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RESEARCH ARTICLE

LETTUCE SEEDLINGS PRODUCTION UNDER PHOTO-SELECTIVE SHADING NETS

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ABSTRACT

The use of shading nets with different spectral characteristics forthe cultivation of certain vegetable crops has become very common in recent years. The influence of solar radiation on plants was accomplished by analyzing the effect of different photo-selective shading nets on the development of lettuce grown hydroponically in floating systems. Studies were conducted the period from June-July, 2012 at the Federal University of Santa Maria, Frederico Westphalen Campus, state of RS. The treatments were: red net, bluenet, silver net, and without a net environment, all nets presented 40% shade, and were fixed at 0.90 m above the beds of lettuce; the cultivar 'Solaris' was used. A randomized complete block experimental design was used, with four environments and three repetitions. The traits evaluated were: number of leaves, leaf area, fresh and dry root biomass, stems and leaf, stem length, ratio shoot/root and specific leaf area. The greatest accumulation of fresh and dry biomass was observed in the seedlings under silver and red nets. Leaf area and specific leaf area were higher in plants grown under the shading treatment. The blue nets did not improve the development of lettuce seedlings.

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INTRODUCTION

The production of leafy vegetables is closely linked to the quality of seedlings used, making it a very competitive crop that has increased levels of productivity and lower production risks. According to Minami (2010), although the production of vegetable seedlings is a common production strategy, there exists a great diversity in the systems. New technologies, and more efficient strategies can be used to improve the quality of seedlings by introducing. One of the techniques currently used in the production of vegetable seedlings is the 'denominated floating system', also known as floating or swimming pool. This system consists of putting trays for seedling production with a substrate in tank containing a nutrient solution; this provide nutrients for the development of seedlings, regardless of the fertility of the substrate, and serves as a water supply and eliminates the use of supplemental irrigation. Considering that this technique is relatively new, studies are being conducted to establish the best combinations of different substrates (Fernandes *et al.,* 2004; SANTIN *et al.,* 2005; Roosta and Afsharipoor, 2012) and nutrient solutions (Fallovo *et al.,* 2009) in order to study how best to configure this system for different cultures (Trang *et al.,* 2010).

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Plastic shading nets or shading screens, commonly known in the region where this study occurred as sombrites, are used in order to reduce direct sunlight which is beneficial for species that need a less intense energy flow. A segment that is of importance in these strategies, is the netthat can be used to change the radiant spectrum and can bring benefits to crop production. Currently many research projects have demonstrated increases in production for many cultures, especially horticultural (Cantu *et al.,* 2013; Tinyane *et al.,* 2013) fruit trees (Scaranari *et al.,* 2008; Costa *et al.,* 2011), medicinal (Brant *et al.,* 2009; Martins *et al.,* 2009) and ornamental plants (Holcman and Sentelhas, 2012). In this context, the aim of this study was to evaluate the effect of thedifferent photo-selective shading netsused in the cultivation environment regarding the development of lettuce seedlings.

MATERIAL AND METHODS

The study was conducted in the experimental area of the Federal University of Santa Maria º 23′ 48″ south latitude, 53º 25′ 45″ of longitude west and average altitude of 490 m. The region studied has sub-humid sub temperate climate, with an annual average temperature of 18.8°C and average temperature of 13.3°C during the coldest months (Maluf, 2000). The experiment was conducted in agreenhouse with the dimensions of 10 x 20 m, and covered with a transparent and low density

polyethylene film 150 µ thick, treated against ultraviolet radiation, and non-selective. A randomized complete block experimental design was used with three replications. The evaluated environments were compounded by different shading nets (blue Chromatinet®, red Chromatinet®, silver Aluminet® net, all with 40% shading, in addition to an environment without shading) for the cultivation of crispheadlettuce seedlings with the cultivar 'Solaris' in a hydroponic floating type system. The nets were fixed 0.90 m above the cultivation beds. Seeding occurred on June 3rd 2012 in expanded polystyrene trays using 200 cells filled with commercial substrate of pine bark (Plantmax®). The trays were placed in the floating irrigation system, with approximately 10 cm of water, and remained floating in the water until complete germination. After emergence, the seedlings received a commercial nutrient solution recommended for leafy vegetables (Hidrogood *fert*), maintaining the electrical conductivity of the solution at approximately 1,8 $mS.cm^{-1}$ and pH in the range of 5.5 to 6.5. At 34 days after seeding, the seedlings were ready for the transplant. At this moment nine plants per plot were collected, with three plots per treatment, and placed in pre-labeled plastic bags and immediately taken to the laboratory. The root systems were washed in order to remove the bonded substrate, and each plant was separated into leaves, stem and roots. Then stem length was determined with the assistance of a graduated ruler and the total leaf area using leaf area meter (LI- 3100 Area Meter, LI COR, USA). All collected material was weighed with an analytical balance in order to determine values of fresh biomass.

