ORIGINAL ARTICLE

SOME AGRICULTURAL AND ECONOMIC ASPECTS OF ENERGY SAVING PRODUCTION TECHNOLOGIES OF MAIZE

TAKÁCS-GYÖRGY[1], K., M. GECSE[2]*

ÖSSZEFOGLALÁS

A művelet- és energiatakarékos termesztési technológiák alkalmazásának szükségességét a mezőgazdaság forráshiánya is indukálja. A takarékos talajművelési rendszerek vizsgálataink szerint jelentős költségcsökkenést nem idéznek elő, a termelői jövedelem leginkább a hozam oldal alakulásától függ. Munkánk során kukorica direktvetéséhez alkalmazott eszközök teljesítményparamétereit, energetikai jellemzőit és költségtényezőit az FVMMI Osztopánban végzett tartamkísérleteire alapozva értékeltük. Az adatokat az FVMMI (Kht.) munkatársai bocsátották rendelkezésünkre. Ökonómiai összehasonlítást a technológiai változatok fedezeti hozzájárulásainak számítása alapján végeztünk. A csökkentett menetszámú technológiák alkalmazhatóságának agronómiai szempontból az állandó művelésmélységből adódó tömörödött talajrétegek kialakulása, illetve az elgyomosodás veszélye szab határt. A szántásos technológiákhoz viszonyítva a fenti művelési móddal nagyobb fedezeti hozzájárulás érhető el. Javaslatként a hagyományos és energia takarékos művelési módok - helyi viszonyokhoz adaptált - kombinált alkalmazását jelöljük meg.

ABSTRACT

The performance parameters, energetic characteristics and cost factors of direct drilling were evaluated by long-term trials carried out in Osztopán and Gödöllő regions. The effect of direct drilling, disking, ploughing, and soil loosening combined with disking and ploughing on the soil conditions, yields and cost factors was evaluated and based on the examination results. The economic comparisons were done by gross margin analyses of various technologies. Reducing the number of field applications is limited by the risk of soil compactions and weed infestations. From an economic part of view cost saving aspects of the various cultivation methods mentioned above cannot be justified in comparison with the ploughing methods. The lowest gross margin value was 61.79 EUR t^{-1}, direct drilling and the highest was 67.34 EUR t^{-1}, with ploughing but it was due to the great difference between the yield as well (6.89 and 4.03 $t.ha^{-1}$).

The results we achieved during our research are valid only in the given conditions, they could be recalculated and complemented under other soil and agro-ecological conditions. Our purpose was to emphasise the necessity of economical calculations before making decisions on changing technology. Our suggestion is: combined application of the traditional and energy saving methods, regarding the local conditions as well.

KEY WORDS: maize, energy saving, direct drilling, gross margin analysis

Manuscript received December 5, 2001.
Accepted for publication December 20, 2001.

JOURNAL Central European Agriculture ISSN 1332-9049

INTRODUCTION

During the last decade the necessity of using operation-, and energy saving methods in maize production has been proved. Among the reasons financial insulting - which is generally characteristic in agriculture - is mentioned. The consequence of which is the general decrease of expenditure level in maize production. Making production more economical is getting more and more important, just as well as carrying research on the conditions and technology using of which the production is profitable. Using a low input plant production processes the operation costs can be reduced and the producers will not have considerable losses comparing them to using high input technologies.

Applying operation-, and energy saving technologies – in case of certain conditions and management - the producer can get the same income as if he used the intensive methods. The conditions for using this technology should be concluded enough expertise (weed-control, nutrition supply), suitable equipment and the existence of a field with relatively good conditions (Birkás,1997).

The yield reached by operation-, and energy saving technologies does not differ substantially from ploughing technologies if suitable technologies and sufficient expenditure level are provided (Kelemen,1998).

Authors have stated that during long term usage of some of the cost saving soil cultivation methods, harmful changes have been detected in the soil structure. At the beginning of the long-term trials a compact layer has formed below the usual depth of tillage. No significant changes have been evaluated after many years, since reduced field traffic causes less trampling, so the different technologies will have similar effects (Birkás et.al.,1997, Kismányoky, Balázs 1996).

During soil tillage soil compaction can often be experienced. This can be due to poor finance and using not the right equipment. It is an unfavorable condition that the compacted layer is situated closer and closer to the surface influencing the plant in a harmful way concerning its treatment and development at the beginning, which is impossible to get over later on and leads to yield decrease (Ruzsányi, 1997). To remediate these layers extra costs are needed, which have to be derived from next year budget for production technologies, and this very often can result losses in plant production.

