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CHANGES IN LEAF COLOR AND RELATIVE WATER CAPACITY OF LETTUCE (*Lactuca sativa* L.) DEPENDING ON THE USE OF THE SHADING NET

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ABSTRACT

Lettuce leaf color is a hereditary trait, and among environmental factors, light/radiation and temperature are the two most influential climatic variables. This research is based on the effect of the application of photoselective nets of different densities, that is, with different percentages of shading, on leaf coloration and relative water content (RWC) at lettuce maturation. Three nets with different shading percentages were used, namely green nets with a shade of 50% and 35% and one white net with a shade of 50%, and plants without shading were used as controls. To determine the full effect of the application of nets on the production of summer lettuce, the experiment was conducted in two planting periods: May-June and September-October 2021 with lettuce Zeralda F_1 and Abbice F_1 in the greenhouse. Colorimetry was performed on three occasions, every seven days, and in the phase when 70% and 80% of the plant mass was reached. Regarding the color of the leaves, it was shown that in the second period of cultivation at the end of the vegetation, a difference in the intensity of the color was found, that is, the net with stronger shading (G50) showed a stronger intensity of lettuce color compared to the other tested variants. RWC was quite different depending on the variant in the first growing period, while in the second growing period, the highest was in the control plants (89.48%) and those under nets with 50% shade (77.69%).

Key words: lettuce, shading net, color, RWC.

INTRODUCTION

Lettuce crops are exposed to significant variations in their environmental conditions. Early spring, late autumn, and even winter lettuce production can be successfully achieved in high tunnels in temperate climates (Gent, 2002), but less potential is recognized for extending seasonal production to hot summer months. In addition to temperature, lettuce production depends mostly on light (Dufault et al., 2009) and on the quality and intensity of light (Ilić & Fallik, 2017). Wang et al. (2021) concluded that the direction of illumination has a strong influence on the morphological characteristics of lettuce, with the plants adapting to changes in light conditions. Excessive solar radiation leads to abiotic stress and is caused by climate change, especially global temperature increases (Mditshwa et al. 2019; Gowdy, 2020). Therefore, innovative practices have been developed to mitigate the rise in temperature and light intensity, as well as new cultivars that can be produced in summer. One of the most effective control methods is the use of photoselective nets (Selahle et al. 2014). Shading nets, owing to their ability to reduce light intensity, modify light, and thus reduce temperature, are effective in prolonging the growing season and improving quality (Briassoulis et al. 2007; Shahak, 2014). The radiometric properties of nets depend on their porosity and color. In addition to affecting the amount of radiation, the photoselective net can also transform radiation from direct to scattered light, allowing light to penetrate plants (Stamps, 2009). This prevents burns, offers a moderate cooling effect and improves pest control (Shahak, 2008). The shading of the photoselective net varies from 20 to 70% depending on the greater or lesser permeability to solar radiation (Briassoulis et al. 2007). Holcman & Sentelhac (2013) found that the type and color of shading nets affect the microclimate below the grid, mainly the intensity and

quality of solar radiation. Obviously, the higher the percentage of shading, the more radiation will be blocked. Reduced light intensity affects the temperature (air, plants, and soil) and relative humidity (Stamps, 2009).

Plants under the nets acclimatize, creating larger and thinner leaves with a triple increase in the chlorophyll content. On the other hand, owing to the reduction of light, plants trigger several compensatory mechanisms, with a significant increase in photosynthetic pigments. Leaves with more pigments show higher light absorption per unit leaf mass, which can provide plants with a better carbon balance due to light limitations, which also affects leaf color and the relative water capacity of leaves (RWC) (Ilić et al. 2021).

