Original Scientific paper
10.7251/AGRENG2301060B
UDC 631.41(497.13)

SOIL ELECTRICAL CONDUCTIVITY IN RELATION TO SOIL MICROCLIMATE AND SOIL RESPIRATION UNDER WHEAT AND BARLEY LAND COVERS

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ABSTRACT

Soil electrical conductivity (EC) is an important indicator of soil health. It affects crop yields and suitability, many soil properties like plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as carbon dioxide i.e. soil respiration. While it is well known that major drivers of soil EC are soil temperature and moisture content, less is known on the relation between soil EC and respiration. Therefore, the objectives of this research were to determine relation of soil EC and soil microclimate (soil temperature and moisture), as well relation of soil EC and soil respiration under three different land covers. A study on soil EC, microclimate and respiration under bare soil, winter wheat and winter barley was carried out from November 2020 until July 2021 on experimental field near Osijek city, continental Croatia. The results showed that EC is more related to soil microclimate elements i.e. soil temperature and soil moisture content than on soil respiration. Between 17% and 47% of EC can be explained by soil microclimate elements and none i.e. only 4% to 12% by soil respiration.

Key words: *soil EC, soil* CO_2 *efflux, soil temperature, soil moisture content, Croatia.*

INTRODUCTION

Soil electrical conductivity (EC) is a measure of the amount of salts in soil. EC levels are indicator of soil health and can serve as an indirect indicator of important soil physical and chemical properties like the amount of water and water-soluble nutrients available for plant uptake. EC is affected by land use, cropping, irrigation, application of fertilizer, manure, and compost. Furthermore, factors affecting EC include soil minerals, climate, and soil texture*, i.e. studies have shown that soil water content and concentration, soil temperature, clay content and mineralogy, cation exchange capacity (CEC), and organic matter content are among the dominating soil properties affecting EC (Rhoades et al., 1976; Sheets & Hendrickx, 1995;* Wei et al., 2013*). Soil EC affects crop suitability and yields, plant nutrient availability, and* activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide i.e. *soil respiration.* Soil respiration is considered to be the largest terrestrial–atmospheric carbon exchange, it is part of global carbon cycle which dynamic presents key issue of global warming. Therefore, any alterations in soil respiration could alter the climate warming (Cox et al., 2000). Although soil microclimate i.e. soil temperature and soil moisture content are considered to be main controlling factors of soil respiration (Cox et al., 2000; Rastogi et al., 2002; Luo and Zhou, 2006; Wan et al., 2007; Bilandžija et al., 2016; Bilandžija et al., 2021, Zhen et al., 2022), understanding of EC role and its impact on soil respiration is important for discerning how carbon balances may shift (Rietz and Haynes, 2003; Xie et al., 2009). EC can affect soil respiration through strong effects on the microorganisms including effects on microbial biomass, population, community structure and activity (Sardinha et al., 2003; Vincent et al, 2006). Soil microorganism activity declines as EC increases and this impacts important soil processes such as residue decomposition, nitrification, denitrification and soil respiration. However, contradictory results have been obtained for the effects of EC on soil respiration rate (Rietz and Haynes, 2003). Therefore, the objective of the study is to determine the relation of EC and soil microclimate (temperature and moisture) i.e. relation of EC and soil respiration.

MATERIALS AND METHODS

Experimental site, soil properties, climate conditions and agrotechnical measures

A study on soil EC and soil microclimate i.e. soil respiration under different land covers was conducted from November 2020 until July 2021 on experimental field near Osijek city in Croatia (φ = 45° 31’ 56.47” N, λ = 18° 44’ 16.07” E; 90m a.s.l.). The experiment includes three different land cover:

- ✓ BS - bare soil;
- ✓ WB - winter barley (*Hordeum vulgare* L.): Rex, Lord, Barun and Panonac cultivars
- ✓ WW - winter wheat (*Tritucum aestivum* L.): Srpanjka, Renata, El Nino and Kraljica cultivar.

More on wheat and barley cultivars can be found in Bilandžija et al. (2021) and AIO (2022).

Soil at the experimental site has silty clay texture, water holding capacity amounts 37.7%, air holding capacity 10.2%, soil porosity 47.8%, and bulk density 1.39 g cm^{-3}. Soil pH_{KCl} amounts 7.24, soil contains 2.3% of humus, 0.11% of total nitrogen, 1.25% of total carbon, 0.06% of total sulphur, 17.9 mg of P_2O_5, and 15.5 mg of K_2O per 100 g of soil.