That is why it is necessary to decrease the harmful effects and moreover to prevent, and to study the correlation of soil - plant - weather and economy in a multidisciplinary way (Hakansson, 1990, Soane, Ouwerkerk, 1994). These harmful effects can be prevented by soil loosening applied at the right time.

Another harmful effects of long-term operation-, and energy saving maize production technologies are weed control technologies based on chemicals resulting in spreading of some weeds that are resistant to herbicides (Forcella, Lindstrom, 1988, Koskinen, McWhorter, 1986, Sörös et al., 1994)

Harmony should be found between each of the soil cultivation technologies and other economic conditions (sufficient level of expenditure, expertise) in order to gain profit by reducing harmful effects. As for the background of our investigation, many of them were carried out in Hungary during the last two decades.

These investigations were dealing with the application of operation-, and energy saving technologies. Results were evaluated by technological and economic points of view to examine the profitability for short and long term usage.

MATERIALS AND METHODS

1. The experiments were carried out at Hungarian Institute of Agricultural Engineering (HIAE) for the technical adaptation of production technologies without ploughing since 1990, as well as experiments were concerning direct drilling maize production technologies (Kelemen, Soós, 1998). Yield parameters of different production technologies, output parameters of machines, equipment (area output data) and energetic data in various soil conditions were recorded.

The series of experiments were located in Osztopán studying mono-cultural corn production. On the experimental field neither ploughing nor middle deep loosening have been done for four years which means that the technology used was ploughless tillage. The machines used were the cultivator and

the disk. In that case here there was no soil preparation used. The experimental field was 550m x 110m on flat sandy loam soil (calcic luvisol) with four replications.

Experimental yields were recorded concerning different technologies used in maize sawing. In the experiment according to the main purpose, it was determined the sawing parameters and other quality parameters of seeding machines based on three different principles. Other elements of maize production technology corresponded to the usual production technologies.

Fuel consumption, speed, performance for the whole area and sowing parameter's characteristics for work quality were determined. The authors have come to the conclusion that the examined direct drilling machines are suitable and Buffalo Plantless/Planter direct drilling machine (Table 1.) is the most suitable one either taking performance characteristics (2.72 $ha \cdot h^{-1}$) or specific fuel consumption (13.9 $l \cdot ha^{-1}$) into consideration in a non ploughing system on sandy loam soil. In the calculation they counted only the fuel consumption as a main characteristic feature of the sowing equipment, because this parameter should be easily measured under general production conditions. All above mentioned are in a very close relationship between performance demand and the real variable cost of soil tillage systems. The human labor cost was not calculated as an independent element of variable costs, because in our further model calculations the machines' costs included the labor cost. By the methodology of prices of agricultural machines and the costs of operation it should have been calculated human labor costs only for that elements of technology, where surplus of human labor is required, e.g. during weed killing (Gockler, 1999).

Table 1.: Energetic parameters of direct drilling machines according to the Osztopán technological variations, 1998.

Sowing and Equipment	Fuel consumption	Speed	Performance (total working hours)	Weed infestation	Soil compaction
	$MJ \cdot ha^{-1}$	$km \cdot h^{-1}$	$ha \cdot h^{-1}$		
Direct drilling Zetor 16045 + White New Idea 6106	570.042	9.52	2.42	❋	✓
Direct drilling Zetor 16045 + Buffalo	549.106	9.47	2.72	❋	✓
Direct drilling Zetor 16045 + Kühne Case IH Cyclo + Yetter disc	566.882	9.14	2.70	❋	✓
Direct drilling(1) Zetor 16045 + White New Idea 6106	570.042	9.52	2.421	❋❋	✓✓

(Source: HIAE)

(1) The difference in yields on plot of lands using the same sowing machine is due to the different weed infestation; Weed infestation: ❋ - under limited level, ❋❋ - over limited level; Compaction: ✓ - light, ✓✓ - moderate

2. Between 1992 and 1996 in an experimental series of Gödöllő concerning technological development of maize production, ploughing, disking, direct drilling, disking and loosening, ploughing and loosening were compared, mainly on the basis of relations between soil characteristics and their changes (Birkás et al., 1997).

The authors were examining the relations of soil cultivation systems, fertilization, and weed infestation, as well as yield data. The experimental design was split-plot with 3 replications on brown forest (chromic luvisol) sandy soil.

Soil nutrient supply was favourable (400 kg $NPK \cdot ha^{-1}$) for maize. In the long-term trial maize was not produced in monoculture but in maize - wheat

crop sequence. The weather was characteristically dry during vegetation period except for the year 1995 (Gyuricza, 2000).

