

## **Production-related and economic conditions of edible carrot cultivation in Poland**

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The issues presented in this paper are connected with the edible carrot production technology as well as cost calculation, which was based on actual data from a horticultural farm. The production means employed in the analyzed technology generated measurable profits such as a satisfying carrot yield. The costs incurred by its production were 20,000 Polish zloty, whereas the surplus obtained (agricultural profit) was nearly 24,000 PLN. Based on these results, our analysis shows that the edible carrot production at this farm is profitable. The positive financial result suggests that this farm can expand the plantation and make investments needful for the production technology, especially for preparation of the product and its sale.

**Key words:** carrot production technology, cost analysis, profitability, distribution.

**Introduction.** Poland is one of the leading carrot producers in the European Union. Bartczak (2009) reports that in Poland carrot is grown on 33 thousand ha and the total yield was 935 thousand tons in 2009, with the yields being quite stable over the years. Poland became a leading producer of this vegetable after its access to the EU. Considering the size of production, carrots come in the second place among vegetables, after cabbage. Carrot is a highly valued vegetable owing to its high nutritive value. It contains much beta-carotene, which is a source of vitamin A, essential for the growth and development of human organism, especially of children and young people (Simon, 1992; Barański et al., 2003). In Poland, the main distributors supplying large urban agglomerations are fruit and vegetable fairs, wholesale markets, fruit and vegetable markets as well as direct sale to shops, supermarkets and hypermarkets. It should be noticed that over 90 % of the wholesale of vegetables, including carrot, takes place on the wholesale market and street markets. Economically speaking, as Jarugowa et al. (1993) or Czuba (2001) claim, decisions concerning choice of distribution channels are among the most important ones in marketing. Distribution channels are of paramount importance as they often share the financial result obtained. In addition, they contribute to the formation of stable links between

producers and market environs. The major suppliers of vegetables to wholesale markets and street markets are producers, followed by trade intermediaries, who often set up a company for a season or two. This situation seriously destabilizes the market and weakens the competitive position of producers among other EU market players. Distribution, from producer to consumer, most often is two-stage process. Poland is a country where wholesale is extremely fragmented, which means that the retail market receives small batches of low quality produce.

The aim. The aim of this study has been to analyze the costs of growing 1 ha of edible carrot under conditions found at an actual farm.

**Object, methods and conditions.** The study has taken advantage of primary and secondary data. The sources of secondary data included mainly:

- references dealing with the issue of the study,
- statistical data bases of the Central Statistical Office in Poland (GUS),
- relevant literature.

The primary data have been gathered based on the authors' observations and a face-to-face survey completed by the farmer, who runs a vegetable farm near Elbląg, a town in Poland. This privately owned farm lies in the delta of the Vistula River, in an area called Żuławy, which has very good soils that can guarantee high yields. The soils in Żuławy belong to the best soil complexes, and are mainly alluvial soils. The area has a drainage network and is suitable for growing high demand crops, particularly vegetables. The farm lies 5 km north of Elbląg, which is the main market for the farm vegetables, although not the only one. The farmer also sells vegetables in Tczew and Gdańsk (located 50 and 60 km away from the farm), which are more attractive than Elbląg as they can offer higher prices. The farm does not sell vegetables on retail markets, although it did so in its early day (1992). The farm has a vegetable storage house with controlled atmosphere, which can hold up to 180 tons of produce, and equipment for washing and packing root vegetables. The primary data focused on the specific nature of running the farm, particular elements of the production technology, market conditions and obtained prices. In addition, it was necessary to gather information on the basic parameters of the machines and tractors used on the farm. The empirical data were introduced and processed using Excel spreadsheets.

**Guidelines for the cost calculations.** The analysis of production costs of growing carrot was based on the actual data from a privately owned farm covering 45 ha. The calculations included gross prices of production means in 2009. Particular categories of costs and revenue were determined according to the following design:

1. Value of production
2. Direct costs
3. Indirect costs
4. Farm income
5. Total costs
6. Direct margin rate
7. Revenue rate

Transport and general costs were not included in the calculation of the cultivation costs.

