POTATO PRODUCTION DEVELOPMENT IN THE SLOVAK REPUBLIC AND THE IMPACT OF MACHINERY ON PRODUCT QUALITY

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Summary. The paper submitted presents the basic problems faced by Slovak farmers cultivating potatoes in terms of the technologies and farm machinery used. It covers individual farming operations, including soil tillage, pre-planting preparation and planting, inter-row cultivation, harvest and product storage. Two fundamental technologies are discussed, namely conventional technology and the technology associated with soil destoning before planting. A comparison of their individual advantages and disadvantages in terms of farm machinery and decreasing tuber damage is included, as is a discussion as to their economic effectiveness discussion. The paper is intended to serve as a methodological outline and a suggestion for the more extensive use of destoning technologies in Slovakia, primarily among farmers cultivating potatoes in the heavier, more stony and clumpy soils of the Liptov, Turiec and Spiš regions.

Key words: potato, soil removing, yield, damage, destoning, cultivation costs

Introduction

Potatoes are the world's fourth most widespread crop, after rice, wheat and corn and represent an irreplaceable component in the world food chain.

The development of potato growing areas in Slovakia following the establishment of the independent state is expressed in Figure 1.

The significant decrease in the growing areas in Slovakia partially reflects the European trend. The reduction in acreage is also affected by the high cultivation costs, at €3 000 - € 6 000 ha^{-1}); potatoes are grown under irrigation as a matter of necessity, while the high costs of chemical protection, the lack of quality storage facilities and, last but not least, the high price of agricultural machinery all contribute to this factor.

Consumption of potatoes has decreased from 85.5 kg per capita in 1990 o 58.7 kg per capita in 2007, which is 27.2% less than the recommended nutritional intake. According to the figures issued by the Statistical Office, the average yield in Slovakia for 2008 was 22.64 $t \cdot ha^{-1}$, though the average yield for top producers ranges from 35 to 45 $t \cdot ha^{-1}$. In addition to the agrobiological conditions, yield and product quality are also influenced by the selection of growing technology, machinery and potato handling equipment.

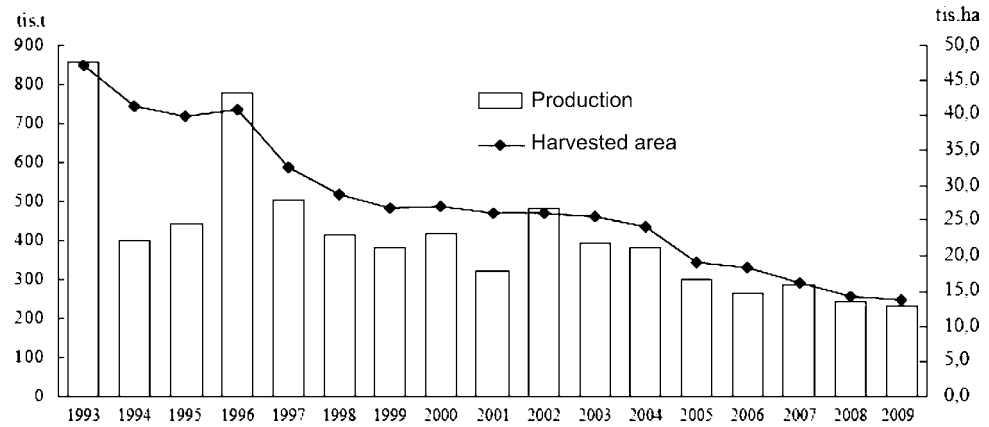

Fig. 1. Development of field areas and potato production

Material and methods

In all the developed countries where production takes place in heavier, relatively stony soils, the destoned soil system of potato cultivation has been adopted. The aim of this study was to compare two potato cultivation technologies:

1. The classic potato cultivation system: without destoning and with normal pre-planting land preparation and planting.
2. Thedestoned soil potato cultivation system: as regards the destoning technology, the ridging, clod and stone separation using a soil separator method was selected for the purposes of this study. larger-sized stones (over 17 cm) are collected in the box, while the transverse staging conveyor places the smaller stones and clods in the furrow, where they are then pushed into the soil by the wheels on the tractor's left during the next pass.

The research was carried out at an agricultural farm specializing in the cultivation of potatoes and operating on soils with a high stone content. The results relate to 2008. The methodological procedure was as follows:

1. In the first case, the classic technology for soil preparation and potato planting in rows was used.
2. In the second case, before destoning, digging tests were carried out in pits measuring 1000 x 1000 x 300 mm and spaced transversely along the plot.