Osijek area has continental climate, with an average annual air temperature of 11.7 °C and average annual precipitation amount of 707 mm in the period 1991–2018. During the studied vegetation season average air temperature was 10.8 °C and precipitation amounted 650 mm. More on climate conditions and agroclimatic factors during period 1991–2018 can be found in Bilandžija and Martinčić (2020/2021) and during vegetation growing season in Bilandžija et al. (2021.).

All agrotechnical measures for winter wheat and barley i.e. reduced tillage, fertilization, planting/harvesting dates, weed and pest control were done according to the good agricultural practices. More on the applied agrotechnical measures can be found in Bilandžija et al. (2021).

Measurement of CO2 concentrations and electrical conductivity

Data on soil respiration rates are obtained from Bilandžija et al. (2021). Soil CO_2 concentrations and microclimate elements were measured once per month during vegetation growing season (November – July). Due to unfavourable weather conditions, measurements were not conducted during two winter months (December – January). Measurements of soil CO_2 concentrations were conducted by portable infrared carbon dioxide detector (GasAlertMicro5 IR, 2011) and *in situ* closed static chamber method was used. More on the measurement procedure can be found in Bilandžija et al. (2021). The aim of the research also requires reliable data on *electrical conductivity, soil moisture and soil temperature* in the soil surface layer (10 cm depth). E*lectrical conductivity (dS/m), soil moisture content and soil temperature* were determined by IMKO HD2 instrument (probe Trime, Pico64, 2011) in the vicinity of each chamber once per month along with determination of soil respiration. Total number of soil CO_2 concentrations, microclimate and EC measurements during vegetation season was 7 per experiment treatment (once per month). Each treatment of wheat and barley includes 4 different cultivars of wheat/barley and all measurements were conducted in three repetitions. Therefore, total number of measurements for WB and WW treatment amounts 84 (7 months' x 4 cultivars x 3 repetitions). Total number of measurements for BS treatment amounts 42 as all measurements were conducted in 6 repetitions (7 months' x 6 repetitions).

Statistical analyses

Correlation analyses between EC and soil temperature, moisture, and respiration is contucted by Microsoft Excel programme. The strength of the correlation coeficients is interpreted according to the Roemer-Orphal scale (Table 1).

Table 1. Roemer-Orphal scale

correlation strength	Correlation coefficient (r)
non	0.0 – 0.1
very weak	0.1 – 0.25
weak	0.25 – 0.4
moderate	0.4 – 0.5
strong	0.5 – 0.75
very strong	0.75 – 0.9
full	0.9 – 1.0

Source: Vasilj (2000)

RESULTS AND DISCUSSION

EC and soil temperature

During the studied period, strong negative linear correlation for bare soil was determined between EC and soil temperature (r = -0.64) (Figure 1). Furthermore, strong negative linear correlation between EC and soil temperature was also determined for wheat (r = -0.60) and barley (r = -0.69) (figure 1). According to the coefficient of determination, 40%, 36% and 47% of EC depend on soil temperature under bare soil, wheat and barley, respectively (Figure 1). Other studies have also found soil temperature to have an effect on EC (McKenzie et al., 1989, Slavich and Petterson, 1990, Sudduth et al., 2001), while Brevik et al. (2004 determined that linear regression analysis is indicating no correlation between soil temperature in the upper soil layer (10cm) and EC values

