Fontes de adubação na cultura do tomateiro e o efeito na qualidade da água percolada

Fertilizer sources on tomato culture and the effect on the quality of percolated water

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RESUMO
O tomate é uma das hortaliças mais produzidas no mundo e que permite um bom retorno econômico aos produtores, além disso, é muito exigente em adubação. Neste sentido, o uso de adubações orgânicas combinada com mineral pode ser uma forma viável e de menor custo, além de poder melhorar o desenvolvimento da cultura. O objetivo deste trabalho é analisar o impacto de fontes de adubação em parâmetros morfológicos e fisiológicos de tomateiro e na qualidade da água percolada. O experimento foi conduzido em área experimental da Universidade Federal de Santa Maria campus de Frederico Westphalen. O delineamento utilizado foi o inteiramente casualizado com esquema bifatorial 4x2, utilizando 4 fontes de adubação e 2 cultivares, com parcelas subdivididas. As fontes de adubação não apresentaram diferenças, se mostrando melhores apenas em relação a testemunha. Os teores de Sólidos Solúveis e Acidez Titulável foram mais elevados para a cultivar Santa Cruz Kada. As adubações com Dejeto de Suínos+NK e Cama de Aves+NK proporcionaram maior lixiviação dos elementos nitrogenados no início do cultivo. O uso de adubações orgânicas combinadas com minerais é uma alternativa viável e de menor custo aos produtores, desde que sua quantidade seja adequada, sem causar problemas ambientais.

Palavras-chave: Água residuária, lisímetros, elementos nitrogenados, *Solanum lycopersicum*

ABSTRACT
Tomato is one of the most produced vegetables in the world and it allows a good economic return to producers, besides, it is very demanding in fertilization. In this sense, the use of organic fertilizers combined with minerals can be a viable and less costly way, and can improve crop development. The objective of this study is to analyze the impact of fertilizer sources on tomato morphological and physiological parameters and on the quality of percolated water. The experiment was conducted in an experimental area of the Federal University of Santa Maria Frederico Westphalen campus. A completely randomized design with a 4x2 bifactorial scheme was used, using 4 fertilizer sources and 2 cultivars, with subdivided plots. The sources of fertilization did not present differences, being better only in relation to the control. The soluble solids and the titratable acidity contents were higher for the cultivar Santa Cruz Kada. The swine manure + NK and poultry litter + NK fertilizers provided higher leaching of nitrogen elements at the beginning of cultivation. The use of organic fertilizers combined with minerals is a viable and less costly alternative for producers, provided their amount is adequate, without causing environmental problems.

Key words: residuary water, lysimeters, nitrogenous elements, *solanum lycopersicum*.

1 INTRODUCTION

Tomato is one of the most produced and consumed vegetables in the world, both in fresh and processed form. Because it has a relatively short growing cycle and high yields, it allows a good economic return to producers.

According to Oliveira (2018), in the agricultural season of 2017, the tomato cultivated area in Brazil was approximately 65 thousand hectares with an average productivity of 67 tons ha^{-1}, and the total production was 4.37 million tons. In the southern region, yield was 61 t.ha^{-1}, slightly below the national average.

One of the factors that influence tomato growth and development is fertilization, which may interfere with good crop yield. According to Luz et al. (2010), nutrient contents and accumulations for tomato culture vary mainly according to the stage of plant development, with to be cultivated and the production desired.

Therefore, the use of organic fertilizers along with minerals may be a more viable and less costly way for the producer, as well as increasing the crop productivity. Because, the use of organic material improves fertility, in addition to be an excellent soil conditioner, improving their physical characteristics, chemical and biological (Mueller et al. 2013).

However, its use should be controlled because when high doses are applied and for a relatively long period, they might cause chemical changes in soil and nutrient availability, impacting negatively on the environment through pollution of surface and subsurface waters (Lourenzi et al. 2017). One of the most common forms of contamination is through nitrogen fertilization, especially nitrate, which is easily leached.

Therefore, the present work aims to analyze the impact of fertilizer sources on tomato morphological and physiological parameters and on the quality of percolated water.

2 MATERIALS AND METHODS

The experiment was conducted in 2018/2019 in a protected environment in the experimental area of the GAMRH Research Group (Environmental Management and Water Resources Management), at the Federal University of Santa Maria, Frederico Westphalen campus, which has the following geographic coordinates: latitude 27° 25' 43 S; longitude 53° 43' 25 W; and average altitude of 488 m.

