

INFLUÊNCIA DO AMBIENTE PROTEGIDO NO CULTIVO DA ALFACE EM ADUBAÇÃO ORGÂNICA E CONVENCIONAL

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RESUMO: O consumo de hortaliças no Brasil aumenta ano após ano, com ênfase nas folhosas. Assim, os aspectos climáticos estão entre os fatores que mais interferem em sua produção, bem como alterações na fisiologia da planta. Portanto, o objetivo do presente trabalho foi avaliar o efeito de diferentes tipos de ambientes protegidos em resposta a adubação mineral e orgânica na produção da alface crespa. O experimento foi conduzido na forma de um delineamento inteiramente casualizado (DIC), no esquema fatorial 3 x 2, onde os tratamentos foram T1: cultivo em ambiente com tela de sombreamento na cor preta com 50% sombreamento com adubação mineral e a orgânica; T2: cultivo em campo aberto com adubação mineral e a orgânica e T3: cultivo em ambiente em forma de túnel com cobertura de polietileno de 125 micras com adubação mineral e a orgânica. Na subparcela dois tipos de adubação (mineral e orgânica) com cinco repetições. As características coletadas foram: massa fresca e seca de parte aérea, caule e raiz, altura de planta, diâmetro de caule, volume de raiz, número de folhas, teores de macronutrientes foliar e produtividade. Pode-se concluir que os melhores resultados foram obtidos no ambiente de cultivo em túnel com cobertura de polietileno de 125 micras combinado com a adubação orgânica.

Palavras-chaves: nutrição de plantas, *Lactuca sativa* L., cultivo protegido.

THE INFLUENCE OF THE PROTECTED AMBIENT ON LETTUCE CULTIVATION UNDER ORGANIC AND CONVENTIONAL FERTILIZATION

ABSTRACT: The consumption of vegetables in Brazil increases year after year, with emphasis on leafy vegetables. Thus, climatic aspects are among the factors that most interfere with its production, as well as changes in the physiology of the plant. Therefore, the objective of the present work was to evaluate the effect of different types of protected environments in response to mineral and organic fertilization on the production of curly lettuce. The experiment was carried out in a completely randomized design (DIC), in a 3 x 2 factorial scheme, where the treatments were T1: cultivation in an environment with a black shading screen with 50% shading with mineral and organic fertilizers; T2: cultivation in open field with mineral and organic fertilization and T3: cultivation in a tunnel-shaped environment with 125 micron polyethylene cover with mineral and organic fertilization. In the subplot two types of fertilization (mineral and organic) with five replications. The characteristics collected were: fresh and dry mass of aerial part, stem and root, plant height, stem diameter, root volume, number of leaves, foliar macronutrient contents and productivity. It can be concluded that the best results were obtained in the tunnel culture environment with a polyethylene cover of 125 microns combined with organic fertilization.

Keywords: crop nutrition, *Lactuca sativa* L., protected cultivation.

1 INTRODUCTION

Lactuca sativa L. is a plant native to Egypt that spread throughout Europe until it was brought to Brazil by the Portuguese. It is an herbaceous plant with a high water content and a small stem to which the leaves are attached. It has broad leaves that grow in a rosette around the stem, which can be smooth or curly, forming a "head" or not, with coloration in various shades of green or purple, varying according to the cultivar (SALA; COSTA, 2012; SOUSA *et al.*, 2018).

Lettuce has a branched and shallow root system, exploring only the first 25 cm of soil when transplanted. When sown directly, the taproot can reach a depth of up to 60 cm. This crop adapts well to medium-textured soils with good water retention capacity. Furthermore, it is not very tolerant of acidic soils and requires a pH range between 6.0 and 6.8 for optimal development (AGUIAR *et al.*, 2014; MALAVOLTA, 1989).

For the proper development of crops, maintaining good soil moisture, a favorable climate, and available nutrients for plants are essential. Among the main macronutrients for plants, phosphorus plays an important role in plant metabolism, as it stimulates the development and formation of the plant's root system and is responsible for the maturation and formation of seeds (LANA *et al.*, 2004).

Therefore, the use of mineral fertilizers in lettuce cultivation is an agricultural practice that yields satisfactory results in terms of productivity. However, the final quality of the product must be considered, as its indiscriminate use can salinize the soil, resulting in high production costs. Thus, the adoption of organic fertilizers from various sources stands out for improving the physical and chemical properties of the soil and reducing

the need for mineral fertilizers (LOPES *et al.*, 2012).

