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# Cucumber cultivation under plastic covers – economic results

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ABSTRACT

Studies aimed at diminishing the negative effect of climate on growth, yielding and profitability of cucumber cultivation by application of various types of covers. Four kinds of cover were used for a tunnel, as well as three additional kinds of thermal insulation, six different dimensions of tunnels, 3 kinds of mulch, and 4 types of direct shading were tested. The highest yields were obtained for 'Marinda $F_1$' cucumber in plastic tunnels, where soil was mulched with colourless or black polyethylene film. The lowest yield was produced by crops shaded directly with perforated film. Increase in yields, including commercial yields and its earliness resulted in the increase in commercial production value, which covered additional costs incurred by covers. The gross margin of 2.42 PLN per $m^2$ was obtained, being three times greater than in the cultivation without covers.

## INTRODUCTION

Favourable natural conditions and long lasting tradition in horticultural cultivation in the Kraków region enhance development of production. Permanent changes on developing market make producers introduce modern technologies aimed at increasing yields, their quality, and accelerating harvest. Production involving high consumption of energy, e.g. in greenhouses and incurring high costs is a barrier to a development of new technologies under conditions in Poland (Lipowiecka 1992). Similarly Świetlik and Mierwiński (1999) emphasise a necessity to enlarge the scale of production with simultaneous decreasing costs and meeting market requirements concerning sizes and dates accepted by consumers. It is directly connected with extending vegetable production under covers and limiting greenhouse production.

A gradually increasing acreage of cucumber cultivation under covers has been observed since 1994 and in the studied period it amounted to 352 ha. The most popular material used for plant covering is PE polyethylene (Siwek 1996), which also gives very good effects in production of lettuce crops (Lipowiecka 1999). Easy accessibility of the material and its relatively low price favour its multifunctional use also in other sectors of agriculture. The aim of this study was to analyse economic effects of different plastic covers, in the accelerated cultivation of cucumber, on the basis of obtained yields and incurred costs.

## MATERIAL AND METHODS

Numerical data used for economic calculations were gathered in the experiment carried out in 1996 – 1998 at the Agricultural University of Kraków. Three parthenocarpic cucumber cultivars were tested in field cultivation: coarse-verrucous 'Marinda $F_1$', small-verrucous 'Othello $F_1$' and smooth-fruit 'Gracius $F_1$'. Tunnel covered with polyethylene film (PE 0.165 mm) and direct shading with polypropylene non-woven (PP 17 g $m^{-2}$) was used as plant cover.

The second stage of the experiment involved testing the methods of: tunnel covering with polyethylene (PE), copolymer ethylene-vinyl acetate (EVA), polyvinyl chloride (PCV) film, and polypropylene (PP) non-woven; decreasing heat losses in the tunnels through application of additional cover layers (PE matting, PP non-woven, and EVA film) or soil mulching with colourless, black, or white PE film; limiting high temperatures by shading tunnels with chalk, shade, or perforation; different dimensions of plastic tunnels (1.5 x 1.0 x 10.0; 1.5 x 1.5 x 10.0; 1.5 x 0.5 x 10.0; 1.5 x 1.0 x 5.0; 1.5 x 1.0 x 20.0; 3.0 x 1.8 x 10.0 m), direct shading with PE perforated film (A - 100 openings, B - 500 openings per $m^2$), PE, or PE and PP, control – plants grown without cover.

In the second stage of the experiment cucumber 'Marinda $F_1$' was used.

The costs of applied materials (constructions, films and shades) were calculated by a rectilinear amortization method according to the predicted period of utilisation. The costs included additional human labour outlays on the plant covering. The value of commercial production, which is a ratio of commercial yield and sale price, was given in conversion to 1 $m^2$ of the cultivation area.

The following economic indices were assumed in the work: land productivity, value of commercial production and the gross margin, i.e. a difference between the value of commercial production and variable costs, which in this study were connected with covers (Skarżyńska and Augustyńska-Grzymek 2002).

The coefficients of linear correlation, estimated by Student t–test at $p = 0.05$, were used to determine the closeness of relationship between costs of covers and some indices of economic effects obtained in the three investigation years.

## RESULTS AND DISCUSSION

Production and economic indices selected for the assessment and comparison characterise various types of plastic covers used for cucumber cultivation. The indices may fluctuate depending on the movement of prices on the market. The present paper aims to provide economic data justifying the advantage of selected covers application in cucumber production.

The films used in the experiments created good light conditions for covered plants. Higher air and soil temperature was generated under polyethylene film than under polypropylene non-woven. These parameters affected the acceleration of flowering and then fruiting by five days on average. In tunnels covered with polyethylene film the first harvesting of 'Marinda $F_1$' cucumbers were carried out 35 days after planting, and under polypropylene non-woven – a day later. On the other hand, in the cultivation without covers the first harvest was done 41 days after planting. At that time a six-day delay in harvesting greatly affected the value of production because sale prices fluctuated considerably; they most often fell rapidly as the product supply on the market increased.

