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Growth and production of tomato fertilized with poultry litter and swine wastewater[1]

Crescimento e produção do tomateiro adubado com cama de aviário e dejeto líquido de suínos

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HIGHLIGHTS:

Combining different sources of organic fertilizers is a viable strategy to balance the nutritional demand for tomato.
Tomato can be produced without soluble mineral fertilizers.
The effect of organic fertilization depends on the cultivar.

ABSTRACT: The objective of the study was to evaluate the vegetative and productive growth of two varieties of tomato plants ('Compack' and 'Gaucho') with organic fertilization of two sources: poultry litter (PL) and swine wastewater (SWW), with and without mineral supplementation. The experimental design was in randomized blocks with seven treatments and four replicates for 'Compack' and five repetitions for 'Gaucho' . The applied treatments were: the control, 100% mineral fertilization, 100% organic poultry litter - PL, 100% organic swine wastewater (SWW), 50% PL and mineral supplementation, and 50% PL complemented with SWW. At 30 and 90 days after transplanting measurements of height, leaflets width and stem diameter were recorded. At harvest, measurements of diameter, length, mass, soluble solids and titratable acidity of fruits were carried out. Also, determination of N, P and K concentrations on foliar tissues were carried out. The vegetative growth of the two tomato cultivars was lower in the control. The highest yield of 'Compack' tomatoes was observed with mineral fertilization, PL and SWW with mineral supplementation and PL + SWW, whereas for Gaucho tomato cultivar, the highest yield was obtained with PL + SWW fertilization.

Key words: *Lycopersicon esculentum*, organic fertilization, wastes

RESUMO: O objetivo deste estudo foi avaliar o crescimento vegetativo e produtivo de duas variedades de tomateiro ('Compack' e 'Gaúcho') com adubação orgânica de duas fontes: cama de aviário (CA) e dejeto líquido de suínos (DLS), com e sem suplementação mineral. O delineamento experimental foi em blocos casualizados com sete tratamentos e quatro repetições para o 'Compack' e cinco repetições para o 'Gaúcho'. Os tratamentos utilizados foram: testemunha, adubação 100% mineral, 100% orgânico de cama de aviário - CA, 100% orgânico de dejeto líquido suíno - DLS, cama de aviário e complementação mineral, 50% de dejeto líquido suíno e complementação mineral e CA 50% complementada com DLS. Aos 30 e 90 dias após o transplantio foram realizadas medidas de altura, largura dos folíolos e diâmetro do caule. Por ocasião da colheita foram realizadas medidas do diâmetro, comprimento, massa, sólidos solúveis e acidez titulável dos frutos. Também foi realizada análise dos teores de N, P e K dos tecidos foliares. O crescimento vegetativo das duas cultivares foi menor na testemunha. A maior produtividade de tomate 'Compack' foi obtida com adubação mineral, CA e DLS com complementação mineral e CA + DLS, enquanto que para o tomate 'Gaúcho' a maior produtividade foi obtida com adubação de CA + DLS.

Palavras-chave: *Lycopersicon esculentum*, adubação orgânica, resíduos

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Introduction

The economy of Western Paraná has focus to the agribusiness area, with emphasis on swine and poultry production. However, there is great waste production, which when indiscriminately disposed in the environment can cause environmental pollution (Silva & Bassi, 2012), consequently, it must have its rational management. It is important to highlight that if swine and poultry wastes are properly managed, this kind of environmental problem will be under control and can even be used as organic fertilizers in agriculture.

Waste application generated in farms, or nearby, is a very common practice during crops for small farmers (Gatiboni et al., 2008). Some studies have shown that the use of organic fertilizers can supplement or replace mineral fertilization (Mueller et al., 2013; Santos et al., 2014). Another point is that animal manures have provided some decrease in expenses, consequently some increase on profit. This is an important fact especially for small and medium-sized producers of fruits and vegetables (Silva et al., 2012).

The use of organic fertilizers can increase cation exchange capacity (CEC), acidity neutralization, as well as improvements in physical, chemical, biological soil properties and, consequently, increases in yield and quality of agricultural products (Lima et al., 2008; Correa et al., 2010).

The most common use for animals' manure has been swine wastewater (SWW) and poultry litter. However, the applied amount of these residues must take into account the crop needs and chemical properties of soil to avoid environmental damages (Aita & Giacomini, 2008; Costa et al., 2009).

Tomato plants (*Lycopersicon esculentum*) have been one of the most important species in the world among other crops that can be grown with organic fertilizer application.