In addition to maintaining soil nutrients, the growing environment also yields good results, as it is characterized by protection of plants against weather agents (temperature, air humidity, radiation and wind) and influences vegetable production (BEZERRA NETO *et al.*, 2005).

Lettuce has significant economic importance in Brazil, with the largest cultivation being by family farmers, who increasingly demand higher-quality products for commercialization. As perishable products, producers sell directly to supermarkets and open-air markets (SALAs; COSTA, 2012). The objective of this study was to evaluate the effects of different types of protection environments in response to mineral and organic fertilization on the production of curly lettuce.

2 MATERIALS AND METHODS

The experiment was conducted from July to August 2018 in Santa Cruz do Rio Pardo-SP, with coordinates of 22° 52' 13" S, 49° 36' 27" E, and an average altitude of 467 m in a protected environment. The plants were grown in plots measuring 1.2 m × 15 m (width and length, respectively). A spacing of 0.25 × 0.20 m was used between rows and plants, with a total of 96 plants per treatment.

The organic matter used in the experiment was analyzed (Table 1). The soil was classified as a dystrophic Red Latosol with a clayey texture (EMBRAPA SOLOS, 2013). For the chemical and physical characterizations (Tables 2, 3 and 4), a composite sample was collected from 3 points in the 0–0.20 m layer in each plot.

Table 1. Results of the analysis of organic matter (poultry manure).

pH	MO	P	Al ³⁺	Density	K	Here	Mg	Gray	Humidity	N	S
CaCl ₂	g dm ⁻³	mg dm ⁻³	mg dm ⁻³	g cm ⁻³	mg dm ⁻³	mg dm ⁻³	mg dm ⁻³	mg dm ⁻³	%	mg dm ⁻³	mg dm ⁻³
6.5	74.5	3.98	0.35	0.66	3.72	2.16	0.56	25.5	20.3	3.78	0.08
B		Ass		Faith		Mn		Zn			
----- mg dm ⁻³ -----											
0.09		9.96		0.20		0.04		0.05			

Table 2. Chemical characterization of the soil from the lettuce trial in an environment with 50% shade net.

pH	MO	P _{resin}	Al ³⁺	H+Al	K	Here	Mg	SB	CTC	V	S
CaCl ₂	g dm ⁻³	mg dm ⁻³	-----	-----	-----	mmol c dm ⁻³	-----	-----	-----	%	mg dm ⁻³
6.0	46.0	989.0	0.0	18.0	9.1	71.0	44.0	126.7	144.7	88	21.0
B		Ass		Faith		Mn		Zn			
----- mg dm ⁻³ -----											
1.27		3.4		29.0		11.8		26.5			

Table 3. Chemical characterization of the lettuce soil in a tunnel environment with 125-micron polyethylene cover.

pH	MO	P _{resin}	Al ³⁺	H+Al	K	Here	Mg	SB	CTC	V	S
CaCl ₂	g dm ⁻³	mg dm ⁻³	-----	-----	-----	mmol c dm ⁻³	-----	-----	-----	%	mg dm ⁻³
6.6	21.0	247	0.0	9.0	4.9	72.0	31.0	112.2	121.2	93	14.0
B		Ass		Faith		Mn		Zn			
----- mg dm ⁻³ -----											
1.59		4.7		8.0		11.1		8.2			

Table 4. Chemical characterization of the lettuce trial soil in the field environment.

pH	MO	P _{resin}	Al ³⁺	H+Al	K	Here	Mg	SB	CTC	V	S
CaCl ₂	g dm ⁻³	mg dm ⁻³	-----	-----	-----	mmol c dm ⁻³	-----	-----	-----	%	mg dm ⁻³
6.5	21.0	436	0.0	11.0	9.6	63.0	25.0	102.2	113.2	93	16.0
B		Ass		Faith		Mn		Zn			
----- mg dm ⁻³ -----											
1.55		5.0		6.0		13.2		12.3			

The plant material used was Vanda Verde curly lettuce. After the soil analysis results were obtained, the necessary amount of lime was determined, along with the amount of fertilizer used for planting and topdressing. In the organic treatment, 0.6 kg m⁻² of organic matter (poultry manure) was added to the soil only, whereas in the conventional cultivation, 04-14-08 fertilizer (140 g m⁻²) was added. Topdressing fertilizer was distributed on the soil surface between plants: 80 kg h⁻¹ of N, 50 kg h⁻¹ of K₂O, split into two applications: the first 15 days after transplanting (DAT) and the second 25 DAT (AGUIAR *et al.*, 2014).