After weighing, the material was placed in a circulating air oven at 65ºC, until a constant weight was achieved, and then the dried material was weighed in order to determine the partition of dry biomass. From these evaluations, the ratio of shoot/root (S/R) and specific leaf area (SLA) was recorded according to Benincasa (2003). During the experimental period was daily air temperature and average relative humidity were taken within each microenvironment through thermo-hygrometers HTR 170 model (Instrutherm Ltda., São Paulo). Data of incident solar radiation was gathered through the use of an automatic station of the National Meteorological Institute (INMET) located150m from the experimental area. The data were submitted to analysis of variance F test and mean comparison was performed by Turkey test ($p < 0.05$) using the computer program Statistical Analysis System v. 8.0 (SAS Inc, Cary, USA).

RESULTS AND DISCUSSION

The data for daily average air temperature recorded during the production of seedlings resulted in variations across the different environments (Figure 1). The environment without the presence of shading showed higher average air temperatures when compared to the environments with shading nets, and higher levels of solar radiation. Similar results were found by Santos *et al.* (2010) and Baeta *et al.* (2011) whom also observed a higher air temperature in the environment without shading nets in lettuce cultivation. There were no differences in daily average air humidity in the different environments.

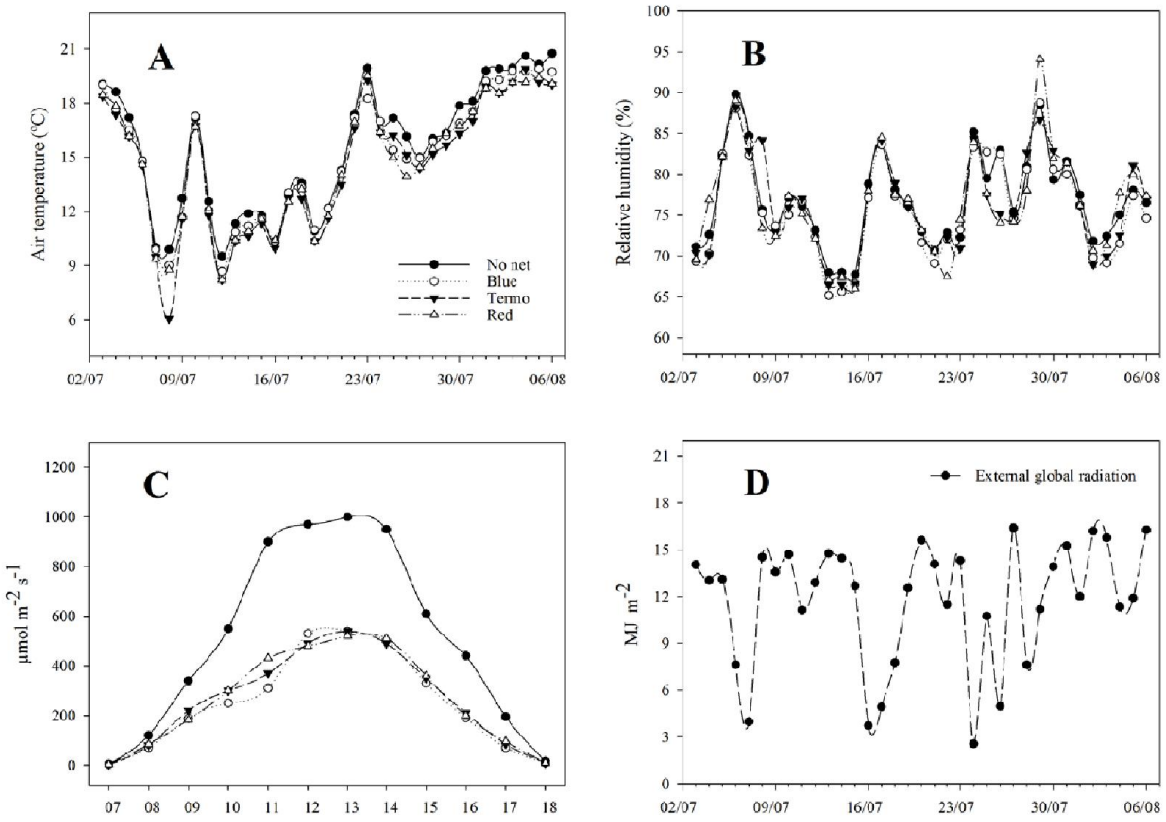

Figure 1. Temperature Variations (A) and average daily relative humidity (B), data of photosynthetic active radiation was obtained on 11/07/2012 (C) under different photo-selective nets and incident global solar radiation (D) (data from an automatic station INMET) during cultivation of crisp head lettuce seedlings in hydroponic systems. Frederico West phalen, RS, 2012

Global external solar radiation, observed duringthe experimental period ranged from a maximum of 16.4 and minimum of 2.55 MJ m^{-2} dia^{-1}. Considering that greenhouse cover plastic has an average transmissivity of 75% (BECKMANN *et al.,* 2006; HELDWEIN *et al.,* 2010), and the attenuation of 40% of shading under the nets during the seedling production period, the incident radiation average was 5.49 MJ m^{-2} $dia^{-1}$for environments with shading nets and 9,16 MJ m^{-2} $dia^{-1}$for environments without shading. These values were above the