Copper and Zinc in Drainage Water and Soil from Swine Wastewater applied to Oilseed Radish Crop

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INTRODUCTION

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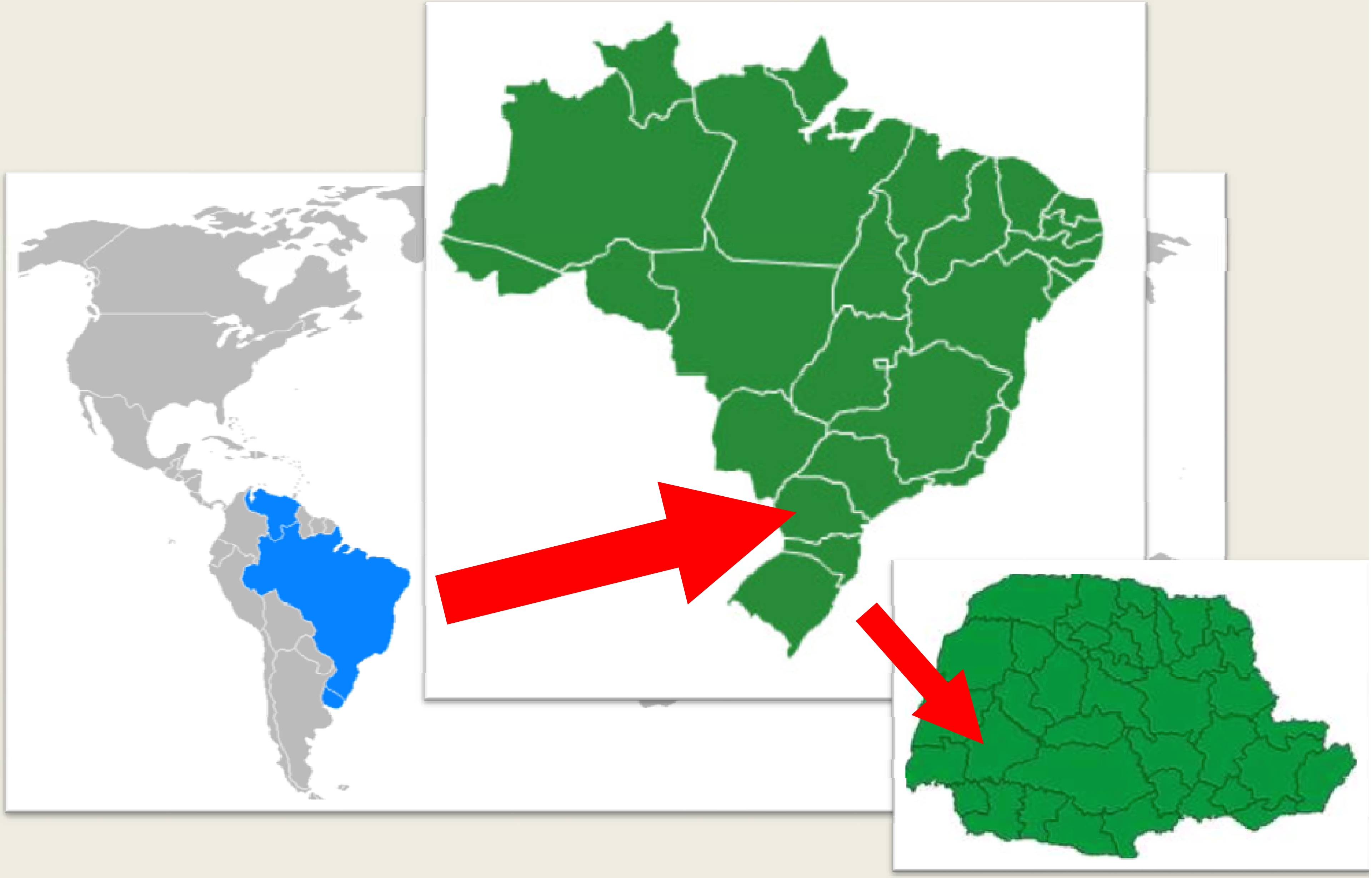
→With the intention of minimizing the drinkable water exploration, many countries are adept to irrigating their cultures through reutilization of wastewater from several different sources;

→ One example of reutilization of water widely spread in Brazil is the application of swine wastewater (SW) in agricultural cultures;

→ The South region of the country is responsible for 58% of the national production;

→The Paraná State produced 507,886 tons of pork in 2007 (Paraná, 2007), and has slaughtered, between September and December of 2010, 1.385.338 pigs (IBGE, 2010), being considered one of the leaders in the sector.

