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WIOLETA SOBCZAK, ANNA SOBCZAK

Warsaw University of Life Sciences WULS – SGGW, Poland

PROFITABILITY OF PRODUCTION OF RED SWEET PEPPERS (*CAPSICUM ANNUUM* L.) IN CULTIVATION UNDER COVER

Key words: profitability of production, peppers, production under covers

ABSTRACT. The aim of the study was to assess the relationship between the value of production, labour and capital expenditure in the production of red sweet pepper (*Capsicum annuum* L.) in selected horticultural farms. The study covered farms involved in the production of sweet peppers in unheated plastic tunnels in the poviat of Przysucha and Radom. The selection of farms was purposeful. The selection was based on the technical solutions used on the farms in the field of construction of plastic tunnels and farm size. The study was carried out in three growing seasons in 2017-2018. The obtained results indicated that the largest share in total costs were the costs of purchasing planting material and fluctuated within 29.5% of total costs. The average production value of red sweet pepper production under covers in tunnels with a wooden structure amounted to 3,116 PLN/240 m^2, while in the case of metal structures, this value amounted to 3,449.20 PLN/240 m^2. In addition, analysis of the Cobb-Douglas production function showed that the gross profit was affected by general costs, labor costs and costs of purchasing seedlings. The results of this study indicate a need to undertake further research on this topic to formulate recommendations aimed at optimizing paprika production to increase and stabilize income resulting from cultivation activity.

INTRODUCTION

The production of vegetables in greenhouse facilities due to changing climatic conditions is a popular form of cultivation [Elwan, El-Hamahmy 2009]. In Poland, the production of sweet peppers (*Capsicum annuum* L.) is carried out both under cover and in the ground. Domestic statistics do not take detailed data concerning pepper growing under covers into account. High film tunnels provide manufacturers with an opportunity to increase production, quality and sales, but little is known about the economic profitability of using these structures. It should be emphasized that these constructions are used to protect the quality of crops in unfavorable weather conditions and extend the crop production season by improving the climate [Galinato, Miles 2013, Bruce et al. 2019]. This contributes to yield increase [Jovicich et al. 2005], and thus translates into an increase in production revenue [Waterer 2003]. High foil tunnels are generally considered to be temporary constructions which, unlike greenhouses, do not have an electrical installation,

and the crops in them are, in most cases, planted directly in the soil [Wells, Loy 1993]. Due to the extension of the growing season and the creation of conditions favorable for plants, high tunnels are proving to be a profitable production tool for many horticultural crops [Zhao X, Carey E 2009, Warren et al., 2015]. Hence, high tunnels are widely used for the production of vegetables [Sydorovych et al. 2013, Lamont 2009].

Increasing prices of funds necessary to conduct agricultural production (fertilizers, plant protection chemicals, fuel) and a significant increase in wage labor costs contribute to considerations regarding the profitability of red sweet pepper production. The profitability of red sweet pepper is expressed by the relationship between the production factor prices and the prices offered for the product. Understanding the relationship between the volume of production and expenditure is important for producers, especially in the case of strong competition, which requires manufacturers to maximize production volume at a given input or minimize input at a production level. It should be emphasized that improving agricultural productivity is a basic condition for sustainable economic development, which is currently of great interest of the governmental scientific community and practitioners. Increasing agricultural productivity is an increasingly important aspect affecting the balance between production and environmental sustainability [O'Donnell 2010].

Improving agricultural productivity is a basic condition for sustainable economic development, which is currently a subject of great interest, for the government scientific community and practitioners. In upcoming years, if populations continue to grow and reserves of natural resources continue to decline, increased agricultural productivity will be progressively important to sustain the environment and improve living conditions [O'Donnell 2010]. The main purpose of the article is to examine the relationship between the value of production, labor and capital expenditure in the production of red sweet pepper (*Capsicum annuum* L.) on selected horticultural farms.

