ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXIII (2) SECTIO E 2008

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Field trials on grain maize cultivation technologies in 2004, 2005 and 2006

Badania polowe różnych technologii zakładania plantacji kukurydzy na ziarno

Summary. The paper presents the results of field studies that assess the influence of various technologies of maize-for-grain cropstand establishment on not only its yield, but also on labour and fuel consumption, and individual cost components. The field studies were carried out since the year 2004 in all maize-growing regions of the Czech Republic. Farm businesses are monitored that perform either a conventional technology of soil cultivation comprising ploughing or a reduced-tillage technology. The studies showed no significant differences in grain yields between both technologies in question. On the other hand, labour consumption demonstrated highly significant differences, i.e. 56.2 % in favour of reduced-tillage. Significant differences in favour of reduced-tillage technology were proved as well with regard to fuel consumption, machinery and total costs.

Key words: grain maize, reduced-tillage, ploughing, costs

INTRODUCTION

History of maize (Zea mays) extends nine thousand years backward, particularly in South America. Obviously, it had a significant influence on the development of South-American culture. In spite of its tropical origin, maize is a crop that is grown nowadays in various climatic conditions. This practice has been enabled by evolvement of breeding, which resulted in the fact that solely hybrid seed is applied at the present time. Maize growers are thus wholly dependent on specialized seed improvers. Maize grown for grain plays an important role in alimentation of population, but also in livestock feeding where it ranks among the most important feeding crops [Vrzal and Novák 1995).

In the Czech Republic, maize cultivation area increases yearly, e.g. from around 40 thousand hectares in the year 2000 to 100 thousand hectares in 2006.

The choice of a suitable variety depends mainly on nature and weather conditions of a grower. In the Czech Republic, varieties appropriate for various production areas are tested regularly. The key feature of a hybrid seed is the length of vegetative period that is indicated using the FAO scale as a number in proportion to a standard. The number, therefore, does not represent any absolute length of vegetative period in days. In the conditions of the Czech Republic, a range of varieties starting with very early hybrids with 200 FAO, i.e. 120 days of vegetative period, to late hybrids with 600 FAO, i.e. 142 to 148 days of vegetative period, is used [Petr and Húska 1997].

Moth-resistant Bt maize is one of the few genetically modified crops allowed for growing in the Czech Republic at the moment. From the selection of farm businesses where the field studies in question were carried out, four farms use genetically modified seed already.

MATERIALS

The aim of the field studies, located in all regions of the Czech Republic is to evaluate major technologies of cropstand establishment of maize grown for grain with respect to its yield, fuel and labor consumption, and costs, but also other variables not mentioned in the paper such as soil compaction, soil pH, soil nutrition content, weed infestation, etc.

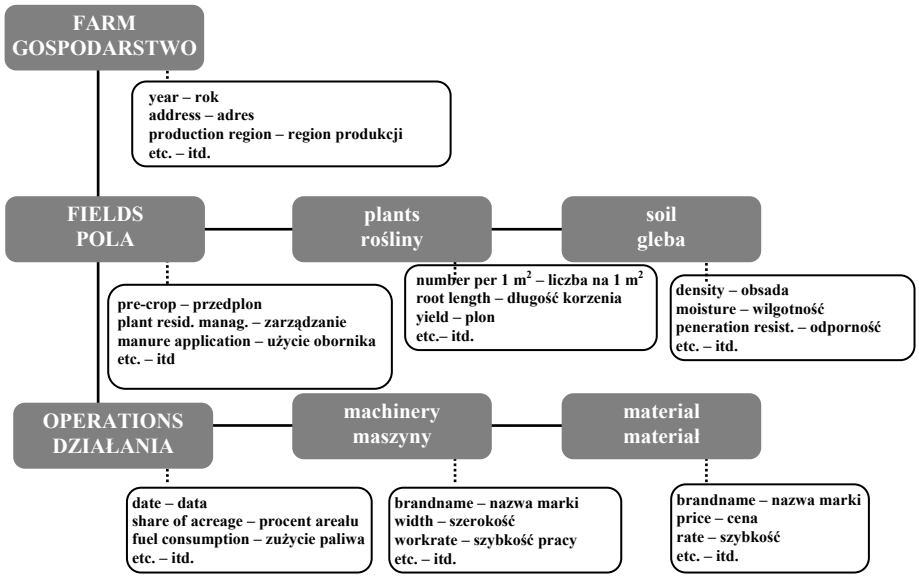

Fig. 1. Chart describing the structure of field-trial data (items in dotted boxes are gained by measurement)

