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PERFORMANCE OF LETTUCE CULTIVARS UNDER ORGANIC SYSTEM IN NORTHERN STATE OF MINAS GERAIS

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ABSTRACT: Lettuce is the most consumed leafy vegetable in the world. In Brazil, production is carried out mainly in green belts around cities. In this context, it is necessary to evaluate lettuce cultivars in specific edaphoclimatic conditions in which they are grown. The aim of this work was to identify the genetic materials of the lettuce cultivars most adapted to the region of Northern Minas Gerais. The experiment was conducted at the Agroecology Unit of the Federal Institute of Education, Science and Technology of Northern Minas Gerais (IFNMG) – Campus of Januária, in an open environment in an organic cultivation system. Seven lettuce cultivars, Isabela, Margarete, Mônica, Valentina, Vanda, Veneranda and Vera, were evaluated in a randomized block design with four replicates. At harvest, number of leaves, leaf area, leaf and stem dry mass, stem length, head dry mass and commercial yield were evaluated. Vera and Veneranda cultivars presented higher yield potential compared to the other cultivars. For combining higher yields and resistance to bolting, compared to Veneranda cultivar, Vera cultivar is the most recommended, and Margarete cultivar is the least suitable for cultivation in the warmer season in Northern Minas Gerais.

KEYWORDS: *Lactuca sativa* L, bolting, yield

DESEMPENHO DE CULTIVARES DE ALFACE TIPO CRESPA SOB SISTEMA ORGÂNICO NO NORTE DE MINAS GERAIS

RESUMO: A alface é a hortaliça folhosa mais consumida no mundo. No Brasil, a produção é realizada principalmente nos cinturões verdes das cidades. Dentro desse contexto é preciso avaliar as cultivares de alface nas condições edafoclimáticas específicas nas quais serão cultivadas. O trabalho foi realizado com o objetivo de identificar os materiais genéticos de alface tipo crespa mais adaptados à região do Norte de Minas Gerais. O experimento foi conduzido na Unidade de Agroecologia do Instituto Federal de Educação e Ciência e Tecnologia do Norte de Minas Gerais (IFNMG) – Campus Januária, em ambiente aberto em sistema orgânico de cultivo. Foram avaliadas sete cultivares de alface tipo crespa, Isabela, Margarete, Mônica, Valentina, Vanda, Veneranda e Vera, em delineamento experimental de blocos ao acaso com quatro repetições. Na colheita foram avaliados número de folhas, área foliar, massa seca de folhas e caule, comprimento de caule, massa seca de cabeça e produtividade comercial. As cultivares Vera e Veneranda apresentaram potencial produtivo superior em relação as demais cultivares. A cultivar Vera por combinar maiores produtividade e resistência ao pendoamento em relação a cultivar Veneranda é a mais recomendada, e a cultivar Margarete é a menos indicada para o cultivo na estação mais quente no Norte de Minas Gerais.

PALAVRAS CHAVE: *Lactuca sativa* L, pendoamento, produtividade

INTRODUCTION

Agroecological organic agriculture seeks to explore the potential of the local agrosystem through forms of sustainable management with regard to economic, social, cultural and environmental principles.

The production of vegetables in the organic system is a growing activity around the world, which

highlights the use of family labor, crop diversity and less dependence on external resources (Sediyama et al., 2014).

Within the production of vegetables in Brazil, lettuce is well developed, but there are some problems in the cultivation of this vegetable under national conditions due to the low tolerance to high temperatures and long days, since it is a typically temperate vegetable, making temperature and light decisive factors for high production (Suinaga et al., 2014). Also according to the authors, to enable cultivation in warmer regions of the country, genetic improvement and evaluation of cultivars are being carried out.

Due to the large territorial extension of Brazil, cultivars and new accessions must be tested under the specific conditions in which they will be produced (Araújo Neto et al., 2012). A good cultivar must present, under different environmental conditions, high yield and quality.

