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Irrigation levels and use of hydro retainer polymer in greenhouse lettuce production

Welcio R. da Silva¹, Leandro C. Salomão², Débora R. M. Pereira³, Henrique F. E. de Oliveira¹, Alexandre I. de A. Pereira² & Fernando S. Cantuário²

¹ Instituto Federal Goiano/Programa de Pós-Graduação em Irrigação no Cerrado, Ceres, GO, Brasil. E-mail: welcio_rs@hotmail.com (Corresponding author) - ORCID: 0000-0002-6673-7182; henrique.fonseca@ifgoiano.edu.br - ORCID: 0000-0001-8698-292

² Instituto Federal Goiano. Urutaí, GO, Brasil. E-mail: leandro.salomao@ifgoiano.edu.br - ORCID: 0000-0001-9436-1488; aiapereira@yahoo.com.br - ORCID: 0000-0001-7957-6691; fernandoscantuario@hotmail.com - ORCID: 0000-0002-8052-4861

³ Prefeitura Municipal de Goianésia/Secretaria do Meio Ambiente. Goianésia, GO, Brasil. E-mail: deboraagronomia@gmail.com - ORCID: 0000-0003-3751-0162

ABSTRACT: One of the potential alternatives to improve the use of water resources is the use of hydro retainer polymer applied to the soil. The objective of this study was to evaluate how irrigation levels and doses of hydro retainer polymer interfere in the production of 'Vanda' lettuce. The experiment was carried out from December 2017 to January 2018 under protected environment in the Instituto Federal Goiano, Urutaí Campus, Goiás State, GO, Brazil (17° 29' 10" S of latitude, 48° 12' 38" W of longitude and 697 m of altitude). The work tested four irrigation levels of 50, 75, 100 and 125% of the evaporation obtained daily by the hook micrometer and five doses of hydrogel polymer (0, 50, 100, 150 and 200 g plant⁻¹). The experimental design was a randomized block design in a scheme of split-plot and four blocks. Canopy fresh and dry mass, plant height, number of leaves and productivity were evaluated. There was 29.24% increase in the dry mass comparing the hydro retainer polymer doses of 0 and 169.28 g and an increase of 14.36% of the height of plants when compared with the irrigation levels of 50 and 125%. The use of a hydro retainer polymer provided a significant increase in all the evaluated productive variables. The irrigation levels influence the fresh mass from aerial part, plant height and productivity. The productivity increased 18.42% for the irrigation levels used and the highest estimated values were presented in the dose of 157.49 g (14.46 t ha⁻¹) hydro retainer polymer.

Key words: hydrogel, *Lactuca sativa* L., water resources

Níveis de irrigação e uso de hidrorretentor na produção de alface em ambiente protegido

RESUMO: Uma das possíveis alternativas para potencializar a utilização de recursos hídricos é a utilização de polímeros hidrorretentores. Objetivou-se avaliar como níveis de irrigação e doses de solução hidrorretentora interferem na produção da alface crespa, cultivar Vanda. O experimento foi realizado de dezembro de 2017 a janeiro de 2018, sob canteiros em ambiente protegido na área experimental do Instituto Federal Goiano - Campus Urutaí, GO (17° 29' 10" S de latitude, 48° 12' 38" O de longitude e 697 m de altitude). Testaram-se quatro níveis de irrigação (50, 75, 100 e 125%) da evaporação obtida diariamente pelo micrômetro de gancho e cinco doses de solução de hidrogel (0, 50, 100 e 200 g planta⁻¹). Utilizou-se o delineamento de blocos ao acaso e esquema de parcelas subdivididas e quatro blocos. Foram avaliadas massa fresca da parte aérea, massa seca da parte aérea, altura de plantas, número de folhas e produtividade. Verificou-se incremento de 29,24% da massa seca da parte aérea comparando as doses de solução hidrorretentora de 0 e 169,28 g e acréscimo de 14,36% da altura de plantas quando comparados os níveis de irrigação de 50 e 125%. O uso de solução hidrorretentora proporciona aumento significativo em todos os parâmetros produtivos avaliados. Os níveis de irrigação utilizados influenciam as variáveis massa fresca da parte aérea, altura de planta e produtividade. A produtividade aumentou 18,42% para os níveis de irrigação utilizados, e os maiores valores estimados foram com a dose de solução hidrorretentora de 157,49 g (14,46 t ha⁻¹).

