Scientific quarterly journal e-ISNN 2449-5999

Agricultural Engineering

2015: 1(153):77-84

Homepage: http://ir.ptir.org

DOI: http://dx.medra.org/10.14654/ir.2015.153.108

COMPARISON OF ECONOMIC EFFICIENCY OF MAIZE CULTIVATION FOR GRAIN IN FARMS, WHICH USE VARIOUS FIELD CULTIVATION TECHNOLOGIES

Paweł Kołosowski*, Tomasz K. Dobek, Patrycja Sałagan

Department of Construction and Use of Technical Devices
West Pomeranian University of Technology in Szczecin
*Contact details: ul. Papieża Pawła VI/3, 71-459 Szczecin, e-mail: Pawel.Kolosowski@zut.edu.pl

ARTICLE INFO

Article history:
Received: October 2014
Received in the revised form: December 2014
Accepted: February 2015

Keywords:
glyphosate
production costs
traditional technology
simplified technology
economic efficiency ratio

ABSTRACT

The increasing crop production costs force to search for alternative cultivation methods of particular crop species, which would reduce production costs and obtain higher income at similar yield. The objective of the research was to evaluate the economic efficiency of maize production for grain. The scope of research covered a simplified and traditional technology of maize cultivation for grain. Maize production costs and costs of fuel, human work, materials and raw materials as well as operation of machines and tools used in the investigated technologies, were calculated. Revenue and income from maize production in the investigated farms were determined. The research, which was carried out, shows that a higher value of the economic efficiency ratio was obtained in the simplified technology of production, where it was at the average of 2.06. Whereas, in the traditional technology, average value of the evaluated ratio was 1.91.

Introduction

Maize is a thermophilic plant, which due to biological progress may be successfully cultivated at a more extended area of the country. Its early varieties with low value of FAO index are recommended for cultivation in the furthest north regions of our country. It concerns not only silage varieties but also varieties cultivated for grain. It is a plant which is comprehensively use in agriculture, which is fine on weaker stands and with periodical water deficiencies (Jasińska and Kotecki, 2003; http://piorin.gov.pl). Therefore, since 2009 area of its cultivation has systematically risen in Poland (Main Statistical Office, 2013).

Maize is a plant, which bears well simplification in soil cultivation. In extreme cases, cultivation treatments may be entirely eliminated or may be limited to cultivation of a narrow area around rows (Banasiak et al., 1999; Piechota, 2011). In some conditions reduction of the number of treatments may result in the increase of the obtained maize crop. However, it is related to intensification of pressure from weeds, which are not destroyed in mechanical soil cultivation (Sekutowski and Rola, 2010; Blecharczyk et al., 2004). Furthermore, giving up treatments limits the scope of available herbicides for foliar fertilization

because substances applied to soil are designed for use in well cultivated soil. Weeds developing on the surface of a field, not damaged during a fall ploughing and slightly limited during spring cultivation treatments, have considerably prevail over maize. It mainly concerns perennial weeds such as couch grass. A low rate of growth of maize in its initial growth stages makes undesired plants effective competitors for the cultivated plant, limiting as a result the obtained crop. One of the methods of eliminating weeds after sowing but before maize germination is the use of total herbicides. This treatment is very effective, cheap and does not obstruct the cultivated plant. Glyphosate *(N-phosphonomethyl glycine)* is currently one of the most popular active total herbicide substances (Kołosowski et al., 2013; Woźnica and Waniorek, 2008). Presently, 5 preparations which include active substance, designed for pre-germination combating of weeds in maize, are registered in Poland (www.ior.poznań.pl). Their use combined with simplifications in soil cultivation may prove to be a good solution for many agricultural farms, which cultivate or are going to cultivate maize. A simplified maize cultivation technology combined with the use of glyphosate allows not only reduction of the incurred costs but also enables more efficient organization of field works and allows limitation of selective herbicides.