In 2013, tomato production in Brazil, according to FAO (2016), was approximately 4.2 million tons. Paraná is the fifth Federation Unit in area in regarding its cropping, with 4.7 thousand hectares, 7% of the total produced (SEAB, 2015).

Based on these facts, this research aimed at evaluating vegetative and productive growth of two varieties of tomato ('Compack' and 'Gaucho') with organic fertilization from two sources: poultry litter (PL) and swine wastewater (SWW), with and without mineral supplementation.

Material and Methods

The experiment was carried out in an experimental area of Federal University of Paraná (UFPR - Palotina Sector), in Palotina city, PR, Brazil (24º 17' 02" S, 53º 50' 24" W), with a 20 ºC mean temperature and 333 m altitude and a climate classified as cfa: Subtropical Moist (Köppen), with hot summers and cold or mild winters (EMBRAPA, 2013).

The soil used was an Oxisol collected in two areas in Palotina city. The analysis was carried out with representative samples that were taken to the UFPR Soil Laboratory of Palotina Sector (Tables 1) according to the recommendations of Silva (2009).

The applied SWW was collected at the finishing swine farm of Larissa company, in Palotina, PR, and removed from anaerobic treatment lagoons, where there is some partial degradation and chemical stabilization of wastes. Poultry litter was also obtained from a rural property in Palotina, PR, and naturally composted in a 3 m height windrow during almost 10 months. This allows some chemical stability to the wastes.

An aliquot of wastes was sampled and taken to the Soil Laboratory of UFPR, Palotina Sector to determine nitrogen (N), phosphorous (P), potassium (K) concentration in accordance with Silva (2009) methodology. The applied wastes in 'Compack' tomato variety presented SWW and PL with 6.2 g L^{-1} and 25.7 g kg^{-1} of N, 3.98 g L^{-1} and 54 g kg^{-1} of P_2O_5 and 2.57 g L^{-1} and 36 g kg^{-1} of K_2O, respectively. While for 'Gaúcho' tomato variety, the applied PL was the same for the 'Compack', however the applied SWW presented the concentration of 3.32 g L^{-1} of N, 1.83 g L^{-1} of P_2O_5 and 0.25 g L^{-1} of K_2O.

The experimental design was in randomized block , with seven treatments and four replicates and for 'Compack' tomato, and five replicates for 'Gaúcho'tomato. The treatments were: control (T1), 100% mineral fertilization (T2), 100% organic with poultry litter (T3), 100% organic of swine wastewater - SWW (T4), 50% poultry litter with mineral fertilization (T5), 50% swine wastewater complemented with mineral fertilization (T6) and poultry litter with swine wastewater (T7), whose dosages are described in Table 2.

The fertilization needs was based on soil analysis according to Filgueira (2008) recommendation, therefore, the obtained values were 660 kg ha^{-1} of P_2O_5, 660 kg ha^{-1} of K_2O and 440 kg ha^{-1} of N. The waste doses were calculated according to the nutrient that reached the recommended dose first. Phosphorus was used as a nutrient to calculate treatments with PL and nitrogen was used to calculate the treatments with swine wastewater.

'Compack' tomato growing was carried out in slabs filled with vermiculite soil (Table 1) 30 days after sowing. For 'Gaúcho' tomato variety, transplanting was carried out in 35-L pots with approximate 30 x 30 x 37 cm (height, width and length) filled with soil (Table 1). During slabs and pots filling, it was added phosphate fertilization and poultry litter.

Nitrogen and mineral potassium fertilizations were divided into one application in transplanting and the other five topdressing applications were made at every 20 days. As the amount of SWW to be applied was very high for slab and to maximize nutrients absorption by the cropping, the waste total amount was divided into 24 weekly applications. For tomatoes in pots, the waste amount to be applied was divided in 15 applications.

Table 1. Chemical attributes of soil used to fill slabs and planting 'Compack' and 'Gaúcho' tomato seedlings

Tomato variety	pH		Al^{+3}	H + Al	Ca^{2+}	Mg^{2+}	K^{+}	P	OM	C
	$CaCl_2$	SMP	($cmol_c$ dm^{-3})					(mg dm^{-3})	(g dm^{-3})	
Compack	4.84	6.15	0.0	4.44	0.90	0.85	0.21	24.10	13.11	7.61
Gaúcho	4.78	6.20	0.0	4.28	2.2	1.00	0.08	4.28	10.59	6.14

OM - Organic matter

Table 2. Dose of the forms of fertilization used in the experiment for the 'Compack' and 'Gaúcho' tomatoes