On the basis of yield results and technological data obtained from the examination series the influence of various cultivation methods on income can be modelled. Data used for model calculation can be found in Table 3.

3. The aim of the experiment is to show the influence of each of the technology categories on income level by using gross margin analysis. By applying gross margin analysis it is possible to evaluate the impact of various technologies on yield and costs (variable costs) at the same time.

Calculating gross margin analysis for various technologies was done by the following formula:

GROSS MARGIN = Value of Yield – Costs (variable), where:

value of yield = Avarage yield for each plot of land x Price of Yield

price of yield = 18 000 HUF·t^{-1} (72.87 EUR)

Variable costs of variable production technologies: soil cultivation, sowing.

Variable costs were defined by operation hours needed for cultivating the field and the costs of machines for one hour. The costs of machine labour are based on the operational costs calculated by HIAE Institute (Gockler, 1999).

RESULTS

1. From the experiments carried out at HIAE for comparing energy-, and operation saving soil cultivation systems of maize production the potential yields and the costs for the monocultural and ploughless tillage technology were used for determination of the income capacity of the technological variations (Table 2.). The relatively high yield can be explained by the conditions of this year rather than by to the results of the experiment to be introduced later. The means of sowing was different concerning technologies. The energetic-, and quality parameters and the yield of certain plots were defined. Sowing machines applied in the experiment were the following:

- White New Idea 6106, conventional maize sowing machine with accessories
- Buffalo Plantless/Planter, suspended 6-row direct drill machine
- Kühne Case-IH-CYCLO-800, conventional maize sowing machine with accessories

Table 2.: Gross margin analysis of maize production using energy-, and operation saving soil cultivation technologies, Osztopán technology,1998.

Sowing and its machines	Yield	Production value		Variable costs		Gross margin analysis		Income capacity
	t·ha^{-1}	EUR·ha^{-1}	EUR·t^{-1}	EUR·ha^{-1}	EUR·t^{-1}	EUR·ha^{-1}	EUR·t^{-1}	100%
Direct drilling Zetor 16045 + White New Idea 6106	7.98	581.54	72.87	76.31	9.56	505.23	63.31	63.31
Direct drilling Zetor 16045 + Buffalo	7.98	581.54	72.87	73.91	9.26	507.63	63.61	63.61
Direct drilling Zetor 16045 + Kühne Case IH Cyclo + Yetter disc	8.18	596.11	72.87	76.23	9.32	519.88	63.55	63.55
Direct drilling(2) Zetor 16045 + White New Idea 6106	6.89	502.10	72.87	76.31	11.07	425.80	61.79	61.79

(Source: FVMMI)

(2) The difference in yields on plot of lands using the same sowing machine is due to the different weed infestation.

First gross margin analyses for each plot of land were determined concluding only sowing and the related machine labor costs as variable costs. All the other elements of the production technology were the same, so these costs were considered constant. In calculating gross margin analysis in the model we consider the following technological elements:

- nutrition : MTZ + Amazone ZAF 403 fertilizer sprayer,
- soil preparing: Zetor 16045 + Conser Till cultivator + light disk,
- weed-control (twice): MTZ-80 + Huniper 500/10 sprayer,
- topdressing: MTZ-80 + OMIKRON 6/4 sprayer,
- harvesting: New Holland TX-62 + chopping adapter,

Significant difference in income capacity was observed only in one case due to the yield differences. The difference comparing to the technology resulting the lowest yield was 1.29 $t \cdot ha^{-1}$ (18.7%). The cost differences of sowing of the highest and lowest technologies could be neglected (0.08 $EUR \cdot ha^{-1}$), so income differences can be definitely due to yields. The third sowing tests in the experiment had got the cost difference of 3.2 %, so its value can also be neglected. It must be noted that these data can be compared only with one another. Other years having different circumstances are not suitable for examining income capacities.

The model calculations show that the variation of the technological elements in the costs of corn production technologies do not gain savings in costs. The income of a certain technology depends on yield, so during the examinations the impact of varied elements on yield has to be determined. Further analyses are needed to examine how energy-, and operation saving cultivation influence yield for long run, or with what kind and how high excess costs can yield decrease and harmful changes in soil condition be prevented.

In practice it is useful to choose and apply the technology according to the planned and harvested yield, so that the producer could get a satisfactory income.

