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ORIGINAL RESEARCH ARTICLE

Modalities and planting seasons in lettuce cultivation in Gurupi, state of Tocantins (Gurupi-To), Brazil

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ABSTRACT

Lettuce (*Lactuca sativa* L.) is the main leafy vegetable grown in Brazil. Its productivity and quality are limited by the growing season, the nearby environment and the type of cultivar adopted. The objective of this work was to verify at different times of the year the best planting environment for lettuce cultivation in a semi-humid tropical climate. For this purpose, an experiment was set up in three different seasons (October–November 2014, January–March, May–July 2015). The experimental design was randomized blocks, in a 3 × 3 × 2 factorial arrangement, consisting of three seasons, three cultivars (cvs. Vera®, Tainá® and Rafaela®) and two growing environments (low tunnel with beds protected with mulching consisting of soil protection with plastic fabric covering, and beds without protection or conventional cultivation) and four replicates per treatment. Plant biomass, stem length, head diameter, number of leaves per head and crop productivity were evaluated as response parameters. The results showed that the May–July period favored biomass production, head diameter and productivity. Despite the similarity between varieties, the variety Vera® is more productive in biomass, number of leaves per head, stem length and productivity. The low tunnel planting system with mulching is adequate under the conditions evaluated for lettuce cultivation. This system in the May–July period favors a superior development in the characteristics biomass, head diameter and productivity, if compared to conventional cultivation during the October–November period.

Keywords: Controlled Environment; Biomass; *Lactuca Sativa* L.; Mulching

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1. Introduction

Lettuce (*Lactuca sativa* L.) is the most widely consumed and traded leafy vegetable worldwide, due to its culinary characteristics and cultural acceptance, as well as its high production throughout the year[1]. In Brazil, this crop is grown in an area of 10,500 ha and production is at 6,778 boxes/ha, each of which includes nine dozen heads of lettuce[2]. With an average annual consumption of 3 kg per capita, it is among the main cultivated vegetables and ranks sixth among the most consumed vegetables in Brazil[3].

Lettuce is a crop that is grown both in the field and in a protected environment, i.e., with soil cover and in greenhouses. In open fields, the crop receives more irradiation than in controlled environments, which benefits the plantations in periods with temperatures that favor the performance of the species, especially when a variety suitable for the region is used[4].

Cultivation in a protected environment facilitates the production of this vegetable under different limiting conditions for its development compared to conventional cultivation in open fields. The soil covering technique, also known as mulching or soil protection with plastic

sheeting, is associated with greenhouse crops and represents an alternative for increasing the production and quality of vegetables[5]. This soil protection technique reduces water consumption and soil temperature variations[6]; it also helps to control invasive plants and pests and to protect cultivated plants from direct contact with the soil[7]. Some studies have shown that the use of ground cover such as mulch favors the establishment of favorable microecology in the soil[8].

The use of "stove" type greenhouses cause an increase in temperature within this type of environment, being an undesirable condition for cultivation in tropical conditions, in addition to the high initial costs for its implementation[9]. Notwithstanding its disadvantages, the greenhouse allows cultivation in seasons that are not normally suitable for outdoor production. This system also allows reducing irrigation needs, through a more efficient use of water for plants and a better use of production resources (nutrients, sunlight and CO_2). This results in a reduction of the crop cycle and the use of inputs[10].

There is a clear lack of studies on the adaptation of lettuce varieties in different environments, so the producer uses varieties recommended by seed companies, often not adapted[11]. In the State of Tocantins, Brazil, lettuce is grown all year round, with a lower proportion during the summer period due to the rainy season and high temperatures. The objective of this study was to verify, in different seasons, which is the best planting environment for lettuce cultivation in the semi-humid tropical climate of the region.

2. Materials and methods

The experiment was conducted in the Olericulture sector of the Gurupi University Campus—CAUG, of the Fundación Universitaria Federal de Tocantins, located at 11°43′45″ S and 49°04′07″ W, at 280 m above sea level. The region has a tropical semi-humid climate, with a dry season of approximately 4 months, an average annual temperature of 29 °C and annual rainfall of 1,804 mm. The climate is AW—Tropical type with a humid summer and a dry period in winter[12]. The dry period varies between 3 and 5 months with an annual rainfall increasing from South (1,500 mm) to North (1,750 mm) and from East (1,000 mm) to West (1,800 mm). January is the rainiest month and August the driest[13]. The climatic conditions in the experimental period are presented in **Figure 1**.