Palavras-chave: hidrogel, *Lactuca sativa* L., recursos hídricos



INTRODUCTION

Lettuce (*Lactuca sativa* L.) is characterized as an annual plant belonging to the Asteraceae family, one of the most consumed vegetables in Brazil and in the world. Since it is originated from a temperate climate, cultivation at high temperatures can reduce its cycle and produce smaller plants due to early tasseling function (Henz & Suinaga, 2009).

The lettuce varieties in Brazil are of the crisphead group, which accounts for approximately 65% of the market, followed by varieties of the American (20%), smooth (10%) and the remaining 5% (Suinaga et al., 2013).

The development of vegetables is strongly influenced by soil moisture conditions. The replenishment of soil water by irrigation systems is a decisive factor for the success of horticulture. Proper application of the irrigation depth promotes a gain in productivity and quality (Marouelli & Silva, 1996; Silva & Queiroz, 2013).

The expansion of the irrigated area and consequent increase in water demand could result in scarcity, thereby increasing the need to study alternatives to minimize wastage (Carvalho, 2017). Therefore, it is necessary to adopt irrigation management techniques that help in making the best decision (Salomão, 2012). In addition to management, one of the possible alternatives to optimize the use of water resources is the use of hydro retainer polymers.

The hydrogel is characterized by being a material capable of retaining large volumes of water without dissolving, and can store hundreds of times its weight in water, which is gradually released to the plants, favoring the possibility of increasing the irrigation interval (Mendonça et al., 2015; Navroski et al., 2015). The objective of this study was to evaluate how levels of irrigation and doses of hydro retainer polymer interfere in the production of the crisphead lettuce cultivar Vanda.

MATERIAL AND METHODS

The experiment was carried out in the Educational Production Unit (EPU) of the Instituto Federal Goiano, Campus Urutaí, Goiás state, Brazil (17° 29' 10" S latitude, 48° 12' 38" O longitude and 697 m of altitude). The region is classified as having a tropical altitude climate, with dry winter and rainy summer, of type Cwb by the Köppen classification. The mean temperature is 23 °C and can reach, during the year, values below 15 °C and maximum of 30 °C, with mean precipitation between 1000 and 1500 mm and mean relative humidity of 71%.

The maximum, minimum and mean air temperatures recorded during the conduction of the experiment, within the protected environment, are expressed in Figure 1A and the mean relative humidity (RH) of the air is in Figure 1B. For this period, maximum temperatures ranged from 25 to 36.8 °C, the minimum temperatures remained in the range of 17.3 to 21.7 °C and the overall mean temperature was 26.46 °C. For the mean relative humidity (RH) of the air, the value of 69.18% was observed in the period of the experiment, and the extreme values were between 59 and 83.5%.

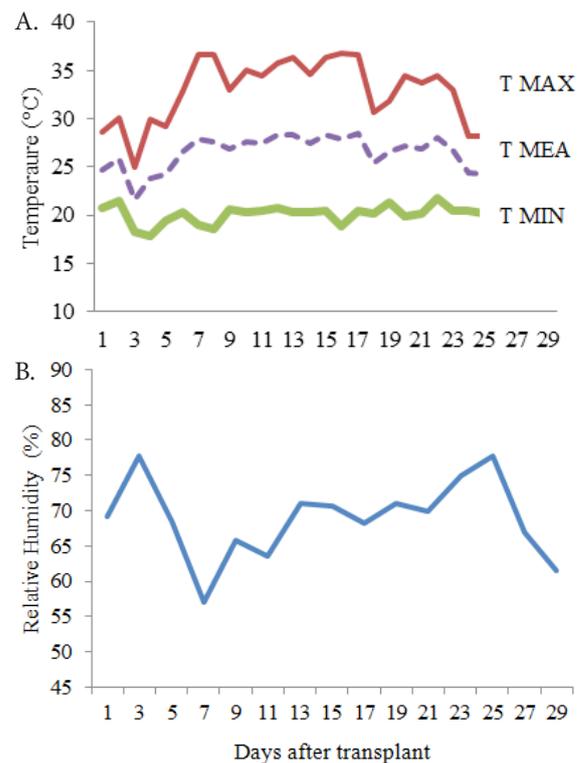


Figure 1. Maximum (TMAX), minimum (TMIN) and mean (TMEA) air temperatures (A) and mean relative air humidity (B) inside the protected environment

The soil of the experimental area has a sandy clay texture, having chemical characteristics of CTC of 10.59 $\text{cmol}_c \text{dm}^{-3}$; pH of 5.8; 85.79% of base saturation; 7.5 $\text{cmol}_c \text{dm}^{-3}$ of calcium, 1 $\text{cmol}_c \text{dm}^{-3}$ magnesium, 193 mg dm^{-3} of potassium and 135 mg dm^{-3} of phosphorus, 15 mg dm^{-3} sulfur and 21 g dm^{-3} of organic matter.