**Costs of tractor and farm machinery work.** The farm has modern equipment for soil preparation and cultivation, complex plant protection treatments, weeding and mechanical harvest of root vegetables. The costs of tractor and machinery work were established according to the methodology for machinery exploitation costs suggested by the Institute of Civil Engineering, Mechanization and Electrification in Agriculture in Warsaw (the IBMER) (Muzalewski, 2007). These costs include costs of machinery depreciation, insurance, fuel, oils and greases, repairs, maintenance, storing, etc. The work time of a basic tractor (100 HP) was set at 600 hours a year (for fifteen years of using the tractor). The cost of one hour of tractor work was then 118.8 PLN. Other tractors, of 28 HP and 80 HP, were also used for production of carrots. The unit costs of using tools and machines aggregated with the tractors were also calculated according to the methods elaborated by the IBMER.

**Results.** Agrotechnological conclusions for carrot in Poland are very favorable, thus Poland is recognized as the main production area all over European Union, and the United Kingdom is a second place producer. Highest production in Poland is due to highest area occupied by carrot plantations but yields are smallest in EU. The way to change it is introducing modern technologies in our country (Reid and English, 2000).

**Table 1.** Carrot production in EU, 2009  
**1 lentelė.** Morkų auginimas Europos Sąjungoje 2009 metais

Country Šalis	Area harvested Plotai (ha)	Produktion (tonnes) Išauginta produkcijos tonomis	Yield Derlingumas (t ha <sup>-1</sup> )
Poland Lenkija	33 000	935 000	28.33
United Kingdom Didžioji Britanija	9 883	677 144	68.52
France Prancūzija	14 980	667 948	44.59
Italy Italija	13 454	602 441	44.78
Holland Olandija	8 800	543 000	61.70
Germany Vokietija	9 858	516 000	52.14

Source: FAOSTAT 2009

The current tendencies on the Polish market encourage many vegetable producers to undertake investment projects for packaging, standardization and unit packing of vegetables. Many of such planned investments have been halted now due to a relatively high exchange rate of euro, which limits import of equipment for unit packing from other countries. However, it is expected that unit packing, which requires modern packing machines, will become more popular when the exchange rate of euro goes down.

The calculation of costs of growing 1 ha of carrot was completed for cv. ‘Nerac’,

produced by the company called Bejo. The soil under carrot belonged to very good wheat complex, characterized by high abundance in N, P, K and Mg. Carrot was preceded by winter wheat.

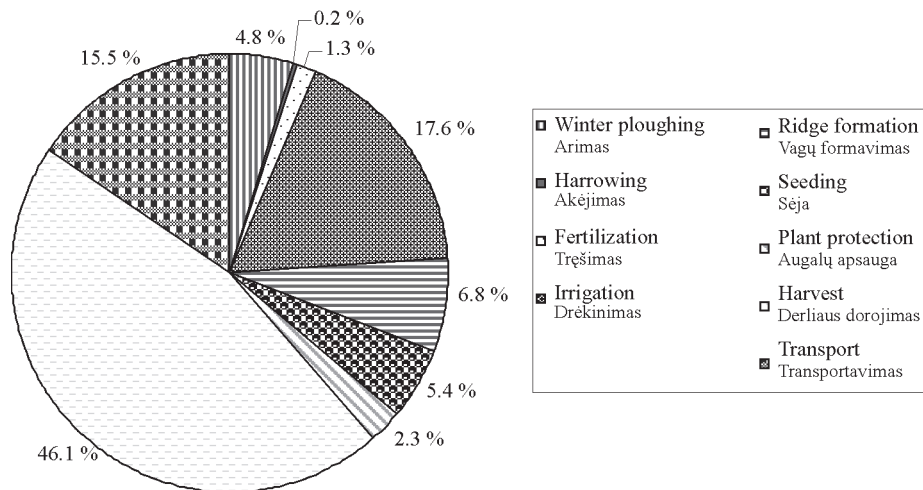
Intensive production, which takes place at the farm presented in this paper, relies on the most modern equipment, which enables the farmer to carry out all agronomic treatments quickly and efficiently, including harvest of root vegetables. The structure of the treatments performed with machines and tractors was dominated by the mechanical harvest using a one-row combine. The costs breakdown shows that the highest percentage (46 %) falls to the harvest. This percentage corresponds to about 3.000 PLN. The producer estimates that despite such high costs, mechanical harvest is less expensive than manual one. The decision he made to purchase a combine for root vegetable harvesting was stimulated by the shortage of available manual labour and frequent absenteeism of the hired labour that he encountered. As a result, harvests were often delayed, which impaired the storability of the vegetables and in extreme cases the yields were left on the field.

