Influences Between Soil Microbiological and Agrochemical Parameters in an Organic Edible Rose Plantation

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Abstract

The aim of this study is to present the results of the organic technology applied to increase and maintain the biological soil activity in an organic edible rose plantation established within USAMV Bucharest. Before and after planting, three ameliorative species: *Sinapis alba* L., *Phacelia tanacetifolia* L. and *Tagetes patula* L. were sown in seven variants for increasing soil biological activity. Two types of mulches, woodchips and wool, were applied on the rose rows. The results presented statistically significant correlations between different microbiological and agrochemical parameters. A strong correlation between the fungi number and soil respiration ($r = 0.94$, $p<0.05$) was observed on the mulched rows. The soil bacteria number was positive correlated with humus content ($r=0.68$, $p<0.05$) and negative with mineral nitrogen ($r = -0.66$, $p<0.05$). Positive correlation between soil respiration and assimilable potassium content ($r = 0.83$, $p<0.05$) was noticed, confirming its role in soil microorganism growth.

Keywords: ameliorative plants; edible *Rosa sp*; organic mulch; soil bacteria; soil fungi

Introduction

In organic orchards, soil biological activity and agrochemical parameters are important for the quality of products. Increasing soil microbiological parameters is one of the most important activities at the beginning and after the orchards establishment (Butcaru *et al.*, 2017b; Butcaru *et al.*, 2018; Butcaru *et al.*, 2019). Many research studies have focused on soil bacteria and fungi importance in horticultural ecosystems. Aghaalikhani and Ehteshami (2008) mentioned their role in agroecosystem, being an important factor in reducing inputs as well. *Pseudomonas sp*. was used in hydrocarbon degradation (Pacwa-Płociniczak *et al.*, 2013); bio surfactants in agriculture for pesticide degradation were mentioned by Grebenişan (2007). The role of *Trichoderma harzianum* Rifai 1295-22 (T-22) in plant growth and pathogen biocontrol was mentioned by Norvell *et al.* (1999) and Velivelli *et al.* (2015).

Vegetative material derived from green fertilizers, respectively ameliorative plants, plays a role in reducing the pathogens in the soil and the diseases (Wang *et al.*, 2009). Neață (2002) emphasized the role of soil microorganisms in the decomposition of organic substances and their participation in soil pedogenesis, contributing to the formation of humus. Bettiol *et al.* (2002) stated that microbial biomass is higher in organic than in conventional managed soil. Lipșa *et al.* (2008), studying the biological activity of the soil under different combinations of plant species, confirmed the higher percentage of soil bacteria compared with fungi. De Araújo and Melo (2010) mentioned that in organic farming the quantities of fertilizers are limited, the plants depending almost exclusively on the nutrient transformations in the soil. These are the result of the action of microorganisms, emphasizing their important role in the organic farming system.

Sinapis alba L. and *Phacelia tanacetifolia* L. are known to improve the soil structure and increase fertility, also as biomass plants in foraging activity of honey bees. Together with *Tagetes patula* L. present anti-nematodes properties and weeds control, having allelopathy properties. *Sinapis alba*, in the form of seed flour, acts as an organic bio-herbicide; it is used in heavy metals recovery from contaminated soils; acts in phosphorus mobilization and availability; controls soil pathogens without affecting the microorganism involved in the nitrogen cycle. *Tagetes patula* L. is involved in microclimate changes and used in disease and pest removal. (Berca, 2011; Bjorkman *et al.*, 2011; De Baets *et al.*, 2011; Dhima *et al.*, 2010; Foucault *et al.*, 2013; Fuks *et al.*, 2013; Hooks *et al.*, 2010; Hossain *et al.*, 2015; ITAB and GRAB, 2011; Liu *et al.*, 2013; Maltais-Landry, 2015; Ramirez *et al.*, 2009; Robacer *et al.*, 2015; Santos *et al.*, 2015; Stănică and Peticilă, 2011; Wang *et al.*, 2015).

The aim of this study is to present the correlations between microbiological and agrochemical soil parameters in an organic edible rose plantation, results of three ameliorative plants (*Sinapis alba* L., *Phacelia tanacetifolia* L. and *Tagetes patula* L.) and two mulch variants (woodchips and wool) used for increasing soil biological activity.