MATERIAL AND METHODS

The experiment was conducted under controlled conditions in the greenhouse of the Faculty of Agriculture in Banja Luka. The greenhouse belongs to the category of unheated greenhouses. This research is based on the effect of the application of photoselective nets of different densities, that is, with different percentages of shading, on the colorimetric changes of the leaves and the relative water capacity of lettuce leaves. Three nets with different shading percentages were used, namely green nets with a shade percentage of 50% (G50), 35% (G35), and one white net with a shade percentage of 50% (GW), and plants without shading were used as controls (C). To determine the full effect of the application of nets on the production of summer lettuce, the experiment was conducted in two planting periods: May-June and September-October 2021. Two cultivars of the were used in the experiment: Zeralda F_1 ("Vilmorin seed company," France) and Abbice F_1 ("Vilmorin seed company," France). Forty plants of both hybrids were placed under shading nets and the control group was without shading net. During the cultivation process, agro-technical measures were applied, which were in line with the principles of organic production.

Colorimetric analyses were performed in a greenhouse, and the relative water content in the leaf (RWC) was determined in the Laboratory for Soil Analysis of the Faculty of Agriculture, University of Banja Luka. Colorimetry was performed using a colorimeter brand WR18/4-8 (FRU) on three occasions, every seven days, and in the phase when 70% and 80% of the plant mass was reached (from BBCH_41 to BBCH_49) (Meier, 2001). Graphic cards were obtained by entering the colorimetric values a*, b*, and L* into the Lab tool option of the Corel Draw x8 program. The values of a*, b*, and L* were converted to the closest values of the standard colors. To determine the relative water content of the leaves (RWC), lettuce leaves were weighed immediately after picking (fresh leaf mass, FW). The weighed leaves were then placed in distilled water until completely hydrated (full turgid weight, TW), and then the dried and dried leaves (DW) were weighed. All average weights were measured with an analytical balance to the nearest 0.0001 g of Kern. The final value was calculated according to the formula: RWC (%)= [(FW-DW)/(TW-DW)]x100 (Weatherley, 1950). Biometric analyses and graphical data processing were performed using the software package SPSS version 22 (IBM, 2013).

RESULTS AND DISCUSSION

Colorimetric display of leaf color change

The amount and distribution of plant pigments (chlorophyll and anthocyanins) significantly affect the color of lettuce leaves (Gazula et al. 2007). Unfavorable conditions in which lettuce is grown can also affect leaf color. Often, due to high summer temperatures and strong intensity of sunlight, central nerve discoloration occurs, which reduces the market value of lettuce (Ilić et al. 2017).

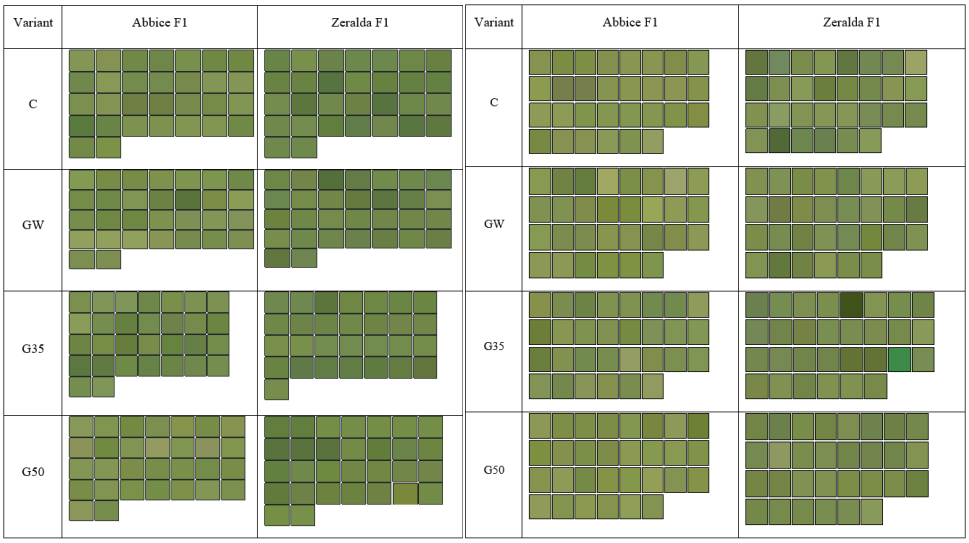


Figure 1. Change of leaf color from BBCH_41 (left) to BBCH_49 (right) in first production period May-June 2021

