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Residual Effects of Foliar Micronutrient Application on the Chemical Properties of Saline-Calcareous Soil in an Arid Environment

Boutheina Miloudi [1], Ali Masmoudi [2], Mohamed Chemseddine Masmoudi[3], Samir Derouiche[4,5*]

[1]Agriculture sciences department, Laboratory Ecosystems diversity and dynamic of agricultural production systems in arid zones DESPAZA, University of Biskra, BP 145 Biskra 07000 ALGERIA;
[2]Agriculture sciences department, Laboratory Ecosystems diversity and dynamic of agricultural production systems in arid zones DESPAZA, University of Biskra, BP 145 Biskra 07000 ALGERIA;
[3]Agriculture sciences department, Laboratory Ecosystems diversity and dynamic of agricultural production systems in arid zones DESPAZA, University of Biskra, BP 145 Biskra 07000 ALGERIA;
[4] Department of Cellular and Molecular Biology, Faculty of Natural Sciences and Life, University of El-Oued, El-Oued 39000, Algeria.
[5] Laboratory of Biodiversity and Application of Biotechnology in the Agricultural Field, Faculty of Natural Sciences and Life, University of El-Oued, El-Oued 39000, Algeria.
[*]Correspondence: Samir Derouiche

ABSTRACT: This research investigated the residual effects of foliar micronutrients applications on soil chemical properties (pH, EC, $CaCO_3$) in arid environment. The study was performed at the department of agricultural sciences, Mohamed Khider University, Biskra, Algeria. Applying the pot culture soil previously cultivated with wheat which improved with foliar micronutrients treatments during the growth cycle. The pH and EC results showed insignificant variation among treatments reflecting the minor effect of foliar sprays solutions on the chemical proprerties of saline calcareous soil. But, $CaCO_3$ results registered a significant effect which reflect the indirect influence of foliar micronutrients treatments on the soil calcium carbonate content. This alteration is may be due to rhizosphere processes activity such us root secretion, microbial activity and redox conditions around the roots which lead to dissolution or transformation of the carbonate without affecting the pH or salinity. Also, the results obtained highlight the weak connection between the dynamic carbonate alterations and pH and salinity.

INTRODUCTION

The increasing population and the demand for high-quality food are the most pressing issues of current global food security. this shows the necessity of developing and using the land, especially areas that have been overlooked so far [1]. According to [2], the soil constitutes an almost completely inert mass in which plants live and the physico-chemeical analysis was recommended to correct the level of its fertility. For [3], both soil fertility and quality depend on wide range of soil properties such as pH, texture, soil structure, soil organic matter, and plant-available water and nutrients, which in turn depend on soil processes such as erosion, leaching, aeration, nutrient cycles, and anaerobiosis. The most common soil fertility parameters include cation exchange capacity (CEC), organic carbon (OC), electrical conductivity (EC), pH, macronutrients (N, P, and K), and micronutrients (Zn, Mn, and Fe) [3].

North African countries are characterized by an arid or semi-arid environment in most of their territory and have limited water resources [4]. Several researches [1 – 5- 6 – 7] defined the characteristics of arid and semiarid soils: low content of organic matter, high phosphorus fixation, high alkaline pH, very high electrical conductivity, low moisture, accumulate potassium, sodium, calcium, presence of carbonate, gypsum and other minerals in high concentrations ultimately damaging plant life. This is because carbon will bond with oxygen to form carbonates in the absence of water and later cations, which will actively repel water, this can lead to carbonates or gypsic crust forms that prevent water from reaching plant roots [1]. and the studies of [8 – 9 and 10] demonstrate the limitation effects of these characteristics on the decomposition of the organic matter (mineralization) by microorganisms decomposing function which reflect negatively the soil fertility in this regions. Consequently, these characteristics make traditional systems used for estimating soil fertility in wet areas inappropriate for this type of soil [1].

This study was carried out at the department of agricultural sciences, University of Mohamed Khider, Biskra. Which situated in the southeastern of Algeria and characterized by an arid climate. This experiment investigated the residual effect of foliar micronutrients solutions of Fe, Zn, Cu, Mn and Mo applied alone or combined on soil chemical properties pH, electrical conductivity (EC) and Calcium carbonate content ($CaCO_3$) and their interactions under saline calcareous soil using pot culture soil previously cultivated with wheat (*Triticum durum* L.). The results help to understand the nutrients dynamics and assist the fertilization strategies efficiency in arid environment.

