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Original Article

Iceberg lettuce cultivated in different systems of planting and sources of fertilizer

Alface americana cultivada em diferentes sistemas de plantio e fontes de fertilizantes

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Abstract

Organic fertilization is a cheaper and highly effective option for profitability and consequent improvement of the soil's physical, chemical, and biological structure. Thus, the objective of this work was to evaluate different types of fertilization: organic (poultry shed litter), mineral, and leaf path on yield parameters of lettuce grown in various types of planting. The treatments consisted of using two planting systems (P1 - Line and P2 - quincunxes) and mineral and organic fertilizers (A1 - mineral fertilization; A2 - mineral fertilization + leaf fertilization; A3 - organic fertilization with poultry shed litter and A4 - fertilization organic + mineral). The experimental units consisted of 36 and 52 plants, respectively, for treatments P1 and P2, and all central plants of the experimental unit were evaluated. Heart height, fresh mass, and leaf number were observed. The mineral and mineral + leaf treatments did not differentiate, either in line or in quincunxes. The treatment that stood out about the analyzed variables was the organic fertilization and quincunxes planting system, reflecting a more significant number of lettuce plants and better use of the area.

Keywords: *Lactuca sativa*, fertilization, vegetal cover.

Resumo

A adubação orgânica é uma opção mais barata e de grande eficácia em relação à rentabilidade e consequente melhoria da estrutura física, química e biológica do solo. Desta forma, o objetivo deste trabalho foi avaliar diferentes tipos de adubação: orgânica (cama de frango), mineral e via foliar sobre parâmetros de produtividade de alface cultivada em diferentes tipos de plantio. Os tratamentos consistiram na utilização de dois sistemas de plantio (P1 - Linha e P2 - Quincôncio) e adubações minerais e orgânicas (A1 - adubação mineral; A2 - adubação mineral + adubação foliar; A3 - adubação orgânica com cama de aviário e A4 - adubação orgânica + mineral). As unidades experimentais foram compostas por 36 e 52 plantas, respectivamente, para os tratamentos em linha e em quincôncio, sendo avaliadas todas as plantas centrais da unidade experimental. Foram observados a altura do coração, massa fresca e número de folhas. Os tratamentos mineral e mineral + foliar não diferenciaram entre si, tanto em linha quanto em quincôncio. O tratamento que se destacou em relação às variáveis analisadas foi aquele baseado na adubação orgânica e sistema de plantio em quincôncio, refletindo em maior número de pés de alface e melhor aproveitamento da área.

Palavras-chave: *Lactuca sativa*, adubação, cobertura vegetal.

1. Introduction

Lettuce (*Lactuca sativa* L.), belonging to the Asteraceae, is an extremely important vegetable in the diet all over the world, and it can be used for consumption in salads or as sandwich ingredients (Favarato et al., 2017). It is rich in macro- and micro-nutrients essential to the human diet, being one of the most produced and consumed leafy vegetables in the world (Hotta, 2008; Geisenhoff et al., 2016; Baudoin et al., 2017; Urbano et al., 2017). In Brazil, in 2017, the production of lettuce was 671.5 thousand tons, representing 50% of the area of all vegetable production, with the iceberg variety ranking second in importance among the types of lettuce (Kist et al., 2020). This is due to the fact that Iceberg lettuce has excellent palatability, is crunchy, and offers a longer post-harvest life, and this has helped to open up the market for use in fast food chains (Yuri et al., 2004; Sala and Costa, 2008; Vilela and Luengo, 2017).

This species originates from temperate climates, and this characteristic is a challenge for crops in tropical climates, therefore, in Brazil, for example, research is carried out in order to increase its agricultural zoning (Aquino et al., 2014). For this reason, the best lettuce development occurs

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under mild temperature conditions, since temperatures above 20 °C encourage the bracing, which is accelerated as this meteorological factor increases, becoming more critical when associated with long days (Santi et al., 2010). However, as it is an intensively cultivated crop, both in time and space, a large part of the production has intensified throughout the year. With cultivation facilitated in the winter, heavy rains, high solar radiation and high air temperatures make summer cultivation difficult, as they favor the early pinning of plants (Filgueira, 2008). Therefore, the genetic improvement of the species must be linked to the lettuce cultivation system, since this is a highly intensive activity, requiring high investment in terms of labor and infrastructure (Favarato et al., 2017).