A completely randomized design was used with a 4x2 bifactorial scheme, and subdivided plots where 4 fertilizer sources and 2 cultivars with 3 replications were used.

The tomato cultivars chosen were Santa Cruz Kada with resistance to Verticilium race 1, Fusarium race 1 and 2 and nematode and Santa Clara cultivar resistant to Verticilium race 1 and Fusarium race 1, both belonging to the Santa Cruz group and with undetermined growth habit.

The seedlings were produced in plastic cups filled with commercial substrate. Since in each cup two seeds were seeded, after germination the weaker plant was removed, leaving one per container. The transplantation was performed to a set of lysimeters, when the seedlings were 12 cm high.

The lysimeters are fiberglass boxes with dimensions of 1.40 mx 0.95 cm and 1.00 m deep. In these boxes was grown oats (*Avena sativa*) as a cover plant, preceding the tomato crop.

Twelve plants were cultivated per lysimeter, being six seedlings of each cultivar, with a distance of 0.24 m between plants, and two rows spaced with 0.30m, totaling 144 plants.

The cultivation mode is the vertical system with the use of staking bamboo, with only one stem per plant. After the issuance of the fifth bunch the topping was performed. Twenty days after transplantation, the pile was grounded in which the stem was ground, stimulating the formation of adventitious roots and improving the absorption of nutrients.

According to the development of the plant, the offspring was made, eliminating the shoots located between the main stem and the paws, which compete for assimilate the plant, affecting the good development of the fruits. This procedure was performed 2-4 times a week, as needed.

Regarding fertilization, the combined form of organic fertilizer and mineral fertilizers was used. For the recommendation, it was based on choosing the dose of organic fertilizer as a function of the nutrient which needed the smallest amount of organic fertilizer, in this case, P (Phosphorus) and supplementing with mineral fertilizer the amount for the other nutrients N (Nitrogen) and K (Potassium).

For this work, 3 fertilizer sources were used: poultry litter+NK, swine manure+NK and only swine manure+NK, besides the control (without fertilization). According Fernandes et al. (2017), these animal sources become an alternative to decrease the amount of external inputs that are used in family properties.

The recommendation was made according to the Brazilian soil science society (2016), after obtaining the soil chemical analysis report in relation to the sample collected in the lysimeters, for a yield expectation of 100 $t.ha^{-1}$, requiring an increment of 3 kg of each element per additional ton, as recommended in the manual (Table 1).

Table 1: Required fertilization recommendation and doses to be applied for the implementation of the experiment. Frederico Westphalen, 2019.

Treatment	Nutrient	Recommendation (kg/ha)	Applied dose (kg/ha)	
			Chemical Fertilization	
Chemical	N P K	250 kg 290 kg 195 kg	555.56 kg of Urea 707.32 kg of SFT 336.21 kg of KCl	
			Organic	Chemical
Poultry Litter	N P K	250 kg 100 kg 120 kg	3543.08 kg of Poultry Litter	176.87 kg of Urea 123.33 kg of KCl
			Organic	Chemical
Swine Liquid Waste	N P K	250 kg 170 kg 240 kg	130.26 m^3/ha of Poultry Litter	22.93 kg of Urea 53.83 kg of KCl

The recommended fertilization was applied only once, one week before seedling transplantation. Irrigation was performed manually by watering, and its application amount and interval varied according to the need for culture and this was homogeneous for all lysimeters.

The morphological analyzes were: plant height - measured from the base of the plant until the last leaf emission with the aid of a measurement tape; stem diameter - using a digital caliper; Fruit diameter - Determined on the middle part of the fruit using a digital caliper; fresh fruit mass - determined by weighing, on analytical balance and plant yield - values expressed in kg per plant. Evaluations were performed at 13 DAT (Days after transplantation), 30 DAT, 50 DAT, 70 DAT.

Regarding the analysis of residual nutrients leached by water, water collections were performed every 45 days, the first one being done before the culture implantation and the others during its development. The samples, after being collected, were sent to the laboratory for analysis of nitrate+nitrite and ammonia contents. The determination was made by the Kjeldhal method, using magnesium oxide to determine ammonia and subsequently Devarda's alloy to determine nitrite and nitrate.