In work carried out in the municipality of Cáceres-MT, Santos et al. (2009) verified that Vanda and Isabela cultivars had the lowest stem length values, indicating greater resistance to bolting, whereas in Brasília-DF, Vanda and Verônica cultivars presented good agronomic performance (Suinaga et al., 2014).

Under the edaphoclimatic conditions of Cáceres-MT, greater stem length was observed for cultivars cultivated in open field, compared to the same cultivars cultivated in protected environments. The cultivar that showed the greatest resistance to bolting was Isabela in the protected environment using 50% heat-reflective screen (Luz et al., 2009).

In Mossoró - RN, it was found that Veneranda and Mônica cultivars produced fewer leaves and smaller leaf area in relation to the other cultivars, while for stem length, Mônica cultivar was superior to Venerada cultivar (Oliveira et al., 2011).

Given the need to study the behavior of different lettuce genotypes under the edaphoclimatic conditions of Minas Gerais, research was carried out with farmers, extension workers from EMATER, supermarkets and open fairs, on the production and marketing of lettuce in the municipality of Januária (MG), identifying that the most required lettuce is the looseleaf type, since it is responsible for 80% of lettuce marketed in the municipality. Difficulties in the production of vegetables due to the hot climate of the municipality were also found, characterized as semiarid tropical, making it impossible for producers to have good yield and quality at level of market standards.

In this context, this work was carried out with the aim of identifying the genetic materials of lettuce cultivars best adapted to the northern region of Minas Gerais.

MATERIAL AND METHODS

The experiment was conducted at the Agroecology Unit of the Federal Institute of Education, Science and Technology of Northern Minas Gerais (IFNMG) - Campus of Januária, from 10/03/2018 to 12/20/2018, in an organic cultivation system in open environment. The municipality of Januária is located in Northern state of Minas Gerais, at 15º 28' 55''S and 44º 22' 41''W, and average altitude of 474 m a.s.l. According to the Koppen's classification, the local climate is of Aw type (humid tropical with dry winter and rainy summer), average annual precipitation of 850 mm, average relative humidity of 60% and average annual temperature of 27ºC.

During the experimental period, air temperatures and relative air humidity were recorded, according to data provided by INMET- National Institute of Meteorology (figure 1).

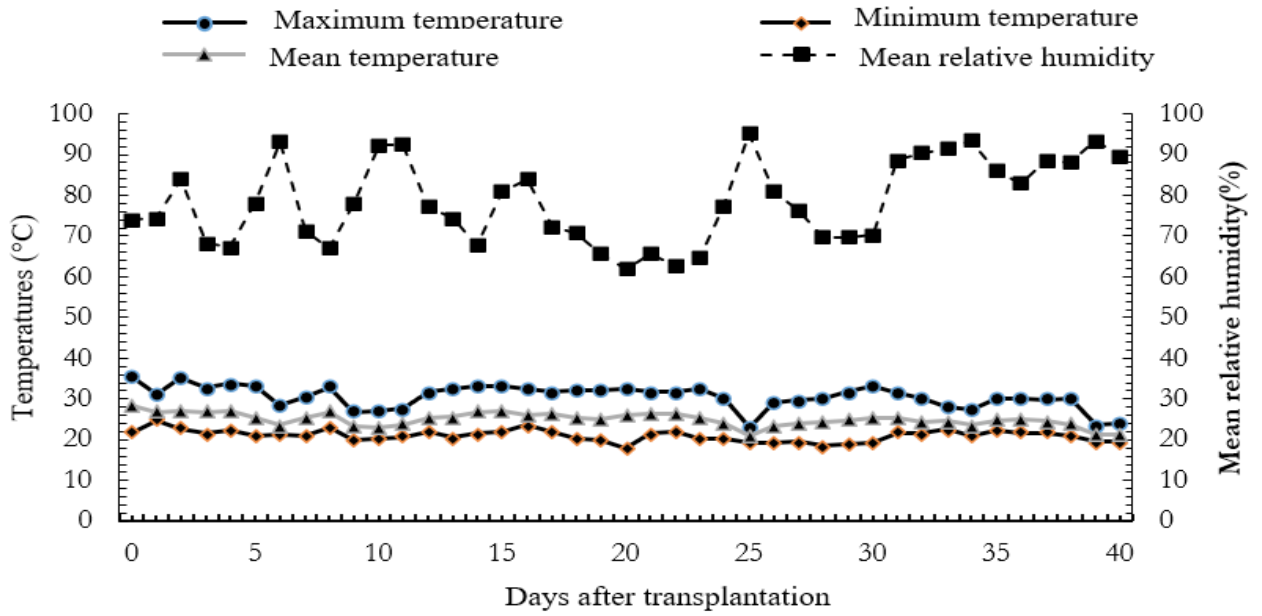
Lettuce was cultivated in beds measuring 10.50 x 1.20 x 0.30 m. Beds were raised with the aid of bed former and leveling was manually performed.