Material and methods

Description of the study site

In 2015, in the Experimental Field of Faculty of Horticulture within USAMV Bucharest, an organic edible rose plantation with three edible climbing varieties from David Austin collection as follows: Crown Princess Margareta, Falstaff and Brother Cadfael was established. Before and after planting, three ameliorative species: *Sinapis alba* L., *Phacelia tanacetifolia* L. and *Tagetes patula* L. were sown in seven variants for increasing the soil biological activity. After flowering the plants were mowed and after 14 days incorporated into the soil. Two types of mulches, woodchips and wool, were applied on the rose rows. Soil type was Tehnosol, Copertic subtype with a clay-sandy texture in 0-20 cm horizon, sandy-clay texture in 20-40 cm and low-alkaline pH. Soil samples were taken at the beginning of the experiment and every year after using the ameliorative plants. Between 2015 and 2017, the average values of temperatures (daily minimum, maximum and medium) didn't differ statistically. The average minimum temperature varied between -10°C and -5°C and the average maximum temperature varied between 30°C - 32°C. The annual rainfall value varied from 688.20 mm (2015), 716.00 mm (2016) to 783.00 mm (2017), with the maximum values in November (2015) respectively October (2016 and 2017). The minimum rainfall values were registered in December (2015, 2016) and September (2017).

Biological material and experimental variants

Three climbing edible roses from David Austin collection (Crown Princess Margareta, Falstaff and Brother Cadfael grafted on *Rosa laxa* Retz) were planted. All the three ameliorative species used (*Sinapis alba* L., *Phacelia tanacetifolia* L. and *Tagetes patula* L.) were sown in 7 variants: V1 Sinapis, V2 Sinapis + Phacelia, V3 Phacelia, V4 Sinapis + Tagetes, V5 Sinapis + Tagetes + Phacelia, V6 Tagetes + Phacelia, V7 Tagetes and a control parcel V8, was kept as black field, without sowing. On the rose rows, the soil was mulched with wool and woodchips for each initial variant (Vn): Vn.1 woodchips and Vn.2 wool, while the control Vn.3, was represented by unmulched soil. Both mulched rows had the same 1 m width with the specific material (Fig. 1, 2 and 3).

Experimental procedures for collecting data

Microbiological (soil bacteria and fungi number and species, soil respiration) and agrochemical (N, P_{AL}, K_{AL}, pH and humus content) parameters analyses to monitor the soil activity were made at the beginning of the experiment and two years after, each autumn, after applying the technological phases (Butcaru *et al.*, 2017; 2018; 2019). Microbiological analysis studied the number of heterotrophic bacteria determined using dilution plate method - by dispersing