Rys. 1. Diagram opisujący strukturę badanych danych (pozycje w kropkowanych polach uzyskano w czasie badań)

The studies were carried out in ten farm businesses where either conventional technology of soil cultivation comprising ploughing or reduced-tillage technology is applied. Besides ploughing, the two technologies in question differ as well according to organic fertilizer application, i.e. manure or slurry application. In all selected farms within one year one field is monitored, or even more fields in the case of different soil cultivation technologies used.

Data that are monitored within the trials (see Fig. 1) concern overall characteristics of farm and field in question as well as particular information on plant and soil, and on all field operations that were carried out. The latter enables to enumerate costs of maize growing. Overhead costs and costs incurred due to land ownership or lease were not included.

RESULTS AND DISCUSSION

An example of a model technology for conventional as well as reduced-tillage technology is shown in Table 1. Some farm businesses applied manure or slurry prior soil tillage. The latter one could be applied as well after plant emergence. In those cases, unit costs show a progressive trend with respect to the organic fertilizer rate.

Table 1. Basic model variants of field operations of conventional and reduced-tillage technologies monitored within the field trials
Tabela 1. Przykłady podstawowych wariantów operacji stosowanych w badanych technologiach konwencjonalych i minimalizacyjnych

Field operation Czynność na polu	Example of machinery and materials used Przykład użytego sprzętu i materiałów
Conventional technology – Technologia konwencjonalna	
Stubble cultivation Ścierń	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Ploughing Orka	services: plough PHX 35 usługi: plough PHX 35
Mould clearing Czyszczenie pleśni	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Fertilization Nawożenie	JD-6720 + Amazone (24 m width – 24 m szer., carbamide 300 kg · ha^{-1})
Fertilizer treatment Zabieg nawożenia	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Sowing – Siew	services: accurate seeder Kinze (seed 60 kg · ha^{-1} + carbamide 30 kg · ha^{-1}) usługi: doskładna sadzarka Kinze
Spraying Opryskiwanie	Hardi Alpha Twin (30 m width – 30 m szer., Guardian 2.5 l · ha^{-1} + + Atranex 50 SC 1.5 l · ha^{-1})
Harvest – Zbiory	JD 2064 (six-row cornhead – głowica 6-rzędowa)
Reduced-tillage technology – Technologia minimalizacyjna	
Stubble cultivation Ścierń	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Cultivation Kultywatorowanie	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Fertilization Nawożenie	JD-6720 + Amazone (24 m width – 24 m szer., carbamide 300 kg · ha^{-1})
Fertilizer treatment Zabieg nawożenia	JD-8200 + Horsch Phantom (6 m width – 6 m szer.)
Sowing Siew	services: accurate seeder Kinze (seed 60 kg · ha^{-1} + carbamide 30 kg · ha^{-1}) usługi: doskładna sadzarka Kinze
Spraying Opryskiwanie	Hardi Alpha Twin (30 m width – 30 m szer., Guardian 2.5 l · ha^{-1} + Atranex 50 SC 1.5 l · ha^{-1})
Harvest Zbiór	JD 2064 (six-row cornhead – głowica 6-rzędowa)

Within reduced-tillage technologies, the most common tillage technology comprised two cultivations, or two cultivations followed by a seedbed preparation in spring. Cultivation to medium depth of around 0.08 to 0.010 m accounted for half of the soil tillage operations. An operation of deeper soil loosening (chiselling) was applied on one third of the fields treated by reduced-tillage technology. Maize yield from those fields reached on average by 12.5% higher figures.