The experiment was carried out between December 2017 and January 2018 in a greenhouse of the simple arc type, East-West orientation, with dimensions of 7 m wide by 30 m in length, covered with a selective plastic film, Suncover AV Blue®.

A drip irrigation system was used, adopting a lateral line for two plant lines, with emitters spaced apart at 0.2 m, flow rate of 1.5 L h^{-1} and at a working pressure of 10 m.w.c. The pumping system consisted of a 1 hp motor pump assembly. A disc filter with holes of 1.25×10^{-4} m (120 mesh) of aperture, registers and manometer were used.

For the experiment, a randomized block design was used with subdivided plot and four blocks, in which four levels of irrigation were used (50, 75, 100 and 125% of the evaporation obtained daily from the Class A tank), and five doses of hydrogel solution (0, 50, 100, 150 and 200 g plant^{-1}). In this scheme, each irrigation level corresponded to a plot and, each dose, to a subplot. Irrigation levels were calculated according to the crop requirement, based on the daily water evaporation of the Class A tank (EV) installed inside the protected environment, adopting a day irrigation interval.

In preparation of the solution, 100 g of the Hydrogelforth Gel® was diluted with 10 L of water, left standing for 15 min, according to the manufacturer instructions. In order to perform the transplant, small pits were opened on the surface of the beds, where the respective doses of the solution were

deposited. The beds were 1 m wide by 20 m long, with 0.5 m between beds. The material was covered with soil and the seedlings were inserted in the range, above the hydrogel.

A spacing of 0.25 x 0.25 m between rows and plants was used. For each dose (subplot), equivalent to 16 plants were used, and only the four central plants were considered for analyses.

Soil preparation was carried out with mechanized plowing by means of a microtractor (YanmarAgritech TC-14). Subsequently, the beds were made manually with the aid of hoes.

The planting and topdressing fertilization were performed by fertirrigation following the recommendations of Trani et al. (2014). This management was performed by means of a negative pressure system with the aid of a venturi-type injector. This operation was performed at weekly intervals.

The seedlings were acquired from a commercial nursery at the age of 30 days post-emergence. The cultivar used was 'Vanda' of the Crisphead group, with an early cycle, that can be harvested at 55 days after emergence, has large leaves, vigorous root system, high resistance to edge burning and lettuce mosaic virus (*Lettuce mosaic virus*, LMV-II), besides being adapted for varying temperature conditions.

According to Sala & Costa (2012), the cultivar Vanda is among the materials that were created to meet the demand of new cultivars of crisphead lettuce with slow tasseling, large plant size and associated resistance to lettuce mosaic virus (LMV) and mildew (*Bremia lactucae*).

The irrigations had a fixed irrigation interval of one day and were performed early in the morning (8 h). The differentiation between the treatments of irrigation depths were given from the 10th day after transplantation (DAT).

The irrigation levels were calculated according to evaporation data (EV), and for the calculation of irrigation time, the methodology presented by Santos & Pereira (2004) was used. The crop coefficient (Kc) used was determined according to the development stage. For phases I, II, III and IV the Kc values were 0.85; 0.90; 1.00 and 0.95, respectively (Trani et al., 2011).

In the center of the protected environment, a meteorological shelter was built, made of wood, painted white and positioned at a height of 1.5 m. A digital hygrometer was installed in this shelter, in which the data of maximum and minimum temperatures and relative humidity were collected. From these data, daily mean values were calculated for the entire period of the experiment.

The temperature values found were relatively low for the locality and time of the year. These results can be attributed to the selective plastic film used in the coverage of the protected environment, Suncover AV Blue®, which is a blue plastic consisting of five layers, with the ability to select the wavelengths of the radiation and thereby reduce the internal temperature of the environment.