Treatments	Applied fertilizer					Available amount of nutrient			Nutritional deficit		
	PL	SWW	SSP	KCl	Urea	P_2O_5	K_2O	N	P_2O_5	K_2O	N
	(t ha^{-1})	(m^3 ha^{-1})	(t ha^{-1})			(kg ha^{-1})					
Tomato Compack											
T1	-	-	-	-	-	-	-	-	-660	-660	-440
T2	-	-	3.7	1.1	1.0	660	660	440	0	0	0
T3	27	-	-	-	-	660	550	196	0	-110	-244
T4	-	90	-	-	-	357	112	440	-303	-548	0
T5	13.5	-	1.9	0.64	0.8	660	660	440	0	0	0
T6	-	45	2.8	0.9	0.5	660	660	440	0	0	0
T7	20	66	-	-	-	727	579	471	+67	-81	+31
Tomato Gaúcho											
T1	-	-	-	-	-	-	-	-	-660	-660	-440
T2	-	-	3.7	1.1	1.0	660	660	440	0	0	0
T3	27	-	-	-	-	660	550	196	0	-110	-244
T4	-	167	-	-	-	305	41	440	-355	-619	0
T5	13.5	-	1.9	0.64	0.8	660	660	440	0	0	0
T6	-	83.5	2.8	1.0	0.5	660	660	440	0	0	0
T7	13.5	83.5	-	-	-	636	296	319	-24	-254	-121

PL - Poultry litter; SWW - Swine wastewater; SSP - Super Simple Phosphate; KCl - Potassium chloride; P_2O_5 - Phosphorus oxides; K_2O - Potassium oxide; N - Nitrogen; T1 - Control; T2 - 100% mineral fertilization; T3 - 100% organic with poultry litter; T4 - 100% organic of swine wastewater - SWW; T5 - 50% poultry litter with mineral fertilization; T6 - 50% swine wastewater complemented with mineral fertilization; T7 - Poultry litter with swine wastewater

During the cycle of both tomato varieties, stem diameter, plant length and plant medium leaflet width were evaluated at 30 and 90 days after transplanting (DAT). The tomatoes were staked with ribbon and bamboo and their training was done in a single stem and there was no harvesting and fruits thinning. The fruits harvest began in December, 2016 until February, 2017 for 'Compack' tomato, while from August to October, 2017, for the 'Gaucho' tomato. The fruits had been harvested when they were completely red. After that they were taken to the Physiology and Vegetal Nutrition Laboratory of UFPR Palotina Sector, where evaluations of diameter (mm), length (cm) and mass (g) regarding the fruits were recorded. Soluble solids concentration (SS, in °Brix) were also determined with a digital refractometer and titratable acidity (TA, expressed as % citric acid) according to IAL methodology (2008).

Soon after the beginning of fruiting, 15 leaves with stems were also collected, close to the top inflorescences (Alvarenga, 2013), to determine N, P and K concentrations according to methodology of Silva (2009).

The data were submitted to analysis of variance and Scott-Knott test, for each variety, using Sisvar software 5.0 (Ferreira, 2008).

Results and Discussion

Both varieties of tomato showed distinct vegetative growth. The Compack variety, at 30 days after transplanting (DAT), showed greater stem diameter, height and width of the largest leaflet in treatments with poultry litter (Table 3). This fact can be explained by the fast mineralization of nitrogen present in this residue, which, according to Azeez &Van Averbeke (2010), is a maximum of 30 days. The greatest initial development of tomato, mainly of leaf, increases plant ability to photosynthesize, consequently to allow it on increasing yield (Alvarenga, 2013).

It was also observed that 'Compack' tomatoes treated with SWW and mineral fertilization presented lower stem diameter when compared to the other treatments at 30 DAT and they were statistically equal to the control. But, at 90 DAT,

Table 3. Stem diameter, height and width of leaflets of tomato plant at 30 and 90 days after transplanting (DAT)