Soil analysis was carried out at depth from 0 to 20 cm to verify physical and chemical characteristics (Table 1).

From soil analysis, it was not found the need for liming, due to the methodology used in the state of Minas Gerais to neutralize aluminum and increase calcium and magnesium levels.

In planting fertilization, cattle manure organic fertilizer was used (Table 2) with MC 60 YOORIN Master 1 Si thermophosphate containing 16.0% of P2O5 (total); 12.0% P2O5 (citric acid); 12.0% Ca; 6.5% Mg; 6.0% S; 0.1% B; 0.05% Cu; 0.3% Mn; 9.0% Si and 0.55% Zn. Complementary fertilization was carried out at 10, 20 and 30 days after transplanting, using cattle manure.

Figure 1. Daily average values of minimum, average and maximum temperatures and relative air humidity under field conditions during the experiment. IFNMG, Januária-MG, 2019.



Maximum temperature / Mean temperature / Minimum temperature / mean relative humidity
Temperature x days after transplantation x Mean relative humidity

Table 1. Values of chemical and physical analysis of soil samples before organic fertilization. Januária MG, IFNMG, 2019

Characteristics*	Values
pH in water	6.1
pH in $CaCl_2$	5.6
O. M. (dag/Kg)	0.8
O. C. (%)	0.5
P (mg/dm^3)	4.0
K (mg/dm^3)	187.6
P rem (mg/dm^3)	47.0
S (mg/dm^3)	3.3
Ca^{2+}(cmol$_c$/dm^3)	2.9
Mg^{2+} (cmol$_c$/dm^3)	0.4
Al^{3+} (cmol$_c$/dm^3)	<0.1
Na^{+} (cmol$_c$/dm^3)	<0.1
H + Al (cmol$_c$/dm^3)	38.0
CEC (cmol$_c$/dm^3)	41.9
V (%)	9
M (%)	0
B (mg/dm^3)	<0.1
Zn (mg/dm^3)	0.2
Fe (mg/dm^3)	80
Mn (mg/dm^3)	32.3
Cu (mg/dm^3)	1.5
Clay (%)	10.2
Silt (%)	19.0
Sand (%)	70.8

*Soil analysis was carried out according to the Manual of Chemical Analysis of Soils, Plants and Fertilizer – 2nd revised and expanded edition. EMBRAPA, Brasília – DF, Brazil, 2009.

Table 2. Values of the chemical and physical analysis of tanned cattle manure used in the fertilization of the lettuce crop. Januária-MG, IFNMG, 2019.

Chemical characteristics	Values
Moisture (%)	<1
pH in $CaCl_2$	7.71
O. M. (%)	17.8
O. C. (%)	10.35
N (%)	0.39
C/N ratio	26.54
P (%)	0.469
K (%)	1.70
Mg (%)	0.1637
B (%)	0.02
Cu (%)	0.0196
Mn (%)	0.0486
Ca (%)	0.433
Fe (%)	0.26
S (%)	0.04
Zn (%)	0.14

Analysis performed according to IN 05/2007 - MAPA Technical Standard.