**Table 2.** Calculation of cultivation, plant protection and harvest costs in vegetable farm

**2 lentelė.** Žemės dirbimo, augalų apsaugos ir derliaus nuėmimo išlaidų apskaičiavimas auginant morkas daržininkystės ūkiuose

Type of treatment Technologinė priemonė	Unit cost of tractor labour Polish zloty ha <sup>-1</sup> Išlaidos, tenkančios traktoriaus darbo valan- dai, Lenkijos zlotai ha <sup>-1</sup>	Unit cost of machine labour Polish zloty ha <sup>-1</sup> Išlaidos, tenkančios mašinių darbo valandai, Lenkijos zlotai ha <sup>-1</sup>	Number of working hours Darbo valan- dų skaičius	Value in Polish zloty Priemonės vertė Lenkijos zlotais
Winter ploughing Arimas	118.8	37.1	2	311.8
Harrowing Akėjimas	37.3	3.2	0.3	12.1
Fertilization Tręšimas	118	55.8	0.5	87.3
Irrigation Drėkinimas	118.8	71.1	6	1 139.4
Ridge formation Vagų formavimas	37.2	110.6	3	443.3
Seeding Sėja	118.8	116.8	1.5	353.3
Plant protection Augalų apsauga	37.2	47.5	1.7	147.9
Harvest Derliaus dorojimas	118.8	130.1	12	2 986.9
Transport Transportavimas	79.3	4.2	12	1 002.1
		Total / Iš viso	39.1	6 484.2

The costs structure (Fig., Table 2) reveals a large share of the costs incurred by irrigation, which considerably reduced the risk of lowered yields due to dry weather spells. In contrast to the previous year (2008), when irrigation consisted of several treatments during the growing season, in 2009 irrigation was performed once during the emergence of carrot plants. The high costs of plant protection treatments were set off by both higher yields and better technological quality.



**Fig.** Cost breakdown of agronomic treatments in vegetable farm  
**Pav.** Agronominių priemonių išlaidų pasiskirstymas auginant morkas daržininkystės ūkiuose

The presented calculations (Table 3) show that the cultivation of cv. ‘Nerac’ edible carrot was profitable, which is confirmed by the high profitability index (2.2). Such a high value of the profitability index was attained by the high volume of yields produced at this farm, which reached 70 t ha<sup>-1</sup>. Carrot has a very high yield potential, but the applied production technology requires technological paths and transport land strips, which excludes some of the field area from production. For the calculations, the average annual price for carrot was taken. In the current year, 2009, one kilo of carrot cost 2.5 PLN at the turn of May and June, but this was an exceptionally high price, which occurs sporadically. In this case, it had a very positive influence on the financial results of the farm production. When analyzing the direct costs of carrot production, it was demonstrated that the cost of seed material purchase had a very large share, followed by fertilization. The favourable soil conditions meant that the rates of applied fertilizers were reduced. The good agronomic practice, in turn, which followed the latest trends in carrot cultivation, brought about high volumes of yield and good technological quality of carrots.

**Table 3.** Cost calculation of 1 ha cv. 'Nerac' carrot production  
**3 lentelė.** Išlaidų iš 1 ha gautam 'Nerac' veislės morkų derliui išauginti apskaičiavimas

No	Specification Sifikacija	Unit of measure Vienetai	Quantity Kiekis	Price PLN Kaina Lenkijos zlotais	Value PLN Vertė Lenkijos zlotais
1	2	3	4	5	6
A	Total production value Bendra produkcijos vertė	PLN	-	-	43 640.00
1	Product value Produkcijos vertė	kg	70 000	0.6	42 000.00
2	Crops direct subsidy Pasėlių tiesioginis subsidijavimas	PLN	1	380	380.00
3	VAT reimbursement PVM kompensavimas	PLN	1	1 260	1 260.00
Production costs per 1 ha of plantation Produkcijos išlaidos, tenkančios 1 ha pasėlio					
B	Total direct costs Iš viso tiesioginių išlaidų	PLN	-	-	5 545.02
1	Seed material Sėklos	kg	2	1 600	3 200.00
2	Mineral fertilization Tręšimas mineralinėmis trąšomis	PLN			1 510.00
	Ammonium salpêtre 34 %: Amonio salietra:	kg	300	1.2	360.00
	Polifoska	kg	500	2.3	1 150.00
3	Plant protection: Augalų apsauga:				835.02
	Afalon WP	1	1.5	54	81.00
	Racer 250 EC	1	1	115	105.00
	Signum 33 WG	1	0.75	256	192.00
	Amistar 25 S.C.	1	0.8	347	277.60
	Nurelle D 550 EC	1	0.6	84	50.40
	Brawo 500	1	2	54.14	108.28
	Fastac 100 EC	1	0.1	207.4	20.74
C	Direct margin (A-B) Tiesioginis pelnas	PLN	-	-	38 094.98
D	Total indirect costs Iš viso netiesioginių išlaidų	PLN	-	-	14 249.18
1	Tractor and machinery work Traktorių ir mašinų darbas	PLN	-	-	6 484.18
2	Preparation for sale and packing Prekinis paruošimas ir pakavimas	PLN	15 % of the product value 15 % nuo produktų vertės		6 300.00
3	Agricultural tax Žemės mokestis	PLN	1	105.00	105.00
4	Labour Darbas	PLN/hour valandai	160	8.50	1 360.00

