EFFECTS OF PLANT ESSENTIAL OILS ON SOIL MICROBIAL COMMUNITY AND SOIL RESPIRATION

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ABSTRACT

Plant essential oils have been known since antiquity to possess notable biological activity, including antibacterial, antifungal and antiviral properties. *Achillea millefolium* (Y_1), *Artemisia dracunculus* (Y_2) and *Salvia officinalis* (Y_3) plant species are well known for their high contents in aromatic compounds, and essential oils. This study focused on the impacts of essential oils of *Achillea*, *Artemisia* and *Salvia* plants on; (a) soil reaction, (b) soil bacteria and fungi population and (c) soil respiration. Soils were collected from the research farm of Ataturk University, Erzurum, Turkey and 0-20 cm depth. We used four different essential oil doses (0, 100, 1000 and 10.000 ppm). Soils were potted and incubated for several weeks and taken soil samples for analysis of bacteria, fungi and soil respiration in different incubation days (0, 15, 30, 45, 60 days).

According to our study soil pH level, bacteria populations and soil respiration decreased with increasing essential oil concentration and the lowest pH level has been obtained in 60 days incubation periods, but opposite effect has been observed on fungi populations at the 60 days incubation period. Among different essential oils Y_1 applications has been shown low effect, and Y_3 application shown high effect on soil reaction, soil bacteria and fungi populations and soil respiration in the soil.

Key words: *Achillea*, *Artemisia*, *Salvia*, Essential Oils, Microbial Community, Soil Respiration

MATERIALS AND METHODS

Soil

Soils were collected from the research farm of Ataturk University, Erzurum, Turkey and the 0-20 cm depth.

Plant

The leaves of *Achillea*, *Artemisia* and *Salvia* plants were collected from Erzurum region of Turkey at the flowering stages.

Essential Oil

Shaded dried leaves were ground and subjected to hydrodistillation (Langenau, 1948), using a Clevenger type apparatus (Clevenger, 1928). Three different plant essential oil doses (0, 100, 1000 and 10.000 ppm) were prepared. Soils were potted and incubated for several weeks (0, 30, 45, 60 days).

Soil Analysis

Soil samples were collected from Ap horizon and sieved through a 2-mm mesh opening on the field and brought to the laboratory for initial chemical, physical and microbial analysis.

Microbial population analysis

Determinations of viable microbial bacteria (Ogram and Feng, 1997) and fungi counts (Alef, 1995) were carried out at five different incubation periods (0, 15, 30, 45 and 60 days) of soils and was analyzed the same day.

Basal respiration

Basal respiration (BR), as a measure of soil biological activity, was determined by using *in vitro* static incubation of unamended field moist soil (Islam and Weil, 2000).

Statistical analysis

Analysis of variance (ANOVA) was used to evaluate the significance of each treatment on soil properties and CO_2 fluxes and on bacterial and fungal populations.

Table 2. Some initial chemical, physical and microbiological properties of the experimental soil.

Soil Properties	Value	Soil Properties		Value
pH (1:2.5)	6.71	Exchangeable cations, cmol kg^{-1} soil	Ca	16.17
Organic matter, g kg^{-1}	3.49		Mg	14.64
Lime (CaCO3), g kg^{-1}	1.01		K	2.25
Total N, g kg^{-1}	0.17		Na	0.35
Available P mg kg^{-1}	13.95	Microelements, mg kg^{-1}	Fe	12.41
Salt, %	0.016		Cu	3.59
EC, dS m^{-1}	0.65 x 10^3		Zn	0.59
CEC, cmol kg^{-1}	34.15		Mn	9.52
Number of bacteria, CFU* g^{-1} soil	6.69 x 10^7	Particle size distribution, g kg^{-1}	Sand	52.44
Number of fungi, CFU g^{-1} soil	1.93 x 10^5		Silt	27.60
Total CO_2-C, Mg ha^{-1} y^{-1}	1.70 Mg C ha^{-1} y^{-1}		Clay	19.96
*CFU, Colony-forming units.		Texture Class		LOAM

RESULTS AND DISCUSSION

Soil Reaction

According to obtained results in this research, the highest pH were observed at 15 days incubation period and 100 ppm essential oil concentration (6.70±0.7, 6.70±0.5 and 6.68±0.4, respectively). The lowest pH from soils in applying essential oils of *Achillea, Artemisia and Salvia plants* were observed at 60 days incubation periods and 10.000 ppm essential oil concentration (6.43±0.6, 6.48±0.4 and 6.45±0.5, respectively). The pH value generally decreased with increasing essential oil concentration. Among the essential oils, the highest soil pH was observed for the *Artemisia* (Y_1) essential oil application and the lowest for the *Salvia* (Y_3) essential oil application. Obtained soil pH value from the Y_1, Y_2 and Y_3 essential oil treatments were shoved significant ($p<0.01$) differences as statistically in different incubation day periods (Figure 1).