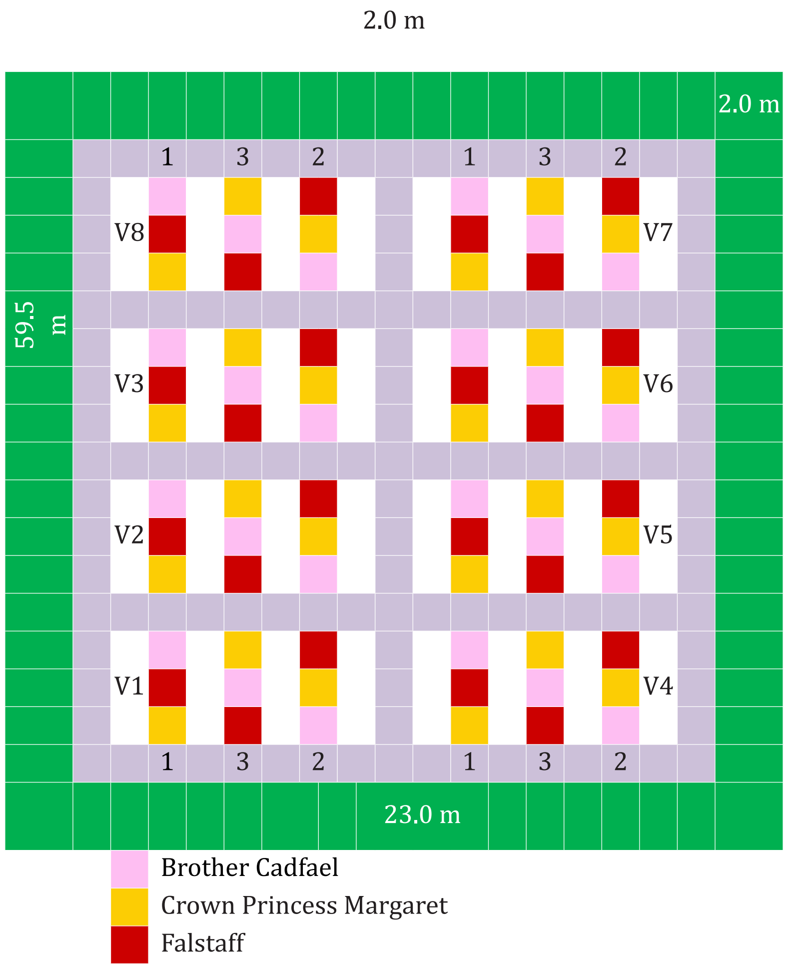

Figure 1. Experimental design (ameliorative plants, mulch and rose cultivars)

soil suspensions on the nutrient agar medium; number of microscopic fungi determined by dispersing soil suspension on PDA medium and soil respiration determined through the substrate induced respiration method according to RS-ISI-14240-1 (2012). The taxonomical identification was carried out on the basis of the cultural, morphological and/or physiological characteristics in accordance with bacteria Identification Manual (Bergey, 1994) and fungi in agricultural soils (Domsch and Gams, 1972). Agrochemical analysis determined the mineral N, mobile forms of P_{AL} and K_{AL}, the amount of humus and soil pH on two horizons 0-20 cm and 20-40 cm. Measurements were carried out according to the following methodologies: soil moisture by gravimetric method, pH by potentiometric method in aqueous suspension (1:2.5), mineral nitrogen as sum of ammonium and nitrate available in soil evaluated by spectrophotometry, mobile forms of P_{AL} and K_{AL} by Egner - Riehm - Domingo method, humus content was calculated from organic carbon determination with Walkley - Black - Gogoașă method (Madjar and Davidescu, 2004).

Statistical analysis

For the descriptive statistics of the data we used Microsoft Excel 2016, and for the inferential statistics (correlation, regression, etc.) we used GNU PSPP 1.0.1 v.2016 (the open source version of SPSS). The linear correlation was considered significant for a significance level $p = 0.05$. Also, for each correlation, the coefficient of determination r^2 was calculated.

Results and discussions

Soil microbiological parameters correlations

On the woodchips rows, positive correlations between bacteria with fungi number (r=0.66, p£0.05), bacteria with soil respiration ($r=0.72$, $p<0.05$), fungi with soil respiration ($r=0.94$, $p<0.05$) were registered (Fig. 4).

Figure 2. *Sinapis alba*, *Phacelia tanacetifolia* and *Tagetes patula* blooming

a **b**

Figure 3. Mulch variants: wool (a) and woodchips (b)

In wool mulched rows, positive correlations between fungi with soil respiration (r=0.94, $p<0.05$) and bacteria number with soil respiration (r=0.68, $p<0.5$) were maintained (Fig. 5).

In the unmulched rows, positive correlations between fungi with soil respiration (r=0.77, $p<0.05$) and bacteria number with soil respiration (r=0.75, $p<0.05$) were also noticed (Fig. 6).

Soil respiration parameter is a result of soil microorganism existence and activity (Muller, 1965; Ștefanic *et al.*, 2006). On the mulched rows, stronger correlations between fungi number with soil respiration comparative with the unmulched rows were noticed, due to specific organic material. The regression coefficients are bigger in the correlation of fungi than of bacteria with soil respiration. *Flaviobacterium* sp. and *Pseudomonas* sp., identified in the soil bacteria, Gram-negative bacteria, could be a possible cause of positive correlation between fungi and bacteria number, besides their multiplication due to organic mulch (Ștefanic *et al.*, 2006).