Irrigation was carried out according to the Thornthwaite–Camargo method, where

temperature and air humidity data were used to determine potential evapotranspiration (ET_o). After determining ET_o, ET_c (crop evapotranspiration) was calculated on the basis of the crop kcal (Phase I - 0.40, Phase II - 0.70, Phase III - 0.95 and Phase IV - 0.90) and the ET_o of the previous day. The purpose of irrigation was to maintain the soil at 90% field capacity. The irrigation depth followed the methodology described by Gomes *et al.* (2015).

The experimental design used was completely randomized (CRD), consisting of a 3 × 2 factorial design, where the treatments were as follows: T1: cultivation in an environment with black shade netting with 50% shading with mineral and organic fertilization;

T2: cultivation in an open field with mineral and organic fertilization; and T3: cultivation in a tunnel-shaped environment with 125-micron polyethylene cover with mineral and organic

fertilization. The subplots had two types of fertilization (mineral and organic) with five replications (Table 5).

Table 3. Sketch of the experimental area with the factorial design.

TREATM ENT	R1					R2					R3					R4					R5				
	TO																								
T1	AM																								
T3	THE																								
T2	AM																								

Mineral Fertilization (MF); Organic Fertilization (OF).

The parameters were evaluated at 40 DAT (days after transplanting), with 5 plants per replicate collected from the central part of the plot. The following parameters were determined: plant height: a graduated measuring tape (cm) was used, and measurements were taken from ground level to the apex of the plant; stem diameter: a digital caliper was used, with measurements taken at the height of the plant's collar (mm); fresh and dry biomass of aerial parts and roots: for fresh matter mass (FMM) analysis, plants were collected at 8 am and weighed immediately; and for dry matter mass (DMM), the plants were kept in paper bags and placed in a forced-air oven at $50\text{ }^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 72 h.

The MMFs and MSMs of the leaves and roots were determined and expressed in g of plant⁻¹; for plant tissue analysis, the plants were washed, the leaves were separated from the roots, and the leaves were packed in paper bags and placed in an oven at $50\text{ }^{\circ}\text{C} \pm 5^{\circ}\text{C}$ until a constant weight was reached. The samples were subsequently ground and sent to the Plant Mineral Nutrition Laboratory of FCA/UNESP to determine their macronutrient contents (N, P, K, Ca, Mg, and S) according to Malavolta, Vitti, and Oliveira (1997).

For root volume, a 1-liter graduated cylinder was used, and deionized water was added until the volume reached 700 mL. After the roots were inserted, the increase in volume (mL) was recorded; heart size, i.e., a graduated measuring tape (cm) was used, was measured from the plant's collar to the tip of the heart;

and the number of leaves, i.e., the number of leaves removed and counted on each plant.

All evaluated parameters were submitted to the R program version 3.5.1, analysis of variance was performed, and when significance was indicated, the means were compared via Tukey's test at the 5% significance level.