The arrangement of plants in the field, according to the adopted cultivation system, can change the microclimate in the region between the soil surface and the leaf canopy, mitigating the effects of temperature, relative air humidity, deficit of vapor pressure and incidence of solar radiation (Carvalho et al., 2016; Marin et al., 2016a, b). These effects are achieved due to the different spacing between rows and between plants that each system has and that result in different architecture, development, weight and quality of plants (Dobosy et al., 2020).

Among the cultivation systems and arrangement of plants in the field, cultivation in rows or in quincunx can be adopted. In this last arrangement, the plants are arranged in groups of five, with one in the center, with the plants equidistant forming equilateral triangles. One of the differences for in-line cultivation is that there is no quincunx as plants are aligned in all directions. This arrangement promotes a totally different microclimate in the cultivated area. This system allows the land to be better used, as a greater number of plants can be cultivated when compared to a system of planting in rows. Changing the number of plants per area indicates increasing or decreasing population density, so it is necessary to pay special attention to fertilization (Dobosy et al., 2020).

In relation to fertilization techniques to be used, foliar fertilization has stood out (Mariano et al., 2021), given the faster correction of occasional or systematic deficiencies. The use of mineral fertilizers in the cultivation of lettuce is an agricultural practice that brings satisfactory results when used correctly (Diamante et al., 2013). As a cost-effective option, organic fertilization stands out. The gradual release of nutrients that occurs in organic waste as it is decomposed is one of the great advantages of organic fertilizers, as it prevents the nutrients present in its constitution from being leached (Oliveira, 2016).

Therefore, the objective of this work was to evaluate the influence of organic, mineral, and foliar fertilization, and their combinations on the growth variables of Iceberg lettuce grown in rows and quincunxes.

2. Material and Methods

2.1. Location and characterization of the experimental area

The experiment was conducted in an experimental area at the Ipanema site, located in Cidade Gaúcha – PR (latitude: 23°21’45” South, longitude: 52°55’33” West and altitude of 350 m). According to the Köeppen classification (Peel et al., 2007), the region’s climate is humid subtropical mesothermal (Cfa), with hot summer months and rare winter frosts. It tends to concentrate rains in the summer, but without a defined dry season, where the average temperature in the warmer months is above 22 °C, and in the coldest months, it is below 18 °C. Rainfall rates reach an annual average of 1300 mm per year.

Two beds 15 m long and 1.20 m wide were prepared, which received localized drip irrigation, using 16 mm drip tapes with emitters spaced 0.10 m, and nominal flow of each emitter of 1.6 Lh^{-1}. The Iceberg lettuce seedlings, cv. Lucy Brown, were acquired in a commercial nursery and transplanted, when they were approximately 40 days old, in the beds in two different planting arrangements, namely: 1) planting in a row of 0.30 × 0.30 m; and 2) planting in quincunxes of 0.35 × 0.30 × 0.25 m. Mulch composed of *Brachiaria decumbens* (Trin.) Griseb. distributed evenly over and between the beds was added to the beds.

Meteorological data were obtained from the National Institute of Meteorology (INMET) automatic station installed in the city of Cidade Gaúcha - PR (INMET, 2019). Data referring to atmospheric pressure, temperature and relative humidity of the air, precipitation, solar radiation, wind direction, and speed are automatically available every hour with the integration of minute-by-minute values. From these data, the reference evapotranspiration (ETo) was determined using the Penman-Monteith FAO 56 method (Allen et al., 1998), and multiplying by the coefficient value of the lettuce crop, and it was possible to find the crop evapotranspiration (ETc) and the water balance of the lettuce crop. The Kc values used were taken from Nunes et al. (2009).

2.2. Treatments and experimental design

The treatments studied consisted of two factors, the main factor being the inline (P1) and quincunx (P2) cultivation systems. As a secondary factor, four fertilization managements were adopted, namely A1 - mineral fertilization, A2 - mineral + foliar fertilization, A3 - organic fertilization, and A4 - organic fertilization + mineral. The combination of these treatments allowed the arrangement of plants in an experiment with a completely randomized design in a 2 × 4 factorial scheme, totaling 8 treatments in 5 replications, resulting in 40 experimental units.

The experimental units were composed of 36 and 52 plants, respectively, for the inline and quincunx treatments, evaluating all the central plants of the experimental unit. The arrangement in quincunxes allows for a greater density of plants, thus, for this reason, the experimental units of this treatment had a larger population.