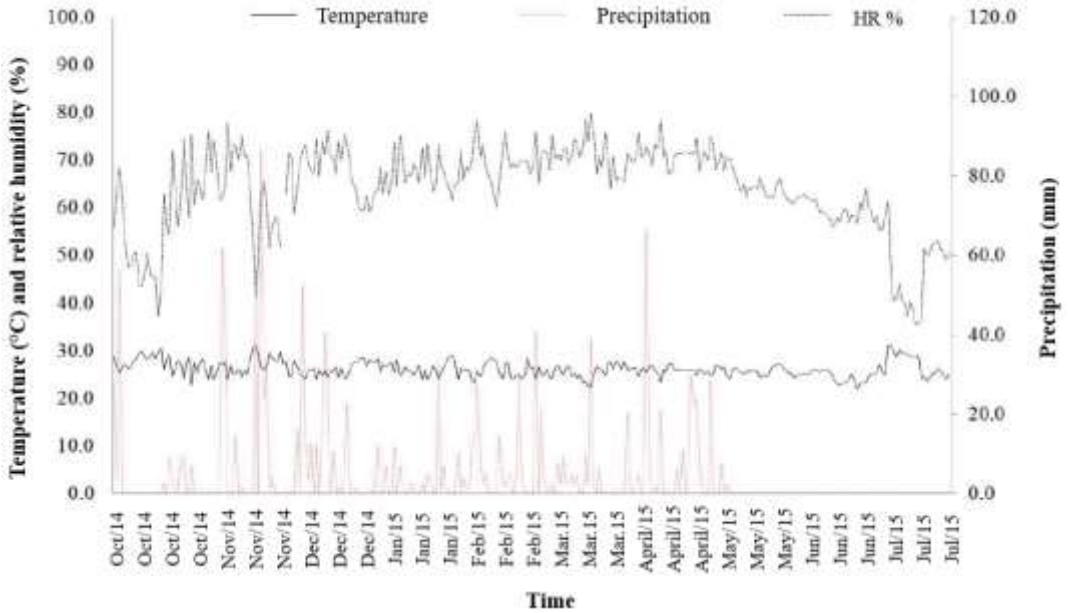

Figure 1. Temperature (°C), relative air humidity (%) and rainfall (mm) during the period of the experiment. Gurupi-TO, 2015[13].

The work included three evaluation periods (1) October–November 2014; (2) January–March and (3) May–July 2015. In each period, the lettuce varieties Vera® and Tainá® from Sakata Seed South

America and Rafaela® from Feltrin were evaluated in two different growing environments: tunnel under a 150 µm plastic sheeting and beds protected with mulching, and unprotected beds or conventional cultivation.

The experimental design was a randomized block design with a 3 × 3 × 2 factorial arrangement consisting of three growing seasons, three lettuce cultivars and two growing environments, distributed in four replicates per treatment. Each plot consisted of 15 plants established at 25 cm between plants and between rows.

At all planting times, seedlings were produced in nursery in expanded polystyrene trays of 200 cells containing commercial Bioflora substrate®. Seedlings were transplanted for both growing environments when they had between 4 and 6 true leaves.

Drip irrigation was used with a 25 cm spacing between drops and a flow rate of 2 lt/h, applied for 2 h/day, distributed equally in the morning and in the afternoon. Fertilization was applied according to the results of the soil analysis. Clay contents were adequate, phosphorus (P) was high and potassium (K) was medium (**Table 1**). The equivalent fertilization doses applied consisted of 400 kg/ha of NPK (formula 04-14-08) and dry bovine manure was incorporated as a source of organic matter.