The soil from the above mentioned sample was separated in square sieves with a hole clearance of 25 mm. Soil Sample Size 1000 x 1000 x 300 mm = 0.3 m^3.

The 32 ha plot used for the study was divided into 2 parts. One half of the plot was destoned and separated and the potatoes were planted in the soil prepared in this way. On the other half, the classical technology, without destining, was used. 36 samples were taken and they were divided into the following groups:

– without separation, untreated soil
– ridged soil without destoning
– separated and destoned soil

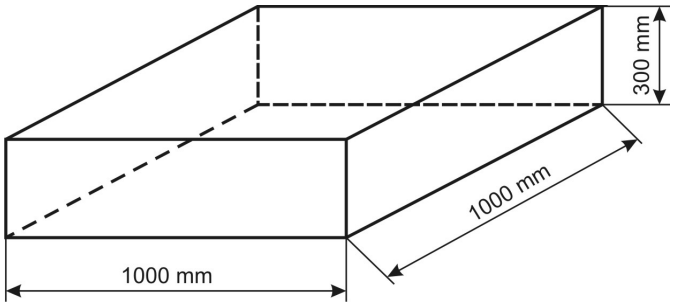

Fig. 2. Diagram of the sample taken (sample volume: 0.3 m^3)

The entire cultivation area was equipped with an irrigation system. The potato variety used in the study was Agria, medium early, with good yield potential. For the harvest, a Reekie two-row harvester was used.

Measurements were taken on the areas destoned by a Reekie separator. Samples were collected from a trailer towed by a running vehicle. Subsequently, samples were collected from the area where the classical cultivation technology had been used. We then compared the yield, tuber damage and percentage content of clods and stones for the twi technologies used.

Total average damage:

$$T_d = 0{,}1 \text{ x } S_d + 0{,}5 \text{ x } M_d + 1{,}0 \text{ x } H_d \quad [\%] \tag{1}$$

where:

T_d − total damage [kg],
S_d − surface damage – to a depth of 1 mm, or scraped skin [kg],
M_d − medium damage − to a depth of 5 mm [kg],
H_d − severe damage − over 5 mm, or tuber cut [kg]
UP – undamaged potatoes [kg].

Percent of damage:

$$P_d = \frac{T_d}{Y} x\, 100\,[\%] \tag{2}$$

where:

P_d − percent of damage [%],
T_d − total damage [kg],
Y − yield from the sample collected [kg].

Macro damage of tubers was evaluated in accordance with relation No. 1, by visual inspection of the samples collected, with the surface, medium and heavy damage being evaluated. The increased costs incurred owing to the use of two workers to remove the stones were added to the costs of the conventional potato cultivation technology. The yield for the classical cultivation technology and the destoning cultivation technology was determined by the square method with the digging tests.

Results and discussion

The above mentioned company has soils that are sandy and sandy-clay; however, owing to high wind erosion, they also include a large number of stones, which reduces the cohesion of the soil and has a negative impact on the degree of damage to the harvested tubers, as well as increasing the damage to the soil treatment and potato-harvesting machinery. It is also reflects negatively onubsequent mechanization interventions, such as the harvesting of cereals, fodder, and so forth.

Technological procedure for working operations

Autumn Soil preparation consisted of manure ploughing-down by deep plowing at a dose of 50 t per hectare. For the manure application, trailers or an automobile adaptor with a capacity of 0.7 to 1 ha per hour were used.

Quality autumn ploughing with the ploughing-in of organic fertilizers ensured conditions for good root-system development, and the more efficient use of moisture and nutrients from the soil.

For the spring soil preparation, two basic growing systems were used in order to evaluate the classical growing technology and the destoning technology:

1. For the classic system, the land was prepared using a compactor and the planting followed,
2. Planting potatoes into separated and destoned soil.

The following table evaluates the samples of clod and stone content at particular stages of the soil preparation process, and the reduction in the specific weight of the soil by means of the stone separation.