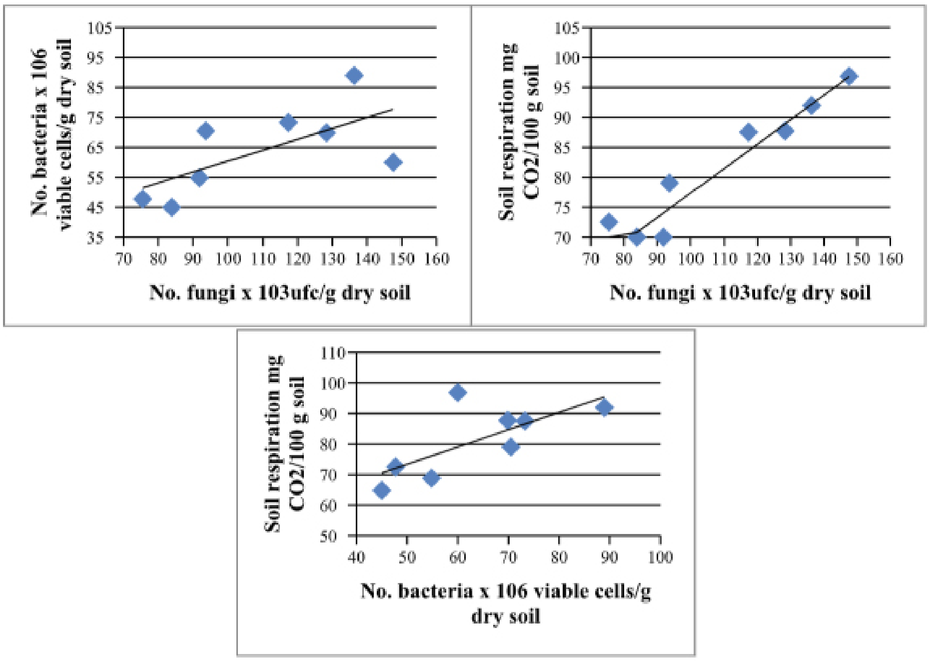

Figure 4. Correlations between soil microbiological parameters in woodchips variants