The physicochemical analyzes performed were: titratable acidity - by the potentiometric volumetry method using a pH meter calibrated with 7 and 4 buffer solutions and the values expressed in ml of the normal solution, percent; pH - using a properly calibrated pH meter; total soluble solids - through the refractometry method, with the aid of a Brix Degree graduated ocular refractometer; Lycopene content obtained by spectrophotometric analysis and values expressed in µg. g^{-1}.

The results of the evaluations were subjected to analysis of variance using the SISVAR statistical program and the averages analyzed by Scott Knott test at 5% probability of error.

3 RESULTS AND DISCUSSION

About the variables analized it was found that none showed significant difference between the cultivars and fertilizer sources, only for the variables separately.

Regarding plant height, we can observe that the cultivar Santa Cruz Kada showed greater plant height compared to Santa Clara (Table 2), this result is related to the intrinsic characteristics of the cultivar itself, which has higher size, with this, extending its growth after 70 DAT, period in which the cultivar Santa Clara had already completed its growth in height.

Table 2 - Comparison of averages between cultivars of tomato and sources of fertilization in the four periods of plant height evaluation. Frederico Westphalen, 2019.

	Evaluation period			
Cultivars	13 DAT	30 DAT	50 DAT	70 DAT
Santa Clara	36.14 B	63.15 B	99.25 B	137.93 B
Santa Cruz Kada	44.16 A	78.11 A	120.87 A	169.98 A
Fertilizer Sources				
Control	34.82 B	59.47 B	93.11 B	117.69 B
Mineral	41.00 A	72.55 A	113.66 A	163.16 A
Swine Manure+NK	42.54 A	73.55 A	118.86 A	165.33 A
Poultry Litter+NK	42.26 A	76.94 A	114.61 A	169.63 A

*averages followed by the same letter in the column do not differ from each other at 5% probability of error by Scott Knott test.
**NK= Nitrogen+Potassium
***DAT= Days after transplantation

Regarding fertilizers, there were positive results with the application of fertilizer sources when compared to the control treatment, however, the three sources used presented similar values among themselves in all evaluated periods. This result corroborates with Higashikawa e Menezes Junior (2017) where observed that both organic and chemical fertilizers showed similar results in onion culture.

However, Islam et al. (2017) evaluating the varieties of tomato Rome and Bari, observed a significant difference for plant height with the combination of organic and mineral fertilizers.

For stem diameter, there was no significant interaction between cultivar and fertilization in any of the four evaluated periods.

According to Table 3, it can be observed that in all evaluations the cultivar Santa Clara obtained larger diameters than the Santa Cruz Kada, this can be explained by the fact that this cultivar has smaller size and with this there is a greater stem thickening.

Table 3 - Comparison of averages between cultivars of tomato and sources of fertilization in the four periods of stem diameter evaluation. Frederico Westphalen, 2019.

	Evaluation period			
Cultivars	13 DAT	30 DAT	50 DAT	70 DAT
Santa Clara	5.21 A	7.42 A	8.82 A	9.21 A
Santa Cruz Kada	4.98 A	6.85 B	7.93 B	8.17 B
Fertilizer Sources				
Control	4.32 B	5.99 B	7.06 B	7.18 B
Mineral	5.36 A	7.29 A	8.42 A	8.74 A
Swine Manure+NK	5.37 A	7.44 A	9.03 A	9.44 A
Poultry Litter+NK	5.32 A	7.82 A	8.99 A	9.39 A

*averages followed by the same letter in the column do not differ from each other at 5% probability of error by Scott Knott test.
**NK= Nitrogen+Potassium
***DAT= Days after transplantation

It is also noted that the sources of fertilization used did not differ from each other, differing only from the control treatment. This result was also observed for the variable average yield per plant, where there was no significant interaction between fertilization and culture sources (Table 4). The average yield obtained with the use of fertilizers was 1 kg. One of the reasons for this low production is related to the time when the experiment was conducted, which showed periods of low temperatures alternating with days presenting high temperatures, these factors, according to Souza (2010), end up hurting fruiting, with accentuated fall of flowers and newly formed fruits.

Table 4 - Comparison of averages cultivars of tomato and sources of fertilization for the mean fruit weight variable. Frederico Westphalen, 2019.