MATERIAL AND METHODS

The conducted study should be considered a pilot programme. The study covered farms that produce red sweet peppers in unheated plastic tunnels. The spatial scope covered the area of Przysucha and Radom poviats. The selection of farms was deliberate. The selection of entities was guided by the technical solutions used on the farms for the construction of foil tunnels (use of modular foil tunnels and individual foil tunnels from wooden structures) and the entity size. Tests were carried out in 10 farms in 3 vegetation seasons. Due to small differences in the structure of costs and revenue obtained, data from these periods were averaged and presented as one repetition. The data was collected by supplementing the questionnaire prepared by farmers at the beginning of the growing season.

In order to calculate the profitability of production in the analyzed farms, the study uses a simple profit equation, with the following function form:

$$Z_b = P_1 * Q_1 - T_c \quad (1)$$

where: Z_b – production value (PLN/kg), P_1 – price of main product (PLN), Q_1 – amount of main products (kg), T_C – total costs.

In order to determine the correlation between income in the analyzed farms and expenditure, in this study, the multiple-Cobb-Douglas multiple regression function was used [Cobb, Douglas 1928, Gujarati 1995], with a general formula in power form presented in as follows:

$$Y = \alpha_0 + X_1^{\alpha_1} + X_2^{\alpha_2} + \cdots + X_J^{\alpha_J} + \varepsilon \quad (2)$$

where: Y – production value (PLN/kg), α – equation constant, X_1 – explanatory variable, α_1 – estimated variable coefficients, ε – random ingredient.

The Cobb-Douglas function is commonly used to study the impact of input levels on production volume. 7 variables were used in the development of the function. In order to estimate the parameters of the Cobb-Douglas function by the KMNK method, it has been transformed to a linear form. The Cobb-Douglas production function, after linearizing, took the following form:

$$lnY = ln\alpha_0 + lnX_1^{\alpha_1} + lnX_2^{\alpha_2} + lnX_3^{\alpha_3} + lnX_4^{\alpha_4} + lnX_5^5 + lnX_6^{\alpha_6} + \varepsilon \quad (3)$$

where: Y – production value (PLN/m^2), α – logarithm of the equation constant, $\alpha_{1 \ldots} \alpha_6$ – coefficient of the corresponding variable, X_1 – general costs of cultivation (PLN/m^2), X_2 – costs of seedlings (PLN/m^2), X_3 – fertilizer costs (PLN/m^2), X_4 – costs of plant protection products (PLN/m^2), X_5 – costs of depreciation of the tunnel construction (PLN/m^2), X_6 – labor costs (PLN/m^2), X_7 – other cost (PLN/m^2).

RESULTS

Sweet pepper is an important species of vegetable produced in the world, the global production of which has steadily been growing for many years. In 2017, the global harvest of sweet peppers amounted to 44.26 million tons (Figure 1). The largest producers of the vegetable are China, Mexico, Turkey, Indonesia, the USA and Spain. In the European Union, the largest producer of sweet peppers is Spain. These are, respectively, followed

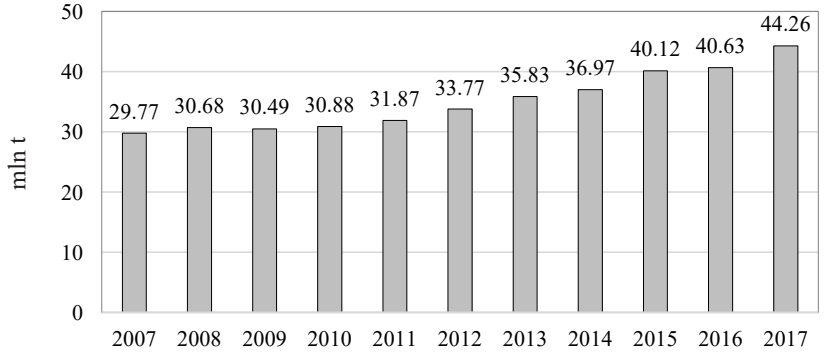

Figure 1. World production of pepper in 2007-2017
Source: own elaboration based on FAOSTAT and Eurostat

by the Netherlands, Romania, Italy, Greece, Hungary and Bulgaria [FAOSTAT 2019]. Unfortunately, FAO data does not include Poland in European paprika production.