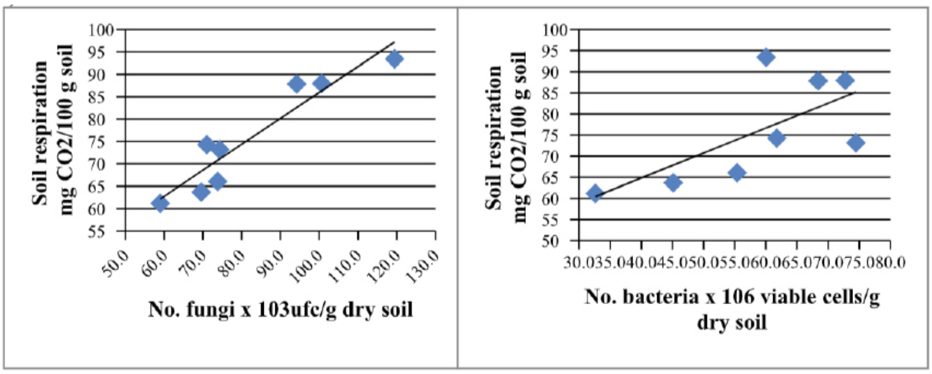

Figure 5. Correlations between microbiological parameters in wool variants

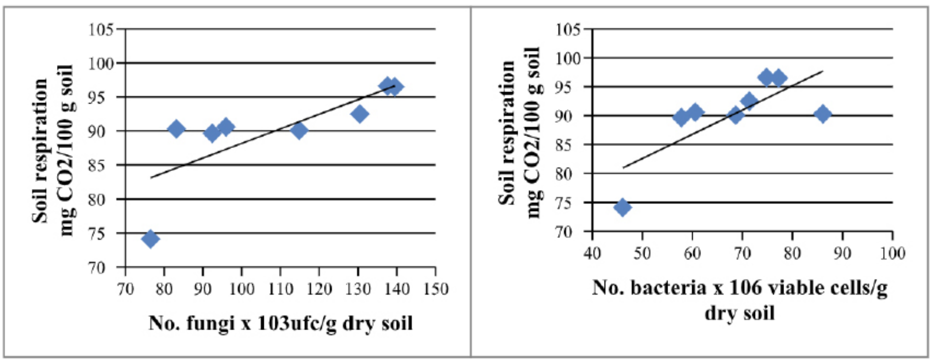

Figure 6. Correlations between microbiological parameters in un-mulched variants

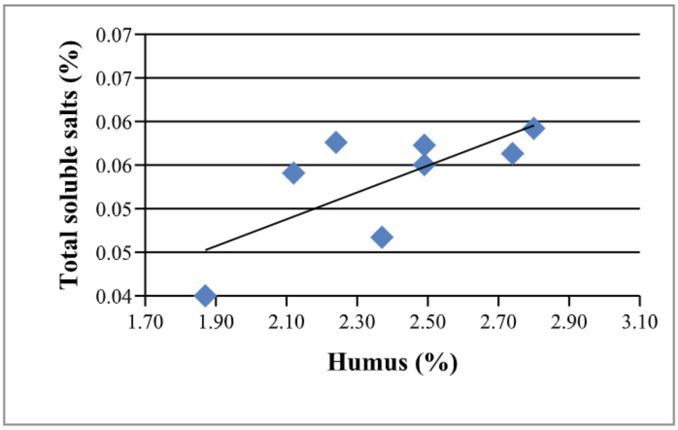

Figure 7. Correlation between soil humus and TSS content

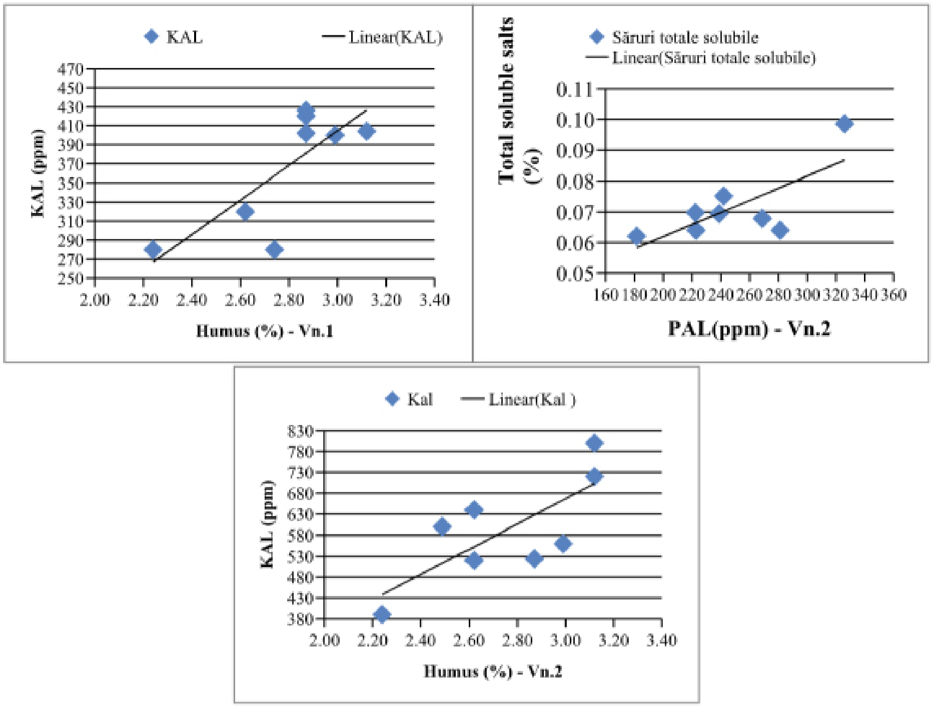

Figure 8. Correlations between agrochemical parameters under the influence of ameliorative plants and mulch variants

Soil agrochemical parameters correlations in 0-20 horizon

Under the influence of ameliorative plants, a positive correlation between soil total soluble salts and humus content was registered (r=0.72, p<0.05) (Fig. 7).

