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Cientific Paper

Response to the foliar application of biofertilizer doses in lettuce

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Abstract

On lettuce fertilization, it has been common the use of alternative sources, among which the biofertilizer. The aim of this study was to evaluate the influence of different biofertilizer doses applied in solution via foliar fertilization under different concentrations over cv. 'Verônica lettuce plants. The experiment was installed in random blocks with three replicates and parcels with 64 plants. The treatments consisted in four biofertilizer doses (0%; 10%; 20% and 30%) applied via foliar fertilization at 17 days after the seedling transplanting. In each parcel, we collected three plants of the useful portion, in intervals of five days after the biofertilizer application – DAA (at 5, 10, 15, 20, 25 and 30 DAA). In each DAA we obtained the dry mass of the leaves and stem for the obtaining of the Net Assimilation Rate – TAL; Relative Growth Rate – TCR; Absolute Growth Rate – TCA; Leaf Area Ratio – RA; Leaf Mass Ratio – RMF; and Stem Ratio – RC. The biofertilizer concentrations affected the TAL, TCR and TCA on the different periods of evaluation, with maximum values reached between 10 and 15 DAA. The concentration of 20% was the one which resulted on the highest absolute growth rate and highest net assimilation rate, providing a better development and growth of lettuce plants.

Keywords: *Lactuca sativa* L.; development; organic matter

Respuesta a la aplicación de dosis de biofertilizantes foliares en lechuga

Resumen

En la fertilización de la lechuga ha sido común el uso de fuentes alternativas, incluyendo biofertilizantes. El objetivo del estudio fue evaluar la influencia de diferentes dosis de biofertilizantes aplicados en solución vía abono foliar a diferentes concentraciones sobre plantas de lechuga cv. "Verónica". El experimento fue en diseño de bloques completos al azar con tres repeticiones y parcelas con 64 plantas. Los tratamientos consistieron de cuatro dosis de biofertilizantes (0%, 10%, 20% y 30%) como aplicación foliar a los 17 días después de trasplantar las plántulas. Se colectaran tres plantas da parte útil de cada parcela en intervalos de cinco días después de la aplicación de los biofertilizantes - DAA (a los 5, 10, 15, 20, 25 y 30 DAA). En cada DAA se obtuve la masa seca de las hojas y tallos para la obtención de la tasa de asimilación neta - TAL; Tasa de Crecimiento Relativo - TCR; Tasa de Crecimiento Absoluto - TCA; razón de área foliar - RA; razón de masa –foliar y la razón caulinar - RC. Las concentraciones de biofertilizantes afectaran la TAL, TCR y TCA en los períodos de evaluación, con valores máximos alcanzados entre 10 y 15 DDA. Se observó que la concentración de 20% fue el que resultó en el crecimiento absoluto más alto y una mayor tasa asimilación neta, proporcionando un mejor desarrollo y crecimiento de las plantas de lechuga.

Palabras clave: *Lactuca sativa L.*; el desarrollo; la materia orgánica

Resposta à aplicação de doses de biofertilizante via foliar em alface

Resumo

Na adubação da alface tem sido comum o uso de fontes alternativas, entre os quais os biofertilizantes. O objetivo do trabalho foi avaliar a influência de diferentes doses de biofertilizante aplicados em solução via adubação foliar em

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diferentes concentrações sobre plantas de alface cv. 'Verônica. O experimento foi instalado em blocos casualizados com três repetições e parcelas com 64 plantas. Os tratamentos constaram de quatro doses de biofertilizante (0 %; 10 %; 20 % e 30 %) aplicados via foliar aos 17 dias após o transplantio das mudas. Em cada parcela foram realizadas coletas de três plantas da parcela útil em intervalos de cinco dias após a aplicação dos biofertilizantes – DAA (aos 5, 10, 15, 20, 25 e 30 DAA). Em cada DAA foram obtidos a massa seca das folhas e do caule para obtenção da Taxa de Assimilação Líquida - TAL; Taxa de Crescimento Relativo - TCR; Taxa de Crescimento Absoluto - TCA; Razão de Área Foliar - RA; Razão da Massa Foliar - RMF; e Razão Caulinar - RC. As concentrações de biofertilizantes afetaram a TAL, TCR e TCA nos diferentes períodos de avaliação, com valores máximos atingidos entre 10 e 15 DAA. A concentração de 20% foi a que resultou na maior taxa de crescimento absoluto e maior taxa de assimilação líquida, proporcionando um melhor desenvolvimento e crescimento das plantas de alface.