2.3. Physical and chemical characterization of soil

In possession of the chemical characterization of the soil (Table 1) collected before the installation of the experiment, liming was carried out with calcitic limestone, PRNT of 65.22%, in the order of 8 kg uniformly distributed and incorporated in the two beds. The recommendation of fertilization for the crop was carried out according to the

Table 1. Chemical and granulometric characterization of the soil in the experimental area.

Ph	M.O*	Na	P	K	Ca	CTC	V	Areia	Silte	Argila
($CaCl_2$)	g dm^{-3}	---mg dm^{-3}--		----$cmol_c$ dm^{-3}----			---------------%--------------			
4.70	9.54	1.09	19.37	0.07	1.85	4.72	50.30	88	2	10

*M.O = organic matter; Na = sodium; P = phosphor; K = potassium; Ca = calcium; CTC = cationic exchange capacity.

Manual of Fertilization and Liming of the State of Paraná (2017) recommended by Pauletti and Motta (2017) and Manual of Fertilization and Liming of the States of Rio Grande do Sul and Santa Catarina (CQFS, 2016).

Tables 2 and 3 show, respectively, the amounts of fertilizers supplied and the doses of fertilization for the evaluated treatments, taking into consideration the fertilization for planting and coverage. It is noteworthy that mineral fertilizers were applied in two splits throughout the lettuce development cycle and that foliar fertilization occurred in three divisions. The splits occurred 15 and 30 days after transplanting, and 45 days after transplanting, only foliar fertilization was performed. The mineral fertilizers used were urea, simple superphosphate, and potassium chloride to supply N, P, and K, respectively.

2.4. Parameters evaluated

The following plant growth characteristics were evaluated immediately after harvest, using ten plants per treatment: number of leaves, heart height (cm), and fresh weight (g). The height of the heart was obtained with the aid of a millimeter scale. Fresh mass was obtained using a semi analytical balance with a precision of 0.01 g.

The temperature data were used to calculate the thermal sum, in degree days, having been carried out considering (Equation 1):

$$GD = \sum_{i=1}^{n} \left(\frac{T\max + T\min}{2} - Tb \right) \qquad (1)$$

where: GD is the total accumulated degree days; Tmax and Tmin are the maximum and minimum temperatures, respectively in °C; Tb is the base temperature, which for this experiment was considered to be equal to 10 °C, as presented by Araújo et al. (2010); Brunini et al. (1976); Segovia et al. (1997).

With the GD values and fresh mass of the plants, the expolinear growth models were adjusted for the studied treatments. For a better fit of the models, Neperian logarithms were applied to the proposed model, as suggested by Tei et al. (1996) (Equation 2).

$$\ln(w) = \ln\left(\frac{c_m}{r}\right) + \ln\left\{\ln\left[1 + \exp^{\left(r\left(x - t_b\right)\right)}\right]\right\} \qquad (2)$$

2.5. Statistical analysis of data

The experiment was conducted over a period of 48 days, corresponding to the period between 06/14/2019 and 07/31/2019. After this period, the parameters evaluated were statistically analyzed by analyzing variance in applying the F test, and unfolding the analyses whenever the interaction was significant. Qualitative parameters were analyzed using the Tukey test at a 5% probability level. The analyses were performed using the SISVAR statistical program (Ferreira, 2011).

Table 2. Fertilizer doses of Mineral and Mineral+foliar treatments in planting and covering.

Fertilizer	Mineral		Mineral+Foliar	
	planting	covering	planting	covering
N (g)	73.3	330	73.3	330
P (g)	450	-	450	-
K (g)	192.5	165	192.5	165

Table 3. Fertilizer doses of Organic and Organic + Mineral treatments in planting and covering.

Fertilizer	Organic + Mineral		Organic	
	planting	covering	planting	covering
N	-	330	-	-
K	-	165	-	-
poultry shed litter (kg)	20		20	-

3. Results and Discussion

The variations in the maximum (Tmax), minimum (Tmin), and average (Tmed) temperatures, as well as the precipitation occurring in the period, are shown in Figure 1. The Tmax ranged from 17 °C to 32.2 °C, and the Tmin ranged from 1.5 °C at 18.6°C. Tmed was verified throughout the experiment of 18.6 °C. According to Rodrigues et al. (2008), the ideal temperature for the lettuce crop is to have average temperatures lower than 22 °C, as temperatures above this threshold prevent the crop from expressing its full genetic potential, resulting in early detection tagging.

