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The Impact of Plastic Covers on the Quantitative and Qualitative Indicators of Tomato (*Solanum Lycopersicum*) Production in the Open Field

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ABSTRACT

This 2022 study at the Kosovo Agricultural Institute in Peja evaluated innovative tomato cultivation techniques in open-field vegetable production. Five covering methods, including small plastic tunnels with black or transparent plastic mulching, were compared against traditional practices. Results revealed that tunnel variants with plastic mulching demonstrated earlier flowering, fruiting, and harvesting, accelerating early production by 3 to 12 days. Statistical analyses showed significant improvements in total tomato production, emphasizing the techniques' effectiveness in enhancing productivity, resource efficiency, and weed control. Notably, small tunnels with mulching proved beneficial, with a 26.9% and 28.3% increase in production for black and transparent plastic mulch, respectively. The study suggests future research directions, including long-term sustainability assessments across different tomato varieties. In conclusion, soil mulching and small tunnels are crucial techniques in vegetable cultivation, contributing to increased total production, early production, and resource savings in controlled environment agriculture.

Keywords: tomato cultivation, plastic mulching, small tunnels, controlled environment agriculture, resource efficiency.

INTRODUCTION

Plastic sheet application in open-field vegetable cultivation, particularly in the context of tomato production, represents a significant advancement in agricultural technology (Marschner, 2011). Widely adopted in advanced agricultural regions, especially in Europe, this technique involves mulching the soil and using small tunnels to cover plants, aiming to enhance yields, accelerate early production, and reduce labor costs (Black, 2017). In the face of these advancements, it becomes imperative to investigate the specific impact of plastic sheeting on tomato production within the unique climatic and soil conditions of our country.

Tomato growth in cooler regions is often constrained by a short vegetation period and low temperatures in both soil and air, leading to delayed harvests and reduced yields (Stanghellini and Wheeler, 2019). Mulching the soil and covering rows with plastic sheets and tunnels offer potential solutions by optimizing plant growth dynamics through improved temperature, humidity, and light conditions (Marschner, 2011; Bhatt and Morison, 1990). Therefore, a comprehensive examination of the influence of plastic covers on soil moisture, air and soil temperature, and their consequential effects on tomato plant fruiting rate, yield, and production quality in open-field conditions is warranted.

Against this backdrop, the current study, conducted at the Experimental Base of the Kosovo Agricultural Institute in Peja in 2022, seeks to address existing gaps in understanding. The introduction of plastic sheets in open-field tomato cultivation holds promise, but its specific impact on our local agroclimatic and soil conditions remains unexplored. Thus, the purpose of this research is to systematically evaluate the effects of various plastic covering

methods on tomato production indicators, providing insights that contribute to the optimization of tomato cultivation practices in our region.

MATERIAL AND METHOD

From the point of view of natural soil fertility, the soil where the experiment was set up had the following content: humus 2.14%, nitrogen 0.18%, P_2O_5 1.75 mg/100 g, K_2O 11.2 mg/100 g soil and water pH 8.2, these findings were taken from the works scientific of Balaj et al. (2017). Five methods of covering (mulching with black and transparent plastic foils accompanied or not with small plastic tunnels) were studied, compared with the traditional way of tomato cultivation, without covering the soil and plants, specifically. Variants studied:

- V1 – control, traditional planting;
- V2 – mulching with black plastic sheets;
- V3 – mulching with transparent plastic sheets;
- V4 – without mulching, but with a tunnel;
- V5 – mulching with black plastic sheets + tunnel;
- V6 – mulching with transparent plastic sheets + tunnel.

Traditional planting methods involve the direct sowing of seeds in open fields, using basic tools, and relying on natural environmental conditions for crop growth. These methods are contrasted with more modern or innovative approaches that may include advanced technologies, improved crop varieties, and optimized cultivation practices. To carry out this study, the seed was planted in polystyrene modules at a controlled temperature on March 4. Germination continued for 6-9 days and the seedling was ready to be planted in the field on May 12, at the age of about 58 days. The cultivar that was taken for the study was "Dombo". This is the specific tomato cultivar chosen for the research study. The experiment was set up according to Fisher's randomized block design (Fisher, 1935), a statistical methodology that involves the random assignment of experimental units into blocks. For a detailed understanding of the experimental design and its implementation, readers are encouraged to refer to Fisher's seminal work on experimental design (Fisher, 1935) (Table 1). The area of the variant was 24 m^2 and is represented by 75 plants. The distance between rows was 80 cm and between plants in a row was 40 cm (Gardner et al., 2008). For mulching, black and transparent plastic sheets with a thickness of 0.05 mm and a width of 120 cm were used. Plastic sheets were fixed on both sides of the row with soil, covering on each side 15–20 cm of its width. The width of the covered (mulched) part of the row remains about 60 cm. The mulching plastic sheets were laid after good soil preparation and after installing the drip irrigation system, about 6–7 days before planting the seedlings in the field. (Hakl and Lošák, 2018; Pattison et al., 2018).