According to Trani et al. (2014), the most suitable temperatures for the crop are between 15 and 20 °C. However, according to Filgueira (2008), over the years, breeders have developed cultivars adapted to the spring and summer seasons, resistant to early tasseling. The minimum air temperature tolerated by the lettuce is 6 °C and the maximum is 30 °C.

The harvest was performed at 29 days after transplantation (DAT), this being the point at which the plants reached maximum vegetative development, as described by Trani et al. (2014). The aerial part was weighed and placed in paper bags, and were placed in an oven with air renewal and forced circulation at 65 °C, until they reached constant mass.

The following variables were analysed: fresh mass of aerial part (FMAP, g) and dry mass of aerial part (DMAP, g) with a digital scale with an accuracy of 0.01 g; plant height (H, cm), number of leaves (NL) and yield (PRO, t ha⁻¹), considering a population of 96000 plants ha⁻¹. Soil moisture (gravimetric) was determined in the layer 0-20 cm.

An exploratory analysis of all data was performed with the Lilliefors (Lilliefors, 1967) tests to verify the normal distribution and the Bartlett homogeneity test using the Assisat statistical software. According to the results of the tests, the data of all the variables presented normal and homogeneous distribution. In sequence, the analysis of variance was performed, and for the results that showed significance, regression analysis was performed in function of irrigation levels and hydrogel doses, and the best fit was defined according to the combination of significance at 0.05 probability and higher coefficient of determination, using the statistical software SISVAR.

RESULTS AND DISCUSSION

The gravimetric moisture (GM) content of the soil corresponding to the doses of the hydrogel 0, 50, 100, 150 and 200 g were, respectively, 15.43; 15.33; 16.22; 17.47 and 17.61%. For irrigation levels 50, 75, 100 and 125%, the means of GM were 15.78; 15.82; 16.55 and 17.33%, respectively. According to the results of the means found, there was an increase in the percentage of moisture, both with increasing dose of the hydro retainer solution (2.18%), as well as with increasing level of irrigation (1.55%).

This behavior is indicative of the contribution of the treatments used in relation to the maintenance of soil moisture. A factor of paramount importance for vegetables, which have a relatively superficial root system and demand high water availability.

Similar data were observed by Mendonça et al. (2015), which indicate that in a soil with 300 g of hydrogel solution per well (dilution 4 g L⁻¹), its moisture was greater in relation to the soil without hydrogel. In this experiment, the presence of hydrogel also promoted an increase of GM when a dose equal to or greater than 100 g plant⁻¹ was used.

Data referring to the accumulated values obtained in the experimental period for irrigation levels of 50, 75, 100 and 125% of the evaporation (EV) were, respectively, 54.68; 67.03; 79.39 and 91.75 mm. These values are inferior to those found in the literature. Valeriano et al. (2016), with a 100% ETC replacement, used a irrigation depth of 123.52 mm in a lettuce crop cycle with 66 DAT. For Silva & Queiroz (2013), the irrigation depth corresponding to 100% replacement of EV in a protected environment was 121.19 mm, with harvest at 45 DAT.

The accumulated lower irrigation depths obtained in this work can be explained, since the conduction period of the experiment was much lower than the other studies, being

only 29 DAT. This occurred due to the high precocity of the cultivar of crisphead lettuce used. Another important point to note is the great temperature variation observed throughout the experiment, starting with low temperatures. This behavior may have accelerated its growth, besides the genetic material already favors precocity.

The irrigation levels used in the cultivation of lettuce had a significant effect ($p < 0.05$), for the variables: fresh mass of aerial part, height and yield, while the hydro retainer dose factor presented a significant response ($p < 0.01$), for all variables. There was no interaction between levels of irrigation and doses of the hydro retainer solution ($p > 0.05$) (Table 1).

The fact that there was no significant interaction between the irrigation levels and the hydro retainer solution, according to the findings of other authors. Lima et al. (2003) working with different irrigation depths and doses of hydroabsorbent polymer in the production of coffee seedlings, had similar results, as well as Fernandes et al. (2015), in the growth of passion fruit seedlings, under the effect of irrigation depths and the use of hydrogel.

Azambuja et al. (2015) evaluating the use of hydrogel and nitrogen doses, also did not obtain a significant effect of the interaction of the factors studied for any of the evaluated variables.

The fresh mass of the aerial part showed a linear response as a function of irrigation levels and quadratic response as a function of the irrigation levels (Figure 2A). By the regression study, there was an increase of 22.4% of the fresh mass of the aerial part compared to irrigation levels of 50 and 125%.