MATERIEL AND METHOD

The current study represents the residual effects of foliar micronutrients (Fe, Zn, Cu, Mn, Mo) sprays treatments single or combined applied on wheat culture (*Triticum durum* L.), Mohamed Ben Bachir variety; during the season (2016/2017) in the experimental site of the department of agricultural sciences of Mohamed Khider University, Biskra, Algeria on the chemical properties (pH, EC, $CaCO_3$) in saline calcareous soil in arid zone.

The physico-chemical characteristics of the soil are represented in the table below.

Table 1. Soil characteristics.

Parameter	Value	Unit
Total $CaCO_3$	40.85	%
Active $CaCO_3$	11	%
pH	7.3	–
Organic matter	1.2	%
Electrical conductivity	4.1	dS/m

The wheat culture pot was at first provided with pre-planting doses of superphosphate, potassium sulfate and nitrogen fertilization (urea) applied at three critical phases of crop development.

Table 2, represent the foliar solutions formulates and concentrations used according to the rates recommended by Fageria et *al.* (2009). These solutions were administered in two sensitive stages of crop development (telliring and stem elongation). The foliar micronutrients treatments contain a one or combined elements.

Table 2. The formulate and concentration of micronutrients used as foliar spray.

Compound	Concentration (ppm)
$FeSO_4$	6000
$ZnSO_4$	3000
$MnSO_4$	2000
$CuSO_4$	1000
$MoO_3 \cdot H_2O$	200

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The experimental site was arranged in randomized complet block design with three replications.

The soil analysis was carried out at the end of crop cycle to assess the effect of foliar spraying soil proprieties were as follow: pH, EC, $CaCO_3$.

Analysis of variance (ANOVA) was used to data were analysed via XLSTAT (2016).

RESULTS AND DISCUSSION

The ANOVA data analysis showed a differential response of the foliar micronutrients application (on wheat culture under saline calcareous soil in arid region) on the chemical proprieties of soil: pH, EC and $CaCO_3$.

The results highlight the highly significant effect of foliar micronutrients spray on the carbonate fraction in soil (p = 0.0009). where the data varied between 37.85 % and 42.92%.

Table 3. The ANOVA data analysis of the effect of foliar micronutrients application on the $CaCO_3$ concentration in soil.

	Source	DDL	Sum square	Square average	F	Pr > F
$CaCO_3$	Template	31	147.1158	4.7457	2.5305	0.0009
	Error	64	120.0246	1.8754		
	Adjusted total	95	267.1404			