The effect of cover application in cucumber cultivation has been illustrated in Fig. 1. Both PE film and PP non-woven proved to be advantageous, cover materials affecting several-fold increase in commercial yield, including the early one, in comparison with non-covered cultivation. It should be mentioned that PE film was a better material because mean yield of the three cultivars ('Marinda $F_1$', 'Gracius $F_1$', and 'Othello $F_1$') under this cover was 21.4% higher in relation to the non-woven.

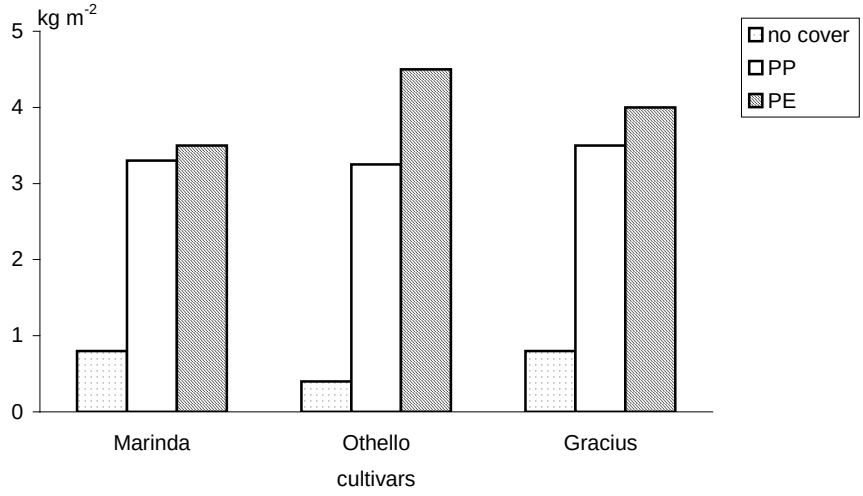


Figure 1. Differences in yield of 3 cucumber cultivars grown under PE, PP, and without cover

On the basis of three-year results the most beneficial effect of PCV on the commercial yield was found (Table 1). Slightly worse results were achieved when the plants were covered with EVA film, i.e. total commercial yield was 4.53 kg $m^{-2}$, being 5.3% lower than under PCV cover.

Among the three methods of tunnel covering in order to decrease heat losses, the best conditions were created in tunnels where EVA film was an additional insulating material, then PP non-woven, whereas in tunnels where mulching was done, soil heated most under colourless foil. The early crop obtained in tunnels with additional covers was higher than yield from the control tunnel. Owing to insulation with PE matting, the yield increased by 17.7%, it raised by 40.3% when PP non-woven was used, and by 80.4% when EVA film was applied. A similar tendency pertained also to the total yield.

Considering limiting excessive temperature, the best conditions for growth and development of plants were provided by the tunnel with the biggest cubic capacity (3.0 x 1.8 x 10 m). Total commercial yield reached 4.74 kg $m^{-2}$, in which early crop constituted almost 30%.

In cucumber cultivation without covers the commercial production value was the lowest (0.85 PLN $m^{-2}$) and did not cover the costs, whereas plants covered with film or non-woven returned the outlays by an increase in yield and production value. Differences were considerable and fluctuated between 2.54 PLN and 7.15 PLN per $m^2$ (Table 1). The best effects were achieved when the cultivation was maintained in tunnels and the soil was additionally mulched. An average value of production per $m^2$ obtained with the three different methods of mulching (colourless, black, or white film) was 6.67 PLN. Also additional plant covering

with PE matting, PP non-woven, or EVA film in tunnels covered with polyethylene film positively affected the production value, which for three presented practices ranged between 4.07 and 5.50 PLN per $m^2$. Direct plant shading with PE perforated film or PP non-woven proved to be a far better solution than non-covered cultivation, although achieved economic results were over twice lower than in the cultivation in tunnels with additional soil mulching.

Table 1. Shaping of cucumber 'Marinda $F_1$' yields (mean for 1996 – 1998) depending on applied covers