those found by Caron *et al*. (2003), whom found that the lettuce growth occurs evenly with global solar radiation values of 4.4 MJ m^{-2} dia^{-1}. The shading nets showed significant effects on morphological traits: fresh leaf biomass, fresh root biomass, fresh stem biomass, dry leaf biomass and total dry biomass. The environment with silver netting showed a higher average for the trait of fresh leaf biomass at 0.82g and was not statistically different from the red net treatment which showed values of 0.71g. The environments with the blue net and without netting had the lowest averages of 0.37g and 0.35g respectively. Kendrick and Frankland (1981) observed that plants growing under shading environment show greater accumulation of foliar biomass compared to plants that develop in full sunlight. Similar behavior was found infresh stem biomass, dry leaf biomass and total dry biomass. Schoeninger *et al.* (2011) found that the use of shading in lettuce resulted in a greater accumulation of total biomass.

different from those without the net environment. The blue net environment presented lower averages for this trait (3.3 leaves). Similar performance was observed for leaf area, where the silvernet had 35.07 cm² and red net 31.89 cm². The environment with the blue net and treatment without nettinghad the lowest averages, 17.73 and 14.73 cm² respectively. Akhter *et al.* (2009) found that plants grown in 50% shading showed higher leaf area than those growing in full sunlight, because the intense light favors the development of long cells in palisades, and shaded environment favors greater formation of lacunaryparenchyma.

There was greater shoot length in environments that showed greater accumulation of leaf and stem biomass. These results are similar to those obtained by Luz *et al.* (2009) and Diamante *et al.* (2013), who found greater length in lettuce plants in shaded environments. Stem length showed no statistical difference among the evaluated microenvironments. Specific leaf area (SLA), showing the ratio of leaf area and dry leaves biomass, is a parameter directly related to a plant's investment in leaf structures. SLA is a highly plastic trait dependent on environmental conditions, especially light (DAHLGREN *et al.,* 2006). In this study, the shaded environments had higher SLA compared to the treatment without shadingnets. The result showed that subjected to shading, the lettuce leaves were thinner compared to those in the environment without netting.