Cultivars	Production / Plant (kg)	Average fruit weight (g)	Fruit Diameter(mm)
Santa Cruz Kada	0.78 A	59.34 B	44.80 B
Santa Clara	0.85 A	74.64 A	49.02 A
Fertilizer Sources			
Control	0.22 B	55.43 A	43.04 B
Swine Manure+NK	1.01 A	68.24 A	48.16 A
Poultry Litter+NK	0.91 A	68.09 A	47.48 A
Mineral	1.10 A	76.21 A	48.98 A

*averages followed by capital letters in the column do not differ from each other at 5% probability of error by Scott Knott test
**NK= Nitrogen+Potassium

For the average fruit weight characteristic, it is observed that the cultivar Santa Clara presented fruits with higher weight compared to Santa Cruz Kada, which can be explained by the characteristics of the cultivar in question. However, this value are well below the commercial weight of the cultivar which is 180 grams, according to data from the company Isla Sementes, from which the seed used in this work were acquired.

When analyzing the sources of fertilization, it can be seen that there was also no significant difference between them, and the average was 66.99 grams per fruit. An opposite result was found by Mueller et al. (2013), where emphasize that organic fertilization promotes an increase in the average mass of commercial fruits.

Regarding the variable average fruit diameter, it is observed that, as for average fruit weight, the cultivar Santa Clara also obtained larger fruit diameter, obtaining an average of 49.02 mm, this average is below that found by Genuncio et al., (2010), where, also working with the cultivar Santa Clara found a diameter of 57 mm.

For the variable pH and lycopene content, there was no significant difference for any of the analyzed factors, and the average obtained for pH was 4.5. This value is consistent with that observed by Zuba et al. (2011), where evaluating fruits of tomato cultivar Santa Cruz Kada found pH values between 4.5 and 4.7, and did not differ between the fertilizers used by the author. However, Araujo (2014), analyzing these characteristics in organic system, observed for Santa Clara cultivar a pH of 4.25, lower than the one found in the present work.

For the variable soluble solids and titratable acidity, there was only a significant difference for the cultivar factor, where Santa Clara presented higher levels of soluble solids and acidity, respectively (Table 5). Regarding fertilization, there was no difference in the values found, agreeing with Ferreira et al. (2006), where states that these variables are not influenced by the use or not of organic fertilization.

Table 5 - Comparison of averages cultivars of tomato and sources of fertilization for the variables pH, SS (Soluble Solids), TA (Titratable Acidity), LC (Lycopene Content). Frederico Westphalen, 2019.

	Averages			
Cultivars	pH	SS	AT	LC
Santa Clara	4.52 A	4.01 A	4.50 A	49.60 A
Santa Cruz Kada	4.55 A	3.24 B	3.78 B	49.36 A
Fertilizer Sources				
Swine Manure+NK	4.51 A	3.71 A	4.13 A	46.98 A
Poultry Litter+NK	4.53 A	3.73 A	4.66 A	49.53 A

Mineral	4.55 A	3.71 A	3.74 A	50.49 A
Control	4.56 A	3.35 A	4.03 A	50.93 A

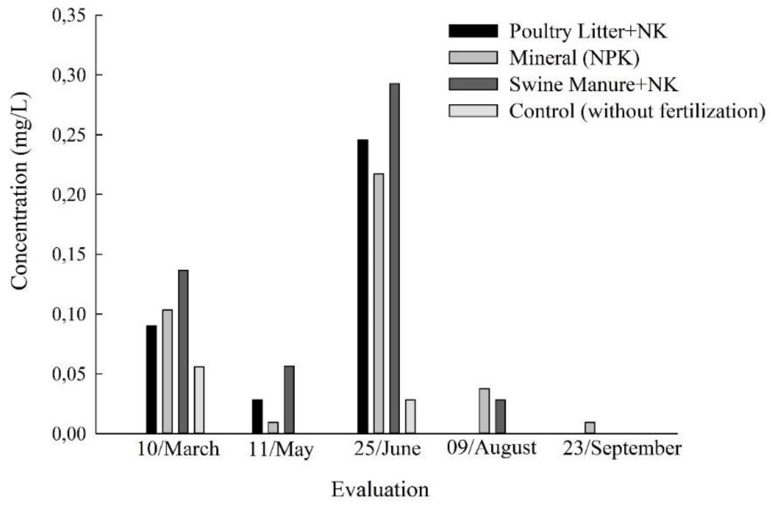
*averages followed by capital letters in the column do not differ from each other at 5% probability of error by Scott Knott test
**NK= Nitrogen+Potassium

However, Bomfim et al. (2020), when evaluating the quality of red bell pepper fruits, observed that the relation between the soluble solids content and the titratable acidity from bell pepper fruits showed greater value with the use of fertilization with 50% organic fertilizer added to 50% mineral fertilizer.