Table 1. Chemical attributes and granulometry of the soil used in the experiment, between 2014 and 2015 in semi-humid tropical climate

Year	pH	P meh	K	—	K	Ca	Mg	Al	H + Al	M.O.	C.O.	—	Clay	Silty	Full sand
	$CaCl_2$	mg dm^{-3}			cmolc dm^{-3}					dag kg^{-1}			%		
2014	5.8	46.3	61		0.16	3.3	1	0	2.0	1.9	1.1		18.5	5	76.5
2015	5.5	12.0	80		0.2	1.6	1	0	1.6	1.9	1.1		18.5	5	76.5

M.O.: organic matter; C.O.: organic carbon.

At each planting time for each variety, the following variables were evaluated: (1) plant biomass (g); (2) stem length (cm); (3) transverse head diameter (cm); (4) number of leaves per head; and (5) equivalent yield (mg/ha) based on the weight of each plant in the useful plot.

In each season, individual analysis of variance followed by joint analysis of variance was performed, after comparison of the ratio between the mean squares of the residuals of each date[14], considering variety, environment and sowing season as fixed effects. Based on the statistically significant value of each factor in the analysis of variance, comparisons of individual averages and interactions were made using Tukey's test[15].

3. Results and discussion

The analysis of variance showed significant effects ($P < 0.05$) of planting times, environments and varieties on all the characteristics evaluated (**Table 2**). However, no effect was found in the interactions for the trait aboveground biomass (**Table 3**). The characteristics head diameter and number of leaves showed significant effect ($P < 0.05$) of time and environment, while the former was affected by the interaction time × variety, the latter was affected by time × environment. Yield was affected ($P < 0.05$) by environment and variety and stem length by growing season. Souza *et al.*[16] worked with heat-resistant lettuce plants in Vitória de Santo Antao-PB, found that the characteristics most affected by environment were stem length and early production of reproductive buds.

Fresh green matter production. In the case of conventional cultivation, differences were found due to the effect of the environment × season interaction (**Table 3**) with high yields in the January–March and May–July seasons; while the lowest results were found in the October–November period, which coincided with the season of highest rainfall.

In the tunnel/mulching environment, the highest yields were found in the May–July period, which coincided with the period of lower rainfall and consequently with a greater availability of root oxygen; in this type of crop, the plant's water demand was satisfied with the application of irrigation.

For the interaction of time and environment, the highest yields were achieved with the varieties grown in tunnels with mulching soil cover. These results coincide with the findings of Al-Assir *et al.*[17] who determined that in soils with plastic

mulching there is a higher level of nitrate in relation to open field (conventional) cultivation, and the level of nitrogen is favorable in the production of romaine lettuce.

The interaction of seasons by varieties (**Table 4**), in the periods from October to November and May to July was not significant ($p > 0.05$), and in January to March, the Vera® variety was superior to the other varieties ($p \leq 0.05$), this is due to the fact that the variety was developed to be tolerant to high temperatures and resistant to bolting. Analyzing the sources of variation within the environments, the Rafaela® variety presented better results in the period from October to November and May to July, and with lower values in the Jan/March period, the three varieties did not present statistical differences in the planting seasons, thus indicating that these materials have good adaptability for this region.

Table 2. Analysis of variance for the variables biomass of aerial part (MF), head diameter (HD), total number of leaves (NL), stem length (SL) and Productivity (PR) of three lettuce varieties in three planting seasons and two growing environments in Gurupi, Centro-Sul region of the state of Tocantins (Gurupi-TO), 2015

FV	GL	QM				
		MF (g)	HD (cm)	NL	SL (cm)	PR (t/ha^{-1})
Epoch	2	6,970.56^{ns}	81.41**	443.95**	63.30**	175.71^{ns}
Block (Repeat)	3	11,095.68*	43'06*	19.32^{ns}	4.78^{ns}	282.88*
Environments	1	77,284.12**	78.29*	190.90**	1.34^{ns}	1.984.71**
Varieties	2	12,326.49*	5.49^{ns}	20.82^{ns}	8.31^{ns}	312.69*
Seasons × Environments	2	6,961.83^{ns}	74.20**	30.38*	5.52^{ns}	179.94^{ns}
Seasons × Varieties	4	4,043.49^{ns}	9.66^{ns}	2.78^{ns}	4.52^{ns}	103.44^{ns}
Environments × Varieties	2	68.94^{ns}	33.55^{ns}	4.8^{ns}	2.78^{ns}	177.39^{ns}
Medium Error	49	2,917.37	13.85	7.75	3.18	74.74
C.V		37.58	14.71	17.98	33.57	37.62
General Average		143.72	25.31	15.49	5.27	22.98

^{NS}: Not significant, at $p \leq 0.05$, by F-statistic value, in Tukey's test.