Palavras-chave: *Lactuca sativa L.*; desenvolvimento; matéria orgânica

Introduction

The lettuce (*Lactuca sativa* L.) is the vegetable of greatest commercial value in Brazil. It is normally consumed in salads and sandwiches, with emphasis to the Southern and Southeastern regions with bigger production volumes and commercialization (LOPES et al., 2005). The organic fertilization with animal manure and organic compounds has been widely used on the lettuce production, with the objective of lowering the quantity of chemical fertilizers and improve the physical, chemical and biological qualities of the soil (GALBIATTI et al., 2007).

According to VITÓRIA et al. (2003), the increasing demand for products ecologically produced and the concern for the environment motivate alternative uses, such as non chemical fertilizers, in order to decrease the impacts caused by men, reducing, thus, the dependence of industrialized inputs. In this sense, the organic biofertilizers can be used as supplementary mineral nutrition for plants. In general, the biofertilizers are constituted by organic compounds, generally rich in nitrogen, an element required in higher relative quantities by the lettuce cultivation, stimulating the formation and development of the plant shoot, ionic absorption, photosynthesis, respiration, multiplication and cell differentiation of plants (MALAVOLTA et al., 1997).

Besides being rich in nitrogen, the liquid biofertilizers have in its composition almost all necessary elements for the mineral nutrition of plants, the concentrations varying according to the composition of the material used in the raw material to be fermented and the fermentation time (SANTOS, 1992).

The plant growth analysis has been used to describe their development, when subjected to different environmental conditions (JAUER et al., 2003). According to NOGUEIRA et al. (1994), the growth analysis is a tool used to quantify the growth components, representing the first support on the evaluation of primary production, and thus considered an efficient method for studying the photosynthetic rate of production. Based on plant growth data, we can precisely infer over the physiological efficiency between genetically different plants or between plants subjected to different environments (BENINCASA, 2003), systematically introduced on the evaluation environment.

The growth of a plant can be studied through measures of different types: linear (height, weight, etc.) and non linear, which are the Absolute Growth Rate (TCA), Relative Growth Rate (TCR), Net Assimilation Rate (TAL), Leaf Area Ratio (RAF), among others (OLIVEIRA et al., 2002).

Based on this context, the aim of this study was to evaluate the influence of different biofertilizer doses applied in solution via foliar fertilization under different concentrations in plants of cv. 'Verônica lettuce.

Material and Methods

The experiment was conducted on the Horticulture Sector of the Experimental Station at the Tocantins Federal University Foundation – UTF, University Campus of Gurupi – TO, located at latitude 11º 43'S and longitude 49º 15'W and 300 m altitude, in Red-Yellow Latosol EMBRAPA (2006), which presented the following results of chemical analysis for the layer of 0-20 cm depth: pH ($CaCl_2$): 5.0; M.O.: 33.8 g.dm^{-3}; P resin: 12.5 mg.dm^{-3}; K: 0.2 cmol$_c$.dm^{-3}; Ca: 3.1 cmol$_c$.dm^{-3}; Mg: 1.5 mmol$_c$.dm^{-3}; H+AL: 4.3 mmol$_c$.dm^{-3}; SB: 4.9 mmol$_c$.dm^{-3}; V: 53.26%.