Table 4 shows the height values of the Iceberg lettuce heart, in which there was a significant difference for the fertilizers used, type of planting, and interaction between the factors ($p \leq 0.05$).When analyzing the unfolding of the interaction, it was found that the Mineral and Mineral + Foliar treatments do not differ statistically from each other in row planting. However, they differ from the Organic + Mineral and Organic treatments, which have the highest heart height, 35.21% and 44.19%, respectively, to treatment with mineral fertilization. For planting in quincunxes,

Table 4. Height of the heart of the Iceberg lettuce observed at the time of harvest.

Treatments	Height of the heart (cm)		CV
	inline	quincunxes	
Mineral	1.73bA	1.77aA	26.50
Mineral + Foliar	2.00bA	1.99aA	
Organic + Mineral	2.67aA	2.04aB	
Organic	3.10aA	2.11aB	

Averages followed by the same lowercase letter in the columns and uppercase in the rows do not differ by the Tukey test at 5% probability. CV = Coefficient of variation.

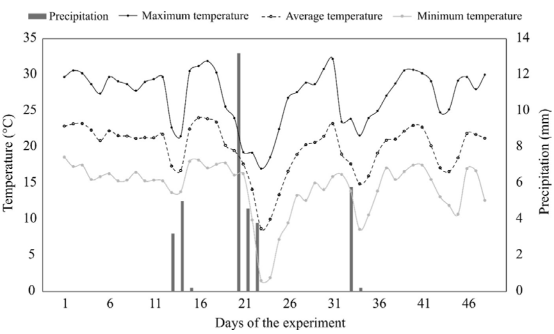

Figure 1. Variation of maximum, minimum, average temperature and precipitation over the 48 days of the experiment.

none of the treatments differed significantly from each other ($p \leq 0.05$). The splitting of the fertilizers within the types of planting indicated that only the Organic and Organic + Mineral treatments differed when the inline and quincunx methods of planting were adopted. In row planting the increase was 23.60% for Organic + Mineral, and 31.94% for Organic.

For heart height, the lowest values should be observed, as this characteristic shows the material's resistance to premature flowering (Hotta, 2008), therefore, the lower the value, the more resistant to premature flowering is a cultivar. These values can be used to assess the stress and adaptability of the cultivar in a given environment and treatment. The development of lettuce plants is greatly influenced by environmental conditions, including temperature, which, when above 20 °C, stimulates the planting to be braced, which is accelerated as it increases. Thus, long days associated with high temperatures further accelerate the bracing, but there is variation in behavior between cultivars (Viggiano, 1998).

In general, iceberg lettuce requires, as an ideal temperature for development, 23 °C during the day and 7 °C at night. Very high temperatures can cause burning of the edges of the outer leaves, form heads that are not very compact and also contribute to calcium deficiency, known as tipburn (Jackson et al., 1999). Stem length is an important feature for the industry, as it is directly related to raw material yield. The stem is discarded at the time of processing (Yuri et al., 2004). Very long stalks, above 7 cm, represent loss of material and, consequently, a decrease in yield. The same authors, evaluating the effect of organic compost on the yield and commercial characteristics of Iceberg lettuce, reported a significant effect between treatments for stem length. The dose of 42.7 t ha^{-1} provided a maximum length of 3.9 cm, considered acceptable by the industry. In our work, the maximum value found for this variable was 3.1 cm, in row cultivation, therefore, also within the standards established by the industry.

Organic fertilizers contain several mineral nutrients, especially nitrogen (N), phosphorus (P), and potassium (K). Although their concentration is considered low, the conditioning effect they exert on the soil must also be considered (Fornasieri Filho, 1992) besides, these can be complemented with the addition of formulated minerals, which will allow the rapid release of nutrients. Thus, such a combination (organic fertilizers + minerals) will result in better utilization, by the plants, of nutrients through the release synchronism throughout their growth (Bissani et al., 2008).

Lettuce produced in an organic system, in addition to presenting excellent productive and nutritional results (Yuri et al., 2004), can present reduced levels of nitrate (Cometti et al., 2004). The toxicity of nitrates results from their conversion into nitrites and N-nitrous compounds, with methemoglobinemia being one of the main adverse effects of nitrate consumption, which can, in the most severe cases, cause death (Monteiro, 2014).