Five days before transplanting, 1,026 kg m^{-2} of tanned manure were incorporated into the soil, corresponding to 7.69 Mg ha^{-1} of manure dry matter. At the time of transplantation, 20.43 g of thermophosphate MC 60 YOORIN Master 1 Si per pit were incorporated into the soil. Ten days after transplanting, 1,026 kg m^{-2} of tanned cattle manure were applied; after application, the soil was scarified to incorporate the fertilizer. At 20 and 30 days after transplanting, 1,538 kg m^{-2} of tanned manure were distributed in each application, and soon after the soil was scarified.

Lettuce seedlings were produced in 128-cell expanded polystyrene trays, stored in protected environments and daily irrigated with a fine-sieve watering can. Trays were previously washed with neutral detergent, and soon after they were disinfected with 2% sodium hypochlorite solution, and then dried in the shade. The substrate used to fill trays was sieved earthworm humus. Sowing was carried out on 10/03/2018, placing one seed per cell.

The transplantation of seedlings to the cultivation site was carried out 28 days after sowing, when plants had four permanent leaves; the operation took place in the late afternoon. Irrigation was carried out by the microsprinkler system and its management was defined according to conditions of soil moisture and water content in the plant. Cultural treatments were carried out according to methodology of the organic production system.

The experiment consisted of seven treatments, carried out in a randomized block design with four replicates. Isabela, Margarete, Mônica, Valentina, Vanda, Veneranda and Vera lettuce cultivars were used in treatments, all indicated for cultivation in the organic system. The experimental unit consisted of four longitudinal rows of 1.50 m in length, with plants at spacing of 0.30 x 0.30 m, totaling 20 plants per plot; the useful area consisted of six central plants in two central rows. Harvest was carried out on 12/10/2019 at 68 days after sowing.

From three plants randomly chosen in the useful area, the following were evaluated:

Number of leaves per plant - obtained by counting all leaves present on the head with minimum size of 5 cm in length.

Leaf area - three leaves at different development stages were removed. From these leaves, three discs from the leaf blade were removed with the aid of a metal disc. These were dried in an oven, and the leaf area was determined using the following equation:

AF = ND*AD*MSL/MSD

Where AF = plant leaf area (cm^2)

ND = number of sampled discs;

AD = disc area (cm^2);

MSL = leaf blade dry matter mass (g);

MSD = disc dry matter mass (g).

Leaf dry mass - obtained after drying in an oven, with forced ventilation at 65°C, until constant mass, expressed in g per plant.

Stem dry mass - obtained after drying in an oven, with forced ventilation at 65°C, until constant mass, expressed in g per plant.

Stem length - obtained by measuring the stem portion present in the commercial head, expressed in cm.

Head dry mass - obtained by the sum of leaf dry mass and stem dry mass values, after drying in an oven, with forced ventilation at 65°C, until constant weight, expressed in g per plant.

Commercial yield - obtained by multiplying the average head fresh mass by the population of plants present in area equivalent to 7,500 m^2 (useful area), expressed in kg ha^{-1}.

Data obtained were submitted to analysis of variance. Cultivar groups were differentiated using the Scott-Knot criterion, adopting 5% probability level. The SISVAR software (Ferreira, 2011) was used as statistical software.

RESULT AND DISCUSSION

During the experiment, from October to December, maximum temperatures ranged from 23.1 to 35.4°C, with maximum average of 30.60°C. Maximum temperatures ranged from 20.84 to 28.52°C, with average of 25.01°C and minimum temperatures ranged from 18.0 to 24.8°C, with average of 21.05°C (Figure 1).

According to Suinaga et al. (2019), these temperatures are unfavorable to the growth and development of lettuce, with optimum temperature for growth and production being around 18 ºC, ranging from 12 to 22 ºC, and extremes of 17-28 ºC during the day and of 3-12 ºC during the night, and depending on the cultivar, it was verified that higher temperatures can stimulate bolting and impair head formation.