2. According to the results of long - term experiments located in Gödöllő the income depends on the yield potential as proved by the values of gross margin analyses. The yields differ very much because of the extreme weather conditions of the years during the examinations were carried out. This difference amounts to 1.78t/ha^{1}, which is equal to 129.7 EUR. Whereas only 12.1 EUR difference in costs can be seen between the various soil cultivation and sowing methods. This means that the difference in costs is one tenth comparing to that of the yields. The big difference in yield is hardly half of the yield (2.31 $t \cdot ha^{-1}$) gain by using direct drilling (56.5 %), which is similar to that of gained by the combined technology (disking + loosening) comparing to the yield which can be obtained when using ploughing technology (57.3 %). According to the authors it is not possible to gain the suitable level of yield in every place and in every year by using the decreased number of applications in maize production. Owing to this low yields under unfavourable and extreme conditions do not contain the suitable income for the producers.

Under the influence of shallow cultivation methods such as direct drilling only some surface layers of the soil are rotated, and weed-control cannot be done mechanically because of the minimized number of operations. The competition between crop plants and weeds can lead to yield decrease, and it is only possible to prevent this by gradual herbicide usage. If the cultivating machines work in the same depth of soil layers for years there will be a compacted layer formed in the fertile layer obstructing water transport up and down in the soil. This phenomena can also lead to yield decrease (Birkás et al., 1997, Gyuricza, 2000).

According to gross margin analyses income capacity of the technologies can be determined if the value reached by the convention tillage is considered 100 % (Table 3.). Based on the results of the given experiment the various soil cultivation methods have got substantial effect -mainly because of less yield - on gross margin analyses carried out on different plots of land. A conventional tillage was used during the experiments, so it was considered as a basis for comparison.

Table 3: Gross margin analyses of maize production using energy-, and operation saving soil cultivational technologies, Gödöllõ, 1992-1966 average values.

Cultivation and tillage type	Yield	Production value		Variable costs		Gross margin		Income capacity	Weed infestation	Soil compaction
	t·ha^{-1}	EUR·ha^{-1}	EUR·t^{-1}	EUR·ha^{-1}	EUR·t^{-1}	EUR·ha^{-1}	EUR·t^{-1}	%		
Direct drilling Zetor 16045	2.31	168.34	72.87	16.19	7.01	152.15	65.86	56.1	✻✻✻	✓✓✓
Disking(3) Zetor 16045 + Kühne IH 10-770 6,2	2.78	202.59	72.87	15.41	5.54	187.18	67.33	68.9	✻✻✻	✓✓✓
Ploughing Zetor 16045 + Kühne IH 10-720-5/4	4.03	293.68	72.87	22.26	5.52	271.42	67.34	100.0	✻	✓✓
Loosening + disking Zetor 16045 + Rába IH 10-14/5 + Kühne IH 10-770 6,2	3.74	272.55	72.87	27.54	7.36	245.01	65.51	90.3	✻	✓
Loosening + ploughing Zetor 16045 + Kühne IH 10-720-5/4- + Rába IH 10-14/5	4.09	298.06	72.87	27.12	6.63	270.94	66.24	99.8	✻	✓

(Source: St. Stephanus University Department of Soil Management)

(3) The difference in yields on plot of lands using the same sowing machine is due to the different weed infestation; Weed infestation:✻ - under limited level, ✻✻ - over limited level, ✻✻✻ - strong; Compaction: ✓ - light, ✓✓ - moderate, ✓✓✓ - strong.

There were substantial differences between cultivation methods of ploughing, ploughing combined with loosening or disking combined with loosening. The income has decreased concerning the land which was cultivated only with disks by one third, while direct drilling technology without any soil preparation has resulted in the lowest income, which is different from the results of the other experimental series (e.g. ECAF data, 1999).

CONCLUSIONS

Profitability of maize production has been worsened in the past ten years, which can be traced back to the fact that production costs haven't been followed by the increase of market prices. In consequence it is getting more and more important how and what means and approaches can be used to make profit in maize production.

This process has to be carried out in two ways basically: either the producers have interests in increasing yields (quantity, quality, higher sales prices), or they decrease their production costs (lower costs and costs and expenses). None of the approaches alone can lead to perfect results, so it is necessary to examine the usage of both factors that have impact on income capacity together.

In our experiments on energy-, and operation saving maize production technologies the following conclusions were discussed:

The impact of energy saving technologies on income level depends mainly on the potential yield. Costs of direct drilling machines used in the experiments are not considerable and amount to 3% only, which is not a significantly difference. This means that the use of a certain sowing machine doesn't influence much the production costs. Annual data cannot be used for evaluation of income changes of the whole technological system.

Costs cannot be decreased significantly by the reduction of numbers of operations. Further examinations are needed if we want to determine how yields change if the other technological elements

are changed, and what is the impact of these changes on the income level.

Direct drilling machines can be labelled by their energetic characteristics, which can have the result of cost decrease, too.

