Effect of restriction of solar radiation and increases of temperature on the growth of radish plants

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Abstract

Solar radiation is the main source of energy for the photosynthesis, while the temperature influences the metabolism of plants by changing the speed of chemical reactions and enzyme activity. This study evaluated the influence of the reduction of solar radiation and the increase of temperatures in the growth of radish plants of two cultivars in Guarapuava (PR). It was evaluated: plant height, number of formed leaves, leaf area and total dry matter. In relation to the control plants, plants of the cultivar Cometa submitted to high temperature and restrict solar radiation showed higher number of leaves and taller plants at the beginning of the growth, and higher leaf area when submitted to higher temperature, while plants of the cultivar Gigante submitted to higher temperature formed higher total dry matter than the control plants at the end of the growth. It was concluded that at this study conditions, low solar radiation or high temperature leads to changes in radish plant morphology, depending on the cultivar.

Key-words: Leaf area; photosynthesis; solar radiation; *Raphanus sativus* L

Introduction

Radish plants (*Raphanus sativus*) have an annual cycle and belong to the family *Brassicaceae*, usually small, generally not exceeding 30 cm of height (FILGUEIRA, 2008). They develop well in conditions of mild to cold climate, and are better adapted to planting in the fall-winter period, to well drained soils, with good fertility and which present good water availability during all the culture cycle (FILGUEIRA, 2008).

Despite being a culture of low importance in terms of planted area, it has good financial viability, since it can be used as intermediate crop between others with longer cycle, once that, besides being relatively rustic, it presents a very short period, enabling a fast financial return (MINAMI et al., 1998).

Among the factors which affect the production of radish plants, the climate variables are of major importance. The sun light is the main source of energy to the plants, being used in the synthesis of highly energetic chemical bonding, and reduced compounds of carbon (LAWLOR, 2001). It is known that sunlight is a fundamental factor to the vegetal growth and development, either trough photomorphogenic or photosynthetic processes (LARCHER, 2000). According to AMUNTS and NELSON (2008), vegetables have the capacity of developing well in a wide range of sun light, varying from 1 μE m^{-2} s^{-1} to certain algae from the Artic until approximately 2000 μE m^{-2} s^{-1} to other plants.

Besides sunlight, temperature also influences the plant metabolism changing the speed of chemical reactions and enzyme activity which are part of this process. Under high temperatures the speed of the reactions is so high that the availability of substrate and the transport of energy do not come with it. According to LARCHE (2000) in the photosynthesis the fixation and reduction of the carbon dioxide (CO_2) occurs slowly in low temperatures, increasing with the heating to a great value and, in temperatures above the great, the carboxylation of the Ribulose bisphosphate (RuBP) decreases considerably. This occurs since, with the increase in temperature, the ratio O_2:CO_2 is changed. The CO_2 solubility decreases if compared to O_2, thus photorespiration is favored, reducing the photosynthetic yield (KERBAUY, 2004). Besides that, high temperatures cause an unbalance in the admission and expulsion of CO_2 by plants (ATKIN et al., 2007).

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The region with great temperature for the plants to express all their potential is that which reaches more than 90% of the photosynthetic capacity. High temperatures provide increase in the photorespiration and in the mitochondrial respiration, which ends up reducing the photosynthetic yield. However, this effect can be reduced if the plant has a wide great temperature range, favoring the photosynthetic yield, since temperature ranges would not prejudice the plant physiology in a significant way. The speed in which the maximum temperature limits the photosynthetic process depends on the sensibility to heat and the intensity of the increase of the respiration in function of the temperature (LARCHER, 2000). Temperature has major influence in the capacity of the enzyme Ribulose 1,5 Biphosphate Carboxylate (Rubisco) in developing its function of carbon fixation (ANDERSSON and BACKLUND, 2008).

Despite verifying the production of radish by farmers of the region of Guarapuava (PR), there is scarce information about the effects of sunlight and temperature in the growth of this species. Thus, to increase the technical information about radish culture, this work aimed to evaluate the effect of the sunlight and temperature in the growth of radish plants cultivated in greenhouse in the city of Guarapuava (PR).

Material and methods

The experiment was performed in the experimental field of the Department of Agronomy of the Universidade Estadual do Centro-Oeste (State University of the Mid West), Guarapuava (PR), conducted under protected cultivation, in gutter-connected greenhouse with dimensions of 23 m x 7 m. Seeding was performed in April 23th 2009, placing 3 seeds of the cultivars Cometa and Gigante in each vase with capacity for approximately 500 mL, filled with washed sand as substrate. Weekly it was added to the vases approximately 100 mL of complete nutritional solution (MACHILIS and TORREY, 1956). Four days after the seedling (DAS) it was made the thinning, leaving only the most vigorous plantlet in each vase and the treatment initiated putting plants in different environments.