**Table 2** continued  
**2 lentelės tęsinys**

1	2	3	4	5	6
E	Total costs per 1 ha Iš viso išlaidų 1 ha	PLN	-	-	19 794.20
F	Agricultural profit (A-E) Žemės ūkio pajamos	PLN			23 845.80
Measures of economic efficiency Ekonominio efektyvumo rodikliai					
G	Indirect margin rate Netiesioginis pelningumas (%)	-	-		87.29
H	Agricultural profit rate Žemės ūkio pajamos (%)	-	-		54.64
I	Total cost/1 kg main product Iš viso išlaidų 1 kg pagrindinės produkcijos gauti	-	-		0.28
J	Production value/1 PLN total costs Produkcijos vertė, tenkanti 1 Lenki- jos zlotui išlaidų	-	-		2.20
K	Agricultural profit/1 hour labour Žemės ūkio pajamos, tenkančios 1 darbo valandai	-	-		149.04

The third largest production cost was generated by the complex plant protection treatments against weeds, diseases and pests. The plant protection chemicals used by the farmer belonged to the most effective preparations. Computer-aided determination of rates of the applied plant protection preparations makes it possible to reduce the costs of plant spraying treatments to about 15 %. Soil conditions do not always enable full and effective plant protection, especially during intensive precipitations, which from May to July 2009 were very high. Under such conditions, diseases and especially weeds can become a serious problem, and additional weeding treatments raise production costs considerably.

In the analyzed farm, the total production costs per ha are around 20 thousand PLN and tend to increase. The producer claimed that in 2008 the total production costs were about 2,000 PLN lower. In the total production costs per ha, indirect costs are prevailing, mainly machinery and tractor work. The second largest category of costs covers preparation for sale, including packing. The producer estimates that these costs equal about 15 % of the product value. Human labour is another large group of costs. Organization of work at this farm should be modified so as to improve efficiency. Many changes attaining this aim have already been introduced, although there are certain limitations caused by lack of sufficient space. Therefore, the farmer plans to extend the storage house to add larger rooms, where the product will be prepared for sale. This will enable optimization of the flow of product during the washing and preparation, and especially service. In the cost calculation presented in this paper, labour is a considerable item, but not as expensive as some years before. The labour expenses also include the work done to prepare the combine for harvest. In the earlier years,

labour costs at the farm grew considerably, particularly in 2008. In 2009, however, due to a very high unemployment rate in Poland, the labour costs decreased, as more human labour was available.

Cost calculation shows that a unit cost of carrot production was 0.28 PLN, which gives a margin of 0.32 per kilo, and this is the minimum that was achieved by the producer.

**Discussion.** The food model that has until recently prevailed in Poland, based on meat products, fish and animal fats providing man with highly calorific food, is now being modified owing to a considerable increase in consumption of plant products, mainly vegetables. In the USA, it has become a norm to eat fruit and vegetables 5 times a day. The main advantage of fruit and vegetables as a foodstuff is that they are low in calories and highly nutritious. This trend should obviously be mirrored in Poland. Vegetables are doubtless a valuable source of fibre, vitamin C, provitamin A, minerals and oxidants. Simon (1992), Jagosz et al. (2000), Barański et al. (2003) explains that the high position of Poland among the EU countries as a producer of vegetables is mainly a result of very large production of the garden beet, cabbage, carrot and cucumber. Once Poland had accessed the EU, vegetable and flower producers were among the farmers who most readily adapted to new conditions by introducing new technologies and production methods. The producers realized that they could and should grow only those cultivars and varieties, which are demanded on the market. As a result, they became competitive on foreign markets. What is important, however, is that production costs and quality expectations grew as Polish farmers had to adjust their production to the EU norms. In Poland, high changeability in vegetable yields is mainly caused by insufficient amounts of rainfall during the growing season. Improvement of water conditions should rely on increasing area of irrigated farmland by at least 40–50 %. At the examined farm, cultivation of carrot was profitable also because the field was irrigated twice during the emergence of carrot plants. Prices of carrots in Germany, the Netherlands and Poland are varied as they depend on a target market. The average selling price of carrot to be sold on fresh vegetable markets is much higher than that of carrot for food processing. The average selling price of carrot obtained at the examined farm was about 0.6 PLN, and was among the lowest prices in Poland because, practically speaking, the average monthly wholesale price of carrots in 2007–2009 was never obtained (Stepka, Smoleński 2009). Under such circumstances, it seems reasonable to look for other, more profitable markets. Elbląg does not belong to the largest Polish cities and the buying power of its population is low. Moreover, some residents of the town have gardens where they grow fruit and vegetables to supply their households.