Domestic statistics do not provide the cultivation area or the harvest of peppers in particular years in the country [GUS 2018]. Despite a lack of detailed data from estimates, it can be concluded that pepper is, next to tomatoes and cucumbers, the third plant occupying the largest area under cultivation in Poland. It is estimated that peppers, in unheated tunnels, cover an area of about 900-1,000 ha, with almost half coming from crops located in the vicinity of Radom (communes of Przytyk, Potworów, Radzanów, Klwów, Wyśmierzyce). The second large area of pepper growth is located around Sandomierz[1].

In the paper, production costs were calculated on the basis of variable inputs such as planting material, fertilizers, plant protection chemicals, human workload, specialized activities as well as other measures, i.e. packaging, crop care material, transport, irrigation and depreciation and tunnel construction amortization. The results of the analyzes were presented in Table 1. It should be indicated that the largest share in total costs was the cost of purchasing planting material and oscillated around 29.5% of total costs. A significant share, namely approx. 22.5%, was depreciation costs for the construction of tunnels and fixed equipment. Labor costs were ranked third, accounting for approximately 20.7% of total production costs in the surveyed farms.

The results of the analyzes showed that the return of pepper production under cover per 1 m^2 for tunnels with a wooden structure amounted to PLN 12.98 or PLN 3,116.00 from a

Table 1. The structure of paprika production costs in the studied farms

Specification	Wooden constructions		Metal constructions	
	PLN/m^2	PLN/240 m^2	PLN/m^2	PLN/240 m^2
Planting material	4.17	1,000.0	4.17	1,000.0
Costs of mineral fertilizers	1.25	300.0	1.40	336.0
Costs of organic fertilizers	0.25	60.0	0.25	60.0
Plant protection products	0.42	100.8	0.50	120.0
Labor costs:				
– wage labor	1.25	300.0	1.25	300.0
– own work	1.67	400.8	1.80	432.0
Transport + trade fair fees	1.25	300.0	1.25	300.0
Construction depreciation	3.17	672.0	4.50	840.0
Specialistic costs	0.29	70.0	0.40	96.0
Other direct costs	0.33	79.0	0.40	96.0
Indirect costs	0.42	100.0	0.50	120.0
Total costs	14.10	3,384.0	15.42	3,700.8

Source: own calculations

[1] Estimates as to the area of cultivation and their location are based on the research of authors of the article and estimates of the Masovian Agricultural Advisory Center.

Table 2. Production and return in the cultivation of peppers under covers

Specification	Wooden constructions	Metal constructions
	PLN	
Production value [PLN/m^2]	12.98	14.37
Production value [per kg of product]	1.57	1.64
Production value [PLN/240 m^2]	3,116.00	3,449.20
Total production value (without direct payments) [per m^2]	27.08	29.79
Total production value (without direct payments) [PLN/240 m^2]	6,522.30	7,172.30
Direct payments	22.30	22.30
The main product – class I	6,500.00	7,150.00

Source: own calculations

tunnel with an area of 240 m^2 (Table 2). In the case of metal structures, this value amounted to 14.37 PLN/m^2, or 3,449.20 PLN/240 m^2. Calculated per 1 kg of product, this return reached a value of PLN 1.57 for wooden constructions and PLN 1.64 for metal tunnels.

The results of the logarithmic parameters estimation of the Cobb-Douglas production function form for the production of sweet peppers under covers are shown in Table 3. They indicate that the dominant positive impact on the gross value of seedlings was the costs of seedlings, (value of the model coefficient 7.352 means an increase of this factor by 1%, while maintaining other factors at the same level will increase the value of production by 7.352%), overhead costs (model factor value 1.073, which suggests that an increase of these costs by 1%, will increase the value of production by 1.073%) and labor costs (value of the model factor 0.239, which suggests that an increase in labor costs by 1% will increase the value of production by 1.073%). Other variables used in the construction of the model turned out to be statistically insignificant.