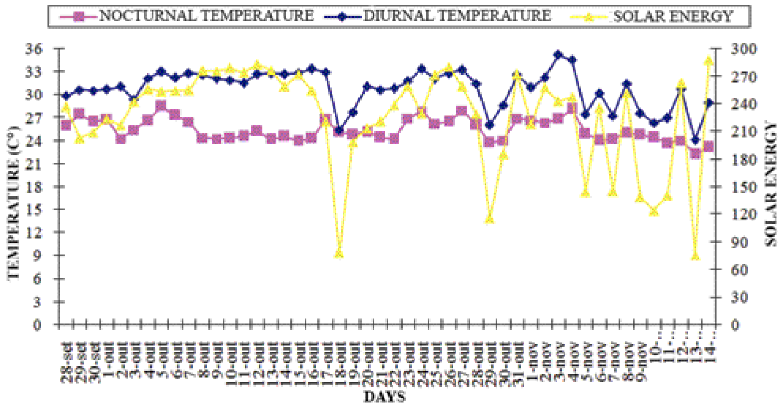

Figure 1. Data of average nocturnal and diurnal temperatures and solar energy in the city of Gurupi-TO, in the period of September to November of 2008.

The climatic information during the conducting of the experiment are in Figure 1.

The experiment was conducted in open environment. We used the Verônica lettuce cultivar and the sowing was performed in expanded polystyrene trays of 128 cells, placing two to three seeds per cell. After the emergence, we performed the thinning, leaving only one plant per cell. The transplant was conducted at 20 days after the sowing to flowerbeds of one meter width, previously fertilized with corral manure on the dosage of 20 ton ha^{-1}. The experimental design was of randomized blocks with three replicates. Each parcel was constituted by 64 plants with spacing of 0.25 x 0.25 m between plants in the line and between the transplant line on the flowerbed, respectively.

The treatments used were four doses of biofertilizer applied via foliar fertilization at 17 days after the transplanting, in a single diluted solution dose, in which: 0 – without biofertilizer, only water; 10% - solution with 10% of biofertilizer; 20% - solution with 20% of biofertilizer; and 30% - solution with 30% of biofertilizer. The biofertilizer was obtained according to the methodology proposed by VILELA JÚNIOR et al. (2003), presenting the following characteristics: pH: 6.4; M.O.: 27.47%; P: 8 $mg.dm^{-3}$; K: 0.887 $cmol_c.dm^{-3}$; Ca: 0.44 $cmol_c.dm^{-3}$; Mg: 10.20 $cmol_c.dm^{-3}$; H+AL: 0.05 $cmol_c.dm^{-3}$. The irrigation was conducted by dripping and the other cultivation treatments were performed according to the recommendation for the culture.

In order to conduct the analyses, we performed the collecting of plants from the useful parcel, in intervals of five days after the application of the biofertilizer (DAA), at 5, 10, 15, 20, 25 and 30 DAA. In each evaluation period, we withdraw from each parcel a sample of three competitive plants of each treatment for the proceeding of the analyses. In these samples, the following characteristics were determined: Leaf dry mass and Stem dry mass, both obtained in greenhouse at 70°C, until it reached the constant dry mass. With the average data of these characteristics we estimated the parameters that compose the analysis of average growth of the plants, according to BENINCASA (2003), which are: Net Assimilation Rate – TAL; Relative Growth Rate – TCR; Absolute Growth Rate – TCA; Leaf Area Ratio – RA; Leaf Mass Ratio – RMF; and Stem Ratio – RC. We adjusted trend curves that explained the data behavior to the average data of each characteristic.

Results and Discussion

According to CONCEIÇÃO et al., (2005), the net assimilation rate (TAL) of a plant is the increment of vegetal material per unit of foliar area and of time. It is dependent of the solar radiation, the plant's internal condition, the foliar area index and the water balance. About this characteristic, it became evident the effect of the concentrations throughout the evaluation periods, showing that there is an interaction between these significant factors. About this aspect, the solution with 20% of biofertilizer provided the highest variation in the TAL in the evaluation periods, reaching maximum values at 10 DAA, with slight decrease after this period until 20

DAA. However, after this period there was a slight increase on the last evaluation period (Figure 2A). This fact probably occurred due to the self shading of leaves and to the sharp decrease of the foliar area, caused by the increase in the foliar senescence rate at the end of the cultivation cycle.