These data corroborate the results found by Valeriano et al. (2016), which also observed significant differences between levels of irrigation in lettuce cultivation. However, these authors

Table 1. ANOVA summary for fresh mass of aerial part (FMAP), dry mass of aerial part (DMAP), number of leaves (NL), plant height (H) and productivity (PRO) of lettuce subjected to irrigation levels and doses of hydro retainer solution in a protected environment

Source of variation	DF	Mean square				
		FMAP	DMAP	NL	H	PRO
Block	3	417.57 ^{ns}	11.61*	7.52 ^{ns}	13.91 ^{ns}	3.70 ^{ns}
Irrigation levels	3	3637.31**	2.98 ^{ns}	14.37 ^{ns}	29.62**	33.70**
Residue a	9	591.33	1.48	3.77	6.39	5.49
Doses	4	4047.52*	10.31*	17.85*	25.02*	37.50*
Dose x irrigation levels	12	411.78 ^{ns}	1.00 ^{ns}	1.68 ^{ns}	1.50 ^{ns}	3.76 ^{ns}
Residue b	48	280	0.57 ^{ns}	1.32	1.66	5.57
CV a (%)	17.65	17.65	15.48	13.56	13.08	17.72
CV b (%)	12.15	12.15	9.33	8.04	6.66	12.11
Irrigation levels	Mean					
	(g)	(g)	(cm)	(t ha ⁻¹)		
50	123.25	7.79	13.91	18.00	11.83	
75	129.51	7.80	14.01	18.56	12.44	
100	151.20	8.45	15.59	20.44	14.53	
125	147.06	8.48	13.78	20.25	14.12	
Doses	Mean					
	(g)	(g)	(cm)	(t ha ⁻¹)		
0	112.54	6.88	12.77	17.49	10.80	
50	131.32	7.75	13.74	18.62	12.61	
100	147.80	8.69	15.38	19.77	14.19	
150	148.85	8.62	14.84	20.59	14.31	
200	148.29	8.70	14.89	20.09	14.24	

CV - Coefficient of variation; ns, * and ** Not significant, significant at 0.05 and 0.01, respectively, by the F test

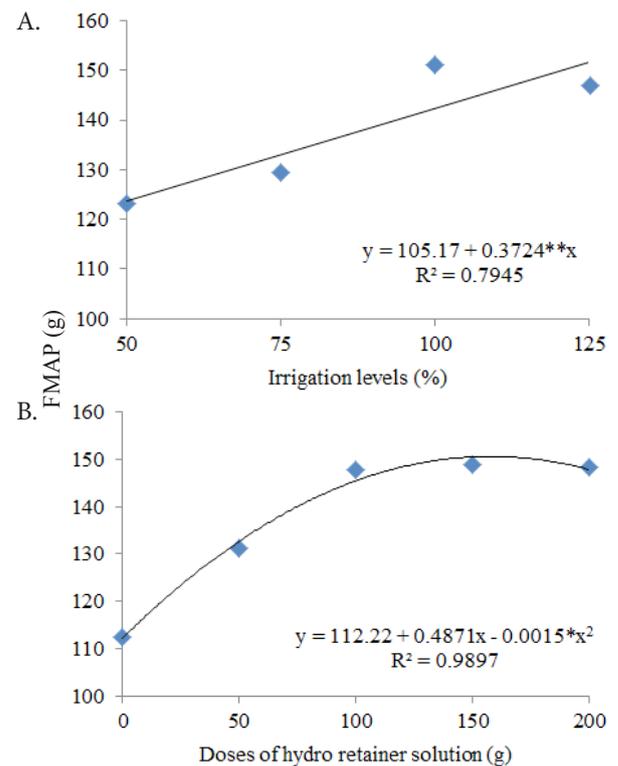


Figure 2. Fresh mass of the aerial part (FMAP) as a function of irrigation levels (A) and of doses of hydro retainer solution (B), in the cultivation of lettuce in a protected environment

found a quadratic behavior, with the maximum efficiency for this variable being 94% of the crop evapotranspiration (ETc).

Vilas Boas et al. (2007) verified that two cultivars of crisphead lettuce (Veronica and Hortência) responded similarly to different water replacements, and there was an increase in the total fresh mass of the aerial part, until the replacement of 125.8%.