Table 1. Evaluation of clod and stone percentages in the samples collected

Sample	Total sample weight	Clod weights	Percentage content of clods	Stone weights	Percentage content of stones	Percentage content of clods and stones
	Q [kg]	Q_1 [kg]	[%]	Q_2 [kg]	[%]	[%]
1 (non-separated, untreated soil)	2172	251.08	11.56	52.12	2.4	13.94
2 (ridged soil without destoning)	1642	124.8	7.6	18.55	1.13	8.73
3 (separated, destoned soil)	1362	73.54	5.4	0.0	0.0	5.4

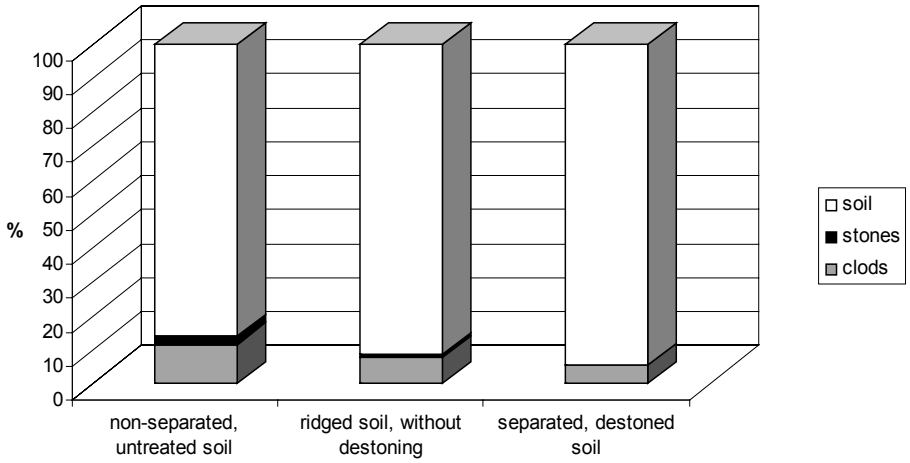

Fig. 3. Graphic illustration of clods and stones in individual soil samples

The two-row ridger and two-row separator are shown in figs. 4 and 5.

The degree of potato tuber damage in the destoned and separated soil is presented in table 2.

The total average damage was expressed by means of relation 1. The extent of potato tuber damage under the conventional production technology is evaluated intable 3.

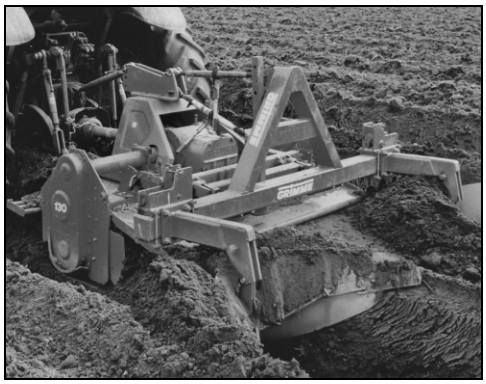

Fig. 4. Machinery set for the destining system

Fig. 5. Stone separator for potato cultivation soil preparation

Table 2. Evaluation of the extent of damage in the samples collected

Sample	Yield from the sample collected	Undamaged potatoes	Surface damage	Medium damage	Severe damage	Total average damage	Percent of damage
	Y [kg]	UP [kg]	S_d [kg]	M_d [kg]	H_P [kg]	TA_d [kg]	P_d [%]
Σ (kg)	157.7	113.7	32.8	6.3	4.9	11.25	
Σ (%)	100	73	21.4	3.4	3.2		7.03

Table 1. Evaluation of the extent of damage in the samples collected

Sample	Yield from the sample collected	Undamaged potatoes	Surface damage	Medium damage	Severe damage	Total average damage	Percent of damage
	U [kg]	N [kg]	P_P [kg]	S_P [kg]	$Ť_P$ [kg]	Z_P [kg]	P_Z [%]
Σ (kg)	186	101.6	49	24	11.4	28.3	
Σ (%)	100	54.6	26.3	13	6.1		15.24

Conclusion

The total cost of potato cultivation is variable and influenced by several factorsm such as seed cost, chemical protection, the amount of machinery used, the amount of the yield, and so forth. For both technologies, the cultivation and harvesting were carried out on the same area of land, half of which was destoned, with the other half being planted using the classic technology.

At the company where the study was conducted, destoning the use of two more working operations for the destining technology led to a 15% increase in cost, from €3 200 to €3 680 per 1 ha. However, the yield increased by 20%, from 26.4 $t \cdot ha^{-1}$ to 31.7 $t \cdot ha^{-1}$.

For the conventional production technology, the production cost per 1 kg of potatoes was €3 200: 26 400 kg = €cent $12.12 \cdot kg^{-1}$.

The production cost per 1 kg of potatoes for the destoning technology was €3 680: 31 700 kg = 11.6 € cent$\cdot kg^{-1}$.

This represents a difference of €cent 0.52 per 1 kg in favor of the destoning line.

Tuber damage was evaluated. The macrodamage in the tubers grown in the destoned soil was 50% lower than the macrodamage in those grown using the classic technology. For the destoning technology, the percentage of damage was 7.03%, while for the conventional production technology, it was 15.24%. We were unable to evaluate either the microdamage caused by the compression of the tuber, or internal cracks visually.