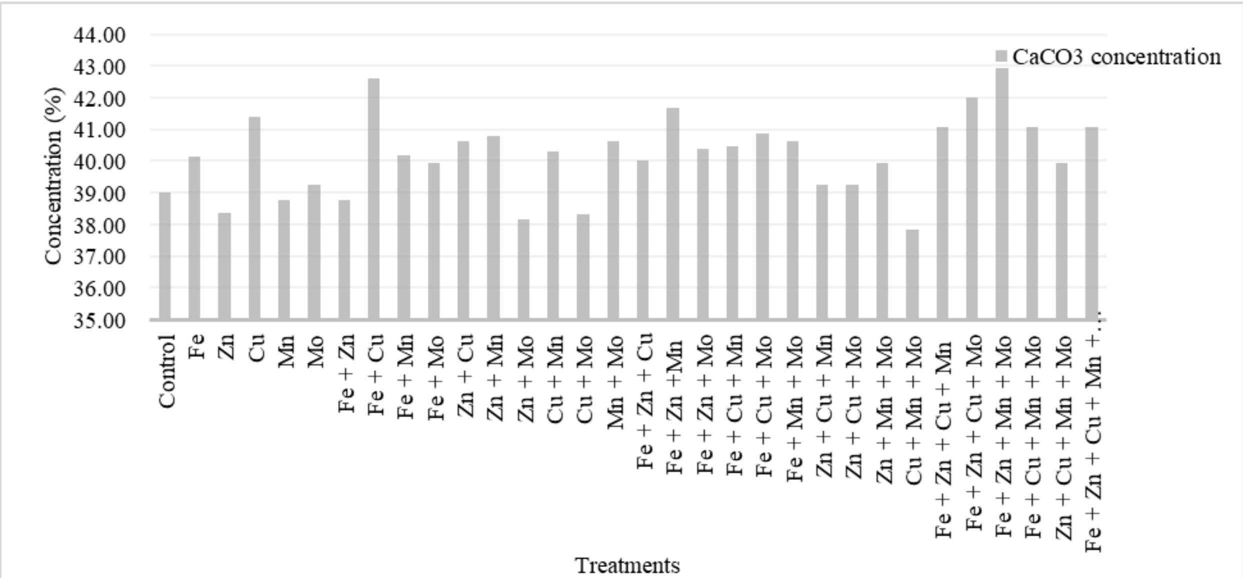

Figure 1. The effect of foliar micronutrients application on the concentration of $CaCO_3$ in soil.

In contrast, the results record the opposite effect of this treatments on pH and EC with p = 0.509 and p = 0.342 respectively. When the values of pH across the treatments were tightly clustered (7.1 – 7.5), also EC values record moderate variation among pots (3.2 – 6.0 dS/m).

Table 4. The ANOVA data analysis of the effect of foliar micronutrients sprays on the pH soil.

	Source	DDL	Sum square	Square average	F	Pr > F
pH	Template	31	0.5863	0.0189	0.9813	0.5098
	Error	64	1.2333	0.0193		
	Adjusted total	95	1.8196			

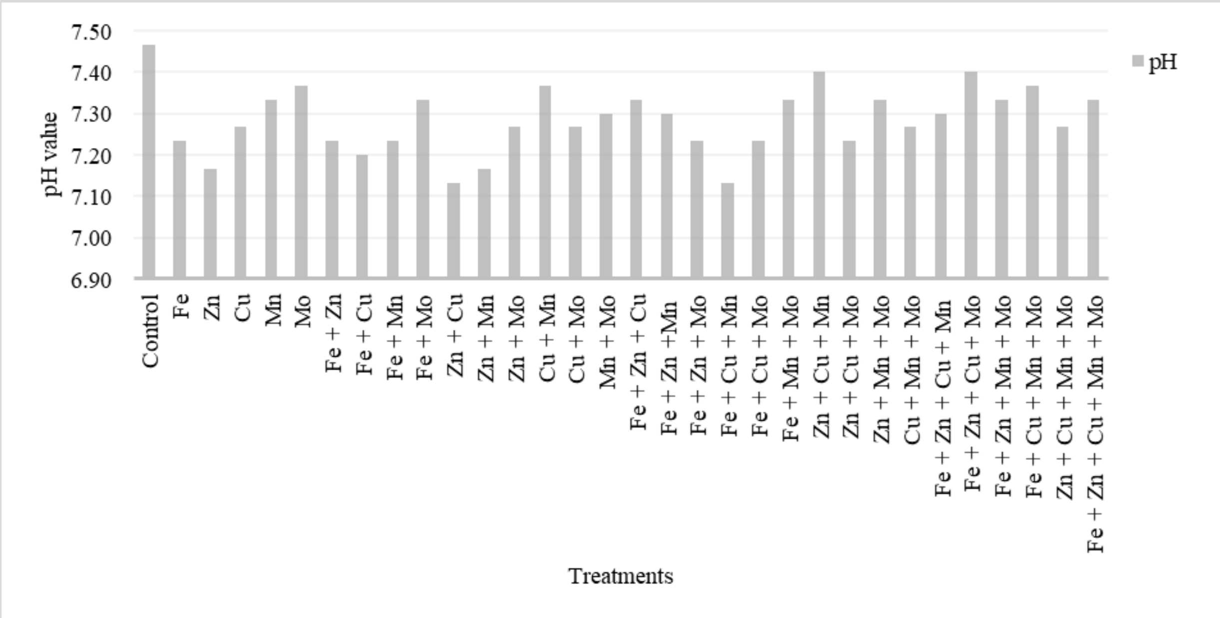

Figure 2. The effect of foliar micronutrients sprays on pH.