As for the use of hydrogel, for the variable fresh mass of the aerial part, it was verified that the lettuce plants reached the maximum value (151.76 g) with a dose of 162.36 g, an increase of 35.23% in relation to the dose 0 (Figure 2B). Santos et al. (2015) working with four doses of hydrogel per pot (0, 8, 16 and 24 g), in the cultivation of lettuce in pots with sandy soil, verified that plants cultivated under a dose of 16 g showed superiority in the fresh mass and dry mass of the aerial part (shoot), and at a dose of 24 g the results decreased.

The quadratic characteristic presented in the work of these authors for the variables fresh mass of aerial part and dry mass of aerial part, may have occurred by the accumulation of moisture in the soil, because according to Nobre et al. (2009), a high water content in the soil negatively influences the accumulation of phytomass in the lettuce crop.

In the present study, the highest value of dry mass of the aerial part (8.86 g) was estimated at a dose of 169.28 g of solution, resulting in an increment of 29.24% of this variable in relation to the dose 0 (Figure 3A).

For the number of leaves, the regression analysis of the results also presented adjustment with a quadratic equation in relation to the doses of hydro retainer used (Figure 3B). The estimated dose of 168.5 g of hydro retainer solution generated an increase of 22.39% in the number of leaves in relation to the

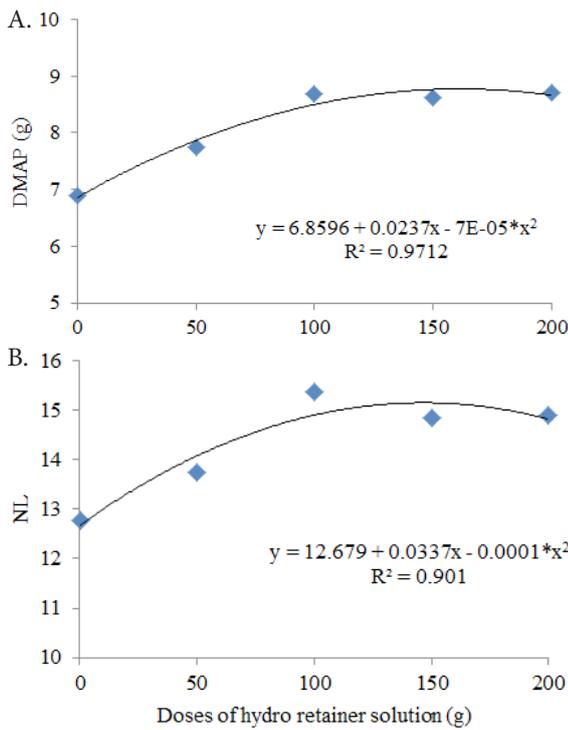


Figure 3. Dry mass of aerial part (DMAP) (A) and number of leaves (NL) (B) as a function of doses of hydro retainer solution in the cultivation of lettuce in a protected environment

dose 0 g. Oliveira et al. (2014) evaluating the performance of lettuce ‘Mimosa Roxa’ in face of different nitrogen and hydrogel doses, did not verify the influence of using hydrogel on the variable number of leaves.

For the regression analysis of the plant height values, a linear and quadratic responses were obtained for the factors irrigation levels and hydro retainer doses, respectively (Figure 4). Comparing the irrigation levels of 50 and 125%, there was an increase of 14.3% of plant height (Figure 4A).

For doses, the regression equation showed that under the dose of 169.41 g, plant height reached a maximum value of 20.32 cm, increase of 17.0% in relation to the dose 0 (Figure 4B). Azambuja et al. (2015) also found a higher plant height of Caserta zucchini plants when they performed the application of hydrogel on the occasion of sowing.

The linear regression model was also the best fit for the variable yield, for the factor irrigation levels and for the solution dose factor, the appropriate model was the quadratic (Figure 5).

For productivity, the comparison of irrigation levels of 50 and 125% showed an increase of 22.6% (Figure 5A). The maximum point of expression of the dose factor was achieved using 157.49 g of the hydro retainer, generating a productivity of 14.46 t ha⁻¹, an increase of 34.25% in relation to the mean obtained with the dose 0 (Figure 5B).

The increasing linear response of lettuce yield as a function of irrigation levels, was also observed by Araújo et al. (2010), when working with the lettuce cultivar Verônica from the crisphead group in a protected environment, in Boa Vista, Roraima state, Brazil, achieved a yield of 17.35 t ha⁻¹, with an evaporation level of 120% of the Class A tank. According to these authors, low productivity is related to local climatic conditions, with a mean temperature value of 31.9 °C.

