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EVALUATION OF THE DIFFERENT TYPE OF TUNNELS COVERINGS APPLIED AT LETTUCE CULTIVATION

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Abstract

The aim of this study was to test different coverings used on low tunnels during the cultivation of lettuce for the winter-spring production, and to compare the results with those obtained in high tunnels. The experiment was conducted in the period 2019-2020 in the experimental field of the University of Forestry - Sofia (42°7' N, 23°43' East). There were selected 3 varieties (2 of Batavia and 1 of Romana) with different requirements for the terms and conditions of cultivation. For the purpose of the study, lettuces were planted in parallel in a high tunnel and in low tunnels with two different coverings - non-woven fabric (geotextile) and green polyethylene. Planting was done simultaneously during the second ten days of November (12.11.19) by the block method with four replications. Immediately after planting outdoors, low tunnels were placed over the bed. During the harvest (April) biometric measurements were made and reporting of quality indicators - dry matter content and nitrates. In low tunnels, the plants have more sugar and dry matter under the green polyethylene coating than the geotextile coating. Both varieties of lettuce grow better under a cover of green polyethylene, while lettuce has better performance when covered with geotextile.

Key words*: geotextile, green polyethylene, lettuce, low tunnels.*

INTRODUCTION

The greenhouse production of salads ensures their supply during the autumn-winter-spring period. They are one of the first vegetable crops grown in a polyethylene greenhouse to produce off-season production (Lamont, 2005).

The Lettuce (*Lactuca sativa* L.) is the most consumed leafy vegetable in world and has great economic importance. It is an herbaceous, delicate plant, with a short stem that holds leaves growing in a rosette pattern. Lettuce has a short growing cycle, large leaf area and shallow root system, requiring sandy-clayey soils rich in organic matter and with high concentrations of readily available nutrients (Silva et al., 2010).

High tunnels are large, framed structures covered with a single or double layer of greenhouse-grade plastic with no electrical or ventilation systems and are typically used to produce high-value specialty crops including lettuce and other leafy greens (Knewtson et al., 2010; Lamont, 2009). High tunnels are employed as crop growth enhancers, providing climate protection during severe weather conditions and enabling season extension (Lamont et al., 2002; Reeves and Drost, 2012). During the winter months, high tunnels provide microclimates suitable for season extension allowing growers to plant lettuce earlier in the season, later in the season, or both. Optimizing the utilization of these microclimates can improve crop yield and quality (Zhao and Carey, 2009).

The product obtained in the high tunnels is of very good quality and the production is more economical than in the glazed greenhouses (Wells and Loy, 1993; Tüzel and Leonardi, 2009), the yields are higher and the harvests start more early, compared to growing lettuce in open areas. (Santos et al., 2009; Wallace et al., 2012; Golzar et al., 2018). For this reason, lettuce ranks as one of the main crops for growing in plastic tunnel greenhouses (Lamont, 2009; Favarato et al., 2020).

An alternative to growing lettuce in high tunnel greenhouses and obtaining earlier products from early field production is the use of low polyethylene tunnels. Low tunnels are temporary structures that are easy to assemble and disassemble with each crop. This mobility

offers an advantage over high tunnels because it allows for rotations with cover crops or other field crops to improve and maintain soil health and productivity. However, this requires an increase in labor costs to set up and remove the structures.

Low tunnels can be of various heights and covered mainly with three types of plastic materials: perforated or slit plastic film, spun-bonded fabrics, and insect nets, depending on the purpose of their use.

These structures are usually 50-80 cm high, arch-shaped and covered with plastic foil, so that they provide a suitable microclimate. (Scarascia-Mugnozza et al., 2011).

Accelerated plant development, earlier harvests, and higher yields lead to higher productivity during the autumn-winter season. (Arin and Ankara, 2001; Favarato et al., 2020).