INTRODUCTION



INTRODUCTION

→This activity concerned about the significant amounts of waste, which, when disposed in the environment, can bring serious environmental problems;

→ The main nutrients present in SW are: nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), sodium (Na), magnesium (Mg), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn);

→ Cu and Zn are added in the swine feeding to improve their digestion and prevent illnesses in the animals (Barros et al., 2003; Kunz et al., 2005);

INTRODUCTION

→Besides that concern, since 2005, with the introduction of biofuel in the Brazilian energy production (Brazil, 2005)**, the use of renewable sources of energy have been receiving stimulus from the government;**

→ It is believed that such studies on the use of wastewater in crops that aim the production of biodiesel are promising due to the quantity and quality of the oil produced being associated to the good development of plant, which depends on soil conditions, such as organic matter and nutrients, highly present in SW;

Therefore, the aim of this study was to examine the contamination of Copper (Cu) and Zinc (Zn) in the leachate with fertigation by SW in the oilseed radish crop, which is an oil-rich seed plant used as green manure in the winter and good forage to the production of biodiesel.

INTRODUCTION

OILSEED RADISH (*Raphanus sativus*)
Green manure and biofuel

MATERIAL AND METHODS

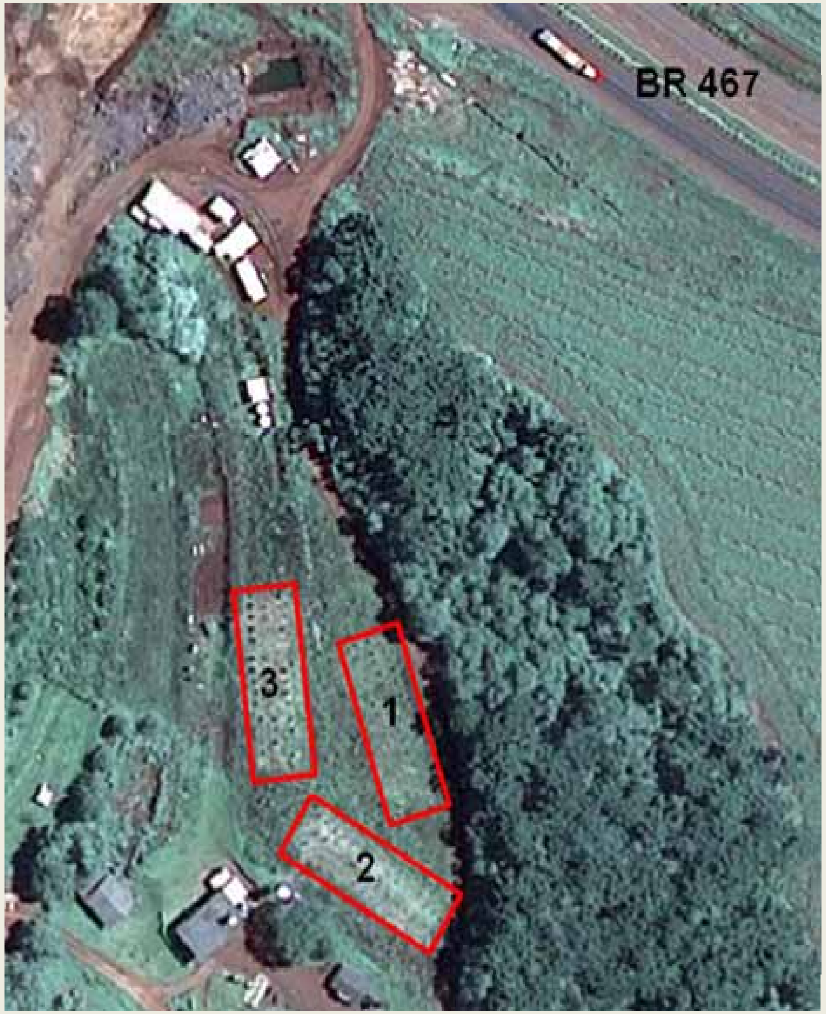
MATERIAL AND METHODS

→The experiment was carried out in the Agricultural Engineering Experiments Center (NEEA) of the Western Paraná State University (UNIOESTE);

→The total area is of 0.162 ha, divided in three treatments, with 540 m² each, defined based on the type of irrigation:

- not irrigated (T1);
- irrigated (T2);
- fertigated with SW (T3).