It is noteworthy that most of the plants order their assimilation surfaces in a way that few leaves receive direct solar radiation permanently, thus most part of the leaves is partially shaded. With this formation, these leaves protect themselves of injuries caused by the overheating and by the excessive solar radiation intensity (LARCHER, 2000). We observed that the solution with 30% of biofertilizer is probably above the plant's necessities, since the TAL of these plants has always been below the control treatment, except for the interval of 20-25 DAA (Figure 2A), showing that this concentration, in practical terms, would not be the most recommended. The utilization of biofertilizer as foliar fertilizer on the concentrations of 10 and 20% propitiated a higher relative maintenance of the leaves at the end of the cultivation cycle, contributing, thus, to improve the pattern of visual aspect for commercialization of plants.

The Relative Growth Rate (TCR) expresses the increment of dry mass in relation to the pre-existent biomass. This characteristic was always decreasing for all biofertilizer concentrations used (Figure 2B). According to BENINCASA (2003), the TCR is not constant during the vegetal development, because the plant frequently presents a phase of rapid increase of the TCR, followed by the relatively continuous decreasing. Under the experiment conditions, we observed that all treatments presented higher value in the first evaluation interval (5-10 DAA), except for the solution with concentration of 20%, which had its maximum value at the second interval (10-15 DAA), decreasing until the fourth interval and again increasing at the last evaluation (25-30 DAA) (Figure 2B). FARIAS (2006) reports that the TCR is an efficiency index, because it represents the plant's capacity of producing new material. It is coherent that it presents initially high va

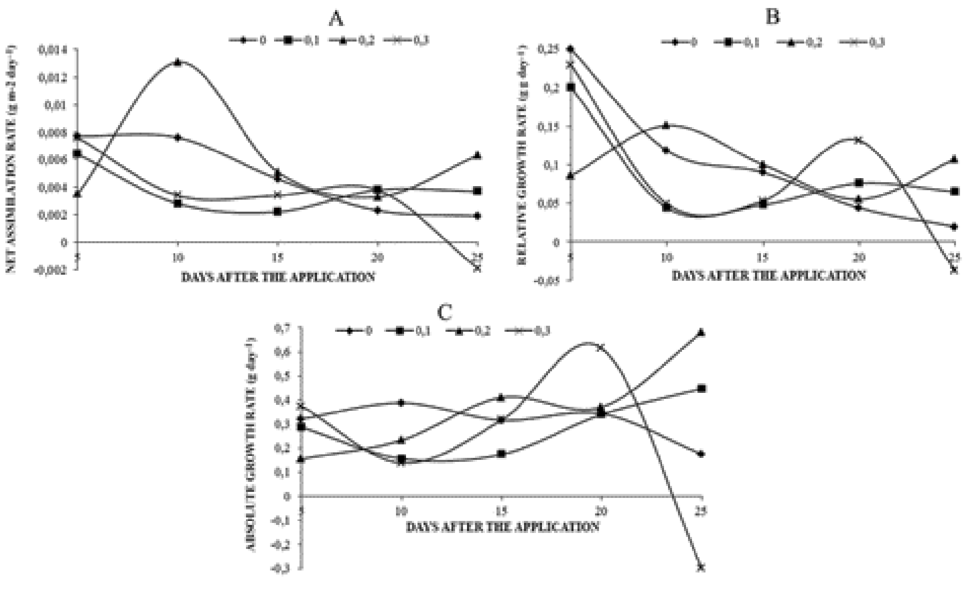

Figure 2. Net Assimilation Rate (TAL) (A), Relative Growth Rate (TCR) (B) and Absolute Growth Rate (TCA) (C) of cv. Verônica lettuce plants, in function of biofertilizer doses applied in solution via foliar fertilization under different concentrations. The values of the horizontal axis: 5, 10, 15, 20 and 25 refere to intervals of days, being 5, interval of 5-10 DAA; 10, interval of 10-15 DAA; 15, interval of 15-20 DAA; 20, interval of 20-25 DAA and 25, interval of 25-30 DAA. Gurupi, UTF, 2008.

lues, to after decrease with the plant's age, by the reduction of production of new leaves. For the solution with concentration of 30% we verified a sharp increase of the TCR in the interval of 20-25 DAA, with decrease after this period, which indicates the approximation of the plant's senescence, moment in which the net assimilation becomes negative.