Table 5. The ANOVA data analysis of the effect of foliar micronutrients sprays on the EC.

	Source	DDL	Sum square	Square average	F	Pr > F
EC	Template	31	11.7674	0.3796	1.1213	0.3420
	Error	64	21.6600	0.3384		
	Adjusted total	95	33.4274			

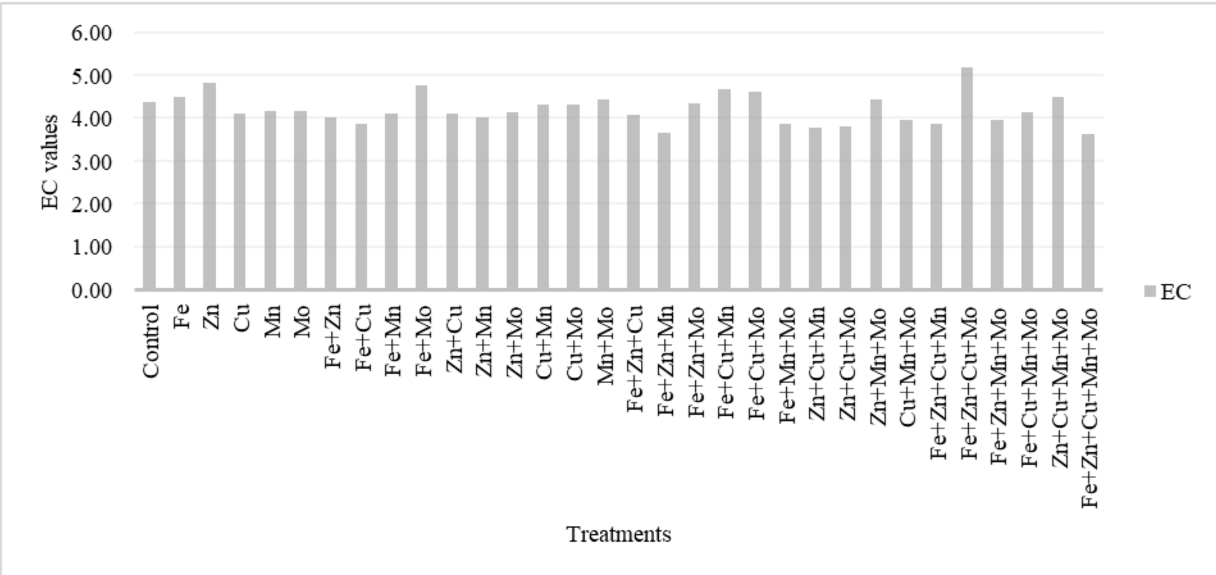

Figure 3. The effect of foliar micronutrients sprays on EC.

Notably, the foliar application of micronutrients transports the nutrients only in trace quantities to the soil by the residues of the application or leaf fall.

The persistence of pH and EC values demonstrate the less impact of foliar micronutrient treatments (single or combined) on the acidity and salinity of the soil. Whereas, the result obtained put the light on the indirect influence of these foliar treatments on the $CaCO_3$ equilibria. This response may due to the plant physiological and biochemical transformations after the spray of micronutrients which affect the rhizosphere processes such us: redox conditions around the roots (with its essential impact on the decomposition of the organic matter, mineral transformation and nutrient availability), root secretion and microbial activity, all these alterations influence the carbonate fraction existed in the soil either by dissolution or reformation. Also, the results obtained highlight the decoupling between the dynamic carbonate alterations and pH and salinity. Where the results obtained by [8] confirmed the effect of physiochemical parameters on the functioning of decomposing microorganisms which regulate the progress of mineralization. Also [12] declared that, multiple element co-limitation of soil C cycle – plant biomass and microbial catabolic profile were most significantly altered by combination of macronutrients and micronutrients when the effect of micronutrients is smaller than the macronutrients.

CONCLUSION

This study demonstrate the impact of the foliar micronutrients treatments applied on wheat on the chemical proprieties of soil, and highlight the significant interaction between plant physiological and biochemical processes and the carbonate fraction in the soil which possibly affect the soil fertility in saline calcareous soils in arid zone without any change registered in pH and CE.

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