On the woodchips mulched rows (Vn.1), positive correlations between soil K_{AL} and humus content were noticed (r=0.78, p<0.05). On the wool mulched rows (Vn.2), positive correlations between soil total soluble salts with P_{AL} (r=0.73, p<0.05) and between K_{AL} with humus content (r=0.75, p<0.05) were observed (Fig. 8).

Soil agrochemical parameters correlations in 20-40 horizon

Under the influence of ameliorative plants, positive correlations between soil total soluble salts with pH (r=0.71, p<0.05), respectively with mineral nitrogen (r=0.75, p<0.05); K_{AL} and humus content (r=0.85, p<0.05) were observed (Fig. 9).

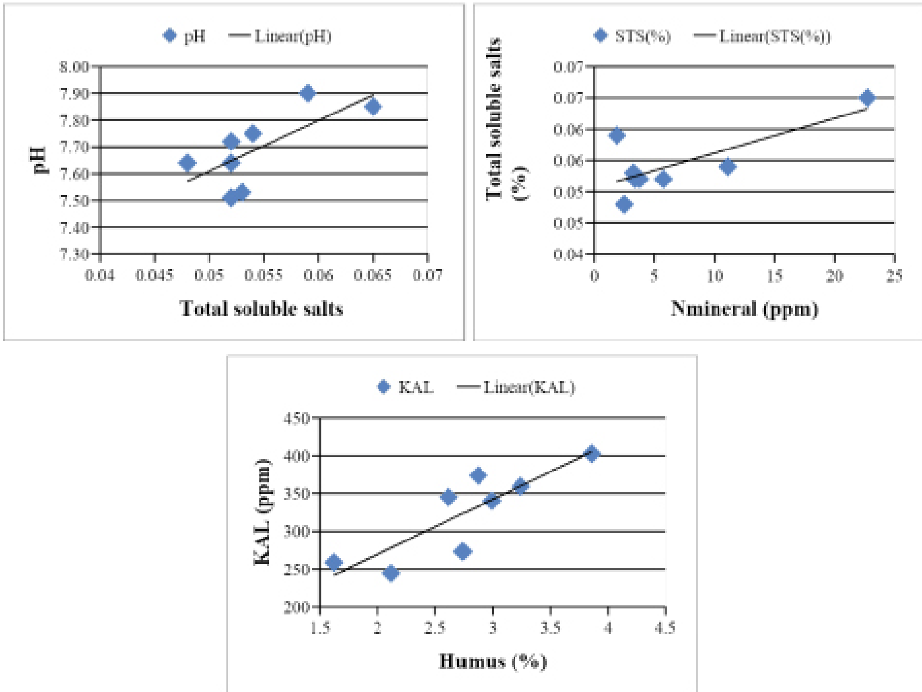

Figure 9. Correlations between soil agrochemical parameters in 20-40 horizon

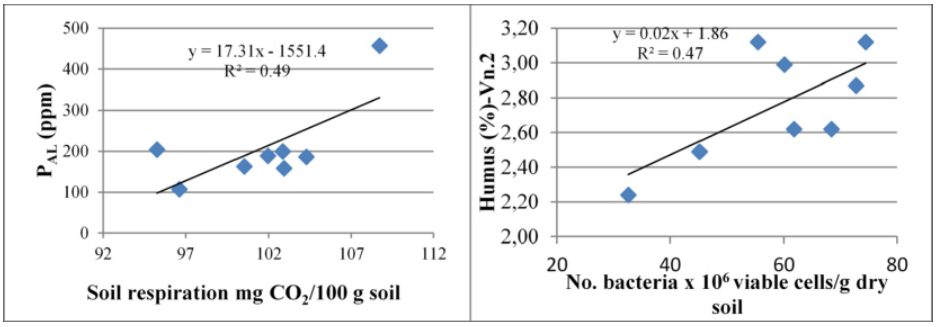

Figure 10. Correlations between microbiological and agrochemical parameters

Correlations between soil microbiological and agrochemical parameters

Analyzing the connections between microbiological and agrochemical parameters, under the influence of ameliorative plants, a positive correlation between soil respiration with P_{AL} content (r=0.70, p<0.05) was observed.