Objective, scope of work and methodology of research

The objective of the research was evaluation of the economic effectiveness of maize production for grain. The scope of research covered two farms with a simplified and traditional technology of maize cultivation for grain. The paper deals with analysis of economic profitability of maize production. The analysis included calculation of costs incurred for particular treatments (cultivation of field, fertilization, sowing, protection and harvesting) as well as costs related directly to maize production and provision of: costs of human work, fuel, exploitation of machines and tools and costs incurred for purchase of materials and raw materials indispensable for maize production. Costs were calculated based on the methodology developed by IBMER [Institute for Construction, Mechanization and Electrification in Agriculture] (Muzalewski, 2010). Moreover, revenue from sale of the produced grains within 2011 and 2013 was calculated. The lists were used for calculation of the income from production and index of economic effectiveness, understood as a relation of the production value to the incurred costs per one hectare. Tests were carried out in two agricultural farms located in Zachodniopomorskie Voivodeship, which uses different technologies of field cultivation in production of maize for grains. The tests were carried out within 2011-2013. The first agricultural farm (marked as A) used a simplified technology of field cultivation with a pre-germination use of glyphosate, the second farm (marked as B) a traditional technology with fall ploughing (table 1). These farms carry out maize cultivation in similar soil conditions and have a similar machinery park (table 2).

The investigated agricultural farms farm on weaker stands from IVb, V and VI of soil classification. The farm A has acreage of 48 ha and maize within three years of research was cultivated on the area from 12 to 14 ha. The farm B has 54 ha and maize cultivation took 15 ha in each year. In both farms, cereals were a forecrop. The investigated agricultural farms sowed mixed varieties with FAO up to 240, used selective herbicides with a similar composition and applied comparable doses of mineral fertilizers and doses of foliar fertilization. The farm A, using a simplified technology in the research period carried out

a pre-sowing manure fertilization in the dose of 30 $m^3 \cdot ha^{-1}$ whereas farm B in its traditional technology applied manure only in the season of 2013 also in the dose of 30 $m^3 \cdot ha^{-1}$. The applied manure came from the same animal farm, which allows presumption that the used natural fertilization had similar parameters. Harvest of maize grains was carried out in the full maturity stage at the moisture of approx. 30%.

Table 1
Comparison of technologies used in investigated farms

Simplified technology – farm A		Traditional technology – farm B	
Date of treatment	Treatment	Date of treatment	Treatment
VIII/2	Disc harrowing	XI/3	Winter ploughing
IV/2	Manure fertilization	III/3	Harrowing
IV/2	Spring cultivation	IV/2	Manure fertilization (only 2013)
IV/3	Sowing with chaff riddle of fertilizers	IV/2	Spring cultivation
V/1	Treatment with total herbicide	IV/3	Sowing with chaff riddle of fertilizers
V/2	Treatment with selective herbicide	V/2	Treatment with selective herbicide
V/2	Top dressing N	V/2-V/3	Foliar fertilizing
V/2 – VI/2	Foliar fertilizing	V/3	Top dressing
X/2 – XI/3	Harvest	X/3-XI/1	Harvest

Table 2
Aggregates used in maize production for grain technologies in investigated farms

Treatment	Farm A	Farm B
Field cultivation	Ursus 1002 + aggregate Unia Ares 3.0 TL (2011)* New Holland T 6.165 + aggregate Unia Ares 3.0 TL (2012 and 2013)*	New Holland T 5.115 + Unia Ibis XL New Holland TD 85 + aggregate Unia Ares 3.0 TL
Manure fertilization	Ursus 1614 + waste removal vehicle 12.6 m^3 (2011)* New Holland T 6.165 + waste removal vehicle 12.6 m^3 (2012 and 2013)*	New Holland T 5.115 + waste removal vehicle 12.6 m^3
Mineral fertilization	Ursus 1002 + spreader Unia MX 1200	New Holland TD 85 + spreader Unia MX 1200
Sowing	New Holland T 6.165 + seeder Maschio Gaspardo SP 4 -row	New Holland TD 85 + seeder Maschio Gaspardo SP 4-row
Protective treatments	Ursus C 330 + sprayer Skotarek P 124	New Holland TD 85 + sprayer Krukowiak 600
Harvest	Case Axial 1629 (service)	Case Axial 1629

* season, when the provided units were used

Results

The most important element in the structure of operation costs of machines in the simplified technology (farm A) were costs related to natural and mineral fertilization, which was related to the use of organic manure fertilization which was carried out in each year. These costs were at the average of 615.30 PLN·ha^{-1} (table 3). Whereas in traditional technology (farm B) the costs of harvesting (except for season 2013) constituted the highest value in the structure of costs of machines and tools operation. Special attention should be paid to approximately 5 times higher average costs of field cultivation in a traditional technology than the costs of field cultivation in a simplified technology (fig. 1), which resulted from fall ploughing in this farm.