Days	Treatment	'Compack'			'Gaúcho'		
		Diameter (mm)	Height (cm)	Width (mm)	Diameter (mm)	Height (cm)	Width (mm)
30	T1 - Control	6.46 d	38.00 b	34.80 b	5.1 b	31.4 b	27.5 b
	T2 - Mineral	8.62 c	38.50 b	45.24 a	10.8 a	44.4 a	48.3 a
	T3 - PL	11.15 a	45.12 a	54.26 a	10.6 a	51.0 a	51.2 a
	T4 - SWW	7.85 c	37.25 b	34.10 b	9.6 a	47.2 a	46.3 a
	T5 - PL + Mineral	9.89 b	42.62 b	36.33 b	11.5 a	52.8 a	52.8 a
	T6 - SWW + Mineral	9.35 b	40.62 b	46.33 a	9.8 a	46.4 a	47.6 a
	T7 - PL+ SWW	11.22 a	50.87 a	57.51a	11.5 a	54.4 a	57.7 a
	CV (%)	10.91	9.48	25.33	14.51	15.86	14.25
90	T1 - Control	5.88 b	65.50 b	20.84 b	5.8 b	104.2 b	31.0 b
	T2 - Mineral	8.57 a	117.83 a	48.01 a	11.6 a	166.8 a	52.1 a
	T3 - PL	10.24 a	131.25 a	43.71 a	12.2 a	172.8 a	51.9 a
	T4 - SWW	10.91 a	127.50 a	49.32 a	11.2 a	167.5 a	49.8 a
	T5 - PL + Mineral	9.58 a	109.50 a	42.48 a	11.7 a	190.6 a	50.8 a
	T6 - SWW + Mineral	9.01 a	117.88 a	46.15 a	12.2 a	172.6 a	54.5 a
	T7 - PL+ SWW	11.10 a	138.38 a	47.05 a	12.7 a	188.6 a	53.8 a
	CV (%)	16.10	14.43	17.73	11.69	8.83	10.41

Different letters in column evidence distinct groups by Scott-Knott's clustering test at $p \leq 0.05$. PL - Poultry litter; SWW; PL + Mineral - Fertilization with poultry litter plus mineral complementation; SWW + Mineral - Fertilization with swine wastewater plus mineral complementation; PL + SWW - Fertilization with poultry litter plus swine wastewater; CV - Coefficient of variation

the plants of both treatments showed a higher stem diameter when compared to the control. A similar fact also happened with height and width of tomato leaflets. This behavior can be explained by the split of SWW applications and the topdressing fertilization with N and K, which increased nutrients over time.

If the total SWW amount were applied in a single dose, probably the tomatoes would not absorb nutrients completely, mainly ammoniacal nitrogen that, in nearly 30 days, is nitrified and can be leached in system (Aita & Giacomini, 2008).

'Gaúcho' tomato showed the same diameter, height and leaflet width at 30 days in all treatments, except for the control, which showed the lowest values. Cosme et al. (2011) worked with hydroponic tomato, and found similar values for stem diameter when compared to this study (from 11.5 to 12 mm). Albuquerque Neto & Peil (2012) observed that Gaúcho tomato plants registered a 1.70 m height, which is consistent with heights observed at 90 days for tomatoes that were treated with some kind of fertilization.

The difference between the growth of both tomato varieties at 30 DAT can be explained by splitting the fertilizers, mainly SWW, which was divided in 15 doses for 'Gaúcho' tomato instead of 24 ('Compack' tomato) and also due to the plant growth place, since the slab has a more restricted area for root expansion, which was different from the vases with the greatest volume.

Both varieties showed the same grouping at 90 DAT. This means that, regarding vegetative growth organic fertilizing was as efficient as the mineral. Some authors also observed the same answers in some papers that showed the same results for SWW and poultry litter fertilization during the vegetative development of several crops, mainly winter pastures (Assman et al., 2009; Santos et al., 2014).

The greatest averages for fruits diameter and yield for 'Compack' tomatoes were obtained with mineral fertilization, PL and SWW fertilization with extra mineral and the mixture of PL with SWW (Table 4). Mueller et al. (2013), during a study with tomatoes cropping, found that organic fertilization plus the supplementation with mineral fertilization supplies more evenly the cropping demand for the primary macronutrients.

The low yield of the treatments with organic fertilization, for 'Compack' tomato, can be attributed to an uneven amount of nutrients in the studied wastes. SWW presented more N than P and K, whereas PL showed more K and P than N. This resulted in deficiency of some nutrients for the crop, consequently, there was a negative impact on yield (Table 2). This also explains why the PL + SWW treatment produced good results, since association of both wastes provided the nearest values of N, P and K required for a good cropping yield.

The treatment that presented the highest yield for 'Gaucho' tomato was the association of SWW with PL (Table 4). Organic fertilizations, with or without mineral complementation, had higher yield when compared to the control and mineral fertilization. The treatment with only mineral fertilization showed superior yield only to the control treatment, even when fertilization was according to the recommendation. These results suggest that 'Gaucho' tomato plant has the highest yield and fruit quality when fertilized with organic material.