The difference observed in the splitting of Organic and Organic + Mineral fertilizers within the types of planting can be justified by the fact that plant densities in row cultivation were lower, avoiding competition for nutrients, which may have occurred in the system in the quincunxes, in which plants, kept at higher density, eventually competed for water, nutrients, and light. The Figure 2 shows the variation of global radiation throughout the experiment, obtained from the automatic meteorological station of the INMET installed in the city of Cidade Gaúcha - PR (INMET, 2019). High light intensity increases photosynthetic activity, resulting in an increase in the accumulated fresh matter. This feature is essential for the development of plant species. In the specific case of lettuce, which has its planting recommended for the winter where the light intensity is lower, its development usually occurs more slowly. However, as can be seen in Figure 2, winter in the region allowed high values of global radiation, with values mostly above 13 MJm^{-2} d^{-1}. These mean radiation values coupled with lower air temperature situations due to winter, resulted in crop evapotranspiration (ETc) values between 0.19 and 2.22 mm d^{-1}.

With these evapotranspiration values and irrigation management, it was possible to maintain the maximum evapotranspiration of the crop in the periods where there was a deficit of water in the soil (Figure 3), with the red hatched areas representing the deficiency in the water balance. Irrigations were concentrated on these days, with watering shifts ranging from one to two days.

With favorable conditions for water development, the fresh mass of Iceberg lettuce (Table 5) was influenced by the fertilizer source, planting types, and interaction ($p \leq 0.05$). When analyzing the unfolding of the interaction, it was found that the treatments based on Mineral and Mineral + Foliar fertilization did not differ statistically from each other in row planting. However, they differed from the Organic + Mineral and Organic treatments, which had the highest fresh mass (Table 5). The values to Organic + Mineral and Organic fertilization, exceeded by 43.71% and 55.73%, respectively, the Mineral fertilization. However, for planting in quincunxes, there was no significant difference

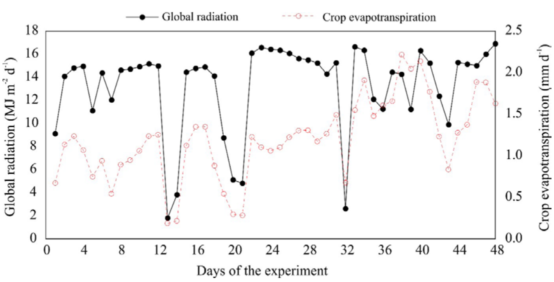

Figure 2. Variation of global radiation and crop evapotranspiration over the 48 days of the experiment.

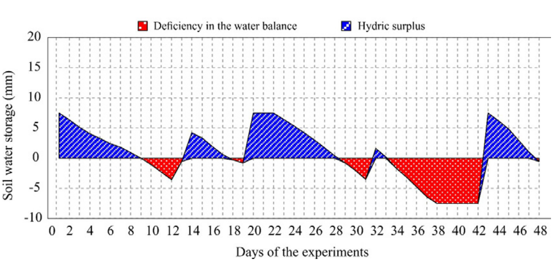

Figure 3. Extract of the water balance of the experimental area during the 48 days of conducting the experiment.

between the Mineral + Foliar and Organic + Mineral treatments; however, they differed from the Mineral and Organic treatments, which did not differ statistically from each other and had higher fresh mass, which were 35.21% and 33.10 and 47.73% and 46.02%, respectively, superior to Mineral + Foliar, and Organic + Mineral ($p \leq 0.05$). The splitting of fertilizers within the types of planting indicated that only the Mineral and Organic + Mineral treatments differed for row and quincunx planting, being the planting in quincunxes 40.14% superior to inline in mineral treatment; and 37.09% inline for Organic + Mineral.

Fresh mass is one of the main parameters to assess yields obtained in production, whether in crops, greenhouse or experimental modules (Rabelo, 2015). The splitting of planting in a row within the fertilizers indicates that the most promising results for the production of fresh mass were obtained in the Organic and Organic + Mineral treatments (Table 5). With organic fertilizer, the soil becomes more fertile and productive, increasing its biodiversity and improving the food quality generated from this practice. It is known that leafy vegetables respond very well to organic fertilization (Oliveira et al., 2010). Therefore, in this experiment, it was possible to infer that the mineralization of organic matter occurred promptly to supply nutrients to the plants (Peixoto Filho et al., 2013).