R^2 coefficient of determination was 0.998, which indicates that approximately 99.8% of changes in gross profit were explained by the independent variables used in the model.

Table 3. Parameters of the Cobb-Douglas function

Variables	Coefficient function	Standard error	T-Student statistics	p-value
X_1	1.073	0.039	27.73	2.04e-08***
X_2	7.352	0.222	33.07	5.98e-09***
X_6	0.239	0.011	21.00	1.40e-07***
const	−3.599	0.138	−26.01	3.18e-08***
R^2	0.998			

*** parameters statistically significant at a level of 0.01

Source: own calculations

CONCLUSIONS

This study examines the impact of selected factors on the profitability of sweet red pepper grown under cover. The results of analysis indicated that the average value of sweet red pepper production under covers, in tunnels, with a wooden structure was 12.98 PLN/m^2, while for metal structures it was 14.37 PLN/m^2. The results of the estimation of Cobb-Douglas production function parameters show that the dominant positive impact on gross return value was the cost of seedlings, overhead costs and labor costs. Other variables that were used in the construction of the model turned out to be statistically insignificant. The results of this study indicate the need for further research on the profitability of sweet red pepper production under cover in order to formulate recommendations aimed at optimizing the production of red sweet pepper, which will translate into an increase and stabilization of income arising from cultivation activity. In addition, it should be noted that national statistics do not provide data on the production of sweet red peppers, hence the issue should be considered further.

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RENTOWNOŚĆ PRODUKCJI PAPRYKI ROCZNEJ (*CAPSICUM ANNUUM* L.) W UPRAWIE POD OSŁONAMI

Słowa kluczowe: opłacalność produkcji, papryka, produkcja pod osłonami

ABSTRAKT

Celem badań była próba oceny rentowności produkcji papryki słodkiej. Badaniem objęto gospodarstwa zajmujące się produkcją papryki słodkiej w nieogrzewanych tunelach foliowych na terenie powiatu przysuskiego i radomskiego. Dobór gospodarstw był celowy. Przy wyborze gospodarstw kierowano się technologią uprawy oraz wielkością gospodarstwa. Badanie przeprowadzono w 3 sezonach wegetacyjnych w latach 2017-2018. Uzyskane wyniki wskazują, że największy udział w kosztach ogółem stanowiły koszty zakupu materiału nasadzeniowego i wahały się w granicach 29,5% ogółu kosztów. Średni zwrot produkcji papryki pod osłonami w tunelach z konstrukcją drewnianą wyniósł 3116 zł/240 m^2, natomiast w przypadku obiektów o konstrukcji metalowej wartość ta wyniosła 3449,20 zł/240 m^2. Ponadto analiza funkcji produkcji Cobba-Douglasa wykazała, że na wielkość zysku brutto istotny wpływ miały koszty ogólnouprawowe, koszty pracy ludzkiej oraz koszty zakupu sadzonek. Wyniki badań wskazują na potrzebę podjęcia dalszych badań w tym temacie, aby mnożna sformułować zalecenia zoptymalizowania produkcji papryki w celu zwiększenia i ustabilizowania dochodów wynikających z prowadzonej działalności uprawowej.

AUTHORS

WIOLETA SOBCZAK, PHD
ORCID: 0000-0003-3812-3877
Warsaw University of Life Sciences WULS
Institute of Economics and Finance
166 Nowoursynowska St., 02-787 Warsaw, Poland

ANNA SOBCZAK, MSC
ORCID: 0000-0003-0383-5372
Warsaw University of Life Sciences WULS
Institute of Horticulture Sciences
166 Nowoursynowska St., 02-787 Warsaw, Poland