Under the influence of ameliorative plants combined with mulch variants, on the wool mulched rows a positive correlation between soil bacteria number and humus content was noticed (r=0.69, p<0.05) (Fig. 10).

On the unmulched rows, correlations between soil bacteria number with humus content (r=0.68, p<0.05), soil respiration with K_{AL} content (r=0.83, p<0.05), soil respiration with humus content (r=0.69, p<0.05) were calculated. A negative correlation between soil bacteria number with mineral nitrogen (r=-0.66, p<0.05) was observed (Fig. 11).

Positive correlation between bacteria number and soil respiration with soil humus content on the wool mulched and unmulched rows confirmed their influences (Muller, 1965; Ştefanic *et al.*, 2006; Madjar and Davidescu, 2009). Nitrogen is the most demanded nutrient by bacteria in residues decomposition (Burges and Raw, 1967), negative correlation between total number of bacteria and mineral nitrogen highlighted its consumption. Phosphorus and potassium are growth stimulants

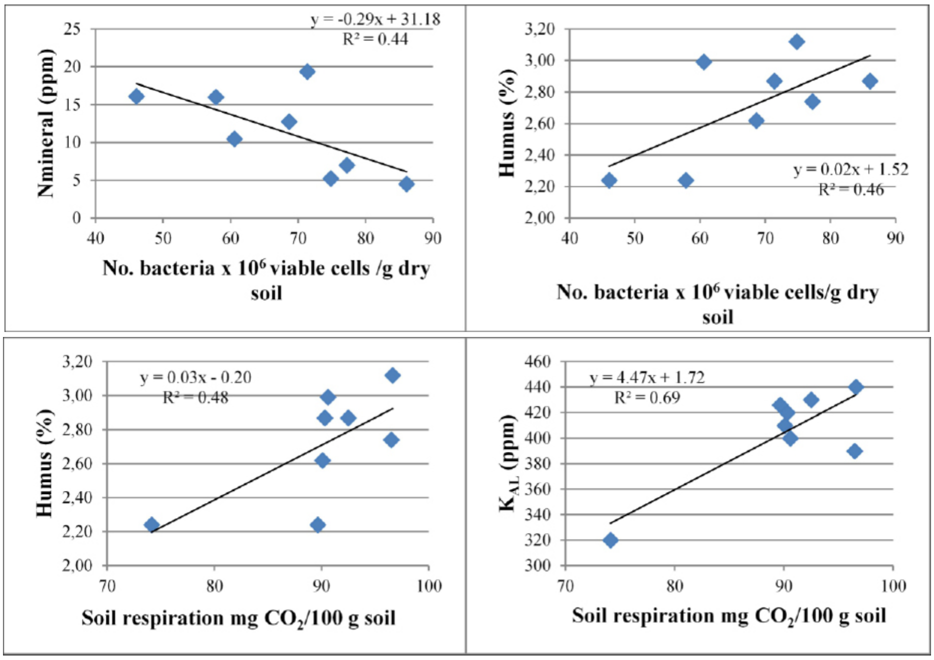

Figure 11. Correlations between microbiological and agrochemical parameters on the un-mulched rows

for soil microorganism (Muller, 1965; Ștefanic *et al.*, 2006), positive correlation with soil respiration confirming this hypothesis.

Conclusions

The present study detailed the impact of using ameliorative plants (*Sinapis alba* L., *Phacelia tanacetifolia* L., *Tagetes patula* L.) and organic mulch (woodchips, wool) in improving the soil microbiological and agrochemical parameters, presenting in the same time the linear regression between soil quality indices. A strong significant correlation between the fungi number and soil respiration ($r = 0.94$, $p<0.05$) comparing with the control plot ($r = 0.77$, $p<0.05$) was registered on the mulched rows. One important positive correlation was confirmed between the soil bacteria number and humus content (correlation coefficient $r=0.68$ on the unmulched rows respectively $r = 0.69$ on the wool mulched rows; $p<0.05$). In the same time, the soil bacteria number increased consuming nitrogen ($r = -0.66$, $p<0.05$). A significant positive correlation between soil respiration and assimilable potassium content ($r = 0.83$, $p<0.05$) was noticed, highlighting its role in growth of soil microorganisms.

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