For the quincunx system, the highest values obtained for fresh mass were observed in the Organic and Mineral treatments (Table 5) which did not differ from each other. However, in the inline cultivation system, the treatments with the highest fresh mass were Organic + Mineral and Organic. In the treatment based on mineral fertilization, a difference was observed between the inline and quincunx systems, which surpassed that one. The Mineral + Foliar and Organic + Mineral treatments with inferior results, however, did not differ from each other. This inferiority in the results may have occurred due to the high number of plants in the area, providing a lower availability of factors that lead to plant development.

The fresh mass estimates presented adjustment to the expolinear model as a function of the accumulated degree days after transplanting (Figure 4). The models presented coefficients of determination of 0.9876 (mineral inline), 0.9750 (mineral in quincunxes), 0.9233 (mineral + foliar inline), 0.9551 (mineral + foliar in quincunxes), 0.9944 (organic + mineral inline), 0.9802 (organic + mineral in quincunxes), 092781 (organic inline) and 0.9325 (organic in quincunxes).

Table 5. Fresh mass (g) of Iceberg lettuce observed at harvest.

Treatments	Fresh mass		CV
	inline	quincunxes	
Mineral	141.67bB	236.67aA	33.50
Mineral + Foliar	173.33bA	153.33bA	
Organic + Mineral	251.67aA	158.33bB	
Organic	320.00aA	293.33aA	

Averages followed by the same lowercase letter in the columns and uppercase in the rows do not differ by the Tukey test at 5% probability. CV = Coefficient of variation.

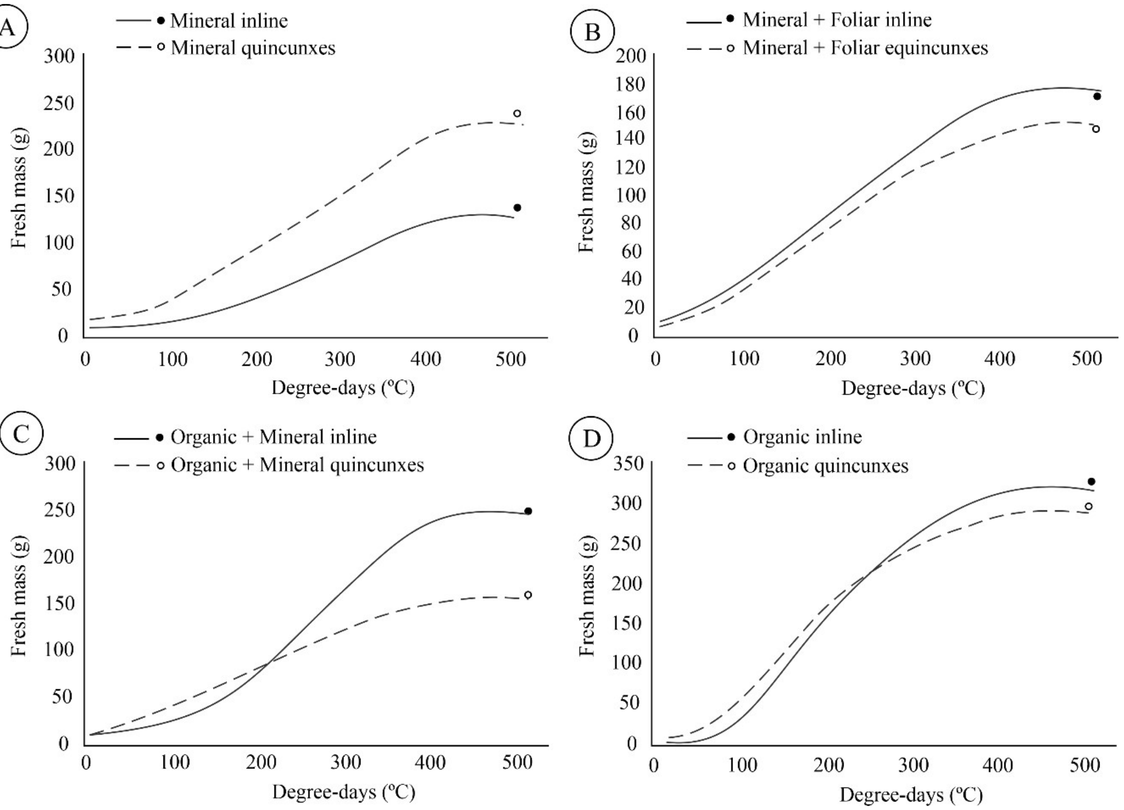

Figure 4. Fresh phytomass in relation to the accumulated degrees-day of Iceberg lettuce after seedling transplantation for the evaluated treatments. (A) Mineral fertilization; (B) Mineral + Foliar fertilization; (C) Organic + Mineral fertilization; (D) Organic fertilization.