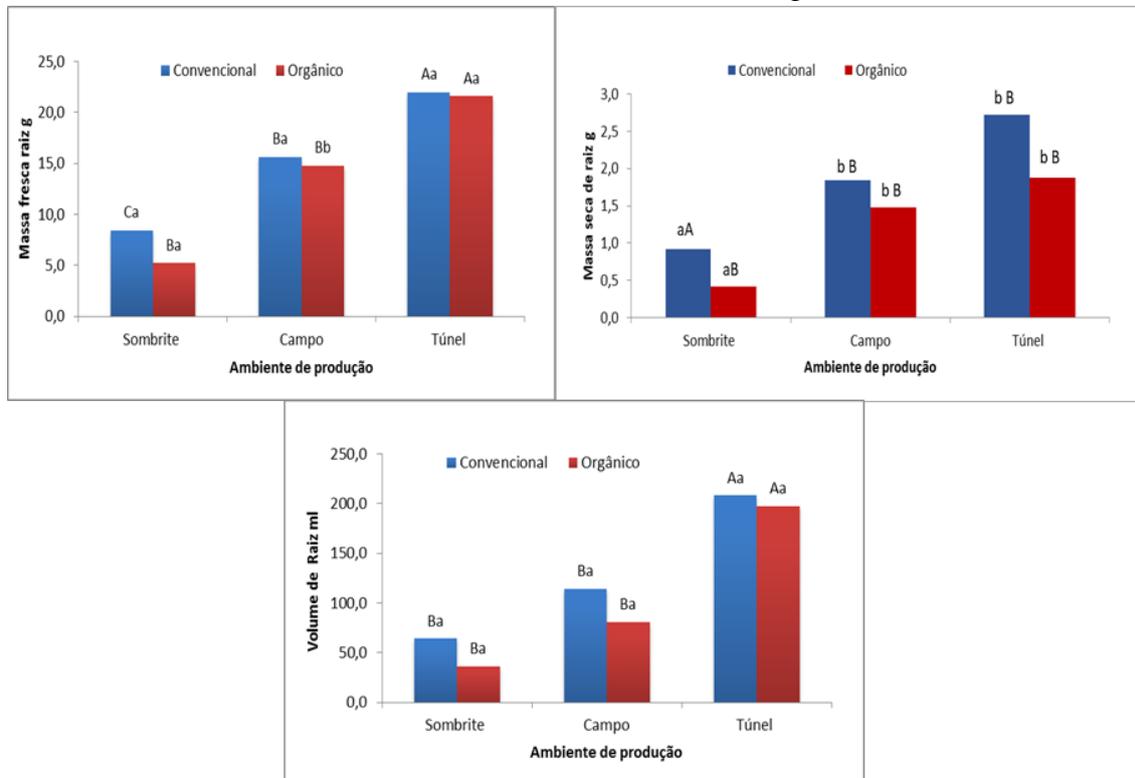
3. RESULTS AND DISCUSSION

As shown in Figure 1, the fresh root mass was greater under T1, T2, and T3 with respect to mineral nutrition than under organic fertilization. For root dry mass, only T1 and T3 presented statistically significant differences in relation to the type of environment and type of fertilization. The root volume was significantly different across the different production environments, whereas there was no difference in terms of fertilization, with T3 having the largest root volume.

According to Calegari *et al.* (1993), organic fertilization tends to increase the soil water content, increase nutrient availability and cation exchange capacity, and decrease the aluminum content and the capacity for nutrient recycling and mobility in the soil. Goto and Tivelli (1998), studying the cultivation of vegetables in a protected environment, reported that environmental conditions influence vegetable production, as do air temperature, humidity and radiation, which interfere with the quality and production of

vegetables, given that the cold and winds of winter prolong the cycle of these crops.

Figure 1. Fresh and dry root mass and root volume in different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and fertilization during lettuce cultivation.

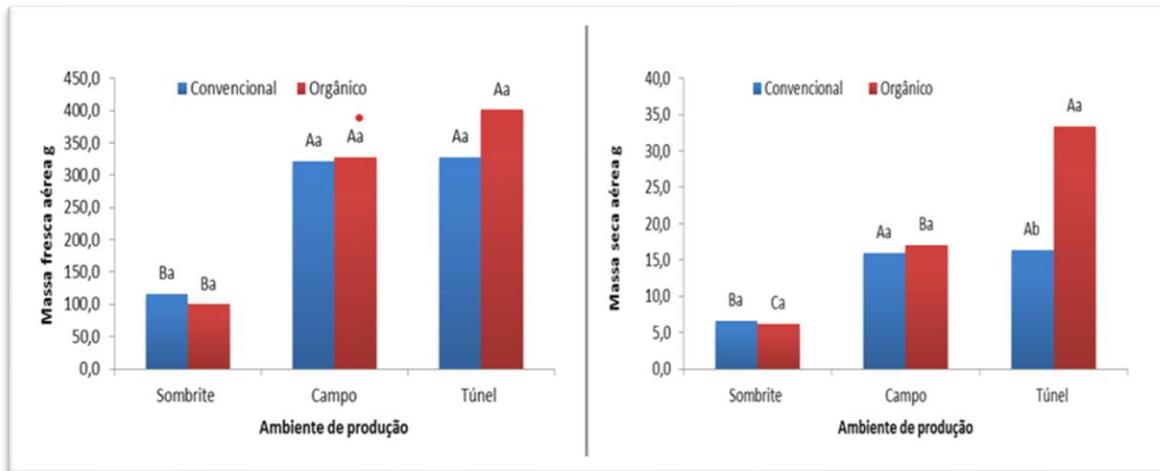


The means in uppercase letters represent environmental treatments, and the lowercase letters represent fertilization via Tukey's test at 5%.