According to Andrade et al. (2012) and Pascale et al. (2016), the plants answer to fertilization depends on several factors and, among them, the cropping species. In addition, it is noteworthy that this cultivar is not a hybrid and, therefore, presents more rustic features. Albuquerque Neto & Peil (2012) worked with 'Gaúcho' tomato and recorded a nearly 38 t ha^{-1} yield, which is similar to PL + SWW treatment yield.

Polat et al. (2010) worked with tomatoes fertilization to evaluate yield and concluded that organic fertilization increased yield and fruit quality, when compared to conventional fertilizing, because of waste composition and the presence of humic substances. These same authors report that this kind of fertilization must be used to make easy the reuse of organic waste, as well as to maintain and/or increase soil fertility by increasing organic matter and nutrient supply, as well as yield and maximize profits.

The highest diameter for the 'Gaúcho' tomato was obtained with organic fertilizations with and without mineral supplementation. Only organic fertilizations stood out for fruit length. This suggests bigger fruits with greater commercial attractiveness, and this results in a product which can be easily sold.

There was no significant difference among the treatments (Table 5) on the soluble solids (SS) and titratable acidity (TA) for 'Compack' tomato. The averages of 5.28 ºBrix and 0.40% of citric acid are next to the values recorded by Ferreira et al. (2010) (5.44 ºBrix and 0.32%), respectively. This suggests a good ripeness degree of the fruits at harvest, regardless the treatment.

Table 4. Diameter, length and yield of fruits of the 'Gaucho' and 'Compack' tomato plants

Treatment	'Gaúcho'			'Compack'		
	Diameter (mm)	Length (mm)	Yield (t ha^{-1})	Diameter (mm)	Length (mm)	Yield (t ha^{-1})
Control	58.92 b	42.50 c	3.10 d	53.00 b	43.97 b	2.83 b
Mineral	57.10 b	40.62 c	16.75 c	66.50 a	53.2 a	11.80 a
PL	73.60 a	49.24 a	30.00 b	57.14 b	47.53 b	4.05 b
SWW	67.92 a	47.96 a	26.46 b	68.92 a	55.72 a	5.71 b
PL + Mineral	64.72 a	45.22 b	33.01 b	61.64 a	50.00 b	10.37 a
SWW + Mineral	56.78 b	40.54 c	24.22 b	68.18 a	53.3 a	8.90 a
PL+ SWW	66.90 a	45.02 b	42.10 a	62.77 a	49.28 b	9.02 a
CV (%)	8.63	6.38	26.44	7.25	8.02	21.29

Different letters in column evidence distinct groups by Scott-Knott's clustering test at $p \leq 0.05$. PL - Poultry litter; SWW; PL + Mineral - Fertilization with poultry litter plus mineral supplementation; SWW + Mineral - Fertilization with SWW + mineral supplementation; PL + SWW - Fertilization with poultry litter plus SWW; CV - Coefficient of variation

Table 5. Titratable acidity (TA) and soluble solids (SS) of 'Gaúcho' and 'Compack' tomato fruits

Treatment	'Gaúcho'		'Compack'	
	SS (°Brix)	TA (%citric acid)	TA (%citric acid)	SS (°Brix)
Control	3.2 b	0.30 b	0.33 ns	4.27 ns
Mineral	4.5 a	0.40 a	0.38 ns	5.37 ns
PL	3.1 b	0.27 b	0.40 ns	5.40 ns
SWW	4.2 a	0.40 a	0.34 ns	4.80 ns
PL + Mineral	4.4 a	0.42 a	0.48 ns	6.10 ns
SWW + Mineral	5.1 a	0.46 a	0.44 ns	5.45 ns
PL+ SWW	3.5 b	0.37 a	0.41 ns	5.63 ns
CV (%)	19.05	19.94	21.20	15.29

Different letters in column evidence distinct groups by Scott-Knott's clustering test at $p \leq 0.05$. PL - Poultry litter; SWW; PL + Mineral -: Fertilization with poultry litter plus mineral complementation; SWW + Mineral - Fertilization with swine wastewater plus mineral complementation; PL + SWW - Fertilization with poultry litter plus swine wastewater; CV - Coefficient of variation

The lowest averages of SS were observed for the control, fertilization only with PL and the association of PL + SWW in 'Gaúcho' tomato. SS concentration is one of the main characteristics of the fruits, because with higher values, the greater will be the industrial income (Shirahige et al., 2010). Thus, it can be inferred that these three treatments provided fruits with less sweetness and lower quality.