Throughout the experiment, the accumulation of degree days was 514 GD, a value very close to that found by Araújo et al. (2010), who observed 557 degree days in a protected environment. The growth model used proved to be faithful to the development behavior of the crop throughout its cycle, which allows for a better understanding of the climate-plant interrelationship. Through the models presented in Figure 4, it is possible to see that treatments with mineral fertilization are a characteristic of more accentuated growth and the initial accumulation of degree days. Conversely, the slope of the curves of treatments with organic fertilizer is smoother. This behavior may be associated with the faster release of nutrients by chemical fertilizers. It is also possible to verify that the inline cultivation allowed a more significant accumulation of fresh mass by the plants, except for the combination of mineral treatments inline.

These results may be associated with less competition between plants since the plots of treatments in lines had a smaller population of lettuce plants. Vasconcelos et al. (2017), using different spacings in the lettuce crop, cultivar Vera, obtained in the 20 × 20 cm spacing, 187.60 g of fresh mass per plant and in the 25 × 25 cm spacing, 195.16 g of fresh mass per plant, in fieldwork under environmental conditions in Pombal – PB, which indicates that a larger plant population results in less fresh mass.

In Table 6 the values referring to the number of leaves of the Iceberg lettuce obtained after harvest are presented. There was a significant difference for the fertilizers, the types of planting, and the interaction between the factors ($p \leq 0.05$). When analyzing the unfolding of the interaction, it was found that the treatments based on Mineral, Mineral + Foliar fertilization did not differ statistically from each other in the row planting. However, they differed from the Organic treatment, which overcame the mineral treatment by 25.48%, and 20.32% compared to Mineral + Foliar. In turn, the Organic + Mineral treatment did not differ from the others ($p \leq 0.05$). For planting in quincunxes, none of the treatments differed significantly from each other ($p \leq 0.05$). The splitting of fertilizers within the types of planting indicated that only the Organic treatment differed for row and quincunx planting, with row planting being 30.33% higher than quincunx planting.

The Organic and Organic + Mineral treatments obtained the highest number of leaves. The greater number of leaves followed in the Organic cultivation system may be related to the functions that organic fertilizers exert on the physical, chemical, and biological properties of the soil since they have conditioning effects and increase the soil's capacity to store nutrients necessary for the plant's development (Oliveira et al., 2010). The highest productions can be obtained from the improvement of the chemical and physical-chemical characteristics of the soil, which can be obtained with the addition of increasing doses of organic compounds (Souza et al., 2005).

Table 6. Number of Iceberg lettuce leaves observed at harvest time.

Treatments	Lettuce leaves		CV
	inline	quincunxes	
Mineral	21.67bA	18.92aA	16.13
Mineral + Foliar	23.17bA	22.00aA	
Organic + Mineral	25.25abA	22.58aA	
Organic	29.08aA	20.25aB	

Averages followed by the same lowercase letter in the columns and uppercase in the rows do not differ by the Tukey test at 5% probability. CV = Coefficient of variation.

In quincunx planting, the treatments did not differ statistically. On the other hand, in splitting the fertilizer within the planting in quincunxes, there was a significant difference only for the Organic treatment. In this case, interspecific competition (nutrient, water, and light) was more intense, probably due to differences in population density compared to row cultivation and plant growth until harvest (Oliveira et al., 2010).

Although the viability of organically grown vegetables has not been evaluated, this seems to be an excellent alternative for small and medium producers due to the ease of obtaining straw and residue used as a source of nutrients, in this case, poultry shed litter. Luz et al. (2007) compared conventional and organic production's agronomic and economic aspects, including productivity, production cost, and profitability. They concluded that the organic system was agronomically viable, with a production cost 17.1% lower than the conventional and profitability up to 113.6% higher.

4. Conclusion

Mineral fertilization, isolated, and associated with foliar fertilization did not differ for the studied variables, both in the row planting system and in quincunx. On the other hand, organic fertilization associated with planting in quincunx stood out in relation to other treatments, reflecting in a greater number of plants and, consequently, better use of the area. Furthermore, in the quincunx planting system, a greater number of leaves was obtained in the plants fertilized with the combination of organic and mineral sources.

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