Three different treatments were formed: temperature, illuminance and control, all conducted under protected cultivation. The control plants were placed in greenhouse, with sunlight restriction. In the treatment with sunlight restriction (illuminance), the plants were placed inside a wooden frame coated with black shading screen (50% of reduction), with dimensions of 80 cm of width and length and 75 cm of height, inside the same greenhouse the control plants. In the treatment with high temperature (temperature), the plants were placed inside another greenhouse, also with the gutter-connected format, also with low air circulation and, therefore, with higher temperatures. The temperature in the treatment illuminance and the illuminance in the treatment temperature were similar to those of the control treatment.

It was registered weekly the maximum and minimum temperature to each environment trough the reading in digital thermometer and the sunlight intensities using a portable digital luxmeter (LD-200, Instrutherm).

The data of height and the number of leaves were collected in three periods of the cycle of culture development: 14, 21 and 28 DAS. 28 DAS, plants were sampled in order to calculate the leaf area and the dry matter mass of the shoot and root. The leaf area was obtained with digital photos of all the leaves of the plant which were later manipulated with the program ImageJ (ABRAMOFF et al., 2004). The total mass of dry matter, calculated with the sum of the dry matter of the shoot and underground material, was determined after drying in greenhouse with forced aeration (70° C) until it reaches constant mass.

The experimental parcel was constituted of a vase and the experimental design used was the completely randomized with four replications. Data were submitted to analysis of variance, with averages compared by the Tukey test at 5% probability (α=0,05). The treatments were compared in each evaluation period.

Results and Discussion

Plants under light restriction (illuminance) received in average 45.6% less sunlight compared to the control plants, and the plants of the treatment under high temperatures were submitted to temperatures, in average, 7° C superior than the control plants during the growth period (Figure 1), being possible to conclude that the treatments provided environment with different quantity of sunlight and temperature.

When comparing the averages of height of radish plants, it was verified difference between the treatments in the cultivar Cometa in the three evaluations, where plants submitted to higher temperature or lower illuminance grew more than the control treatment (Figure 2a). However, the same behavior was not observed to the cultivar Gigante

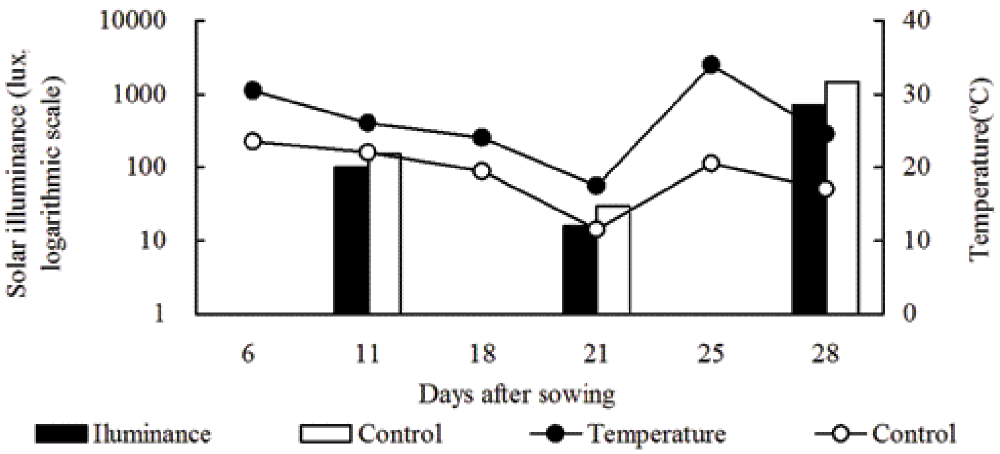
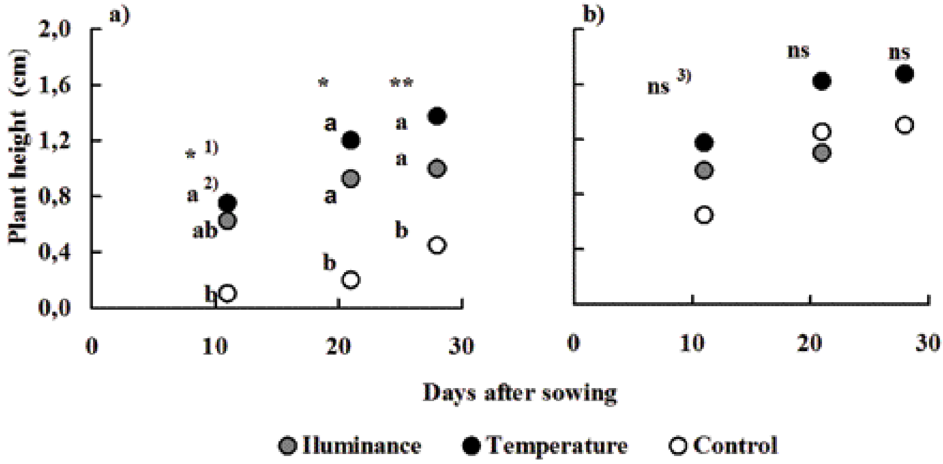


Figure 1. Sunlight (a) and temperature (b) variation over the development of radish plants (*Raphanus sativus* L.) cultivated under protected cultivation in Guarapuava (PR), 2009.