In relation to titratable acidity, the lowest values for 'Gaúcho' tomato were found for the control treatment and poultry litter. This fact is probably related to the amount of nitrogen present in these treatments that was inferior to the others (Table 2).

According to Chitarra & Chitarra (2005), the great majority of organic acids are translocated from the roots or leaves to the fruits and their synthesis occur due to changes along Krebs cycle respiratory pathway. In such a way, although the treatment with PL presented good vegetative development, probably the amount of organic acids produced by leaves and roots was low and also resulted in lesser acidity and lesser soluble solid concentration. On the other hand, the development of vegetative phase for the control treatment was reduced, which indicates a lower photosynthetic rate and consequently lower production of sugars and acids.

Regarding macronutrient concentration, it was observed that tomatoes of the control treatment showed the lowest N and K values for Compack variety (Table 6). According to Trani et al. (2015), the values adjusted for the tomato plant leaf ranged from 40-60 g kg^{-1} for N, 4-8 g kg^{-1} for P, and 30-50 g kg^{-1} for K. So, it can be considered that the plants of the control treatment presented nitrogen deficiency and this caused less vegetative growth and consequently minor yield (Alvarenga, 2013). In relation to P concentration, it did not have significant difference among the studied treatments, which can be explained by the high concentration of phosphorus in soil (Table 1).

The concentrations of K for 'Compack' tomato are below expected for this crop, however, visual deficiencies had not been found out, except for the control treatment. Moreover, the concentrations cited in literature depend on several factors as handling, cropping tolerance/strength and weather conditions (Alvarenga, 2013).

Leaf concentration of N in 'Gaucho' tomato was lower for the control and PL treatments; this can be justified by the low amount of N available from the poultry litter that was less than half the crop demand (Table 2). The remaining values are close to the desired pattern for the crop (Trani et al., 2015).

Phosphorus concentrations in tomato plants were lower for the treatments control, mineral and the fertilized one with SWW only. Nevertheless, only the plants from the control treatment showed values below the ones considered adequate for the crop (Trani et al., 2015). In relation to potassium, the highest concentration was found out for plants of the treatment with mineral fertilization, however, all the treatments showed adequate concentrations for the studied crop.

The control and PL treatments presented the least potassium concentrations, for 'Gaucho' tomato, as well as the lowest concentrations of SS. According to Alvarenga (2013), potassium deficiency may reduce the percentage of soluble solids in tomato, reducing its nutritional value. Thus, even all K values were within the range considered adequate for the crop, there was a deficiency in potassium supply in these two treatments, which influenced the fruits sweetness.

It should be observed that the treatment with PL + SWW, which presented the highest yield average for 'Gaúcho' tomato, showed statistically equal levels of N and K to the treatment with only mineral fertilization and almost twice P concentration. The results have corroborated the hypothesis that 'Gaúcho' tomato responds positively to organic fertilization, since there is a balanced nutritional management. Although both varieties have presented different results, mainly in relation to mineral fertilization, it's important to stand out that organic fertilization with poultry litter and swine wastewater, in this study, can be used in substitution to mineral fertilization, without damage for the vegetative development and yield of 'Gaucho' and `Compack' tomatoes. This allows some sustainable application of organic waste and greater profit for the farmers.

Table 6. N, P and K concentration on 'Compack' and 'Gaúcho' tomato leaves

Treatment	Tomato Compack			Tomato Gaúcho		
	N	P	K	N	P	K
	(g kg^{-1})					
Control	29.67 b	6.27 a	9.16 b	35.00 b	2.64 b	32.86 c
Mineral	48.47 a	4.74 a	14.30 a	46.66 a	4.82 b	51.54 a
PL	52.00 a	8.27 a	18.10 a	38.74 b	8.42 a	31.32 c
SWW	50.53 a	7.51 a	13.41 a	44.56 a	4.54 b	41.64 b
PL +Mineral	50.23 a	8.00 a	15.20 a	41.14 a	6.82 a	37.10 c
SWW+ Mineral	54.43 a	6.00 a	15.70 a	41.64 a	7.24 a	42.90 b
PL+SWW	50.85 a	4.86 a	17.00 a	41.64 a	8.00 a	33.56 c
CV (%)	12.33	39.76	24.50	10.18	28.73	16.24

Different letters in column evidence distinct groups by Scott-Knott's clustering test at $p \leq 0.05$. PL -: Poultry litter; SWW swine wastewater; PL + Mineral - Fertilization with poultry litter plus mineral complementation; SWW + Mineral - Fertilization with swine wastewater plus mineral complementation; PL+SWW - Fertilization with poultry litter plus swine wastewater; CV - Coefficient of variation

Conclusions

1. Despite differences at 30 days after transplanting (DAT), all the fertilization treatments promoted satisfactory growth in both tomato cultivars at 90 DAT.