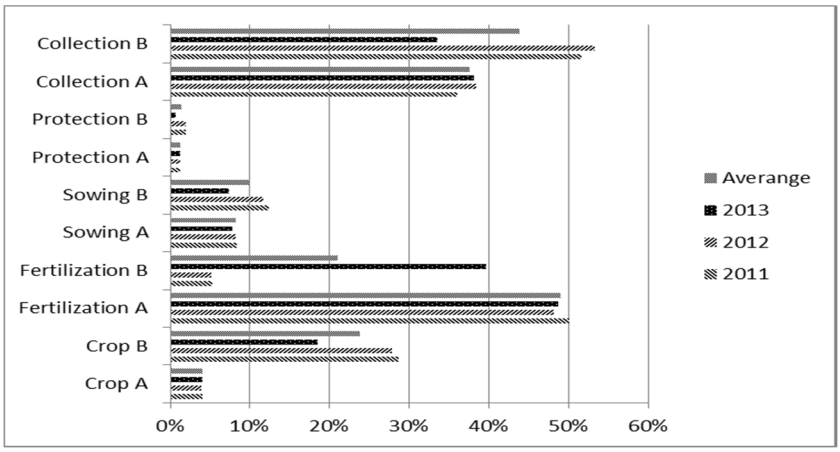

Figure 1. Operation costs of machines used for maize production in farms, which use simplified technology (A) and traditional one (B) divided into treatment groups

Table 3
Costs of treatments in corn production for grain in analysed technologies

Year	Farm	Unit	2011	2012	2013	Average
Cultivation	A	(PLN·ha^{-1})	47.37	51.58	52.80	50.58
	B		238.19	266.97	280.51	261.89
Fertilization	A		584.13	628.34	633.42	615.30
	B		43.89	49.00	599.52	230.80
Sowing	A		98.05	106.73	102.16	102.31
	B		103.51	112.28	112.23	109.34
Protection	A		14.91	16.38	15.77	15.69
	B		16.32	18.14	10.27	14.91
Harvest	A		420.00	500.00	495.00	471.67
	B		429.15	511.20	507.32	482.56

Costs of materials and raw materials for production in the structure of direct costs in both farms constituted the most important element in the structure of direct costs in both farms, which at the average in three years of research amounted to 1258.97 PLN·ha^{-1} in the farm which used a traditional technology and 1281.23 PLN·ha^{-1} in the farm with a simplified technology (table 3). Costs of operation of machines and tools in the farm A were by approx. 22% higher than in the farm B. Also fuel costs were higher there by 12% (table 4). Whereas, costs of human work in both farms were at a similar level.

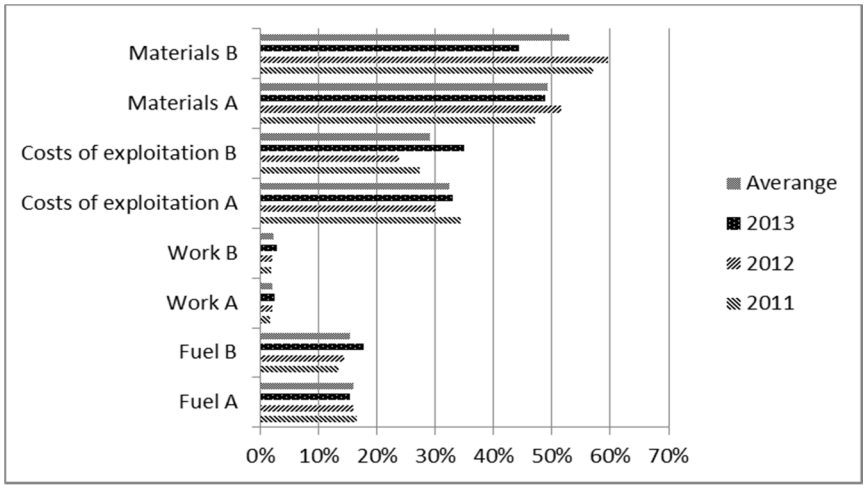

Figure 2. Costs of direct maize production in farm with simplified technology (A) and traditional one (B)