The arches were placed about 2 m apart from each other. The plastic sheet of the tunnel was fixed to the side with soil. The tunnel at the base was 60 cm wide, 60 cm high, and 14 m long, depending on the length of the variant. The tunnel covers only one lane. The plastic sheet cover was completely removed from the tunnels when the plants had reached a height of about 45–50 cm and the temperatures were optimal for normal plant development. In basic fertilization, no organic fertilizers are used, but only minerals, specifically: 40 kg/100 m^2 DAP, and 30 kg/100 m^2 potassium sulphate. In the vegetation, 40 kg/100 m^2 of ammonium nitrate is used, distributed in 3–4 hands, together with the irrigation water (Lal, 2018). During the vegetation, agrotechnical services were performed and data were collected on the biological and biometric indicators of plants and the quantitative and qualitative indicators of production (Jones Jr., 2012; Taiz and Zeiger, 2014). The production harvest started in the sixth variant on July 17, in the fifth variant on July 18, in the fourth variant on July 20, in the third variant and the second variant on July 26, and in the first variant on July 29. Variants were analysed for both probability levels ($p = 0.05$ and $p = 0.01$).

Table 1. Schema of setting up the experiment in the field

	Variants of setting up the experiment in the field					
Random variants	5	2	3	6	4	1
	4	6	1	2	5	3
	1	3	4	5	6	2
	2	5	6	1	3	4

RESULTS AND DISCUSSION

The impact of plastic covers (mulching and small tunnels) on the earliness of tomato production

Plants grown in the variants covered with tunnels accompanied by plastic mulching flowered, fruited, and were harvested earlier. Observing the phonological overview, it results that the plant period (germination – first harvest) in the first variant is 139 days, the second and third variants 136 days, the fourth variant 130 days, the fifth variant 128 days, and the sixth variant 127 days. So, it is seen that the use of plastic sheets for mulching influences the early production, it turns out to be from 3 to 12 days.

Impact of plastic covers (mulching and small tunnels) on tomato plant biomass

The plants cultivated under tunnels (combined with mulching) in addition to reaching the flowering stage faster (respectively according to the variants 95, 93, 91, 87, 85, and 85 days from germination) formed a larger plant mass than the control and those cultivated only with mulching. The year 2022 was a year with a warm spring, and the differences in the physical development of the plant are evident but not very visible. Mulching with transparent plastic sheets had positive effects on the amount of biomass formed by plants in the flowering phase, especially when this was accompanied by covering the plants with small tunnels. The opening of the tunnels was done gradually to avoid wilting, and burns from external factors, why not possible mechanical damage. So, as it appears from mirror no. 1, the height of the plants grown under plastic covers (mulching and tunnel) is about 13.4–15.2 cm higher than the cultivation in the conditions of the open field.

Impact of plastic covers (mulching and small tunnels) on tomato production.

The total marketable production in plants cultivated in tunnels combined with mulching and transparent and black plastic sheets compared to the traditional one and mulching without tunnels is presented with differences in favour of mulching. This production differs in two directions:

1. The earliness of the variants, which goes 3–12 days according to the variants
2. In the realized yield, which is presented more completely in Table 3.

The data obtained in the conditions of 2022 show an indisputable superiority of the influence of the use of small tunnels accompanied by mulching in tomato cultivation. Thus, V4 with tunnel without mulching has 99.5% additional data, V5 with tunnel and black mulching has 106.5% additional production data, and V6 with transparent plastic tunnel for mulching has reported an additional production of 120.5% more than the control (verified by 0.05 and 0.01 V5). Also important is the additional production benefits from the use of plastic sheets for mulching without tunnels. Thus, V2, where mulching was done with a black plastic sheet, gave a production increase of 26.9%, while V3, where a transparent plastic sheet was used for mulching, gave a production increase of 28.3% (verified by 0.05 and 0.01). The obtained data and their differences are clearly expressed in Figure 1. The type of mulching used under the tunnel has had a significant effect on the earliness and total tomato production.