The positive financial result and easier sale of carrots have stimulated further increase of carrot cultivation at this farm and increasing specialization of its production. Newer, better yielding cultivars of carrots and other vegetables are grown, more efficient production technologies are introduced. Consequently, the profitability of carrot cultivation increases, the farmer feels some stability and his products are more competitive. Even more modern technologies of production improve of quality of product (Rubatzky et al. 1999). Based on the present analysis, it can be concluded that the rational use of good natural and economic conditions as well as large-scale

production of vegetables, particularly field ones, should be based on proper farmstead management which involves development of professional vegetable storage houses and the state-of-the-art packaging technologies. Packing vegetables is an economically viable activity (Szwejskowska, Winnicki, 2008). Cąderek (2005) reports that high competitiveness on the fruit and vegetables market forces producers to undertake activities, which will show the best side of their produce. On the market of homogenous products, it is especially important to be distinguishable and quality values alone may not suffice. With the today's consumer awareness, good quality is a basic requirement, which enables a given product to function on the market. More and more often, buyers look at packaging and its attributes. The role of packaging of horticultural products is still neglected in Poland, although it facilitates product turnover and is among the factors, which condition sales. Thus, good packaging means that product will do well on the domestic market and will be exportable. Furthermore, large chains of retailers promote sale of ready-made food products, which forces food producers to invest in technologies that will enable them to prepare products properly for sale. In western European countries washing and polishing of carrots before they are put to sale is a standard procedure, but it is often done by large packaging companies or producer co-ops. The role of a single producer is to supply them with high quality raw product. In Poland, this is still the producers' job.

**Conclusions.** 1. The analysis of the available relevant literature as well as own research have enabled us to draw the following final conclusions:

2. The analyzed farm has invested much to specialize in production of root vegetables, which has a considerable positive effect on the quantity and quality of products.

3. For production of carrots, an extremely important element of the technology involved is precise preparation of soil using appropriate equipment for this purpose.

4. The fruit and vegetable wholesale market in Elbląg does not offer attractive prices, therefore the decision to enter other markets (Tczew and Gdańsk) was well-grounded.

5. The observable market tendencies suggest that sale of fruit and vegetables sold in unit packaging is increasing. Thus, it becomes necessary to buy packaging equipment, although the high cost of such purchase should encourage producers to form groups.

6. Carrot production must include complex plant protection, which has a large effect on production costs. As much important is that such treatments should be performed with high precision.

7. Carrot production at the analyzed farm is profitable, which is confirmed by the value of the profitability index, which reached 2.2.

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## Ūkinė ir ekonominė morkų auginimo būklė Lenkijoje

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### *Santrauka*

Šiame darbe nagrinėjami klausimai susiję su valgomųjų morkų auginimo technologija ir savikainos apskaičiavimais, kurie pagrįsti iš daržininkystės ūkių gautais duomenimis. Panaudotos technologinės priemonės duoda gana didelę naudą – išauginamas gausus morkų derlius. Morkų auginimo išlaidos buvo 20 000 Lenkijos zlotų, o gautas pelnas siekė 24 000 Lenkijos zlotų. Rezultatų analizė parodė, kad auginti morkas šiuose ūkiuose yra pelninga. Teigiami finansiniai rezultatai rodo, kad šie ūkiai gali didinti pasėlių plotus ir investuoti į naujas technologijas, ypač prekinį produkcijos paruošimą ir pardavimą.

**Reikšminiai žodžiai:** morkų auginimo technologija, išlaidų analizė, pelningumas, skirstymas.