Table 1. Means of fresh leaf biomass (FLB), fresh root biomass (FRB), fresh stem biomass (FSB), dry leaf biomass (DLB), dry root biomass (DRB), and total dry biomass (TDB) of lettuce seedlings grown under photo-selective shading nets. Frederico Westphalen, RS, 2012

V.F.	FLB	FRB	FSB	DLB	DRB	TDB
	(grams/plant)					
RedNet	0.71 a*	0.17 ab	0.02 a	0.043 a	0.011 a	0.079 a
TermoNet	0.82 a	0.22 a	0.03 a	0.047 a	0.012 a	0.089 a
Blue Net	0.37 b	0.11 c	0.01 b	0.023 b	0.006 a	0.043 b
NoNet	0.35 b	0.12 bc	0.02 b	0.028 b	0.009 a	0.054 b
CV(%)	19.36	29.27	27.38	22.94	51.93	24.55

*Means followed by the same letters do not differ by Tukey test (p<0,05)

Table 2. Average number of leaves (LN), leaf area (LA), shoot length (SL), stem length (ST), specific leaf area (SLA) and ratio shoot/root (S/R) lettuce seedlings grown under photo-selective shading nets. Frederico Westphalen, RS, 2012

V.F	LN	LA	SL	ST	SLA	S/R
		(cm²)	(cm)		(cm^2. g^{-1})	
RedNet	4.0 a*	31.89 a	9.49 a	1.90 a	764.01 a	5.29 a
Termo Net	4.0 a	35.07 a	10.10 a	2.00 a	761.40 a	5.27 a
Blue Net	3.3 b	17.73 b	7.54 b	1.81 a	767.31 a	4.13 a
NoNet	3.7 ab	14.73 b	5.52 c	1.79 a	525.63 b	3.29 a
CV(%)	9.2	13.3	6.44	12.47	11.72	58.41

*Means followed by the same letters do not differ by Tukey test (p<0,05)

For the trait of fresh root biomass, the environment with the blue nets presented the lowest average. Even presenting difference among the averages, there was no statistical difference between the nets for values of dry root biomass. Ramos (1995) found that the shading effect provided greater production of dry biomass of lettuce seedlings in both the formation phase and in the commercial production stage. The shading nets showed significant effects on many morphological traits: leaf area, shoot length, specific leaf area and leaf number. The environments with silver and red nets showed four leaves per plant which was not statistically

In general, plants which possess anatomical plasticity see increased specific leaf area when grown in environments with low light availability (MORAIS *et al.,* 2004). Similarly, other studies have shown that lower values of this trait are usually found in high light conditions (MARKESTEIJN *et al.* 2007 SARIJEVA *et al.* 2007). The increased leaf area is one of the adjustments that allows plants to invest in growth and elongation of photosynthetic leaf surface, increasing the efficiency for capturing light (LENHARD *et al.,* 2013). Although there are no significant differences among environments for the ratio of shoot/root, we may observe that

there is a greater tendency to directing biomass to roots in plants grown under full sunlight, and direction of biomass to shoots in plants under shading nets. Seedlings grown under silver and red nets showed better development compared to seedlings grown under blue net and those grown without netting (Figure 3). This result is similar to those found by Seabra *et al.* (2010) who observed an increase of lettuce plants production by approximately 20% when using silver net. The blue net even with the same percentage of attenuation of radiation to that of the silver and red net did not favor the development of lettuce seedlings, possibly due to photo-selectivity in different light spectra.

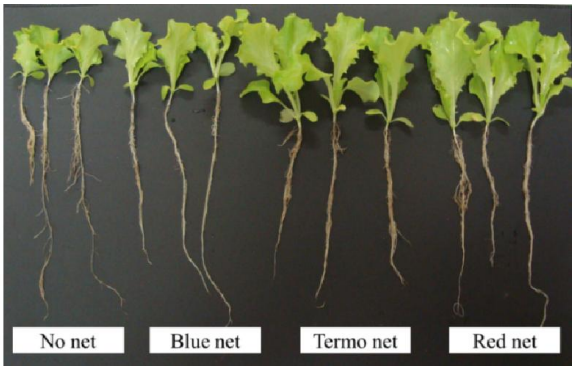

Figure 2. Lettuce seedlings grown in floating hydroponic systems under different photo-selective shading nets, at 34 days after seeding. Frederico Westphalen, RS, 2012

Conclusion

The different environments affected the development of lettuce seedlings. The silver and red net provideda greater accumulation of biomass and overall better development of lettuce seedlings. The blue netting did not favor the development of lettuce seedlings. It was concluded that not only the intensity, but also that the quality of light influences the dry biomass accumulation of lettuce seedlings. The variations which resulted from the different shading net environments reinforce the fact that intercepted solar radiation is of great importance when determining the biomass accumulation of plants. This is relevant to not only growth, but various chemical and physiological processes which occur due to plants' utilization of solar radiation.

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