Regarding the analysis of the leachate residual, it can be analyzed that the highest levels of ammonia were observed in the third evaluation/collection, corresponding to 50 days after the application of fertilization, especially for the poultry litter+NK and Swine Manure+NK (Figure 1). The levels observed in the first evaluation can be explained by the decomposition of the existing vegetation cover before the implementation of the experiment. The low levels observed in the second evaluation are due to the fact that the fertilization had not yet been incorporated into the soil, a fact that occurred over time by the application of irrigation water which provided the leaching of these elements.

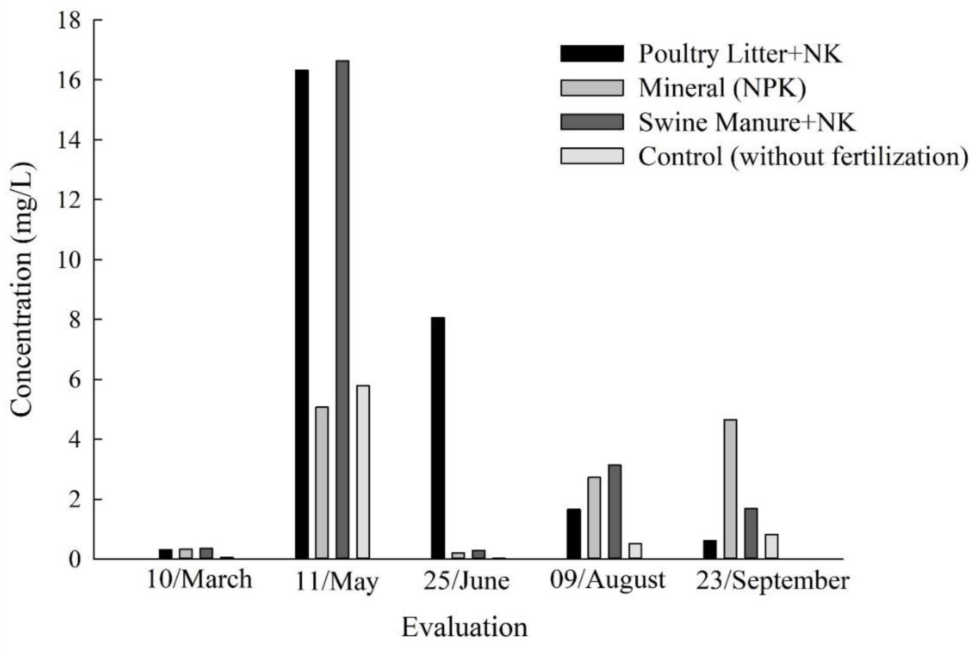
After the other evaluations, these values decreased dramatically. This decrease is explained by the fact that ammonia is rapidly converted to ammonium (NH_4^+), which is converted to nitrate through the nitrification process (Zoppas et al. 2016). The highest concentration found was close to 3.0 mg/L for swine manure+NK fertilization, which is close to the maximum limit allowed by the Conama resolution (2005), which is 3.7 mg/L.

Figure 1. Ammonia (NH_3^-) concentration in the drainage water in relation to the fertilization sources according to the evaluation periods. Frederico Westphalen, 2019.



Regarding nitrate, its observed in Figure 2, that in the first assessment, levels are almost zero, this is related to the degradation of vegetation cover (black oat) which was still in the initial process, resulting in higher concentrations of ammonia, as shown in Figure 1. The highest concentration was observed in the second evaluation, corresponding to the first after fertilization application, which occurred one week before the culture implantation.

Figure 2. Nitrate (NO_3^-) concentration in the drainage water according to the fertilizers. Frederico Westphalen, 2019.