→ Each treatment has three replications, which measure 180 m² each.



MATERIAL AND METHODS

→ **In the area there were two independent reservatories, to keep SW and water, which were conducted until the treatments through an irrigation per aspersion system (spaced 6 x 12 cm and with the help of a 6 CV's engine, tabulation of 2' and 16 plastic sprinkler, full circle, with 1 bocal and flow of around 1,200 L.h^{-1}).**

MATERIAL AND METHODS

→ The water as well as the effluent were applied in the experimental area in a rate of 370 m^3 ha^{-1} during the whole cycle of the culture. The fix rate applied was divided into five irrigations, every 15 days, being calculated based in the mean probable precipitation for the region, according to the recommendations of Longo et al. (2006);

→ The irrigations occurred at the 34th, 49th, 72nd, 87th and 101st days after seeding (DAS) of oilseed radish crop;

→ The SW used in the experiment was obtained from a local cooperative, in a waste stabilization pond effluent at the end of an anaerobic biodigestor, once it is a system widely used and expanding in the Western Paraná region, in order to obtain carbon credit

Fonte: EMBRAPA, 2007

MATERIAL AND METHODS

Table 1. Initial characterization of the soil of the experimental area for the three treatments before the planting of the oilseed radish.

T	pH $CaCl_2$	EC $dS\ m^{-1}$	P mg dm^{-3}	S	H + Al	Al	Ca	Mg	K	Na	BA	CEC
					-----	-----	-----	mmol$_c$ dm^{-3}	-----	-----	-----	-----
T1	6.43	0.040	5.3	6.4	35.9	0.4	46	14	1.7	0.5	62.4	98
T2	6.07	0.031	6.7	17.1	46.2	0.4	44	14	1.2	0.6	59.6	106
T3	5.96	0.049	2.9	7.9	48.2	0.4	45	14	2.1	0.7	61.2	109

T	V	m	Mn	Cu	Fe	Zn	B	Sand	Clay	Silt	OM
	-------- %	------	-----	-----	mg dm^{-3}	-----	-----	--------	g dm^{-3}	------	g.dm^{-3}
T1	63	2.0	63	7.2	39	9.6	0.3	46	785	169	28
T2	56	2.7	42	6.9	21	6.5	0.3	49	758	192	31
T3	56	2.0	61	6.9	53	33.0	0.29	56	758	186	31

T	Total N	NO_3+NO_2	N-NH_3	Inorg N	Org N	Org P	Total P	Org C
	-----	-----	-----	mg dm^{-3}	-----	-----	-----	g dm^{-3}
T1	966.0	3.7	2.6	6.3	959.7	276.0	437.0	16.17
T2	938.0	4.6	2.9	7.5	930.5	417.0	456.0	17.83
T3	945.1	7.9	3.0	10.9	934.2	358.0	485.0	17.93

T: Treatments; T1: Non-irrigated treatment; T2: Irrigated treatment; T3: Fertirrigated treatment; EC: electric conductivity; BA: bases addition; CEC: Cations Exchange Capacity; V%: Base saturation; m%: Aluminium saturation; OM: Organic matter.

MATERIAL AND METHODS

Table 2. Characterization of the SW applied during the oilseed radish cycle.

	Parameter							
	pH	CE	OCD	TKN	NO_3	P total	Cu	Zn
	$CaCl_2$	dS m^{-1}	---------- g L^{-1}	--------	---------------------- mg L^{-1}			----------------------
SW1	8.00	2.93	1.20	10.41	42.13	1.07	0.73	3.33
SW2	7.90	5.94	1.13	10.01	22.13	1.31	0.34	1.92

SW1: First load of SW applied from the first to the third irrigation; SW2: Second load of SW applied in the fourth and fifth irrigation. EC: Electrical conductivity; TKN: Total Kjeldahl Nitrogen; DQO: Oxygen Chemical Demand.

→ The water applied in the T2 treatment had the following characteristics:

6.77 pH; 0.100 dS cm^{-1} of electrical conductivity (EC), 1.9 mg L^{-1} of TKN, 0.067 mg L^{-1} of NO_3, 0.34 of Cu, 0.11 of Zn, 3.64 of K, 3.00 of Mg, 0.05 of Mn, 6.61 of Na and 34.53 mg L^{-1} of Ca.