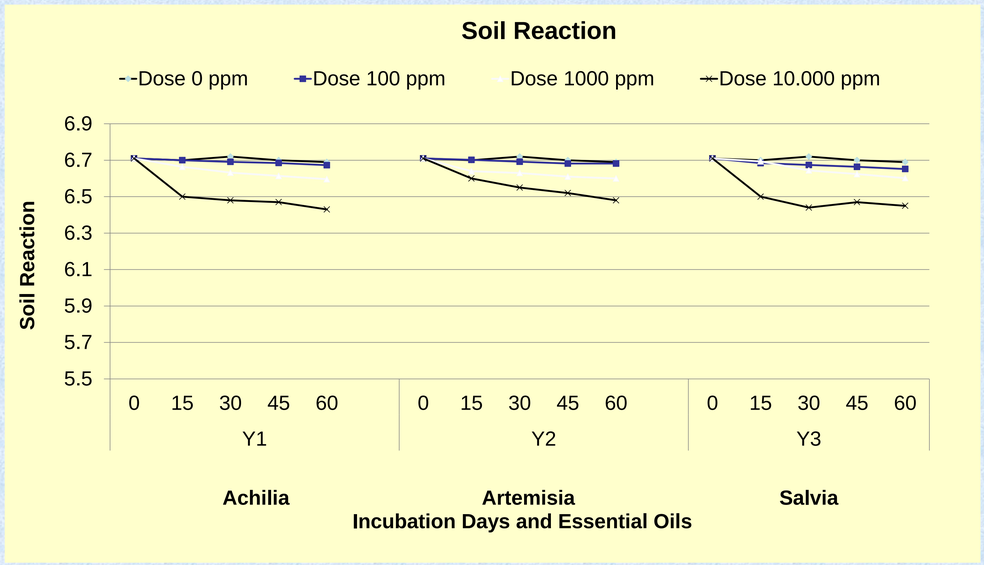

Figure 1. Effect of different essential oil doses on soil reaction at different incubation day periods.

Bacterial and fungi population

The highest bacteria populations were observed at 15 days incubation periods and 100 ppm essential oil doses in all essential oil applications (6.65±0.7, 5.51±0.8 and 5.18±0.6 CFU g^{-1} dry soil, respectively). The lowest bacteria populations were observed at 60 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (5.04±0.5, 4.04±0.7 and 3.63±0.6 CFU g^{-1} dry soil, respectively).

Among the essential oil applications, Y_1 application supported the highest bacteria population (6.65±0.7 CFU g^{-1} dry soil) at 15 days incubation periods and Y_3 application supported the lowest bacteria population (3.63±0.6 CFU g^{-1} dry soil) at 60 days incubation periods, respectively (Figure 2).

The highest fungi populations were observed at 60 days incubation periods and 1000 ppm essential oil doses in all essential oil applications (2.12±0.4, 2.03±0.5 and 2.17±0.5 CFU g^{-1} dry soil, respectively). The lowest fungi populations were observed at 15 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (1.92±0.5, 1.81±0.5 and 1.82±0.5 CFU g^{-1} dry soil, respectively).

Y_1 application supported the highest fungi population (2.32±0.5 CFU g^{-1} dry soil) at 60 days incubation periods and Y_2 application supported the lowest fungi population (1.81±0.5 CFU g^{-1} dry soil) at 15 days incubation periods, respectively when compared to initial soil treatments (0 days incubation) (Figure 2).

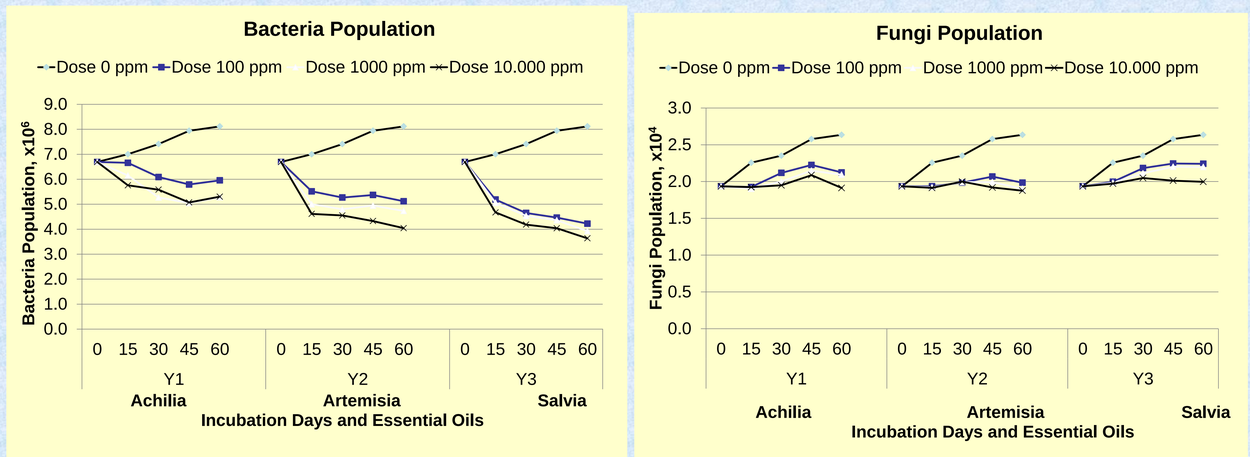

Figure 2. Effect of different essential oil doses on bacteria and fungi populations at different incubation days periods.