In addition to the type of construction (high or low tunnels), the type of coverage also has an impact. The non-woven fabrics (agro-textiles) are one of the coatings used for low tunnels to improve the microclimate (Hamamoto, 1996; Hamouz et al., 2006; Buta and Apahidean, 2009; Olle and Bender, 2010).

Colorless polyethylene coatings are used, but colored coatings are also of interest. When comparing different color coatings, studies show that green colored ones stimulate vegetative development and slow down the onset of fruiting, while red colored ones improve fruit formation (Henschel et al., 2017). Quintero-Arias et al. (2021) found that it is necessary to select varieties of salads (green or red leaf type) with the type of plastic coating (UV-blocking or UV-transparent polyethylene) to improve the quality of production.

The aim of this study was to test different coverings used on low tunnels during the cultivation of lettuce for the winter-spring production, and to compare the results with those obtained in high tunnels.

MATERIALS AND METHODS

The field experiment was conducted during 2019–2020 at the experimental field (42°7′N, 23°43′E and 552 m above sea level) of the University of Forestry, Sofia, Bulgaria, on the fluvisol, which is slightly stony and slightly acidic (pH (H_2O)6.2).

For the aim of the experiment, a total number of 3 types of lettuces have been studied (2 of Batavia and 1 of Romana), as follows:

1. Gentilina: open type Batavia, cold-resistant and resistant to high temperatures variety (does not shoot). The recommended term for outdoor cultivation for Bulgaria is March-October.
2. Aquarel (Bejo Zaden): Batavia type salad suitable for planting spring-summer and summer-autumn outdoors.
3. Cherna Gyumyurdzhinska: Medium early winter variety of lettuce, intended for autumn planting. Characterized by good cold resistance. Grown by overwintering for earlier spring production.

Two different types of covering used on low tunnels were used and the results were compared with those obtained in high tunnels. The types of coverings are as follow:

Geotextile (GT) - for low tunnel: white non-woven polypropylene coating with UV protection. No chemicals - non-toxic and safe for plants. Helps warm the soil and protects plants from frost in early production. Allow of plants to breathe, be irrigated and treated with water-soluble substances. It does not absorb water and dries quickly after rain. The coating leads to an earlier harvest 1-2 weeks ahead.

Green polyethylene (GP) - for low tunnel: UV stabilized 120-micron polyethylene for covering greenhouses, with excellent transparency, high conductility and tensile strength. UV stabilizers protect the film from solar radiation and anti-oxidants by increasing the durability of polyethylene.

Reinforced and stabilized polyethylene (RSP) - for high tunnel: high-quality polyethylene coatings for greenhouses transmit, reflect, absorb and emit different parts of the spectrum of sunlight. Polyethylene film with reinforcement that makes it resistant to weathering and has a long service life. Polyester threads significantly improve the mechanical properties of polyethylene.

The cultivation technology is standard: by pre-produced seedlings. Transplanting in the polyethylene greenhouse and in the low tunnels took place on 12.11.19. One week later was carried out planting to replace the dead plants. The growing scheme used in the greenhouse is 50 + 30 + 30 + 30 x 30 cm, and outdoors is 30x30, in four rows.

For the purposes of the study were tracked: Biometric indicators: plant height (cm); plant diameter (cm); mass of one plant (g). Biometric indicators were measured at harvest.
Qualitative indicators: determination of the dry matter content in the production; determination of sugar content in the plant cell (Brix,%) with a refractometer (model - Digital refractometer 32145, manufactured by B & C Germany).
The collected data from these indicators were analysed by ANOVA and were expressed as mean ± standard deviations. Post hoc analyses were conducted using Fisher's protected LSD test.