Table 3. Biomass (g) of three lettuce varieties in three planting seasons and two growing environments in the Centro-Sul region of Tocantins state, Gurupi-TO, Brazil, 2015

Environments × Seasons			
	Oct/Nov	Jan/Mar	May/Jul
Conventional	97.58 Bb	120.42 Aa	114.88 Ba
Low tunnel with mulching	167.87 Ab	149.75 Ab	211.83 Aa
Seasons × Varieties	Rafaela	Taina	Vera
Oct/Nov	131.73 Aa	135.12 Aa	131.34 Aa
Jan/Mar	95.75 Bb	127.22 Aab	182.28 Aa
May/Jul	136.89 Aa	166.50 Aa	186.66 Aa
Environments × Varieties			
	Rafaela	Taina	Vera
Conventional	97.44 Ba	120.98 Aa	114.46 Ba
Low tunnel with mulching	145.48 Ab	164.92 Aa	219.06 Aa

Means with the same lowercase letters horizontally and uppercase letters vertically are statistically equal to each other (Tukey $p \leq 0.05$).

Table 4. Transversal diameter (cm), of three lettuce varieties in three planting seasons and two growing environments in the Centro-Sul region of the state of Tocantins, Gurupi-TO, 2015

Environments × Seasons			
Conventional	Oct/Nov	Jan/Mar	May/Jul
Low tunnel with mulching	22.90 Ba	24.69 Aa	25.21 Ba
	26.91 Aa	22.72 Ba	29.43 Aa
Seasons × Varieties			
	Rafaela	Taina	Vera
Oct/Nov	25.50 ABa	24.53 Aa	24.68 Aa
Jan/Mar	22.97 Ba	25.53 Aa	22.61Aa
May/Jul	27.95 Aa	26.99 Aa	27.02 Aa
Environments × Varieties			
	Rafaela	Taina	Vera
Conventional	23.29 Ba	25.86 Aa	23.65 Aa
Low tunnel with mulching	27.65 Aa	25.51 Aa	25.89 Aa

Means with the same lowercase letters horizontally and uppercase letters vertically are statistically equal to each other (Tukey $p \leq 0.05$).

In the environment × variety interaction, there was no significant difference between the varieties evaluated in the conventional and low tunnel cultivation systems with mulching. The varieties Taina®

and Vera® did not differ statistically and presented superiority over the variety Rafaela®, this is due to the fact that the variety Vera® was developed with characters of resistance to flowering and to be more tolerant to higher temperatures[18,19].

In the performance of the varieties by environments, the three varieties show superior results in low tunnel with mulching, this is due to the cultivation conditions and the good response of the varieties, since they belong to the American group and are adapted to climatic conditions similar to those of Gurupi, Tocantins.

Oliveira *et al.*[20] evaluated the phenotypic stability of lettuce varieties, and highlighted that whole plant biomass is influenced by variety, photoperiod and temperature. This work showed the superiority of cultivation in low tunnel in relation to the other environments, in the three seasons evaluated. The use of this technique resulted in an increase in the earliness and quality of the harvested lettuce plant.

The low tunnel prevents the direct incidence of light on the plants, allowing better development, and mulching helps maintain soil moisture and reduce competition with weeds for nutrients. When these two types of cultivation methods were compared with the conventional method, the plant biomass results were lower in the conventional method.

According to Vecchia *et al.*[18] the Vera® variety was developed to be resistant to premature flowering, which makes it more tolerant to temperature variations considered not ideal for lettuce cultivation.

In the interaction between environments and seasons (**Table 5**), no significant differences were found between planting seasons for the plant diameter characteristic of the conventional crop, and the same was observed for the low tunnel crop with mulching.

