | | | | | | |
| Slot with compost | 32.83 | 15.81 | 72.60 | 3.67 | 0.0015 | 8.50 | 2.37 |
| 0.5 m from slot with compost | 19.46 | 13.63 | 59.24 | 2.07 | 0.0021 | 1.60 | 2.33 |
| Slot with straw | 21.38 | 14.60 | 91.19 | 0.36 | 0.0009 | 3.24 | 0.19 |
| 0.5 m from slot with straw | 14.92 | 12.42 | 43.79 | 0.00 | 0.0013 | 2.31 | 0.56 |
| **After harvesting, 2014** | | | | | | | |
| Slot with compost | 82.03 | 10.12 | 29.89 | 4.80 | 0.0020 | 2.60 | 8.10 |
| 0.5 m from slot with compost | 32.26 | 12.04 | 33.39 | 0.55 | 0.0052 | 2.70 | 1.33 |
| Slot with straw | 44.08 | 12.51 | 55.67 | 1.02 | 0.0015 | 3.40 | 2.00 |
| 0.5 m from slot with straw | 16.12 | 5.34 | 19.17 | 0.15 | 0.0022 | 2.80 | 0.67 |

ANOVA (1) p = 0.000321; HSD[.05] = 16.62; HSD[.01] = 21.4; M1 vs M2 P < .01; M1 vs M3 P < .05; M1 vs M4 P < .01; M2 vs M3 nonsignificant; M2 vs M4 nonsignificant; M3 vs M4 nonsignificant.
(2) p = 0.030912 HSD[.05] = 5.86; HSD[.01] = 7.54; M1 vs M2 nonsignificant; M1 vs M3 nonsignificant; M1 vs M4 nonsignificant; M2 vs M3 nonsignificant; M2 vs M4 nonsignificant; M3 vs M4 P < .05.
(3) p = 0 .000214; HSD[.05] = 14.72; HSD[.01] = 18.96; M1 vs M2 nonsignificant; M1 vs M3 nonsignificant; M1 vs M4 P < .05; M2 vs M3 P < .01; M2 vs M4 nonsignificant; M3 vs M4 P < .01.
(4) p = 0.001398; HSD[.05] = 1.66; HSD[.01] = 2.14; M1 vs M2 P < .01; M1 vs M3 P < .05; M1 vs M4 P < .01; M2 vs M3 nonsignificant; M2 vs M4 nonsignificant; M3 vs M4 nonsignificant.
(5) NS.
(6) NS.
(7) p = 0 .008149; HSD[.05] = 2.3; HSD[.01] = 2.96; M1 vs M2 P < .05; M1 vs M3 P < .05; M1 vs M4 P < .05; M2 vs M3 nonsignificant; M2 vs M4 nonsignificant; M3 vs M4 nonsignificant.

## CONCLUSION

1. When applying vertical mulching method with minimal tillage in the conditions of calcareous chernozem in Ruse region on slope lands, besides the proven anti-erosion effect in previous studies, an applied organic substances increase the microbiological activity of the soil.
2. In our study the uses of compost in vertical mulching enriches the soil with nutrients and stimulate microbial activity.

3. By using straw for vertical mulching, part of the nitrogen is immobilized which prevents the feeding of the plants that are next to the slot.
4. Cellulose-decomposing activity using compost is higher than that using straw as mulch material.
5. Application of compost in vertical mulching instead of straw mulching has some advantages:
   - higher microbiological activity of the soil;
   - improved nitrogen nutrition of plants, avoided the initial immobilization of nitrogen available forms;
   - enhanced cellulose-decomposing activity which leads to a more rapid degradation of the mulch material.

## REFERENCES


BELOEV, H. I., DIMITROV, P. D., MARKOV, N. M. et al. 2008. *Technology for minimum tillage on slope lands in the context of sustainable agriculture.* Sofia: SAA.

BELOEV, H. I., STOYANOV, K., RADULOV, P. et al. 2011. Composting materials on farmland. *Soil Science, Agrochemistry and ecology (Sofia)*, N1-4.

DIMITROV, P. D., RADULOV, P. D., TODOROV, T. T. 2004. Study the effectiveness of erosion control method vertical mulching. In: *Scientific Works of RU "Angel"*, 41(1.2.). Ruse.

DIMITROV, P. D., LAZAROV, A. L., BELOEV, H. I. et al. 2008. *Device for vertical mulching. Patent for invention of the Republic of Bulgaria*. N 6539381. Sofia: Patent Office of the Republic of Bulgaria.

RUSEVA S. et al. 2010. *Risk of water erosion in Bulgaria and recommendations for soil protection agricultural land use, Part I.* Pablish Sai Seth Eco-Sofia.

PIEMENTEL, D., KUNANG, N.1998. Ecology of Soil Erosion in Ecosystems. In: *Ecosystems 1*. 416–426.

VOYNOVA-RAYKOVA, G. 1983. *Microorganisms and fertility*. Sofia: Zemizdat.



Contact information

Gergana Slavova Kuncheva: g1nikolova@abv.bg