Figure 2 shows that the fresh shoot mass did not significantly differ among the T1, T2, and T3 treatments, but organic fertilization in the tunnel environment was notable. In terms of dry shoot mass, there were differences between the environmental and fertilization treatments, with T3, which has organic nutrients, resulting in the highest plant dry mass, as the climatic conditions within this treatment favored its better production.

According to Purquerio and Tivelli (2006), protected cultivation has characteristics that protect plants against weather agents and allow crops to perform greater photosynthesis, resulting in better aerial development of lettuce. It also promotes partial control of edaphoclimatic conditions that can cause stress to plants.

Figure 2. Fresh weight of the aerial part and dry weight of the aerial part of lettuce grown in different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and different fertilization treatments.

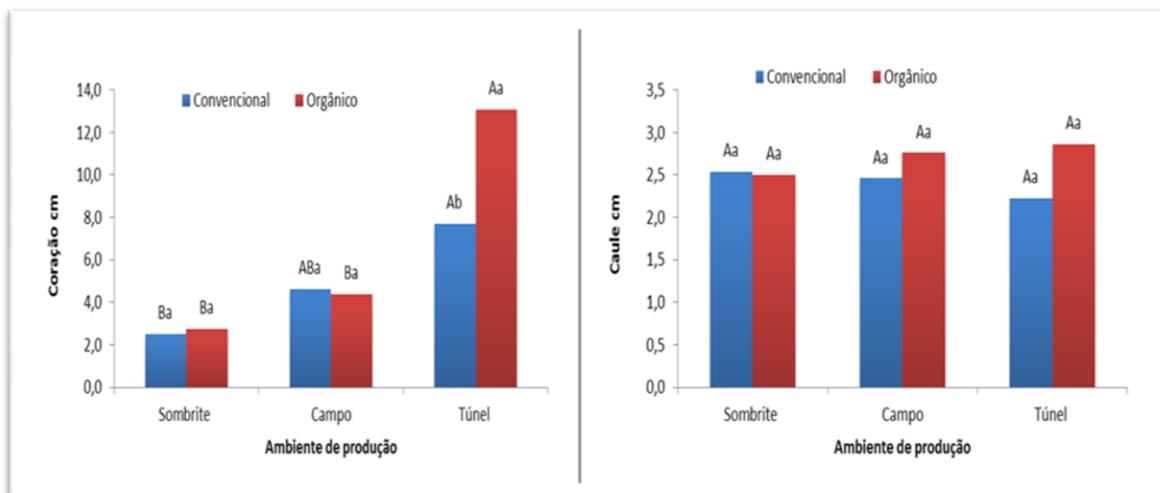


The means in uppercase letters are used to compare the environmental treatments, and the lowercase letters represent fertilization by Tukey's test at 5%.

Figure 3 shows that statistically significant differences were obtained between the environmental treatments for lettuce heart size; however, for fertilization, treatments 1 and 2 did not result in differences, but T3 was superior. Notably, organic fertilization promoted a greater green color among the plants in this treatment (T3). This result may influence chlorophyll formation, a factor influenced by photoperiod and especially temperature.

Bliska Junior and Honório (1996) reported that the choice of greenhouse covering material influences the amount of light inside the environment, benefiting plants according to their needs. In terms of stem diameter, fertilization is a primary factor, as is water availability; however, for this parameter, there was no statistically significant difference between the environmental and fertilization treatments.

Figure 3. Development of lettuce hearts and stems in different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and watering.