2. For the Gaúcho cultivar, it is recommended the fertilization with two wastes combined; poultry litter (PL) + swine wastewater (SWW), because it promoted greatest yield.

3. For the Compack cultivar, it is recommended the mineral fertilization, PL, SWW fertilization with extra minerals, and the mixture of PL and SWW, because they promoted greatest yields.

4. In relation to the quality of the fruits, the Compack cultivar was not affected by the types of fertilization. For the Gaúcho cultivar the fertilization with only PL caused low values of soluble solids (SS) and titratable acidity (TA)

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Literature Cited

Aita, C.; Giacomini, S. J. Nitrato no solo com a aplicação de dejetos líquidos de suínos no milho em plantio direto. Revista Brasileira de Ciência do Solo, v.32, p.2101-2111, 2008. https://doi.org/10.1590/S0100-06832008000500031

Albuquerque Neto A. A. R.; Peil R. M. N. Produtividade biológica de genótipos de tomateiro em sistema hidropônico no outono/inverno. Horticultura Brasileira, v.30, p.613-619, 2012. https://doi.org/10.1590/S0102-05362012000400009

Alvarenga, M. A. R. Tomate: Produção em campo, casa de vegetação e hidroponia. 2.ed, Lavras: Editora Universitária de Lavras, 2013. 455p.

Andrade, E. M. G.; Silva, H. S.; Silva, N. S.; Souza Júnior, J. R.; Furtado, G. F. F. Adubação orgânomineral em hortaliças folhosas, frutos e raízes. Revista Verde de Agroecologia e Desenvolvimento Sustentável, v.7, p.7-11, 2012.

Assmann, J. M.; Braida, J. A.; Cassol, L. C.; Magiero, E. C.; Manteli, C.; Griz, E. Produção de matéria seca de forragem e acúmulo de nutrientes em pastagem anual de inverno tratada com esterco líquido de suínos. Ciência Rural, v.39, 2009. https://doi.org/10.1590/S0103-84782009000800021

Azeez, J. O.; Van Averbeke, W. V. Nitrogen mineralization potential of three animal manures applied on a sandy clay loam soil. Bioresource Technology, v.10, p.5645-5651, 2010. https://doi.org/10.1016/j.biortech.2010.01.119

Chitarra, M. I. F; Chitarra, A. B. Pós-colheita de frutos e hortaliças: Fisiologia e manuseio. 2.ed. Lavras: UFLA, 2005, 783p.

Corrêa, R. M.; Pinto, J. E. B. P.; Reis, E. S.; Costa, L. C. B.; Alves, P. B.; Niculan, E. S.; Brant, R. S. Adubação orgânica na produção de biomassa de plantas, teor e qualidade de óleo essencial de orégano (*Origanum vulgare* L.) em cultivo protegido. Revista Brasileira Plantas Medicinais, v.12, p.80-89, 2010. https://doi.org/10.1590/S1516-05722010000100012

Cosme, C. R.; Dias, N. S.; Oliveira, A. M.; Oliveira, E. M. M.; Souza Neto, O. N. Produção de tomate hidropônico utilizando rejeito da dessalinização na solução nutritiva aplicados em diferentes épocas. Revista Brasileira de Engenharia Agrícola e Ambiental, v.15, p.499-504, 2011. https://doi.org/10.1590/S1415-43662011000500010

Costa, A. M.; Borges, E. N.; Silva, A. A.; Nolla, A.; Guimarães, E. C. Potencial de recuperação física de um latossolo vermelho, sob pastagem degradada, influenciado pela aplicação de cama de frango. Ciência e Agrotecnologia, v.33, p.1991-1998, 2009. https://doi.org/10.1590/S1413-70542009000700050

EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. Sistema Brasileiro de Classificação de Solos. 3.ed. Brasília: EMBRAPA, 2013. 356p.

FAO - Organização das Nações Unidas para Alimentação e Agricultura. Produção e cultivo de tomate por país. Available on: http://faostat3.fao.org/browse/Q/QC/S. Accessed on: Jul. 2016.