Table 4
Direct costs of corn production for grain in the analysed technology

Year	Farm	Unit	2011	2012	2013	Average
Costs of fuel	A	(PLN·ha^{-1})	378.94	451.08	412.24	414.09
	B		275.82	341.50	482.83	366.71
Costs of human work	A		41.46	63.03	69.33	57.94
	B		39.55	49.21	78.25	55.67
Operation costs of machines and tools*	A		785.52	851.96	886.92	841.47
	B		555.23	566.88	948.79	690.30
Costs of materials and raw materials	A		1077.03	1460.38	1306.28	1281.23
	B		1158.63	1412.20	1206.08	1258.97

* with no costs of fuel and human work

Average costs of maize production per one hectare of crop were higher in the farm A with a simplified technology. They amounted to 2595 PLN·ha^{-1} and were higher by 223 PLN·ha^{-1} than the costs incurred by the farm B with a traditional technology. Higher costs incurred in the farm A are caused by expensive manure fertilization, which they use

every year. In the season 2013, when also the farm B fertilized plantations with natural fertilizers, the costs incurred by both farms were at a similar level. Within three years, the farm which uses a simplified technology obtained higher crops of grain. It had greater effect on the revenue from production. Average revenue obtained from the farm A was 5248 PLN·ha^{-1} and was by 15% higher than in the farm B. The smallest difference in revenues from production was obtained in 2013 and it was 266 PLN·ha^{-1}. Considerably higher revenue from production was developed by the farm A with a simplified technology, it resulted in a higher revenue obtained by them. Average income from production of this farm was by 586 PLN·ha^{-1} higher. What is interesting, in all years of research both farms reported a considerable majority of revenue from sale of grains over the incurred costs. It resulted in obtaining the index of economic efficiency above the value of 1, which constitutes the threshold of profitability. Average index of economic efficiency was higher in farms, which use a technology based on the total herbicide treatment and simplified field cultivation and was 2.06. This index reached the maximum value of 2.64 in 2011, whereas the lowest value was obtained for 2013 – 1.72. In the farm B with a traditional technology, this value was 1.91 (table 4) and was from 2.43 in 2011 to 1.60 in 2013.

Table 4
Economic effectiveness of maize production in farms with simplified technology (A) and traditional one (B)

Year	Cost of production		Revenue from production		Income from production		Index of economic effectiveness	
	(PLN·ha^{-1})							
	A	B	A	B	A	B	A	B
2011	2283	2029	6016	4935	3733	2906	2.64	2.43
2012	2826	2370	5130	4050	2304	1680	1.81	1.71
2013	2675	2716	4598	4332	1923	1616	1.72	1.60
Average	2595	2372	5248	4439	2653	2067	2.06	1.91

Manure fertilization was significant for the obtained yield. It is particularly visible in 2011 and 2012 seasons, when a farm with a simplified technology obtained considerably higher incomes. It complies with the research carried out by Sulewska et al. (2007), which proved a positive impact of manure fertilization on the obtained yield of grain and maize silage.

Conclusions

In both analysed farms, costs of materials and raw materials were the most important element of maize production costs structure. While, the lower costs relate to human work costs. The highest costs in the farm A, which used a simplified technology, were related to manure organic fertilization and mineral fertilization; those costs were at the average of 615.30 PLN·ha^{-1}. Whereas, in the farm B, with a traditional technology, the most expensive treatment was harvest with the average of 489 PLN·ha^{-1}.

In both farms (A and B) the lowest costs were related to plant protection chemicals, with the average of 15 PLN·ha^{-1}.

Due to higher yield in a farm with the simplified technology in this farm, a considerably higher value of production was obtained, at the average by 809 PLN·ha^{-1}. It was crucial in the evaluation of the production profitability. In the analysed conditions, a simplified technology proved to be more profitable, which was proved by a higher value of the economic effectiveness of maize production for grain.