MATERIAL AND METHODS

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→The cultivar used, CATI AL 1000, was seeded broadcast in May 2009, at a density of 27 kg ha^{-1};

→ After the full blossoming of the oilseed radish, three subsamples were collected from the vegetal material in each plot, resulting in 9 replications per treatment, to the evaluation of the parameters as:

- height of the canopy;
- height of the root system;
- basal diameter;
- number of plants per area;
- volume of the root;
- leaf area.

MATERIAL AND METHODS

→ **In the three subsamples obtained it was evaluated: dry matter of shoot and root system;**

→ **The grain productivity was evaluated after the threshing of the pods collected in the three splot of 180 m² per treatment, correcting the humidity to 13%;**

→ **From the total of silique, 100 units per repetition were counted to determine the number of grains per silique;**

→ **The crop cycle took 125 days to be completed, approximately, and the harvest was manual, taking away all the superficial hay in the internal area of the parcels.**

MATERIAL AND METHODS

→ The experiments area has nine drainage lysimeters in fiber box, distributed in the three main splots, so there were three replications per treatment (capacity of 1 m, depth of 1.1 m, diameter of 1.43 m and area of 1.6 m², and they are sustained by a concrete base of 10 cm of width);

→ The collections of material from the lysimeters were carried out after the pluviometric events (55, 67, 72, 98, and 118 DAS) and the total drained volume was quantified, along with the analysis of pH and EC;

→ Three collections were selected, in the beginning, middle and at the end of the oilseed radish crop cycle (55, 98, and 118 DAS) for the analyses of Cu and Zn, according to APHA's (1998) methodology;

→ It can be highlighted that the registered precipitation of the region was of 402 mm until August 2009.

MATERIAL AND METHODS

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Table 3. Testing of comparing means for productivity and agronomical indexes of the oilseed radish.

Treatment	Productivity	Shoot dry matter	Root dry matter	Leaf area	Grains/ Silique
	Parameters				
	----------------------	kg ha^{-1}	----------------------	----- cm^2 ------	----- unid.-----
T1	66.270 a	3.197 a	467.27 a	103.15 a	5.34 a
T2	112.24 b	4.076 a	674.56 a	82.830 a	5.45 a
T3	115.59 b	5.670 a	693.81 a	90.840 a	5.66 b
Mean	98.067	4.314	611.88	92.27	5.48

Treatment	Root volume	Root lengh	Base diameter	Plant height	Number of plants/ m²
	Parameters				
	------ cm^3 -----	----------------	cm ----------------	------ m ------	-------- unid.--------
T1	4.95 a	13.38 a	0.950 a	1.52 a	35.4 a
T2	6.32 b	14.71 a	1.01 a	1.47 a	42.4 a
T3	6.62 b	15.89 a	1.19 b	1.58 a	42.4 a
Mean	5.96	14.66	1.05	1.52	40.1

Same small caps letters in the columns and same capital letters in the line do not differ from each other, according to the Scott-Knott test, in a significance level of 5%; T1 = non-irrigated treatment; T2 = irrigated treatment; T3 = fertigated treatment.

→ The application of SW increased the values of all the production components of the oilseed radish crop, when comparing to the non-irrigated, except for the leaf area parameter.

RESULTS AND DISCUSSION

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treatment; T3 = fertigated treatment.

→ The seed production of the oilseed radish was smaller than expected, once, according to Derpsch (1992), the productivity may vary between 300 and 450 kg ha^{-1}. The smaller production of grains may be justified by the lodging of the crop when intense rains start and the frost precipitation which took place in September, before the harvest.

→ Even with inferior values than those presented by other authors (Derpsch, 1992; Costa, 1993; Brasi et al., 2008), the irrigation benefited the productivity: it increased to 74 and 69% in the treatments T3 and T2, respectively, compared with the T1.

RESULTS AND DISCUSSION

Table 3. Testing of comparing means for productivity and agronomical indexes of the oilseed radish.

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[illegible]	[illegible]	[illegible]	693.[illegible]	90.840 a	5.66 b

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- For the root dry matter, there was an increase of 48 and 44% in the plants cultivated with SW and water, respectively, when compared with the plants that were not irrigated;

- In general, the results here obtained for the dry matter and grain productivity parameters confirm the fact that the oilseed radish crops do not need fertilization, but that the results are positive if there is a fertigation and irrigation, with higher productions, as reported by Derpsch (1992).