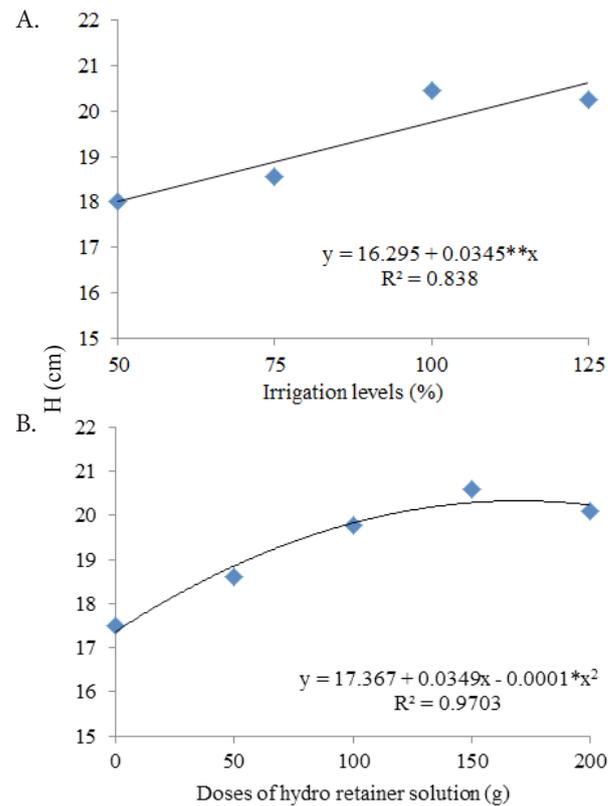


Figure 4. Plant height (H) as a function of irrigation levels (A) and of doses of hydro retainer solution (B) in the cultivation of lettuce in a protected environment

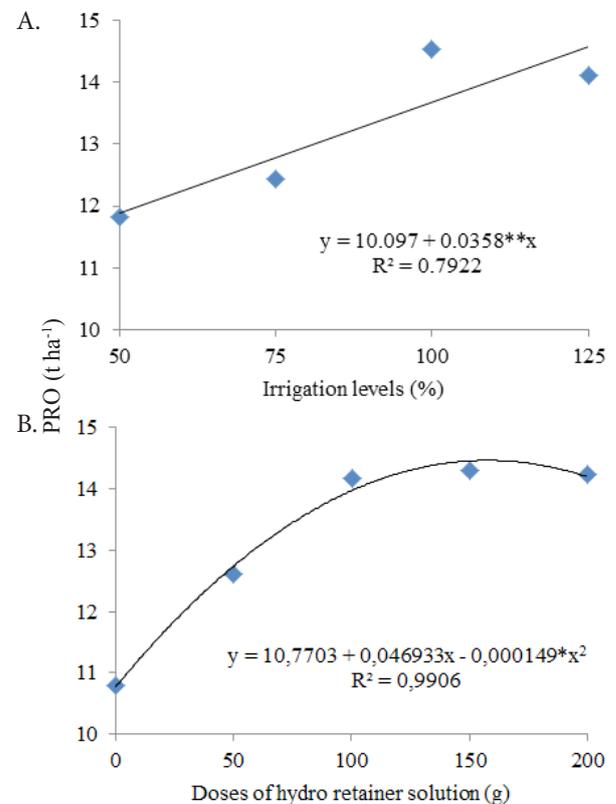


Figure 5. Productivity (PRO) as a function of irrigation levels (A) and of doses of hydro retainer solution (B), in the cultivation of lettuce in a protected environment

For other authors (Andrade Junior & Klar, 1997; Vilas Boas et al., 2008; Lima Júnior et al., 2010), the response of lettuce productivity as a function of irrigation levels was quadratic.

Lima Júnior et al. (2012), with a 95% replacement factor of Class A tank evaporation, obtained maximum productivity for the American lettuce.

CONCLUSIONS

1. The use of hydro retainer solution in crisphead lettuce, cultivar Vanda, provided a significant increase in all the productive variables.
2. The irrigation levels used significantly influenced the variables fresh mass of aerial part, plant height and productivity.
3. The productivity increased 22.6% for the irrigation levels used and the highest estimated values were obtained with hydro retainer solution dose of 157.49 g (14.46 t ha⁻¹).

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