References

Banasiak, J. (red). (1999). *Agrotechnologia.* Warszawa-Wrocław. Wyd. Naukowe PWN, ISBN 83-01-12697-3.

Blecharczyk, A.; Małecka, I.; Skrzypczak, G. (2004). Wpływ uproszczonej uprawy roli na plonowanie i zachwaszczenie kukurydzy oraz na właściwości gleby. *Acta Sci. Pol., Agricultura, 3*(1), 157-163.

GUS. (2013). Wyniki produkcji roślinnej w 2012 r. Warszawa, ISSN 1507-9678. Obtained from: *http://www.stat.gov.pl.*

Jasińska, Z.; Kotecki, A. (red). (2003). *Szczegółowa uprawa roślin.* T.1, Wyd. AR we Wrocławiu, ISBN 83-89189-16-X.

Kołosowski, P.; Dobek, T.; Sałagan, P. (2013). Analiza efektywności ekonomicznej alternatywnej technologii uprawy kukurydzy na ziarno z wykorzystaniem glifosatu. *Inżynieria Rolnicza 4*(147), T.1,121-128.

Metodyka integrowanej produkcji kukurydzy. (2009). Państwowa Inspekcja Ochrony Roślin i Nasiennictwa – Główny Inspektorat Warszawa. Obtained from: *http://piorin.gov.pl*.

Muzalewski, A. (2010). *Koszty eksploatacji maszyn*. Wyd. ITP Falenty-Warszawa.

Piechota, T. (2011). Wpływ międzyplonu na zachwaszczenie kukurydzy w różnych systemach uprawy roli. *Progress in Plant Protection/Postępy w Ochronie Roślin, 51*(1), 469-472.

Sekutowski, T.; Rola, H. (2010). Wpływ monokultury i systemu uprawy roli oraz ochrony herbicydowej na agrofitocenozę kukurydzy. *Fragm. Agron., 27*(1), 128-140.

Sulewska, H.; Koziara, W.; Panasiewicz, K.; Jazic, P. (2007). Efekty stosowania nawozów naturalnych w uprawie kukurydzy na ziarno i kiszonkę. *Journal of Research and Applications in Agricultural Engineering, 52*(4), 75-79.

Baza środków ochrony roślin. Instytut Ochrony Roślin, Poznań. Obtained from: *http://www.ior.poznan.pl/baza/*

Woźnica, Z.; Waniorek, W. (2008). Znaczenie kondycjonerów wody dla skuteczności chwastobójczej glifosatu. *Progres in Plant Protection/Postęp w Ochronie Roślin, 48*(1), 329-335.

PORÓWNANIE EFEKTYWNOŚCI EKONOMICZNEJ UPRAWY KUKURYDZY NA ZIARNO W GOSPODARSTWACH STOSUJĄCYCH RÓŻNE TECHNOLOGIE UPRAWY ROLI

Streszczenie. Ze względu na wzrastające koszty produkcji roślinnej poszukuje się alternatywnych metod uprawy poszczególnych gatunków roślin, które pozwolą ograniczyć koszty produkcji i, przy podobnych plonach, uzyskać wyższy dochód. Celem przeprowadzonych badań była ocena efektywności ekonomicznej produkcji kukurydzy na ziarno. Zakres badań obejmował uproszczoną i tradycyjną technologię uprawy kukurydzy na ziarno. Obliczono koszty produkcji kukurydzy z uwzględnieniem kosztów paliwa, kosztów pracy ludzkiej, kosztów materiałów i surowców oraz kosztów eksploatacji maszyn i narzędzi stosowanych w badanych technologiach. Określono przychód i dochód z produkcji kukurydzy w badanych gospodarstwach. Z przeprowadzonych badań wynika, że wyższą wartość wskaźnika efektywności ekonomicznej uzyskano w uproszczonej technologii produkcji, gdzie wyniosła ona średnio 2,06. Natomiast w technologii tradycyjnej średnia wartość ocenianego wskaźnika wyniosła 1,91.

Słowa kluczowe: glifosat, koszty produkcji, tradycyjna technologia, uproszczona technologia, wskaźnik efektywności ekonomicznej