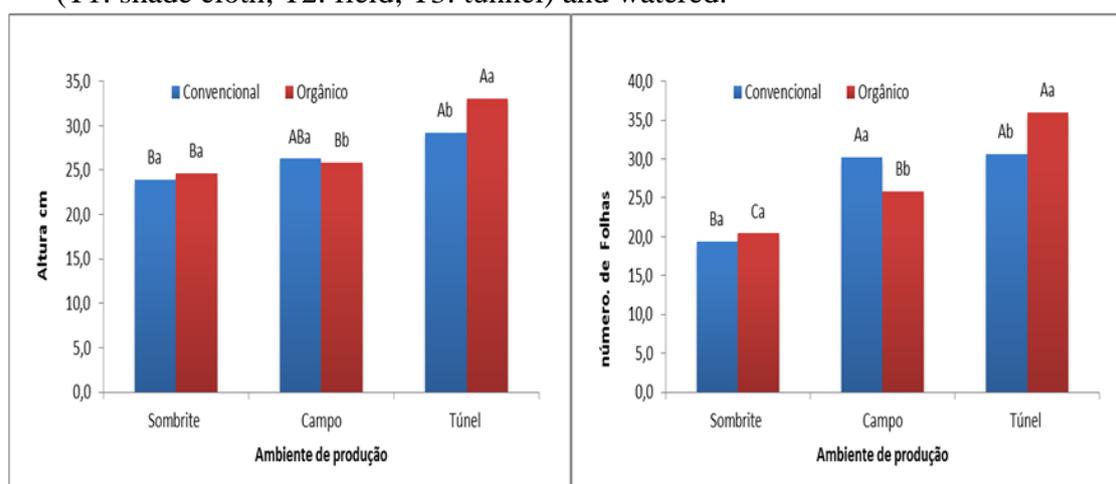


The means in uppercase letters represent environmental treatments, and the lowercase letters represent fertilization via Tukey's test at 5%.

Figure 4 shows the differences in the effects of the environmental and fertilization treatments on plant height and number of leaves; with respect to treatment 3, organic fertilization yielded the best results. Fertilization, when combined with favorable environmental factors, promotes lettuce growth

in the different phenological phases of the crop, since photoperiod and temperature affect the number of leaves, plant mass, and height (SALA; COSTA, 2005; TAIZ; ZEIGER, 2008). Furthermore, a microclimate was created that favored its development, similarly promoting a greater number of leaves.

Figure 4. Plant height and number of leaves of lettuce in different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and watered.

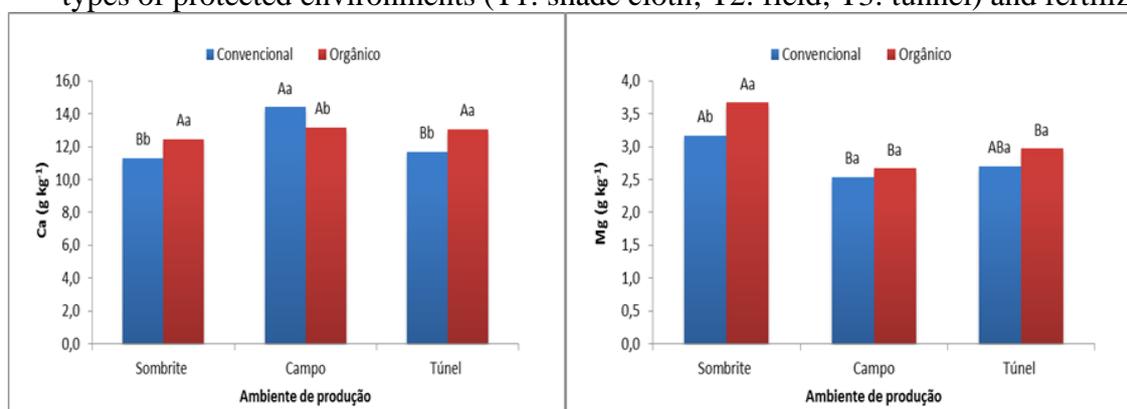


The means in uppercase letters are used to compare the environmental treatments, and the lowercase letters represent fertilization by Tukey's test at 5%.

For the Ca and Mg contents in the leaves (Figure 5), the plants in the organic cultivation treatment presented the highest amounts of nutrients, as did those in the T1 and T2 treatments. However, there was a difference between the ambient treatments. Thus, there

was greater translocation of these nutrients to the aerial part of the plant as a function of the fertilization source used. Malavolta (2006) reported that ideal soil conditions tend to favor nutrient translocation in plants.

Figure 5. Leaf contents of macronutrients (Ca and Mg) in lettuce plants as a function of different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and fertilization.