DISCUSSION

The study reveals a substantial impact of plastic covers, especially mulching with small tunnels, on the early stages of tomato production. Variants with tunnels and plastic mulch showed accelerated

Table 2. Tabular representation of plant length

No.	The variants	The height of the plant in cm
1.	V1 – control, traditional planting	47.3
2.	V2 – mulching with black plastic sheets	51.7
3.	V3 – mulching with transparent plastic sheets	52.4
4.	V4 – without mulching, but with a tunnel	60.7
5.	V5 – mulching with black plastic sheets + tunnel	61.9
6.	V6 – mulching with transparent plastic sheets + tunnel	62.5

Table 3. Harvest production up to August 12/ kg

The variants	Harvest production /kg	The harvest area m^2	Yield quintal/ hectare	% to the control
V1- Control, traditional planting.	84	24	350	100
V2- Mulching with black plastic sheets.	106.6	24	444.1	126.9
V3- Mulching with transparent plastic sheets.	107.8	24	449.1	128.3
V4- Without mulching, but with a tunnel.	136.8	24	570	199.5
V5- Mulching with black plastic sheets + tunnel.	141.6	24	590	206.5
V6- Mulching with transparent plastic sheets + tunnel.	151.2	24	630	220.5
LSD 0.05			28.98011	
LSD 0.01			40.62802	

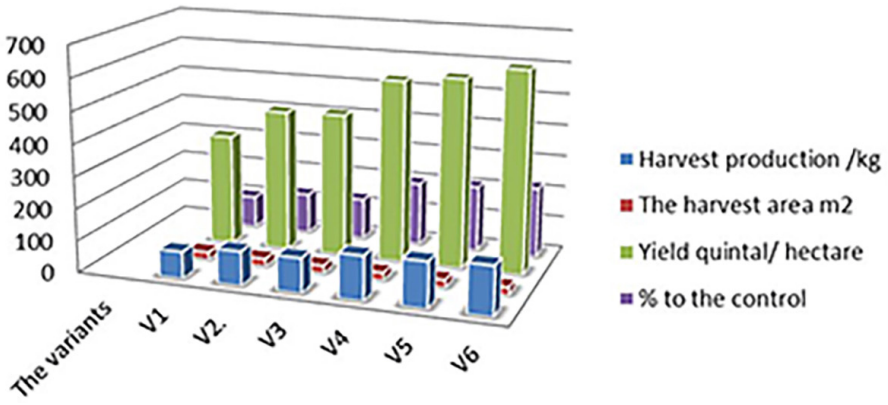

Fig. 1. The obtained data and their differences are clearly expressed

flowering, fruiting and harvesting, leading to a significant reduction in the plant period. Comparisons between variants showed a significant reduction, ranging from 3 to 12 days. This is in line with previous studies by Hakl and Lošák (2018) and (Balaj at al. (2017), confirming the positive impact of plastic covers. However, our research refined this understanding by specifying variations in the earliness of different mulching methods. Plants grown under tunnels, especially when combined with transparent plastic mulching, not only reached the flowering stage faster, but also showed greater plant mass compared to control conditions and mulching alone. The positive effect of transparent plastic cover on biomass is consistent with the findings of Blok (2010). However, our study contributes uniquely to the field by demonstrating the nuanced influence of mulching materials and tunnel application on plant development. The observed increase in plant height under plastic covers further emphasizes the growth promoting effects of these techniques.

The most convincing result of this research lies in the impact on total tomato production. Small tunnels accompanied by mulching, especially with transparent plastic sheets, showed indisputable superiority, resulting in significant additional production compared to traditional methods. This study goes beyond existing knowledge by providing a detailed overview of yield benefits across varieties. Importantly, the influence of different mulching materials under the tunnel reveals additional insights into optimizing earliness and total yield. Comparative analyses with the studies of Balaj at al. (2017), Blok (2010), and Hakl and Lošák (2018) confirm the robustness of our findings as our study goes beyond clarifying nuanced effects of mulching materials and tunnel application.

CONCLUSIONS

The findings underscore the significant impact of soil mulching and small tunnels on tomato cultivation, offering advantages in early production, total yield, and resource efficiency. The study recommends further research and

practical implementations to optimize these techniques for broader adoption in diverse agricultural settings.

The benefits of mulching with plastic sheets include a substantial increase in total production ranging from 26.9% to 28.3%. Additionally, the implementation of small tunnels has proven to be a game-changer, resulting in a remarkable 99.5% increase in total production compared to traditional planting methods. Furthermore, the combination of tunnels with both black and transparent plastic sheets has yielded exceptional results, with production increases of 106.5% to 120.5%. Not only do these techniques accelerate early production by 3 to 12 days, but they also contribute to a more efficient plant period, reducing it by 3 to 12 days. The extended harvesting period further adds to the appeal of these methods, providing an additional 3 to 12 days for crop collection.

Moreover, the positive effects of mulching extend beyond production metrics. These techniques offer advantages such as substantial savings in manpower, efficient water utilization through improved moisture retention, and a significant reduction in weed development. The results of this study emphasize the potential of integrating plastic mulching and small tunnels as essential components in modern agricultural practices. As we face challenges such as changing climates and resource constraints, these techniques not only enhance productivity but also contribute to sustainable and resource-efficient tomato cultivation. Further research and practical implementations of these methods are warranted to refine and optimize these techniques for broader adoption in diverse agricultural settings.

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