RESULTS AND DISCUSSIONS

Climate may influence fresh market crop production, including lettuce yield and quality (Dufault, et al., 2006; Lamont, 2009). Early plant exposure to increasing irradiance, temperatures, and day lengths has been found to significantly reduce lettuce quality because of factors such as bolting (Dennis and Dulforce, 1974). Reduced lettuce yield and quality may also be associated with environmental stresses (high temperatures and winds) during later crop growth, or from damaging diseases and insect pests (Simonne et al., 2002; Zhao and Carey, 2009).
In terms of climate, the experimental field falls in the temperate continental climate area, in the mountain climate region. The climate is influenced by the general climate of the neighboring lowlands, which is why it bears the characteristic features of the temperate continental climate.
Long-term observations show that the coldest months of the year for this region are December, January and February, with average temperatures ranging between 0 and 1.8°C. Sometimes the daily temperatures drop below -20°C.
The warmest months of the year are July and August, typical of the entire continental subregion. During the experimental period (November-April), the air temperature is characterized by some peculiar dynamics.
The average daily temperature for November is 9.7°C (+4.7°C warmer for many years), which helped to take root the plants after transplanting (Figure 1).

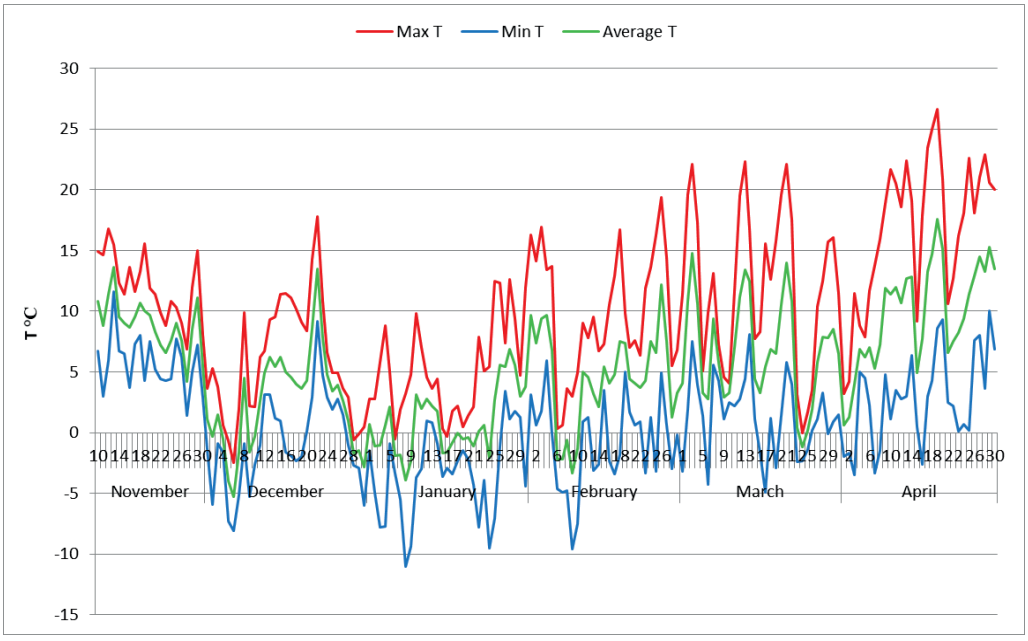

Figure 1. Atmospheric temperature for Sofia, during the experimental period (November 2019 - April 2020)

Over the next three winter months, the trend continues and despite the low temperatures that have been reported, they remain warmer than in the multi-year period (1981-2010), respectively +1.5°C for December, with +0.9°C for February and + 3.0°C for February (Figure 1). From the spring months, March is also warmer - by + 1°C, while April is cooler - the average monthly temperature is 9.7°C, which is -0.8°C lower than the average data from previous years (Figure 1).

During the lettuce growing the biometric indicators of the plants are influence more by the type of construction - high or low tunnels, as well as the various tested coatings.

In all three varieties the influence of the size of the facility on the diameter of the plants is significant for each variety: F (2.66) = 9.36, p <.05 - for the variety Gentilina, F (2.81) = 17.51, p <.05 - for the variety Aquarel and F (2.73) = 10.44, p <.05 - for the variety Cherna Gyumyurdzhinska. While the influence of different coatings is less.