Soil Respiration

The highest soil respirations were observed at 15 days incubation periods and 100 ppm essential oil doses in all essential oil applications (1,54±0.2, 1,62±0.2 and 1,70±0.15 Mg CO_2-C ha^{-1} y^{-1}, respectively). The lowest soil respirations were observed at 60 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (1,25±0.15, 1,17±0.12 and 1.02±0.14 Mg CO_2-C ha^{-1} y^{-1}, respectively).

Among the essential oil applications, Y_1 essential oil aplication supported the highest soil respirations (1.70±0.2 Mg CO_2-C ha^{-1} y^{-1}) at 15 days incubation periods and Y_2 application supported the lowest soil respirations (1.02±0.3 CFU Mg CO_2-C ha^{-1} y^{-1}) at 60 days incubation periods, respectively. The soil respirations generally decreased with increasing incubation day periods. Among the different incubation days, the highest soil respirations were observed at 15 days incubation period and the lowest for 60 days incubation period (Figure 3).

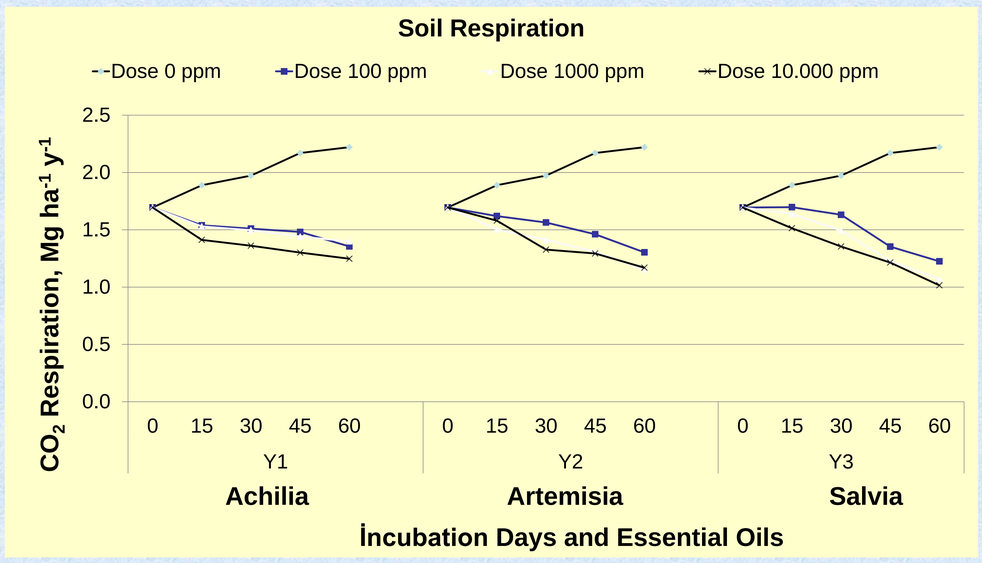

Figure 3. Effect of different essential oil doses on soil respiration at different incubation day periods.

CONCLUSION

In this study, we examined the effects of different essential oil doses on average soil pH, bacteria and fungi population and soil respirations in soils.

√ Soil pH level of the soil in different incubation periods were the highest in 15 days incubation periods among all incubation day periods and the lowest in 60 days incubation periods.

√ The highest soil pH level were observed in Y_3 applications in 15 days incubation periods and the lowest pH level were observed in Y_1 applications in 60 days incubation periods among different essential oils

√ The highest bacteria populations were observed in 15 days incubation among all incubation day periods, the highest fungi population were observed in 60 days incubation among all incubation day periods.

√ The highest bacteria populations were observed in Y_3 application and the lowest in Y_1 applications among different essential oils. The highest fungi populations were observed in Y_1 application and the lowest in Y_3 applications among different essential oils.

√Soil respirations in different incubation periods were the highest in 15 days incubation days and the lowest in 60 days incubation periods among all incubation day periods.

√ The highest soil respirations were observed in Y_3 application in 15 days incubation periods and the lowest soil respirations were observed in Y_1 applications in 60 days incubation periods among different essential oils.

Acknowledgement

This research was supported by the Scientific Research Administration Unit of Ataturk University, Erzurum, Turkey.

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