- The biggest production was found in the treated that received SW, which corresponded to an increase of 77% when compared with T1. Brasi et al. (2008) report that the oilseed radish may produce from 5 to 10 tons of shoot dry matter per hectare;

RESULTS AND DISCUSSION

→**SOIL:**

- **Concerning to the amounts of micronutrient Zn in the soil, there was a decrease when compared before and after this study implementation (passed from 9.6, 6.5, and 33.0 mg dm^{-3} to 2.67, 1.37, and 2.20 mg dm^{-3} to T1, T2, and T3, respectively);**

- **For all treatments and collections, the amounts of Cu and Zn are under the limits determined by CONAMA's resolution number 420, whose limits for prevention are of 60 and 300 mg kg^{-3}, respectively (Brazil, 2010);**

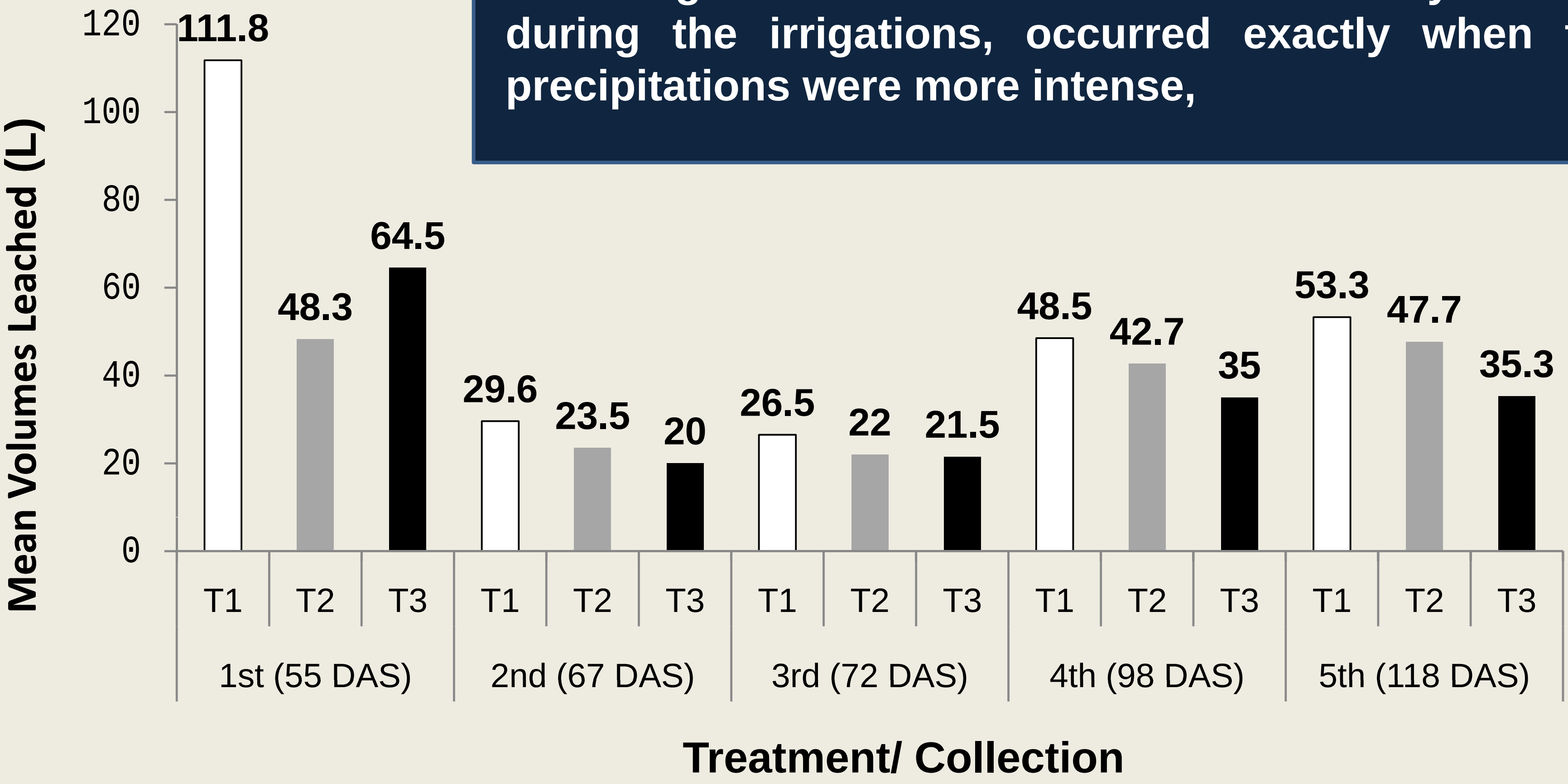
Parameter	
Cu	Zn
------------------- mg dm^{-3} -	
7,17 a	2,67 a
6,93 a	1,37 a
7,63 a	2,20 a