From the presented results, it is evident that during the first period of cultivation (Figure 1). There were no significant differences in the color of the lettuce among the tested variants. At the end of the vegetation period (BBCH_49), a slightly lighter leaf color was observed compared to the color of the vegetation. Minor differences were found between the examined hybrids, that is, Zeralda F_1 had, on average, a darker leaf compared to Abbice F_1. During the second cultivation period (Figure 2) at the end of the vegetation (BBCH_49), differences in color intensity were determined, that is, nets with stronger shading (G50) showed a stronger intensity of lettuce color compared to other tested variants.

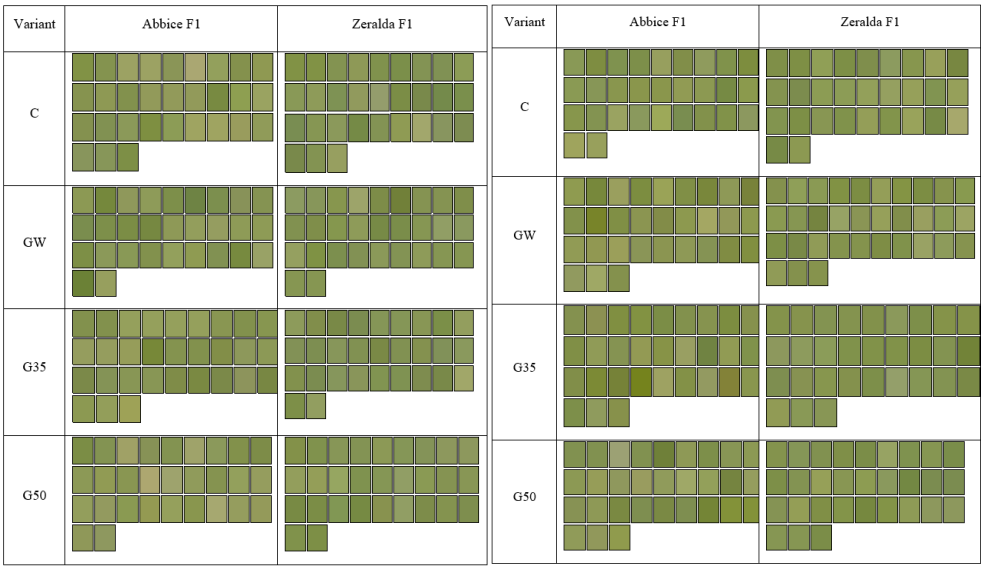
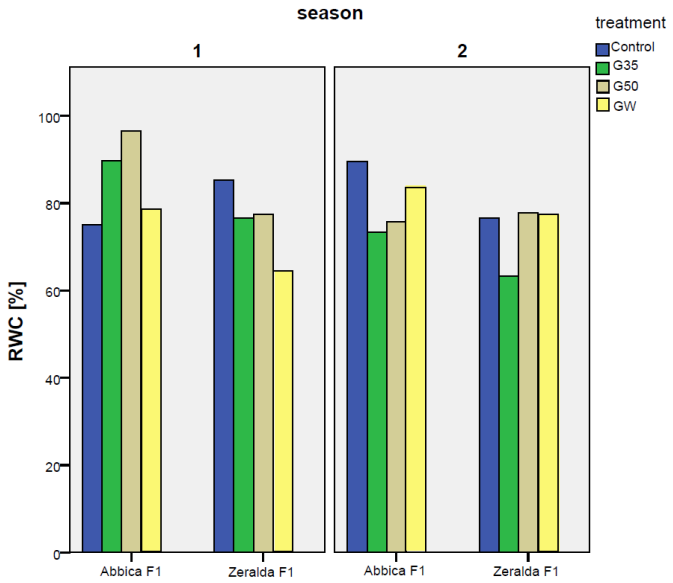


Figure 2. Change of leaf color from BBCH_41 (left) to BBCH_49 (right) in the second production period September-October 2021

If we compare the seasons of lettuce production in terms of color intensity, we can conclude that at the end of the growing season in the summer season, a greater intensity of green color was observed than at the end of the growing season in the autumn planting period. Lara et al. (2020) by growing spinach under red, blue and gray photoselective nets with 65% shade showed that the nets affected the color intensity of leafy vegetables.