In the Gentilina variety, the lettuces have a smaller diameter when grown under geotextile, in the Cherna Gyumyurjinska variety the plants are grown under green polyethylene. In Aquarel, the difference in the diameter of plants grown under low tunnels with different coatings is insignificant (Figure 2).

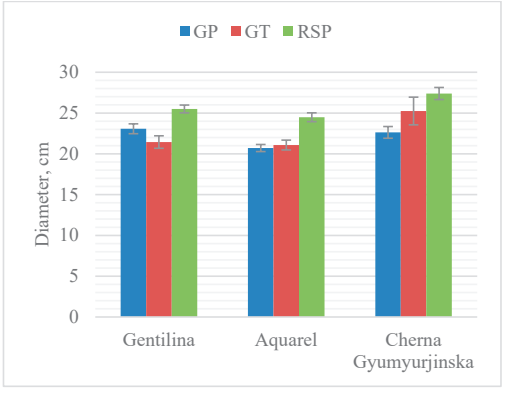

Figure 2. Diameter of plants grown under different coverings and tunnels

Significant is the influence of high tunnels on the height of plants - F (2.66) = 41.09, p <.05 - for the variety Gentilina, F (2,81) = 41,69, p <.05 - for the variety Aquarel and F (2.73) = 34.42, p <.05 - for the variety Cherna Gyumyurdzhinska. Again, the influence of the different coatings tested in the low tunnels is less, as the observed differences in the individual varieties appear as in the diameter of the plants In general, the Cherna Gyumyurdzhinska variety has a higher plant height, but this is a characteristic feature of the variety (Figure 3).

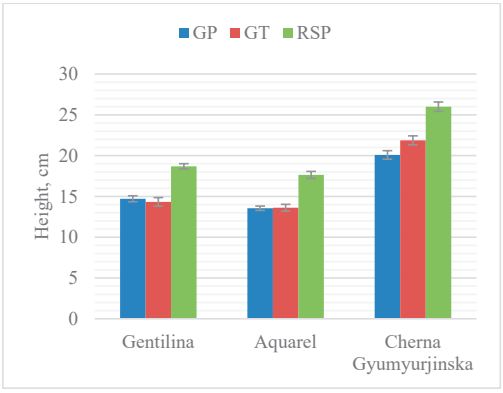

Figure 3. Height of plants grown under different coverings and tunnels

The average weight of one plant is also higher in lettuces grown in high tunnels, and the difference with those grown in low tunnels is significant: F (2.66) = 41.62, p <.05 - for the Gentilina variety, F (2.81) = 46.84, p <.05 - for the variety Aquarel and F (2.73) = 46.76, p <.05 - for the variety Cherna Gyumyurdzhinska (Figure 4).

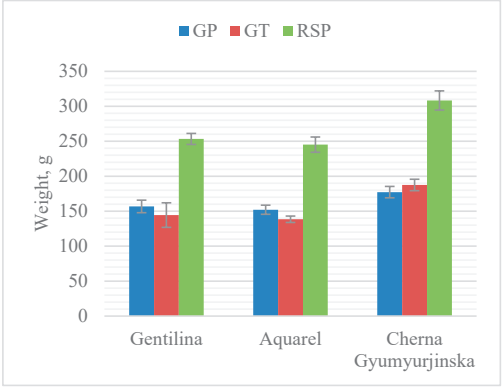

Figure 4. Mass of plants grown under different coverings and tunnels

In contrast to the diameter and height of the plants, in the case of Cherna Gyumyurjinska lettuce the mass of one plant is also influenced by the type of coverings tested in the low

tunnels, as the plants grown under geotextiles have a higher mass than those grown, under green polyethylene F (1.41) = 5.86, p <.05. In addition to biometrics, analyzes of dry matter and sugar content were performed to determine whether and to what extent the coatings tested affected these parameters. The established differences are not unambiguous.

The Gentilina variety and the Cherna Gyumyurdzhinska variety have a higher dry matter content when grown under a low tunnel covered with geotextiles (Figure 5).