For choosing the best production technology during the application of various technologies it is necessary to make models of the potential income levels according to various field conditions. Furthermore it is also necessary to determine the approaches of making the producers interested in using energy-, and operation saving technologies (financing methods).

Long-term trials should be extended, so that the excess costs due to ploughless shallow type of soil cultivation can be estimated (compact layer close to the surface, changing weed conditions, weed resistance against chemicals, worse parameters of soil water supply). Several analyses are being carried out for experiments the harmful effects.

Direct drilling and ploughing combined with appropriate crop sequence may prevent soil degradation (harmful compacted layers) as well as preserve weed flora. From an economic point of view direct drilling decreases the costs to an extent which is not really sufficient, which doesn't really have an impact on gross margin analysis. Increase of weed infestation and location of compacted layers are disadvantages. Ploughing systems need more energy and use more technological elements. That is why it is important to prevent the possible negative effects by using and combining the right approaches.

During the gross margin analysis based on variable costs caused by the different soil cultivation technologies and different sawing machines we stated that there were a small difference between the variable costs per one ton yield. The gross margin of direct drilling – in Osztopán – with New Idea 6106 sawing machine was 63.31 EUR t^{-1}, in the second case it was 61.79 EUR t^{-1}, with Buffalo it was 63.61 EUR t^{-1}, with Kühne Case IH Cyclo and Yetter disc it was 63.55 EUR t^{-1}. The gross margin of direct drilling – in Gödöllő – with direct drilling was 65.86 EUR t^{-1}, with Kühne IH 10-720 6.2 it was 67.33 EUR t^{-1}, with Kühne IH 10-720-5.4 it was 67.34 EUR t^{-1}, wit loosening and disking it was 65.51 EUR t^{-1}, with loosening and ploughing it was 66.24 EUR t^{-1}. These data strengthened our opinion that the profitability depends mainly on yield production and not on the technologies' costs. It could be brought back either that the decrease of reduction of numbers of operations or the decrease in corn yield. So in order to reach higher profit it is necessary to chose the right technology that fit to the soil conditions and the previous technologies, the equipment system of the producer, and the knowledge of them.

The results we achieved during our research are valid only in the given conditions, they could be recalculated and complemented under other soil and agro-ecological conditions. Our purpose was to emphasise the necessity of economical calculations before making decisions on changing technology.

As we didn't find significantly difference during the gross margin analysis on maize-production using energy-, and operation saving soil cultivation technologies, we suggest using the combined technologies of conventional and energy-, and operation saving soil cultivation technologies both from the aspect of agronomy and economics based on the results of their experiments and literature data.

REFERENCES

[1] Birkás M et al. (1997): Results of maize direct drilling long-term trials on brown forest soil. *Plant Production*. 46. (4): 413-430

[2] ECAF (1999): Conservation agriculture in Europe: Environmental, economic and EU policy perspectives. Brussels

[3] Gockler L. (1999): Prices of agricultural machines and the costs of operation in 1999. Agricultural machine operation, 1. FVMMI (HIAE)

[4] Gyuricza Cs. (2000): Physical and biological impact of sustainable and conventional soil cultivation methods. Ph.D. dissertation, GATE, Gödöllő (in Hungarian)

[5] Kelemen Zs., Komlodi I., Kassai Zs., Mészáros Gy., Soós S. (1997): Report on „1997 experiment on energy-, and operation saving maize production technologies" in „Forming a new energy-, and operation technology with machine and equipment system for cereal and fodder production". FVMMI (HIAE) Gödöllő.24, (in Hungarian)

[6] Kelemen Zs., Soós S. 1998. Report on „Developing energy-, and operation saving technologies of maize production", which was a task of public utility. FVMMI (HIAE), Gödöllő. 24, (in Hungarian)

[7] Kismányoky T., Balázs J.(1996): Keszthely long-term trials. PATE. Keszthely

[8] Ruzsányi L. (1997): Plant production, breeding and protection. In: Present and future of Hungarian agricutural economy. MTA. Budapest

[9] Sörös I., Soós S., Birkás M., Futó Gy. (1994): Report on „Adaptation and technical basis of ploughless maize production technologies". FVMMI (HIAE) Gödöllő, 40, (in Hungarian)

[1] Takács-György K.,
Szent István University Gödöllő Faculty of Social Sciences and Economics - Department of Farm Management and Economics,
H-2103 Gödöllő, Páter K. u. 1., Hungary

[2] Mónika Gecse, gecsem@hotmail.com, *to whom correspondence should be addressed
Szent István University Gödöllő Faculty of Agriculture, Department of Soil Management,
H-2103 Gödöllő, Páter K. u. 1., Hungary