Cu and Zn after the implementation of the experiment

RESULTS AND DISCUSSION

→ ***Loss of material via percolation***

- The highest volumes collected from the lysimeters during the irrigations, occurred exactly when the precipitations were more intense,



RESULTS AND DISCUSSION

The lowest percolated volume in treatment T3, in general, might be associated to:

- **SW may have promoted superficial sealing of the soil, obstructing the macro and microspores opening, so that the infiltration rates were reduced and increasing the runoff when the water hits the soil (Dal Bosco, 2007; Bertol et al., 2005; Mori et al., 2009);**

- **Besides, it was observed that the agronomic development of the oilseed radish was higher in the T3 treatment. A greater development can be translated in higher rates of evapotranspiration and water absorption by the plant, which, consequently, reduce the volume of percolated material in the soil.**

RESULTS AND DISCUSSION

Table 4. Testing of comparing the means of the evaluated parameters of the leached material.

Treatment	pH					
	1st collection	2nd collection	3rd collection	4th collection	5th collection	Mean
T1	6.65	6.71	6.66	6.67	6.74	6.68 a
T2	6.60	6.79	6.74	6.71	6.69	6.70 a
T3	6.82	6.88	6.82	6.89	6.87	6.86 b
Mean	6.69 A	6.80 A	6.74 A	6.76 A	6.76 A	

Treatment	EC ($dS\ m^{-1}$)					
	1st collection	2nd collection	3rd collection	4th collection	5th collection	Mean
T1	0.104	0.116	0.0994	0.105	0.0972	0.104 b
T2	0.0804	0.0993	0.0853	0.0869	0.0783	0.0860 a
T3	0.126	0.126	0.105	0.116	0.132	0.121 b
Mean	0.103 A	0.114 A	0.0964 A	0.103 A	0.102 A	

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pH parameter has suffered minimum variation in the collections, staying between 6.6 and 6.8; The same minimum variation happened to EC.

RESULTS AND DISCUSSION

Table 5. Testing of comparing the means of the evaluated parameters of the leached material.

Treatment	1st collection / 55 DAS	4th collection / 98 DAS	5th collection / 118 DAS	Mean
	Cu (mg L^{-1})**			
T1	0.000 aA	0.000 aA	0.010 aA	0.003 a
T2	0.000 aA	0.000 aA	0.020 aA	0.007 a
T3	0.140 aA	0.241 bA	0.010 aB	0.131 b
Mean	0.047 A	0.080 A	0.014 A	
	Zn (mg L^{-1})**			
T1	1.951 aA	0.045 aB	0.052 aB	0.680 a
T2	1.649 bA	0.071 aB	0.080 aB	0.600 a
T3	1.399 bA	0.154 aB	0.116 aB	0.550 a
Mean	1.666 A	0.089 B	0.083 B	

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→ The CONAMA'S resolution number 396 establishes the maximum concentrations of 2 and 5 mg.L^{-1} to the micronutrients Cu and Zn, respectively, in subterraneous waters (Brazil, 2008). These results were lower than thee ones established by CONAMA's Resolution.

RESULTS AND DISCUSSION

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→It can be observed, in general, that the nutrient Zn was lixiviated in a higher concentration in the first collection (at 55 DAS) in comparison with the others. This fact can be associated with the higher precipitation in the first event and just before the irrigation and fertigation.

CONCLUSION

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The SW application in a 370 m^3 ha^{-1} rate has produced a greater agronomic indexes in the oilseed radish crop, and can provide a higher biofuel production.
There was no significant difference of Cu and Zn in both leached material and soil.

Thank you for your attention!

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CAPES

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