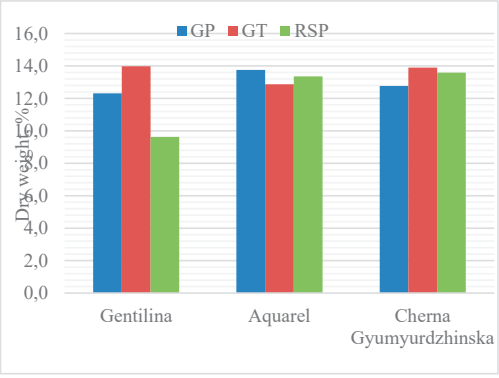

Figure 5. Dry matter content in% of plants grown under different coverings and tunnels

In the Aquarel variety, higher dry matter content was observed in plants grown under a low tunnel covered with green polyethylene.

In the Gentilina variety, a higher sugar content in the fresh mass was observed when it was grown under a low tunnel covered with green polyethylene (Figure 6).

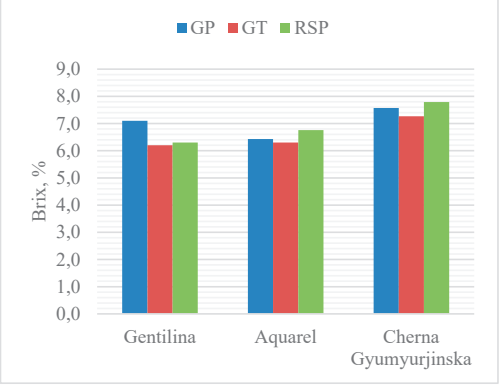

Figure 6. Total sugar content in % of plants grown under different coverings and tunnels

In general, lettuce has more sugars in the production than the two salads. When comparing the results obtained from plants grown under different coatings, it is seen that the differences between them are minimal. However, a higher sugar content is reported for both polyethylene coatings - a high tunnel with reinforced polyethylene and a low tunnel with a green polyethylene coating (Figure 6).

CONCLUSIONS

The present work was developed to evaluate the influence of different coatings on the development of salads.

Based on the results of biometric measurements, as well as some indicators responsible for the quality of production, the following conclusions can be made:

Of the two varieties of lettuce grown under a low tunnel, the Gentilina variety grows better when covered with green polyethylene - the plants are larger in diameter and height, with a larger mass, with a higher sugar content.

The Aquarel variety grows equally well under both types of low tunnel coverings.

Lettuce, Cherna Gyumyurdzhinska variety, is better developed when grown under a low tunnel covered with geotextile - the plants have a larger diameter, height and mass.

Compared to low tunnels, all three varieties grow better when grown under high tunnels.

REFERENCES

Arin, L., & Ankara, S. (2001). Effect of low-tunnel, mulch and pruning on the yield and earliness of tomato in unheated glasshouse. *J. Appl. Hort*, 3(1), 23-27.

Buta, E., & Apahidean, A. S. (2009). Observations Concerning the Effect of Agryl on Environmental Factors of Cabbage Cultivated in Plastic Tunnel and Field. Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Horticulture, 66(1).

Dennis, D.J. & Dulforce, W.M. (1974). Analysis of the subsequent growth and development of winter glasshouse lettuce in response to short periods in growth chambers during propagation. *Acta Hort*., 39, 197-218.

Dufault, R.J., Ward, B. & Hassell, R.L. (2006). Planting date and romaine lettuce cultivar affect quality and productivity. *HortScience*, 41, 640-645.

Favarato, L. F., Fornazier, M. J., Eutrópio, F. J., Guarçoni, R. C., & Mendes, L. (2020). Cropping

system to produce lettuce in autumn season at different elevations. *Australian Journal of Crop Science AJCS*, 14(10):1555-1562.

Golzar F., Heeren N., Hellweg S., Roshandel, R. (2018). A novel integrated framework to evaluate greenhouse energy demand and crop yield production. *Renewable and Sustainable Energy Reviews*, 96, 487-501.