For all evaluated leaf characteristics, significant differences were observed; for number of leaves per plant, there is an average superiority of 26.49% per plant when comparing groups with the highest and lowest averages (Table 3).

Table 3. Mean values of number of leaves per plant (NFP), leaf area (AF) and leaf dry mass (MSF) of seven lettuce cultivars. Januária-MG, IFNMG, 2019

Cultivars	NFP (ud)	AF (cm^2)	MSF (g)	MSC (g)	CC (cm)	MSCA (g)	YIELD (kg ha^{-1})
Vera	19.89b	1.316.52a	8.12a	0.65a	5.15b	8.72a	16.038.12a
Veneranda	18.00c	1.259.98a	7.38a	0.60a	5.94a	8.39a	14.231.04a
Isabela	21.44a	1.080.52a	6.00b	0.53a	4.02c	6.53b	11.899.86b
Vanda	17.56c	932.16b	5.40b	0.53a	4.12c	5.93b	12.113.47b
Mônica	17.22c	1.063.96a	6.34b	0.56a	4.89b	6.89b	10.908.54b
Valentina	21.99a	876.41b	5.22b	0.39b	3.80c	5.61b	8.706.46c
Margarete	15.89c	643.11c	3.92c	0.27c	3.10d	4.19c	6.977.98c
CV (%)	5.75	16.27	14.76	15.77	7.43	14.21	12.43

* Means followed by the same letter do not differ from each other by the Scott-Knott cluster test at 5% probability level.

Cultivars evaluated were grouped into three segments (Table 3), and those that formed the highest number of leaves per plant were Valentina (21.99) and Isabela cultivars (21.44) and those with the lowest values were Veneranda (18 .00), Vanda (17.56), Mônica (17.22) and Margarete cultivars (15.89).

Sousa et al. (2018) evaluated lettuce cultivars of the looseleaf group grown in conventional system under the conditions of Jataí-GO and verified significant difference, with Valentina cultivar emitting the highest number of leaves per plant (37.0), followed by Vanda (31.3) and Isabela cultivars (25.0), with intermediate values, and Veneranda and Vera cultivars, with values of 21.02 and 20.2, respectively, expressing the behavior of characteristics as a function of the interaction between cultivars and the cultivation environment.

In Cáceres-MT, Santos et al. (2009) evaluated lettuce cultivars grown in conventional system and obtained significant differences for number of leaves per plant, with Isabela (14.4), Mônica (13.0) and Vera cultivars (12.0) being superior than Veneranda (11.4) and Vanda cultivars (10.9).

As it is a leafy vegetable, whose leaf represents the commercial part, the characteristic number of leaves per plant is extremely relevant for crop production (Sousa et al., 2018), another striking factor is that lettuce is acquired by the consumer in the form of a unit and not by weight, facilitating marketing when there is greater volume and number of leaves (Diamante et al., 2013). According to Silveira (2016), number of leaves per plant can be influenced by climatic and genetic factors, with tendency for greater leaf production under milder temperatures.

As for leaf area, cultivars were classified into three groups (Table 3), and those with the highest averages were Vera (1316.52 cm2), Veneranda (1259.98 cm2), Isabela (1,080.52 cm2) and Mônica (1,063.96 cm2) and the cultivar with the lowest average was Margarete (643.11 cm2). It was verified that the local climatic conditions provided higher leaf area for the majority of cultivars under study. These results were higher than those obtained by Zuffo et al. (2016), with value of 412.33 cm2 for Grand Rapids cultivar grown in protected environment.

Regarding leaf dry mass (Table 3), cultivars with the highest averages were Vera (8.12 g) and Veneranda (7.38 g), with average superiority of 97.70% in relation to the group with the lowest average, represented by Margarete cultivar (3.92 g).