Ferreira, D. F. SISVAR: Um programa para análises e ensino de estatística. Revista Cientifica Symposium, Lavras, v.6, p.36-41, 2008.

Ferreira, S. M. R.; Freitas, R. J. S.; Karkle, E. N. L.; Quadros, D. A.; Tullio, L. T.; Lima, J. J. Qualidade do tomate de mesa cultivado nos sistemas convencional e orgânico. Ciência e Tecnologia de Alimentos, Campinas, v.30, p.224-230, 2010. https://doi.org/10.1590/S0101-20612010000100033

Filgueira, F. A. R. Novo manual de oleiricultura: Agrotecnologia moderna na produção e comercialização de hortaliças. 3.ed. Viçosa: UFV, 2008. 421p.

Gatiboni, L. C.; Brunetto, G.; Kaminski, J.; Rheinheimer, D. S.; Ceretta, C. A.; Basso, C. J. Formas de fósforo no solo após sucessivas adições de dejeto líquido de suínos em pastagem natural. Revista Brasileira de Ciência do Solo, v.32, p.1753-1761, 2008. https://doi.org/10.1590/S0100-06832008000400040

IAL - Instituto Adolfo Lutz. Métodos físico-químicos para análise de alimentos. 4.ed. São Paulo:Instituto Adolfo Lutz, 2008. 1020p.

Lima, R. L. S.; Severino, L. S.; Albuquerque, R. C.; Beltrão, N. E. M.; Sampaio, L. R. Casca e torta de mamona avaliados em vasos como fertilizantes orgânicos. Revista Caatinga, v.21, p.102-106, 2008.

Mueller S; Wamser A. F.; Suzuki A; Becker W. F. Produtividade de tomate sob adubação orgânica e complementação com adubos minerais. Horticultura Brasileira, v.31, p.86-92, 2013. https://doi.org/10.1590/S0102-05362013000100014

Pascale, S.; Maggio, A. A.; Orsini, F.; Barbieri, G. Cultivar, soil type, nitrogen source and irrigation regime as quality determinants of organically grown tomatoes. Scientia Horticulturae, v.199, p.88-94, 2016. https://doi.org/10.1016/j.scienta.2015.12.037

Polat, E.; Demir, H.; Erler, F. Yield and quality criteria in organically and conventionally grown tomatoes in Turkey. Scientia Agricola, v.67, p.424-429, 2010. https://doi.org/10.1590/S0103-90162010000400008

Santos; L. B.; Castagnara; D. D.; Bulegon, L. G.; Zoz; T.; Oliveira, P. S. R.; Gonçalves Júnior, A. C.; Neres, M. A. Substituição da adubação nitrogenada mineral pela cama de frango na sucessão aveia/milho. Biosciense Journal, v.30, p.272-281, 2014.

SEAB - Secretaria de Estado da Agricultura e do Abastecimento. Análise da conjuntura agropecuária Março de 2015. Available on: <http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/olericultura_2014_15.pdf> Accessed on: Jul.2016.

Shirahige F. H.; Melo A. M. T.; Purquerio L.F. V.; Carvalho C. R. L.; Melo P. C. T. Produtividade e qualidade de tomates Santa Cruz e Italiano em função do raleio de frutos. Horticultura Brasileira, v.28, p.292-298, 2010. https://doi.org/10.1590/S0102-05362010000300009

Silva, C. L.; Bassi, N. S. S. Análise dos impactos ambientais no oeste catarinense e das tecnologias desenvolvidas pela Embrapa Suínos e Aves. Informe Gepec, Toledo, v.16, p.128-143, 2012.

Silva, F. C. (ed.). Manual de análises químicas de solos, plantas e fertilizantes. 2.ed. rev. ampl. Brasília: Embrapa Informação Tecnológica, 2009. 627p.

Silva, J. A. S.; Oliveira, A. P.; Alves, G. S.; Cavalcante, L. F.; Oliveira, A. N. P.; Araújo, M. A. M. Rendimento do inhame adubado com esterco bovino e biofertilizante no solo e na folha. Revista Brasileira de Engenharia Agrícola e Ambiental, v.16, p.253-257. 2012. https://doi.org/10.1590/S1415-43662012000300003

Trani, P. E.; Kariya, E. A.; Hanai, S. M.; Anbo, R. H.; Basseto Junior, O. B.; Purquerio, L. F. V.; Trani, A. L. Calagem e adubação do tomate de mesa. São Paulo: Instituto Agronômico de Campinas - IAC. 2015. 35p. Boletim Técnico