Analyzing time × environment, between the months of October to November in the low tunnel cultivation, the highest results were obtained, while for the months of January to March, the highest averages were observed with the conventional system, in some cases the protected environment can accelerate the development of the plant, making it reach its commercial stage faster and with smaller diameter, this fact was observed for that specific time. The varieties from May to July, the largest diameters were observed in low tunnel environment with mulching.

Table 5. Mean stem length size (cm) of three lettuce varieties in three planting seasons and two growing environments in the Centro-South region of Tocantins state, Gurupi-TO, 2015.

Environments × Seasons			
	Oct/Nov	Jan/Mar	May/Jul
Conventional	5.94 Aa	6.66 Aa	2.80 Ab
Low tunnel with mulching	6.29 Aa	5.94 Aa	3.99 Ab
Seasons × Varieties			
	Rafaela	Taina	Vera
OctNov	5.70 ABb	4.93 ABb	7.71 Aa
Jan/Mar	6.30 Aa	6.21 Aa	6.38 Aa
May/Jul	3.59 Ba	3.03 Ba	3.58 Ba
Environments × Varieties			
	Rafaela	Taina	Vera
Conventional	4.73 Aa	4.93 Aa	5.75 Aa
Low tunnel with mulching	5.67 Aa	4.51 Aa	6.04 Aa

Means with same lowercase letters horizontally and uppercase letters vertically are statistically equal to each other (Tukey $p \leq 0.05$).

The purpose of total or partial plant protection is to reduce climatic weathering. Maggi *et al.*[21] evaluated lettuce varieties in protected environments, also found greater head diameter in the American type lettuce crop in the period from May to June, coinciding with the same time of the experiment.

Analyzing the season by variety interaction (**Table 4**), there was no significant difference between the three varieties when they were evaluated in the period from October to November, while for the period from January to March the best results were obtained for the varieties Taina® and Vera®. And for the period from May to July, there were no significant differences between the three varieties. In the interaction of varieties within seasons, the

best results were obtained for the Rafaela® variety in the period from May to July. There was no significant difference for the varieties Taina® and Vera®, regardless of the time of sowing.

In the interaction, environments by varieties (**Table 4**), there was no statistical difference between the three varieties in conventional cultivation (in bed), and the same was true for low tunnel cultivation with mulching. Therefore, the results obtained indicate that the environments do not interfere for a greater plant diameter. However, analyzing the varieties in the same environment-by-variety interaction, it was found that the Rafaela® and variety® for low tunnel cultivation with mulching obtained the best results, and the Rafaela® and Vera® varieties did not differ between the two cultivation environments.

According to Colturato *et al.*[22], the use of agro textile as plant protection has shown good results, showing as advantages the early harvest, increased production, physical barrier, improvement in the quality of the final product, improved sanitation, maintenance of soil moisture, precocity and quality in the production of seedlings, among others.

Santi *et al.*[23] evaluated the head diameter of different lettuce varieties subjected to organic matter sources and found that the Rafaela® variety had the highest organic matter assimilation and consequently the largest head size.

Radin *et al.*[24] studied different environments for the cultivation of lettuce, and found that lettuce plants grown in protected environments reached a higher leaf area index, and consequently a greater volume of leaves, in Eldorado del sur—RS, possibly due to the difference in humidity and temperature inside the low tunnel, resulting in a corroboration for those found for the Rafaela variety®.

For the characteristic stem length in the interaction of environments by seasons, for conventional cultivation, the highest results were found in the periods from October to November and from January to March, showing superiority in the period from May to July (**Table 5**), the same occurs for cultivation in low tunnel with mulching, where the periods from October to November and from January to March were superior to the period from May to July, where in this period there was a greater range of temperature variation (18 to 34 °C), possibly causing a physiological disorder in the plants.

Plants grown in greenhouses or greenhouses are subject to a spatial variability of evapotranspiration more intensified than in an open environment, due to the confinement of air temperature inside the greenhouse, since there is a reduction in the incidence of winds, reducing heat exchange[25].

In the splitting of seasons by environments, the varieties in the periods from October to November and from January to March did not show statistical differences and presented results superior to those found in the periods from May to July, for the two lettuce environments. These characteristics cannot be analyzed in isolation due to the relationship of stem length with the number of leaves per plant, and also to take into consideration that plants with greater stem length indicate early bolting, which is an undesirable characteristic in lettuce.