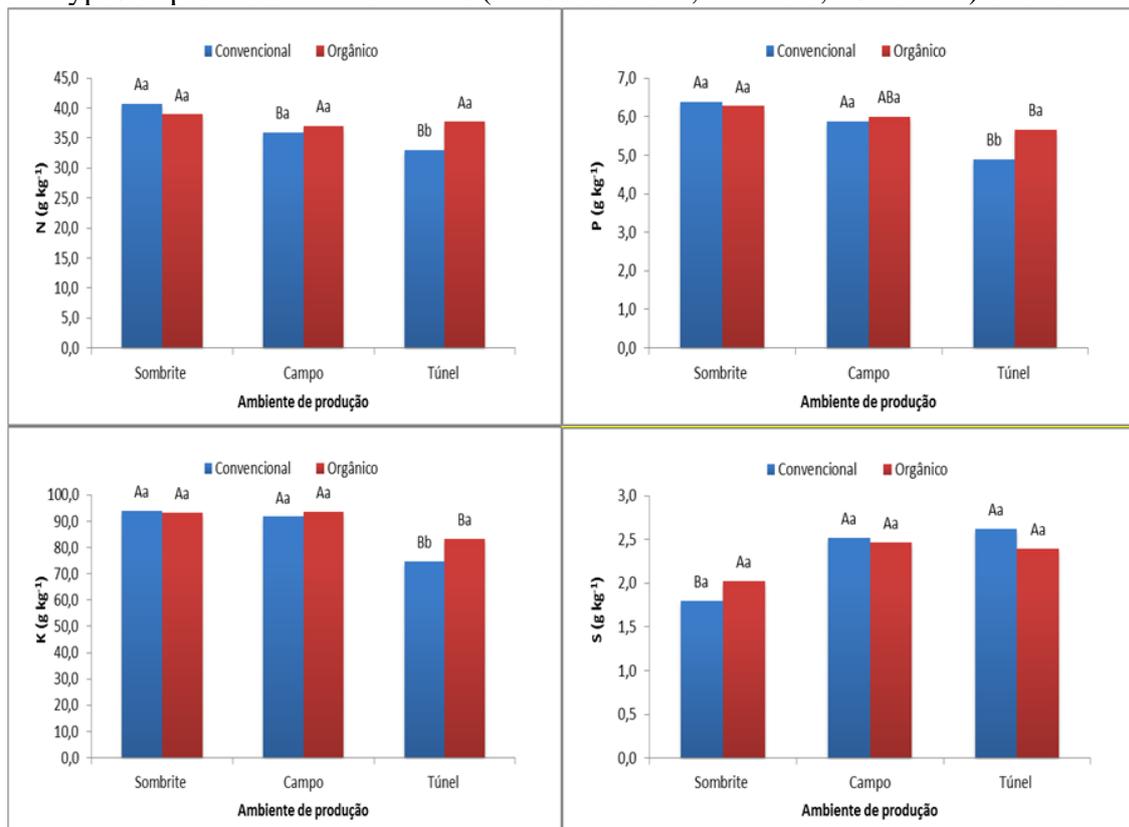
The means in uppercase letters are used to compare the environmental treatments, and the lowercase letters represent fertilization by Tukey's test at 5%.

Figure 6 shows that the macronutrients nitrogen, phosphorus, and potassium did not significantly differ between the fertilization treatments; however, the Sulfur treatment had a greater effect on organic fertilization than on conventional fertilization because poultry manure has high levels of S in its composition.

In Treatment 3, the nutrients nitrogen, phosphorus, and potassium (N, P, and K) were present in greater quantities in the plants under

organic fertilization than under conventional fertilization. Therefore, it is believed that the combination of the correct environment and ideal fertilization can lead to greater development and mineral quality. Abo-Sedera *et al.* (2016) reported that fertilization, when applied in the right quantity and at the right time, can result in greater translocation of nutrients to the aerial part of the plant.

Figure 6. Leaf contents of macronutrients (N, P, K and S) of lettuce plants as a function of different types of protected environments (T1: shade cloth; T2: field; T3: tunnel) and fertilization.



The means in uppercase letters represent environmental treatments, and the lowercase letters represent fertilization via Tukey's test at 5%.

4 CONCLUSIONS

Thus, it was possible to conclude that superior results were obtained in the tunnel cultivation environment with 125-micron polyethylene covering combined with organic fertilization, since it is possible to create the best conditions for the vegetative development of lettuce, as well as greater translocation of nutrients to the aerial part, due to the organic fertilization used.

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