Hamamoto, H. (1996). Effect of non-woven rowcover on plant environment and growth. *Japan Agricultural Research Quarterly*, 30(1), p. 49−53.

Hamouz, K., Lachman, J., Dvorak, P., Trnkova, E. (2006). Influence of non-woven fleece on the yield formation of early potatoes. *Plant, Soil and Environment*, 52(7), p. 289−294.

Henschel, J. M., Resende, J. T., Giloni-Lima, P. C., Zeist, A. R., Lima Filho, R. B., & Santos, M. H. (2017). Production and quality of strawberry cultivated under different colors of low tunnel cover. *Horticultura Brasileira*, 35(3), 364-370.

Knewtson, S.J.B., Carey, E.E. & Kirkham, M.B. (2010). Management practices of growers using high tunnels in the central great plains of the United States. *HortTechnology*, 20, 639-645.

Lamont, W. J. (2005). Plastics: Modifying the microclimate for the production of vegetable crops. *HortTechnology*, 15(3), 477-481.

Lamont, W. J. (2009). Overview of the use of high tunnels worldwide. *HortTechnology*, 19(1), 25-29.

Lamont, W.J. Jr, McGann, M., Orzolek, M., Mbugua, N., Dye, B. & Reese, D. (2002). Design and construction of the Penn State high tunnel. *HortTechnology*, 12, 447-453.

Olle, M., & Bender, I. (2010). The effect of non-woven fleece on the yield and production characteristics of vegetables. *Agraarteadus*, 21(1), 24-29.

Quintero-Arias, D. G., Acuña-Caita, J. F., Asensio, C., & Valenzuela, J. L. (2021). Ultraviolet Transparency of Plastic Films Determines the Quality of Lettuce (*Lactuca sativa* L.) Grown in a Greenhouse. *Agronomy*, 11(2), 358.

Reeves, J. & Drost, D. (2012). Yields and soil quality under transitional organic high tunnel tomatoes. *HortScience*, 47, 38-44.

Santos Filho, B. G., Lobato, A. K. S., Silva, R. B., Schimidt, D., Costa, R. C. L., Alves, G. A. R., & Neto, C. O. (2009). Growth of lettuce (*Lactuca sativa* L.) in protected cultivation and open field. *Journal of Applied Sciences Research*, 5(5), 529-533.

Scarascia-Mugnozza, G., Sica, C., & Russo, G. (2011). Plastic materials in European agriculture: actual use and perspectives. *Journal of Agricultural Engineering*, 42(3), 15-28.

Silva, F. A. de M.; Boas, R. L. V.; Silva, R. B. (2010). Resposta da alface à adubação nitrogenada com diferentes compostos [Response of lettuce to nitrogen fertilization with diferente organic composts in two successive cycles]. *Acta Scientiarum Agronomy*, vol. 32, n. 1, p. 131-137.

Simonne, A., Simonne, E., Eitenmiller, R. & Coker, C.H. (2002). Bitterness and composition of lettuce varieties grown in the southeastern United States. *HortTechnology*, 12, 721-726.

Tüzel, Y., Leonardi C. (2009). Protected Cultivation in Mediterranean Region: Trends and Needs Ege Üniv. *Ziraat Fak. Derg*., 46(3): 215-223.

Wallace, R. W., Wszelaki, A. L., Miles, C. A., Cowan, J. S., Martin, J., Roozen, J., Gundersen, B., Inglis, D. A. (2012). Lettuce yield and quality when grown in high tunnel and open-field production systems under three diverse climates. *HortTechnology*, 22(5), 659-668.

Wells, O. S., Loy, J. B. (1993). Rowcovers and high tunnels enhance crop production in the northeastern United States. *HortTechnology*, 3(1), 92-95.

Zhao, X. & Carey, E.E. (2009). Summer production of lettuce, and microclimate in high tunnel and open field plots in Kansas. *HortTechnology*, 19, 113-119


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