GARCIA et al. (1982) found values of TCR of about 0.1 g g^{-1} day^{-1} at 41 days of lettuce culture cultivated in soil. In this study we found superior values to this at 46 days after the emergence (Figure 1B). That probably occurred due to the climatic conditions of the region, mainly intense solar radiation that favors a higher TAL and, consequently, higher efficiency in producing new photosynthetically active leaves. According to GLIESSMAN (2000), among the environmental conditions that can affect the photosynthesis rate are the air temperature, the intensity and quality of light, the duration of exposure, carbon dioxide availability, water availability and wind speed.

The Absolute Growth Rate (TCA) indicates the variation or the increment between two samples and it is used to have an idea of the average speed of the plant growth, throughout the observation period. The tendency presented by the used treatments, in relation to this physiological index, was varied, verifying an increase throughout the time for the concentration of 20% (Figure 2C). For the solutions with concentration of 10 and 30%, we verified a higher increment at the beginning, followed by decrease in the interval of 10-15 DAA. After this period, the plants that received biofertilizers in the concentration of 30% had an increment until the interval of 20-25 DAA, with a decrease from then, demonstrating a stoppage of its growth (Figure 2C).

In general, the lettuce cultivated with 20 and 30% concentration of biofertilizer in solution presented the highest values of TCA, reaching 0.68 g day^{-1} in the period between 25 and 30 DAA and 0.61 g day^{-1} in the period of 20 to 25 DAA, respectively (Figure 2C). As for the treatments with 0 and 10% concentration of biofertilizer, it was presented smaller values of TCA, in the order of 0.17 and 0.44 g day^{-1} in the period of 25 to 30 DAA, respectively. In conventional cultures, GARCIA et al. (1982) observed growth rates of lettuce (Brasil 48 cultivar) of about 0.48 g day^{-1} between 62 and 72 days after the transplanting. In another study, GARCIA et al. (1988), also working with conventional cultivation, found, for the cultivar Clause's Aurélia, a maximum TCA of 0.40 g day^{-1}, in the period between 51 and 62 days after the transplanting, with slight decrease after this period. We observed that the biofertilizer allowed the maintenance of more elevated values of the TAL, TCR and TCA at the end of the experiment, indicating a retarding effect of the physiological senescence process of the culture.

The Foliar Area Ratio (RAF) is a morphological component of growth that represents the assimilatory surface per unit of total dry mass. The RAF was higher at the beginning, with decrease after 10 DAA and a small increase at 20 DAA, and subsequent decrease until the end of the cycle. This fact indicates that the photoassimilates are being directed to the formation of the photosynthetic system of the plants (Figure 3A). BENINCASA (2003) states that the RAF declines as the plant grows, because, along with the growth, the interference of superior leaves to inferior leaves increases (self shading). LOPES and MAESTRI (1973) suggest that the relative growth rate and the foliar area ratio present similarly a strong tendency of decrease as the plants grow old, which, according to GOMIDE and GOMIDE (1999), signals an impairment for the plants' carbon economy, because it reflects a progressive decrease of the photosynthetic system in relation to the increase of the plant's mass.

The Leaf Mass Ratio represents the dry mass of the leaves in relation to the total dry mass of the plant. The leaf mass ratio increased sharply at the beginning of the developing cycle, showing that there was higher allocation of assimilates for the leaves, being at the occasion the preferential metabolic drain (Figure 3B).