The characteristic leaf dry mass is related to leaf area, since increase in dry matter is a result of photoassimilated compounds produced in photosynthesis (Oliveira et al., 2018). In addition, plants are strongly influenced by dry matter production, according to the local edaphoclimatic conditions, and this factor, together with the genetic component, are the most responsible for morphological changes in plants (Santos et al., 2009).

For all stem characteristics evaluated (Table 3), significant differences were found, with the highest stem dry mass obtained for Vera (0.65 g), Veneranda (0.60 g), Mônica (0.56 g), Isabela (0.53 g) and Vanda cultivars (0.53 g) and the group with the lowest average was composed of Margarete cultivar (0.27 g). Higher stem dry mass values become a negative aspect, suggesting that cultivars with larger stems have greater susceptibility to bolting (Blat et al., 2011). In this aspect, as it has the lowest stem dry mass, Margarete cultivar has lower tendency to bolting compared to the other cultivars.

Regarding stem length (Table 3), cultivars were divided into four groups, the superior group, composed of Veneranda cultivar (5.94 cm) and that with the smallest average, represented by the Margarete cultivar (3.10 cm). It was observed that the stem length of Vera cultivar (5.15 cm) is significantly shorter than that of Veneranda cultivar (5.94 cm) and higher than that of Vanda, Isabela, Valentina and Margarete cultivars, with values of 4.12; 4.02; 3.80 and 3.10 cm respectively. In experiment carried out in Jataí-GO in conventional system, similar results were reported, with Veneranda cultivar having larger stem compared to Vera cultivar (Souza et al., 2018).

Stem length may be related to plant development, and the commercial pattern, according to Suinaga et al. (2019) for Vera and Veneranda cultivars are 6.64 cm and 6.45 cm, respectively. This characteristic is indicative of resistance to bolting, and its positive correlation is observed as early flowering. Furthermore, this factor is not only related to resistance to bolting, but also to the formation of head and leaves, being thus the main responsible for the loss of quality in tropical climate regions (Amaral e Silva, 2018; Sousa et al., 2018).

For head dry mass and commercial yield, there were significant differences (Table 3) and for head dry mass, the highest means were observed for Vera (8.72 g) and Veneranda cultivars (8.39 g) and the lowest average for Margarete cultivar (4.19 g), representing superiority of 104.18%. These values were higher than those observed by Flôres et al. (2016), who evaluated lettuce cultivars under conventional fertilization system in greenhouse in the municipality of Humaitá – AM.

In Jataí - GO, head dry mass values were 34.44; 34.14; 30.12; 27.52 and 25.75 g for Vanda, Valentina, Isabela, Veneranda and Vera cultivars, respectively (Sousa et al., 2018). It is noteworthy that these values were higher than those found in the present experiment. This difference can be explained by the planting time, soil fertility and organomineral fertilization performed.

Cultivars with the highest commercial yield were Vera and Veneranda, with superiority of 116.89% in relation to Margarete cultivar, with the lowest average (Table 3).

It is noteworthy that the present experiment presented values higher than those of Silva et al. (2015), who reported 8,635.00 kg ha-1 for Vera cultivar grown under no-tillage system and organic system in the state of Acre. In research carried out in the municipality of Chapecó-SC, value of 11,530.00 kg ha-1 was found for Vera cultivar in open field cultivation, under organic fertilization (Amaral e Silva, 2018).

Similar to results observed in this study, commercial yields for Vera and Veneranda cultivars (Souza et al., 2018) have been reported, but Veneranda cultivar had longer stem length, thus evidencing that Vera cultivar is more resistant to high temperatures.

Thus, it could be concluded that Vera and Veneranda cultivars presented superior production potential in relation to the other cultivars. Vera cultivar, for combining higher yields and less tendency to early bolting in relation to Veneranda cultivar, is the most recommended, and Margarete cultivar is the least suitable for cultivation in the warmer season in Northern Minas Gerais.

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