| Cultivation methods and practices | Marketable yield (kg $m^{-2}$) | Early crop (kg $m^{-2}$) | Commercial production value (PLN $m^{-2}$) | Gross margin (PLN $m^{-2}$) |
|---|---|---|---|---|
| Kind of tunnel covering | | | | |
| PE | 3.33 | 0.62 | 3.63 | 2.77 |
| PCV | 4.77 | 0.95 | 5.19 | 4.30 |
| EVA | 4.53 | 0.90 | 4.94 | 3.84 |
| PP | 3.72 | 0.47 | 3.82 | 3.30 |
| Additional covering in tunnels | | | | |
| PE | 3.33 | 0.62 | 3.63 | 2.77 |
| PE + PE mat | 3.72 | 0.73 | 4.07 | 2.75 |
| PE + PP17 | 4.46 | 0.87 | 4.88 | 3.66 |
| PE + EVA | 4.92 | 1.12 | 5.50 | 3.46 |
| Soil mulching in tunnels | | | | |
| No mulching | 3.33 | 0.62 | 3.63 | 2.64 |
| Colourless PE | 6.56 | 1.32 | 7.15 | 5.80 |
| Black PE | 6.46 | 1.43 | 7.13 | 5.78 |
| White PE | 5.15 | 1.15 | 5.72 | 4.37 |
| Different tunnel sizes | | | | |
| 1.5 x 1 x 10 m | 3.33 | 0.62 | 3.63 | 2.77 |
| 1.5 x 1.5 x 10 | 3.94 | 0.74 | 4.23 | 3.37 |
| 1.5 x 0.5 x 10 | 4.24 | 0.90 | 4.69 | 3.83 |
| 1.5 x 1 x 5 | 4.05 | 0.83 | 4.56 | 3.70 |
| 1.5 x 1 x 20 | 3.47 | 0.62 | 3.73 | 2.87 |
| 3 x 1.8 x 10 | 4.74 | 1.41 | 5.64 | 4.78 |
| Limiting of temperature in tunnels | | | | |
| PE | 3.33 | 0.62 | 3.63 | 2.77 |
| PE + chalk shading | 3.85 | 0.71 | 4.11 | 3.21 |
| PE + shading film | 3.01 | 0.46 | 3.21 | 2.13 |
| PE + perforation | 3.81 | 0.75 | 4.15 | 2.87 |
| Different direct covers | | | | |
| No cover | 0.90 | 0.07 | 0.85 | 0.85 |
| A. Perforated PE | 2.61 | 0.26 | 2.54 | 2.08 |
| B. Perforated PE | 2.45 | 0.33 | 2.81 | 2.35 |
| PP 17 g $m^{-2}$ | 3.05 | 0.40 | 3.14 | 2.62 |
| PE B + PP 17 | 3.26 | 0.29 | 3.59 | 2.65 |
| PE tunnel | 3.33 | 0.63 | 3.97 | 3.11 |

An early crop affected the high value of commercial production obtained under covers. The covered plants began fruiting earlier than the non-covered ones and also the share of the early crop in total yield was much higher. At the time of first harvest market supply is still small, so the price is high. When great mass of commodities from open field cultivation appears on the market, the market responds with a fall of prices.

Another criterion used to present economic results was a gross margin lower than the produce value by variable costs, in this case involving application of covers, which ranged between 0.46 and 2.04 PLN per $m^2$ (Table 1). Higher financial outlays were correlated with generating higher incomes, while cucumber cultivation in tunnels with additional soil mulching with colourless or black film proved an optimal economic solution among many, which were applied. Obtained gross margin per $m^2$ was 5.80 PLN, whereas cultivation in the open field generated only 0.85 PLN.

Cultivation in tunnels, especially over 1.5 m high, positively affected proper organisation of production and work. All measures, such as plant protection, weeding, and, first of all, harvesting could be carried out irrespective of the weather conditions. Moreover, cultivation under covers diminishes production risk, due to bad weather conditions.

Mean cost of covers used in the experiments was 0.97 PLN $m^{-2}$ and affected an average increase in commercial cucumber yield by 3.05 kg $m^{-2}$. EVA film was found to be a material worth recommending for covers used in horticultural production. Despite its high price, it allowed to generate economic effects exceeding the other solutions. Statistical analysis of correlation between the features studied in the experiment revealed a strictness of the relationship, as presented in Table 2. The calculated coefficients of linear correlation indicated a high significance of relationship between tested parameters.

Table 2. Indices of correlation among selected features

| Factors | Cost of covers (PLN $m^{-2}$) |
|---|---|
| Value of early crop (PLN $m^{-2}$) | 0.7115* |
| Value of total commercial yield (PLN $m^{-2}$) | 0.7553* |
| Gross margin (PLN $m^{-2}$) | 0.5203* |
| Additional commercial yield (PLN $kg^{-1}$) | 0.6366* |

* significance at p = 0.05

## CONCLUSIONS

1. Cucumber production without covers proved ineffective as the outlays exceeded the value of obtained produce.
2. Among the methods of cultivation tested in the experiment the best results were obtained when cucumber was cultivated in tunnels where soil was additionally mulched with PE film.

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## EFEKTY EKONOMICZNE UPRAWY OGÓRKÓW POD OSŁONAMI Z TWORZYW SZTUCZNYCH

Streszczenie: Celem badań była optymalizacja mikroklimatu i jego wpływu na wzrost, plonowanie i opłacalność uprawy ogórków poprzez stosowanie różnego typu osłon. Stosowano 4 rodzaje pokrycia, 3 dodatkowe rodzaje izolacji cieplnej, 6 różnych form i wymiarów tuneli, 3 rodzaje ściółek oraz 4 rodzaje osłon bezpośrednich. Pod względem plonowania najlepsze wyniki uzyskano, uprawiając ogórki odmiany 'Marinda $F_1$' w tunelach foliowych, w których gleba była ściółkowana folią polietylenową, bezbarwną i czarną. Najniższy plon uzyskano w uprawie z bezpośrednim osłanianiem folią perforowaną. Wzrost plonów, w tym handlowego oraz jego wczesność wpłynęły na zwiększenie wartości produkcji towarowej, która zapewniła pokrycie dodatkowych kosztów związanych z osłonami, co spowodowało powstanie średniej nadwyżki bezpośredniej, która miała wartość 2,42 zł z 1 $m^2$ i była 3-krotnie większa niż przy uprawie bez osłon.

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