Within conventional technology, the most common process comprised one stubble cultivation, one ploughing and one ore two operations of seedbed preparation. Medium ploughing was the most frequent tillage operation. Compared to reduced-tillage technology, the share of soil tillage operations within conventional technology increased.

Over the whole period of three years of trials, the average maize grain yield of all the thirty-five trial fields attained 8.52 t · ha^{-1}. Figure 2 shows average maize grain yields according to the cultivation technology and year. In all the three years, reduced-tillage technology reached higher average yields than conventional one. When compared to the conventional technology, the average yield of reduced-tillage technology was higher by 8.2% over the three years. Uneven location of trial fields into production areas might have adverse effect on the results reached by conventional technology. Corn production area demonstrated the highest average yield that surpassed 10 t · ha^{-1}, but within this area particularly reduced-tillage technology with new machinery of high workrate was employed. Average grain yield varied in individual years, though the differences were only minor.

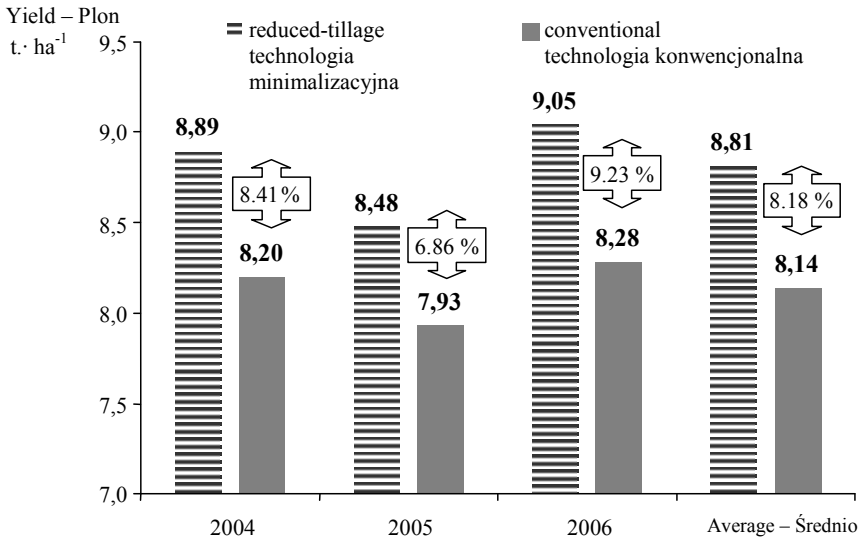

Fig. 2. Average maize grain yields of technologies in question within individual years and in total
Rys. 2. Średnie plony ziarna kukurydzy uzyskane w badanych technologiach w poszczególnych latach

Table 2 presents average fuel and labour consumption, material and machinery costs and total costs as the sum of both prior mentioned, and finally average costs per one ton of maize grain produced.

Higher fuel and labour consumption was noted with conventional technologies. The overall difference in fuel consumption over the three trial years was by 24.1% lower for reduced-tillage technology. Even a higher difference, i.e. 56.2% in favour of reduced-tillage technology, could be noted within labour consumption. The extent of differences was influenced by field operations of ploughing done within conventional technology where there were also organic fertilizers applied more often.

Table 2. Average values of fuel and labour consumption, individual cost components and costs per a unit of production, i.e. a ton of maize grain, according to cultivation technologies and years (figures in italic: statistically significant differences for $p \leq 0.05$)

Tabela 2. Średnie wartości zużycia paliwa, nakładów pracy, składników kosztów produkcji w analizowanych technologiach w badanych latach (wartości zapisane kursywą – statystycznie istotna różnica dla $p \leq 0,05$)