*1) ns, * and **: Statistic difference not significant and significant at 5 and 1%, respectively. The treatments were analyzed separately in each evaluation period.*

2) Averages followed by the same letter do not differ by the Tukey test (α=0,05).

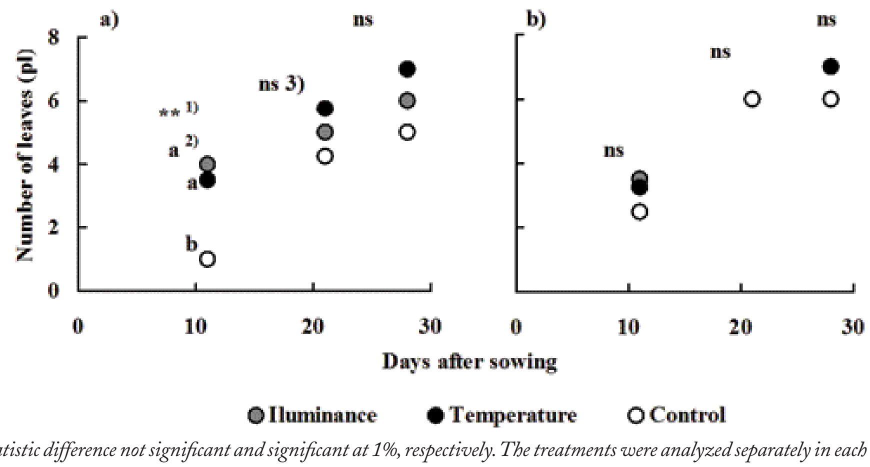
Figure 2. Effect of sunlight restriction (illuminance) and high temperatures (temperature) over the radish (*Raphanus sativus* L.) plant height of the cultivars Cometa (a) and Gigante (b), conducted under protected cultivation in Guarapuava (PR), 2009.

(Figure 2b), so that it is presumed that the illuminance restriction or the higher temperature may affect the height of the cultivars in a different way. Even though radish develops well in mild temperatures, the great range to the well growth of this plants is from 7 to 32° C. Probably the highest temperature may have provided increase of the photosynthetic activity, once that temperatures during the experiment did not exceed the range considered great to the culture (Figure 1). In experiment performed by BARROS and LEMONS FILHO (2007) with plants of *Dalbergia nigra*, they had photosynthetic yield reduced when exposed to extreme temperatures, i.e., out of the great range.

Concerning the number of leaves, it was found difference only in the first evaluation to the cultivar Cometa, in which the plants of the treatment temperature and illuminance obtained a higher number of leaves compared to the control plants (Figure 3a). Similar result was obtained by SOUZA et al. (1999), who observed that the number of radish leaves was not affected by the reduction of light intensity. This result demonstrated that the number of leaves of radish plants is a characteristic little affected by the treatments proposed in the experiment. This may be, in a certain way, an advantage to the producer, once the increase of the temperature or a lower illuminance do not affect in an intense way the number of leaves of radish plant.

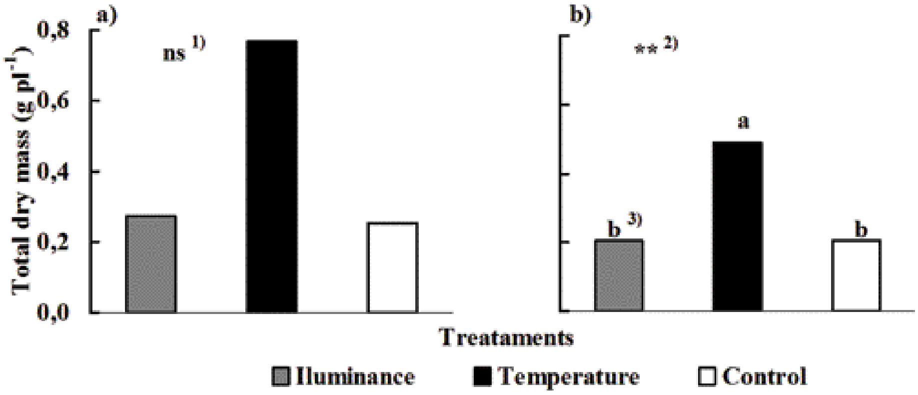
In the evaluation of the mass of total dry matter (shoot dry matter + underground) of the plants it was not found significant difference between the treatments in the cultivar Cometa (Figure 4a). Although it was not found significant statistic different in the total dry matter to the cultivar Cometa, it was observed that the averages of the treatments had a similar behavior to the one observed in the cultivar Gigante. This result corroborate with the results obtained by PEREIRA (2002) who observed higher production of dry matter mass in radish plants cultivated in low tunnels compared to plants cultivated without plastic cover and under lower temperature. However, the results of the study in which for both cultivars it was not observed difference between control plants and illuminance (Figure 4a and 4b) contradict the result observed by SCHMITT et al. (1986) who observed a lower growth of plants submitted to a lower quantity of sunlight. This discrepancy among the results is probably due to the difference of illuminance restriction employed in each work.