The Stem Ratio (RC) represents the dry mass of the stem in relation to the total dry mass. This ratio is inversely proportional to the foliar mass ratio. Initially, the RMF is high, because the plant needs to form active parts photosynthetically in order to obtain assimilates for the development. At the end of the cycle, when the plant presents developed canopy, it starts to allocate the photoassimilates from leaves to stem, increasing the RC (Figure 3C). For the solution with 30% concentration, we observed that there was a decrease in the RC in the interval of 20-25 days. In general, under higher concentrations, it occurs greater nutrient supply for the plants, which promoted a relative reduction on the plant cycles.

The liquid biofertilizer, when applied by foliar spraying, in water diluted solution under proportions that vary from 10 to 30%, presented considerable nutritional effects, favoring the development of

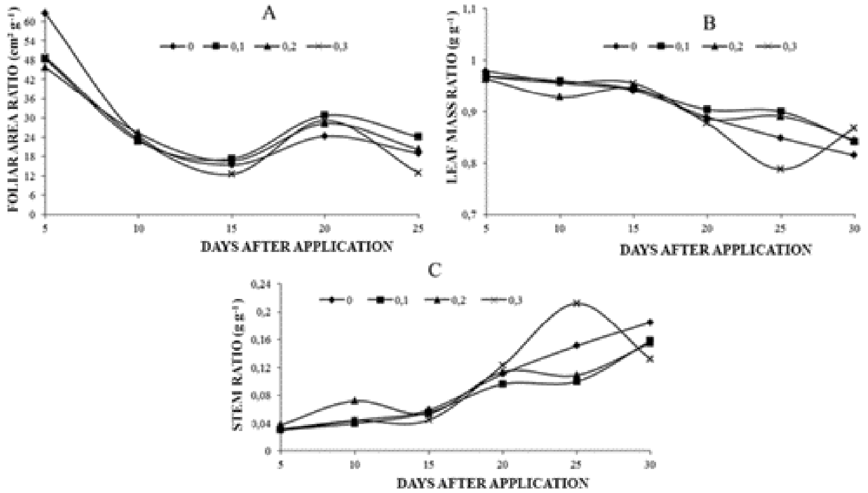

Figure 3. Foliar Area Ratio (RAF) (A), Leaf Mass Ratio (RMF) (B) and Stem Ratio (RC) (C) of lettuce plants cv. Verônica, in function of biofertilizer doses applied in solution via foliar fertilization under different concentrations. The values of the horizontal axis: 5, 10, 15, 20 and 25 refere to interval of days, being 5, interval of 5-10 DAA; 10, interval of 10-15 DAA; 15, interval of 15-20 DAA; 20, interval of 20-25 DAA and 25, interval of 25-30 DAA. Gurupi, UFT, 2008.

plants, mainly by the increase of the foliar area (SANTOS, 1992). For the lettuce, since it is a leaf vegetable, this aspect is of relative importance, since it allows obtaining plants with greater commercial pattern. PIMENTEL et al. (2009) observed that for the agronomic index of lettuce, it occurred a positive influence of the fertilization, since the plant shoot in the parcels were higher and heavier when the highest level of organic compound was incorporated.

PINHEIRO and BARRETO (1996) attribute these facts to the presence of hormones or hormonal precursors, thus, they recommend the use of biofertilizer by foliar application, normally in diluted solutions that vary from 0.1 to 5%. Higher concentrations, between 20 and 50%, were used by SANTOS e AKIBA (1996), with the biofertilizer "Vairo". In their study, it was evident that in very high concentrations, the biofertilizer can cause physiological stress in the plant, retarding its growth, flowering or fruiting. That is probably due to the metabolic deviation for the production of defense substances. For leaf vegetables, it is recommended weekly sprayings, using between 0.1 and 3% concentration of biofertilizer (D´ANDRÉA and MEDEIROS, 2002). In this study, the solution with 20% of biofertilizer was the one which provided a higher absolute growth rate, as well as a higher net assimilation rate, being, therefore, the one that provided a better development and growth of lettuce plants, cv. Verônica cultivar.

Conclusion

The maximum values of TAL were reached between 10 and 15 DAA.

The concentration with 20% was the one that resulted in the highest absolute growth rate, as well as a higher net assimilation rate, providing a better development and growth for lettuce plants.

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