Similarly, we evaluated the shape of tubers from the destoned soil visually; they were much more regular than the those grown in the non-destoned soil. This is because their shape is not deformed by clods or stones. At the same time, losses during the processing of the potatoes, such as scraping, peeling, and so forth, in preparation for consumption, are lower.

Given the cultivation area of 150 ha held by the company under study, the yield can thus be increased from 3 960 tons to 4 755 tons by the use of the soil destining technology. The costs will increase from €480 000 to €552 000, but the difference in the cost item of €cent 0.52 per 1 kg means a saving of €23 775.

In absolute terms, what the destoning technology means for the company is:

+ €106 000 from the increase in yield

+ €23 775 from the cost reduction per 1 kg of potatoes harvested

- €72 000 € owing to the higher cost of the destining technology.

The overall summarization of the economic indicators means an annual profit of €57 933 for potatoes alone.

Within one economic year, this is a compelling financial argument in favor of the destoning technology, which has the capability of paying back the initial investment within 1-2 years.

Bibliography

Budyn, P., Kiełbasa, P., Frančák, J. 2001. Wplyw rodzaju gleby na warunki zbioru ziemniaków. In: Uzytkowanie maszyn rolniczych i lesnych, badania naukowe i dydaktyka: Materialy II Miedzynarodowej Konferencji Naukowej. Krakow-Polska Akademia Umiejetnosci, 2001. pp. 39-47.

Frančák J., Budyn P., Korenko M., Simoník J. 2001. Ekonomické hodnotenie uplatnenia techniky na pestovanie a zber zemiakov (Economical evaluation of planting and harvest machinery utilisation). In: Ekonomika a efektívnosť poľnohospodárskej techniky: Zborník referátov z medzinárodnej vedeckej konferencie. Nitra. pp. 24-28.

Frančák J., Korenko M. 2004. Vplyv kvality sadenia zemiakov na dosahovanú úrodu (Effect of potato planting quality on achieved yield). In: Acta technologica agriculturae. Vol. 7. No 2. pp. 42-48.

Szilard I., Popescu S., Bria N., Frančák J. 2007. Present achievements concerning the working parts of the potato planting machines. In: INMATEH scientific papers. Bucharest: Ministerul educatiei si cercetarii autoritatea nationala pentru cerecetare stiintifica. No. IV. pp. 56-63.

Szilard I., Popescu S., Bria N., Korenko M. 2007. Cosiderations concerning the woring technologies of the potatoes planting machines. In: INMATEH scientific papers. Bucharest: Ministerul educatiei si cercetarii autoritatea nationala pentru cerecetare stiintifica. No. IV. pp. 48-55.

Tibenská, H. 2009. Zemiaky. Situačná a výhľadová správa k 31.XII. 2008. Ministerstvo pôdohospodárstva Slovenskej republiky. ISSN 1337-4494.

Žitňák M. 2008. Efektívne využívanie dopravných prostriedkov pri zbere zemiakov In: VOZIDLÁ Nitra: SPU v Nitre. ISBN 978-80-552-0106-1.

ROZWÓJ PRODUKCJI ZIEMNIAKÓW W REPUBLICE SŁOWACKIEJ A WPŁYW WYPOSAŻENIA W MASZYNY NA JAKOŚĆ PRODUKTU

Streszczenie. W pracy zaprezentowano podstawowe problemy słowackich rolników w uprawie ziemniaków w zależności od technologii i wykorzystania maszyn rolniczych. Przedstawiono poszczególne czynności wykonywane w gospodarstwach indywidualnych, w tym uprawę gleby, przygotowanie do sadzenia i sadzenie, uprawę międzyrzędową, zbiór i przechowywanie produktu. Omówiono dwie podstawowe technologie - konwencjonalną i technologię związaną z odkamienianiem gleby przed sadzeniem. W artykule zawarto także porównanie ich zalet i wad w odniesieniu do maszyn rolniczych i uszkodzeń bulw. Analizie poddano także efektywność ekonomiczną. Artykuł może służyć jako metodologiczny zarys i sugestie w celu szerszego wykorzystania procesu odkamieniania na Słowacji, głównie wśród rolników uprawiających ziemniaki na kamienistych, zbitych glebach (w regionach Liptov, Turiec i Spisz).

Słowa kluczowe: ziemniak, usuwanie gleby, pole, uszkodzenia, odkamienianie, koszty uprawy

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