It was found difference between data of the plant leaf area of the cultivar Comenta, in which those under the treatment temperature differed from



*1) ns, and **: Statistic difference not significant and significant at 1%, respectively. The treatments were analyzed separately in each evaluation period.*
2) Averages followed by the same letter do not differ statistically by the Tukey test (α=0,05) in the same evaluation period.

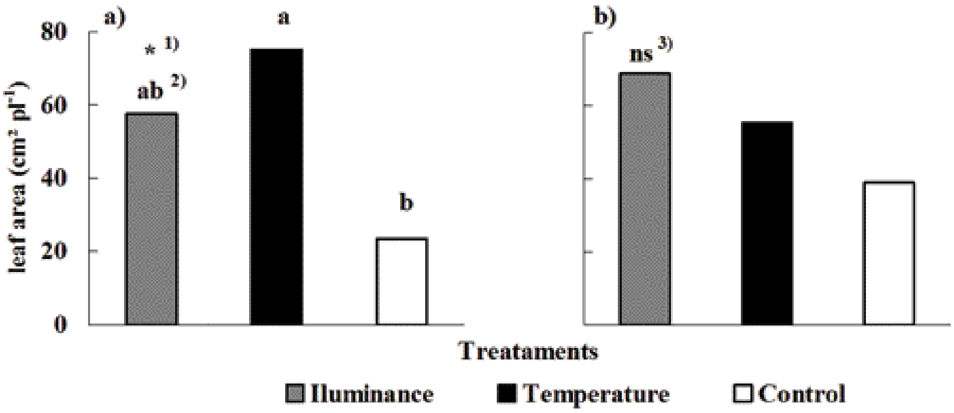
Figure 3. Effect of sunlight restriction (illuminance) and high temperatures (temperature) over the leaf number of radish plant (*Raphanus sativus* L.) of the cultivars Cometa (a) and Gigante (b), conducted under protected cultivation in Guarapuava (PR), 2009.



*1) ns and **: Statistic difference not significant and significant at 1%, respectively.*
2) Averages followed by the same letter do not differ by Tukey test (α=0,05).

Figure 4. Effect of the sunlight restriction (illuminance) and high temperature (temperature) in the total dry matter of radish plants (*Raphanus sativus* L.) of the cultivars Cometa (a) and Gigante (b), conducted under protected cultivation in Guarapuava (PR), 2009.

the control, presenting larger leaf area (Figure 5a). Similar result was obtained by CRACKER et al. (1982) who observed that the light influenced in the development of leaf and storage radish organs. On the other side, MARCELIS et al. (1997) observed a production of average leaf area of 140 cm^2 pl^{-1} and found that radish plants submitted to 40% of sunlight reduction formed a lower leaf area when compared to the control without sunlight restriction. In plants of the cultivar Gigante there was no statistic difference in the leaf area between treatments (Figure 5b). This result contradicts those obtained by Cracker et al. (1982), who working with radish plants concluded that the daily input of solar energy was the main



*1) ns and *: Statistic difference not significant and significant at 5%, respectivelly.*
2) Averages followed by the same letter do not differ by Tukey test (α=0,05).

Figure 5. Effect of sunlight restriction (illuminance) and high temperatures (temperature) in the leaf area of radish plants (*Raphanus sativus* L.) of the cultivars Cometa (a) and Gigante (b), conducted under protected cultivation in Guarapuava (PR), 2009.

factor which affected the leaf growth.

Conclusions

It was concluded that in the studied conditions the restrictions of the sunlight radiation causes radish plants that are lower and with larger number of leaves in the beginning of their development, and, when submitter to higher temperature, inside the great range, present higher length, higher total dry matter weight and higher leaf area, depending on the cultivar.

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