According to Whitaker and Ryder[26], lettuce is characterized as a temperate climate species, and temperature is the environmental factor that most influences the formation of leaves, head and stem elongation. According to Souza *et al.*[16], the emission of floral bolting is stimulated by high temperatures.

In the period by variety interaction (**Table 5**), in the period from October to November the Vera® variety obtained superior results, for the period from January to March there was no significant difference between the three varieties, and the same occurred for the period from May to July. In the interaction between varieties by season, the Rafaela® variety obtained better results in the period from January to March, and the same occurred for the Taina® variety, while the Vera® variety obtained superior results in the periods from October to November and from January to March.

According to Sala and Costa[27], the variety Vera® was developed as a slow bolting variety, suitable for tropical areas and high temperatures, a condition existing in the state of Tocantins. In the interactions environments by varieties and varieties by environments (**Table 5**), there was no statis-

tical difference, showing that there was no effect of environment on the varieties and vice versa. For the varieties Taina® and Vera®, there was no statistical difference between environments.

Souza *et al.*[16], when studying the progenies of heat tolerant lettuce, found variation in stem length from 3.44 cm to 9.94 cm, in the state of Pernambuco, concluding that the effect of temperature environment interfered for a greater stem length, a characteristic that is correlated to bolting.

Long photoperiods and high temperatures (above 25 °C) stimulate stem length and flower bolting, which indirectly affect the other characteristics evaluated.

For the number of leaves in lettuce, the best results were obtained in the period from October to November (**Table 6**), the same was observed for the low tunnel cultivation with mulching, which is acceptable, considering that lettuce is a leaf vegetable.

For the interaction between seasons and environments, from October to November the low tunnel crop showed the best results, and for the periods from January to March and May to July there was no significant difference between the two environments.

In the interaction of seasons by varieties, there was no statistical difference between the three seasons for the three varieties (**Table 6**), however, for the interaction of varieties by seasons, all varieties presented greater quantities of leaves in the period from October to November, with the planting season being a decisive factor for greater productivity.

Table 6. Means for total number of leaves of three lettuce varieties in three planting seasons and two growing environments in the Centro-Sul region of the state of Tocantins, Gurupi-TO, 2015

Environments × Seasons			
	Oct/Nov	Jan/Mar	May/Jul
Conventional	17.33 Ba	10.89 Ab	13.36 Ab
Low tunnel with mulching	23.19 Aa	12.91 Ab	15.25 Ab
Seasons × Varieties			
	Rafaela	Taina	Vera
Oct/Nov	19.69 Aa	20.22 Aa	20.50 Aa
Jan/Mar	11.22 Ba	13.83 Ba	12.50 Ca
May/Jul	13.69 Ba	11.99 Ba	16.08 Ba
Environments × Varieties			
	Rafaela	Taina	Vera
Conventional	12.54 Ba	13.76 Ba	12.28 Ba
Low tunnel with mulching	16.73 Aa	16.00 Aa	17.00 Aa

Means with the same lowercase letters horizontally and uppercase letters vertically are statistically equal to each other (Tukey $p \leq 0.05$).

Table 7. Means for productivity (mg ha^{-1}), of three lettuce varieties in two planting seasons and three growing environments in the Centro-Sul region of the state of Tocantins, Gurupi-TO, 2015

Environments × Seasons			
	Oct/Nov	Jan/Mar	May/Jul
Conventional	15.61 Ba	19.27 Aa	18.31 Ba
Low tunnel with mulching	26.85 Aba	23.96 Ab	33.88 Aa
Seasons × Varieties			
	Rafaela	Taina	Vera
Oct/Nov	21.08 Aa	20.36 Aa	21.00 Aa
Jan/Mar	15.32 Bb	20.62 Aab	29.17 Aa
May/Jul	21.90 Aa	26.62 Aa	29.78 Aa
Environments × Varieties			
	Rafaela	Taina	Vera
Conventional	15.59 Ba	19.34 Ba	18.26 Ba
Low tunnel with mulching	23.28 Ab	26.40 Ab	35.03 Aa

Means with the same lowercase letters horizontally and uppercase letters vertically are statistically equal to each other (Tukey $p \leq 0.05$).