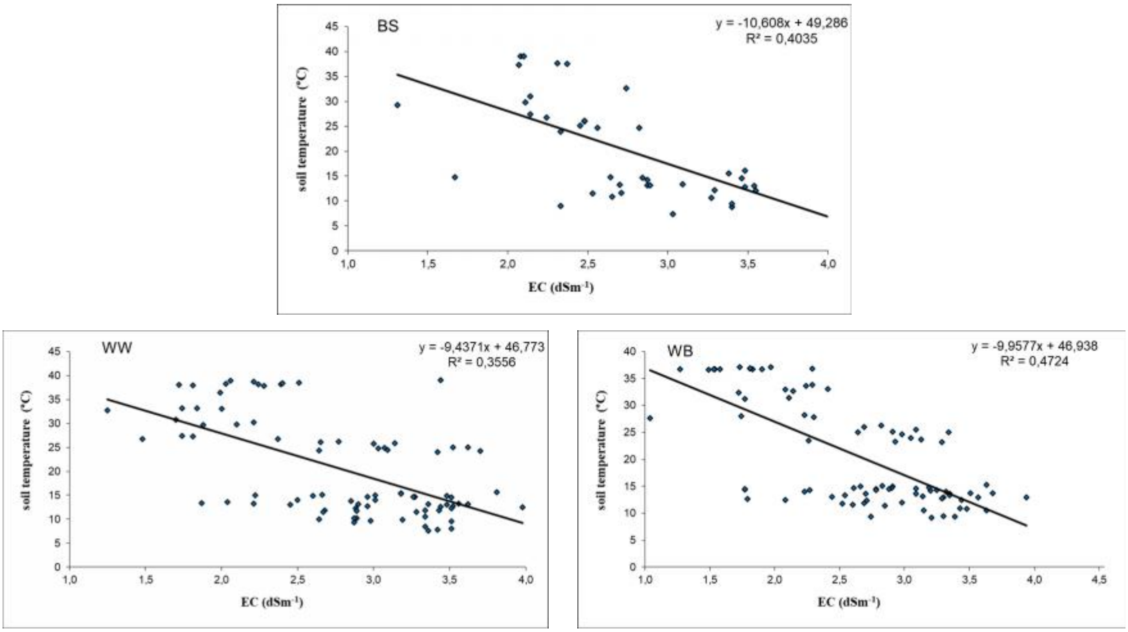

Figure 1. Correlation of EC and soil temperature for bare soil, wheat and barley covers

EC and soil moisture content

Between EC and soil moisture content, moderate positive linear correlation was determined for bare soil (r = +0.41) and strong positive linear correlation for wheat (r = +0.64) and barley (r = +0.56) (Figure 2). According to the coefficient of determination, 17%, 41% and 31% of EC depend on soil moisture under bare soil, wheat and barley, respectively (Figure 2). Positive correlation of EC and soil moisture content was determined by Mueller et al. (2003), and also other previous studies determined a simple linear relationship between EC and soil moisture content (Kachanoski, et al., 1988; Sheets, and Hendrickx, 1995).

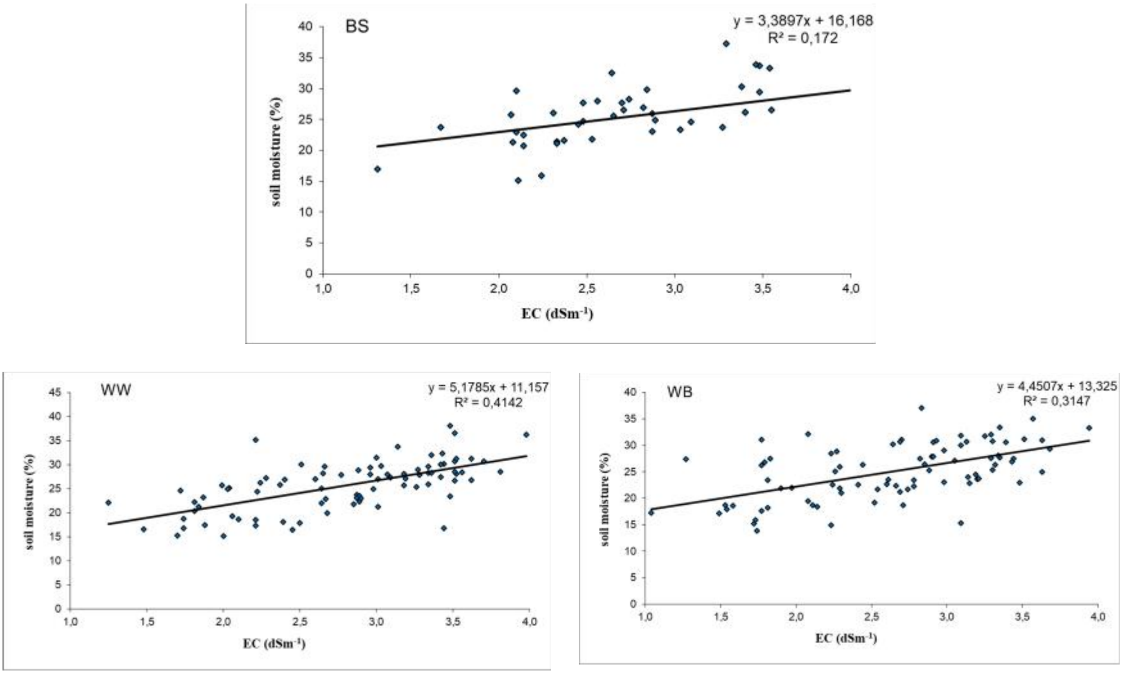

Figure 2. Correlation of EC and soil moisture content for bare soil, wheat and barley covers