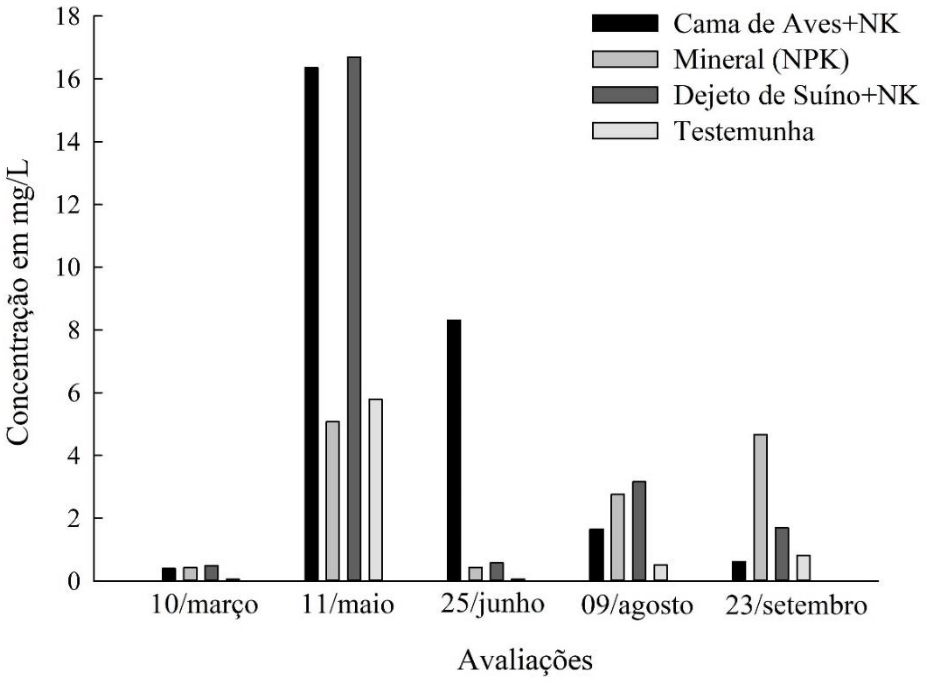
The poultry litter+NK and Swine Waste+NK fertilizers presented the highest values, decreasing during the next evaluations. This result is in agreement with that found by Basso et al. (2005), where using swine manure in black oat and turnip crop observed that the highest nitrate levels were obtained at the beginning of the crop development, decreasing throughout the cycle.

Regarding the rate of release, it is noticed that the mineral fertilization provided a slower release of nitrate compared to the other sources, extending until the last evaluation.

According to Figure 3, it can be noted that in the second evaluation, all fertilizer sources presented total nitrogen values (ammonia + nitrate) above the maximum allowed by Conama (2005), which is 3.7 mg / L, especially the Swine Manure + NK and Poultry + NK fonts.

Lourenzi et al. (2017) states that these sources of fertilizer, when applied wrongly (by high doses and for a relatively long period) can cause chemical changes in soil and nutrient availability, causing an imbalance in the cultures. In addition, Trombetta et al. (2020) emphasizes that the improper disposal of organic waste has a high contaminating power to the environment, which can cause eutrophication of water bodies and nitrate leaching, which can reach the water tables. In a study carried by Rosa et al. (2015), the authors, when assessing the levels of nitrate, nitrite and ammonia, observed that fertilization with poultry litter presented a greater polluting potential, followed by chemical fertilization and fertilization with swine manure.

Figure 3. Effect of fertilizers on total nitrogen levels of drainage water. Frederico Westphalen, 2019.



After the application of fertilizer sources, there was a rapid release of total nitrogen in fertilizers with Poultry Litter+NK and Manure Swine+NK soon after the implementation of culture, which declined throughout the evaluations.

Regarding fertilization with NPK, its concentration was lower than the others, but there was a slower and increasing release starting from the second evaluation, extending until the end of the cycle. Opposite result was found by Rosa et al. (2018), where working with the same sources of fertilization, observed the highest peak of total nitrogen concentration at 90 DAS, decreasing over time.

These results may be related to fruit yield per plant, since it is observed that the total nitrogen contents of the sources of swine manure+NK and poultry litter+NK fertilization were faster leached, and in the fruit development phase (corresponding to the third evaluation), there was practically no more leaching of these elements (Figure 3). Consequently, it may have affected fruit production, which was lower for these fertilizers.

4 CONCLUSIONS

Tomato growth and development is similarly influenced by the fertilizer sources used

in the present work. The sources of fertilization analyzed do not influence the physicochemical characteristics of the fruits.

The levels of soluble solids and titratable acidity are statistically higher for the cultivar Santa Cruz Kada. The fertilization of swine manure+NK and poultry litter+NK give a higher nitrogen leaching of these elements.

The use of organic fertilizers combined with mineral fertilizers is an alternative environmentally more viable and less costly, however can cause environmental problems when used incorrectly.

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