Grangeiro *et al.*[28], in work with lettuce, verified that shading provided higher dry mass production, both in the seedling formation phase and in the field phase.

In the interaction of environments by varieties (**Table 6**), there was no difference in the environments of conventional cultivation and low tunnel cultivation with mulching. For the three varieties, the best results were obtained in the low tunnel environment with mulching.

According to Souza *et al.*[16] the characteristics number of leaves, plant diameter and plant fresh

weight are the most important agronomic traits for commercialization.

Radin *et al.*[24], evaluated the number of leaves of lettuce cultivated in open field and in protected environment, finding that when the culture is conducted in protected environment, the number of leaves is higher than those cultivated in open field. The use of protected environments helps to increase the number of leaves, if compared to cultivation with direct solar radiation, mainly in tropical climate regions. This result was confirmed in the present study.

According to Oliveira *et al.*[20], in lettuce production, leaf number is an important characteristic and is closely associated with the temperature of the growing environment and photoperiod. Radin *et al.*[24] observed differences in the number of leaves between Regina, Veronica and Marisa varieties, both those grown in greenhouses and those grown in open fields.

Results similar to those of this study were found by Grangeiro *et al.*[28] who verified leaf number means between the environments of ample light from 16.05 to 18.28. Suggesting that this difference in the results found may be related to the difference between growing environments, since the characteristic leaf number can be influenced by the environment, climate and genetic factor.

For productivity, in the interaction of environments by planting seasons (**Table 7**), there was no significant difference between the three seasons in the conventional crop. While for the low tunnel crop with mulching, high results were obtained in the periods from October to November and from May to July.

For the interaction between seasons and environments, in the period from October to November good results were obtained in the low tunnel cultivation with mulching, in the period from January to March there was no significant difference, for the period from May to July the best result obtained was the low tunnel cultivation with mulching.

In the interaction of seasons by varieties (**Table 7**) in the period from October to November, no significant difference was observed among the varieties, for the period from January to March the best results were obtained in the Vera® variety. For the experiment that was installed in the period from May to July, there was no significant difference between the three varieties.

Analyzing the interaction between varieties within seasons (**Table 7**), the Rafaela® variety showed high results in the period from October to November and from May to July, while for the Taina® and Vera® varieties no significant difference was observed.

In the interaction between environments and varieties (**Table 7**), there was no significant difference between the three varieties in the evaluation of conventional cultivation; however, for low tunnel with mulching, the best results were obtained for the Vera® variety. In the interaction between varieties and environments, the three varieties performed best when grown in low tunnel with mulching.

The air temperature inside the protected environment can vary according to the type of cover, opening, windows and curtains, with the soil cover and the incidence of solar radiation. According to Cermeño[29], these temperatures are not closely linked to the energy balance, which can accelerate the vegetative development of the plants. For the experiment installed in the months of January to March, there was no statistical difference between the cultivation environments, however, the low tunnel cultivation proved to be the one with the highest productivity, when productivity was compared between the environments.

Tosta *et al.*[11], verified that lettuce productivity, when planted in beds protected by black plastic, allowed higher productivity (42.31 mg ha^{-1}), with results superior to conventional cultivation. Araújo *et al.*[30] evaluated lettuce varieties in protected environments, obtaining productivity ranging from 16.9 to 29.5 mg ha^{-1}, values lower than those found in this study.

4. Conclusions

The May/Jul planting period favors the lettuce crop in biomass, head diameter and productivity for the low tunnel system with mulching. The Vera® variety is the most recommended lettuce crop

for biomass, number of leaves per head, stem length and productivity despite having similarity with the other varieties evaluated. The low tunnel cultivation system associated with mulching is considered adequate under the conditions evaluated for lettuce cultivation. The May/Jul period associated with the low tunnel cultivation system with mulching presented a superior development in the characteristics biomass, head diameter and productivity, in relation to the conventional cultivation during the Oct/Nov period.

Conflict of interest

The authors declare that they have no conflict of interest.

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