EC and soil respiration

Considering EC and soil respiration, non to weak negative linear correlations was determined. For bare soil, non correlation was determined between soil respiration and EC (r = -0.08). Furthermore, weak negative linear correlation was determined between EC and soil respiration for wheat (r = -0.35), and very weak negative linear correlation for barley (r = -0.20) (Figure 3). According to the coefficient of determination, soil respiration does not depend on EC under bare soil i.e. only 4% and 12% of soil respiration depends on EC under barley and wheat covers, respectively (Figure 3). This may be attributed to the depressive effects of EC on the microorganisms. Similar results for the inhibition effects of EC on soil respiration have been obtained in many other previous studies (Xie et al., 2009; Rietz and Haynes,2003; Sardinha et al., 2003; Lai et al., 2012).

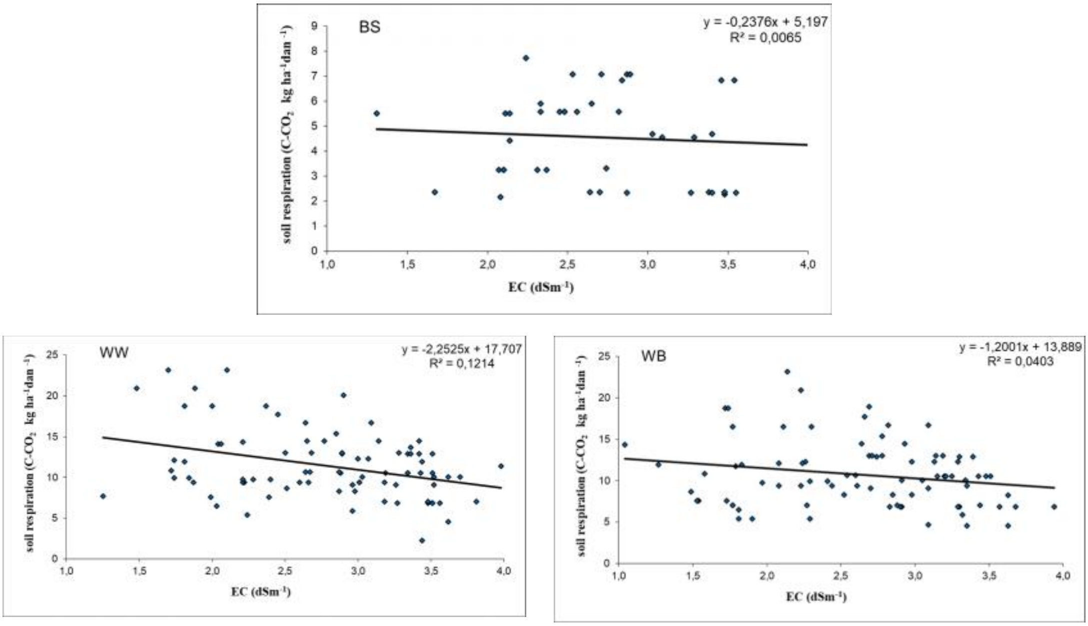

Figure 3. Correlation of EC and soil respiration for bare soil, wheat and barley covers

CONCLUSIONS

In a study on EC and its relation to soil temperature (10 cm depth), soil moisture content (10 cm depth) and soil respiration under three different land covers, conducted during 2020/2021 vegetation season on experimental field in continental Croatia, the following was determined:

- ✓ EC and soil temperature: strong negative linear correlation for all three studied land covers (bare soil, wheat and barley)
- ✓ EC and soil moisture: moderate positive linear correlation for bare soil, strong positive linear correlation for wheat and barley
- ✓ EC and soil respiration: none correlation for bare soil, weak negative linear correlation for wheat, and very weak negative linear correlation for barley

The obtained results indicate that EC is more related to soil microclimate elements i.e. soil temperature and soil moisture content than on soil respiration. Between 17% and 47% of EC can be explained by soil microclimate elements and none i.e. only 4% to 12% by soil respiration.

ACKNOWLEDGMENTS

This research was funded by European union from Operational Program Competitiveness and cohesion of European Regional Development Fund via project “Production of food, biocomposites and biofuels from cereals in the circular bioeconomy” (grant number KK.05.1.1.02.0016).

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