Year Technology Rok Technologia	Consumption Zużycie		Costs, CZK · ha^{-1} Koszty			Costs per production unit CZK · t^{-1} Koszty na jednostkę produkcyjną
	fuel l · ha^{-1} paliwo l · ha^{-1}	labour hour · ha^{-1} praca godz. · ha^{-1}	material materiał	machin. sprzęt	total razem	
2004						
Reduced-tillage Technologia minimalizacyjna	75.8	3.65	5 638	6 358	11 995	1 398
Conventional Technologia konwencjonalna	99.7	8.25	6 233	6 747	12 980	1 596
2005						
Reduced-tillage Technologia minimalizacyjna	74.9	3.49	5 580	6 225	11 805	1 425
Conventional Technologia konwencjonalna	98.6	8.05	6 300	7 073	13 373	1 716
2006						
Reduced-tillage Technologia minimalizacyjna	73.5	3.41	5 590	6 114	11 704	1 328
Conventional Technologia konwencjonalna	97.0	7.79	5 840	6 993	12 833	1 568
2004–2006						
Reduced-tillage Technologia minimalizacyjna	74.7	3.52	5 603	6 232	11 835	1 384
Conventional Technologia konwencjonalna	98.4	8.03	6 124	6 938	13 062	1 627
Total – Razem	84.9	5.45	5 826	6 535	12 361	1 488

Concerning economic aspects, reduced-tillage technology demonstrated lower material and machinery costs, hence also total costs. Over the monitored period of three years, the difference in favour of reduced-tillage technology proved to amount to 8.5% for material costs, 10.2% for machinery costs, and 9.4% for total costs. Since reduced-tillage technology generally a higher maize grain yield, the costs per one ton of grain produced by reduced-tillage technology were by 14.9%, i.e. by 243 CZK·t^{-1}, lover compared to conventional ones.

All the differences among variable means in Figure 2 and Table 2 were statistically tested with respect to cultivation technologies within each year, to cultivation technologies for all three years together, and finally with respect to the year of cultivation. The latter one, i.e. the year of cultivation, did not prove to influence any of the mentioned variables significantly, not even the grain yield. Within individual years of cultivation, only labour consumptions of different cultivation technologies varied significantly, and they did so within each of the three years in question (probability level $p = 0.007882$ in the year 2004, $p = 0{,}000632$ in the year 2005, $p = 0.034244$ in the year 2006). Over the whole period of three years of trials, differences between the means of variables with respect to different cultivation technologies proved significant for fuel consumption ($p = 0.008912$), for labour consumption ($p = 0.0000000003$), for machinery costs ($p = 0.020860$), and for total costs ($p = 0.012028$).

CONCLUSIONS

Within the conditions of the Czech Republic, field studies focused on maize grown for grain were carried out in the years 2004 to 2006. Those trials proved that maize can be cultivated using conventional as well as reduced-tillage technologies. Reduced-tillage technology produced good results regarding labour and fuel consumption as well as regarding material and machinery costs. Costs of one ton of maize grain, which is the key criterion of successful growing for any farm business, were by 14.9% lower within reduced-tillage technology compared to conventional one. Both cultivation technologies reached a high quality grain yield, but there are still substantial reserves with respect to genetically modified seed.

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Streszczenie. W artykule przedstawiono wyniki badań polowych wpływu różnych technologii zakładania plantacji kukurydzy na ziarno na uzyskiwane plony, nakłady pracy, zużycie paliwa oraz na poszczególne składniki kosztów produkcji. Badania prowadzone są od roku 2004 w wybranych gospodarstwach rolnych w regionie kukurydzianym Czeskiej Republiki. Zakłady te stosują technologie konwencjonalne przygotowania roli do siewu, czyli technologie z orką albo technologie minimalizcyjne. Uzyskiwane wyniki w technologiach orkowych i minimalizacyjnych nie wykazują statystycznie istotnych różnic w plonach kukurydzy. Natomiast w przypadku nakładów pracy wystąpiły statystycznie istotne różnice na korzyść technologii minimalizacyjnej. Statystycznie istotne różnice na korzyść technologii minimalizacyjnej stwierdzono też w przypadku zużycia paliwa, kosztów eksploatacji sprzętu rolniczego oraz całkowitych kosztów produkcji kukurydzy.

Słowa kluczowe: kukurydza na ziarno, koszty produkcji, technologia minimalizacyjna, orka

This work was supported by Research Project of the Ministry of Education of the CR no. MSM 6046070905, and by the project NAZVA QH72257.