Relative water content

Relative water content (RWC) provides a measurement of the "water deficit" of the leaf and can indicate the level of stress due to drought or high temperatures and the plant's response to it. It is very important for lettuce to remain well hydrated during long storage periods to maintain its sensory properties such as texture and appearance. Butter lettuce is more sensitive to water loss than other lettuce varieties such as crystal lettuce (Saltveit, 2004).



Graph 1. Relative water content (RWC) in leaves (%)

Based on the obtained results, in the first period of cultivation, Abbica F_1 had the highest percentage of RWC under green nets with 50% shade (96.48%), whereas in the case of Zeralda F_1, the highest percentage of RWC was noted in the control group (85.2%). For Abbica F_1 (70.29%) and Zeralda F_1 (64.34%), the lowest percentage of relative water content was determined using white nets (GW). In the second growing season, Abbica F_1 had the highest RWC in the control group (89.48%), whereas in the case of Zeralda F_1, the highest value of this parameter was measured in plants that were under nets with 50% shade (77.69%). It should be noted that, with this hybrid, approximate values were also obtained for the control group, but also with white nets. In contrast, in Abbica F_1, the lowest percentage of RWC was in plants under the net with a shading percentage of 35% (73.36%), and in Zeralda F_1, in plants growing under a net with a shading percentage of 35% (63.33%). Abbice F_1 had a higher relative water content in leaves during both growing periods than Zeralda F_1. During the summer period, the highest relative water content in the leaf was registered in G50 nets, when it comes to Abbice F_1, while in case of growing Zeralda F_1, the control group (unshaded plants) had the highest relative water content in the leaf. Different results were found in the second period of production, where in Abbica F_1, the highest relative water content in the leaf was recorded in the control group, whereas in Zeralda F_1, the highest relative water content in the leaf was determined in plants that were covered with G50 net. It should also be noted that the relative water content in the leaves of Zeralda F_1 in control plants, as well as in the plants covered with a white net (GW), is at the same level as the relative water content in the leaves of the plants that were covered with the G50 net. On the other hand, Zeralda F_1 nets had a certain influence on the relative water content in the leaf, with the best results observed with G50 nets, as well as with white nets (GW).

The results obtained in our research show that the average relative water capacity of lettuce hybrids in this research is, in most cases, lower than that reported in the literature (Esparza Rivera et al. 2006), except for Abbica F_1 under the net with 50% shading in the first period of production, where the RWC was over 95%. Đekić et al. (2022) had the average RWC in control lettuce plants grown at autumn period of 90.69%, while in plants below shading net of 50% density it was lower (82.73%) which in general, was a slightly higher RWC on the same hybrids.

CONCLUSIONS

In the summer growing season, there were no visible differences between the treatments in the color of lettuce leaves. In the second season, in the end, it was shown some differences in color intensity, where the nets with stronger shading (G50) showed a stronger color intensity compared to the control, white and net with a shade index of 35%.

In addition, there were differences between seasons in the average relative water content in the leaves, where higher values of this parameter were observed during the summer production of lettuce. RWC was quite different depending on the variant in the first growing period; Abbica F1 had the highest percentage of RWC under green nets with 50% shade (96.48%), whereas Zeralda F_1 had the highest percentage of RWC in the control group (85.2%). In the second growing period, the highest percentage was observed in the control plants (89.48%) and those under nets with 50% shade (77.69%).

From the research data thus far, it can be seen that it is still necessary to examine the influence of different colors and densities of shading nets on vegetables.

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