Influence of factors on the maize-grain mechanized technology net margin

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Abstract: a tendency to reduce number of operations by their association carries technical, environmental as well as economic aspects. Technical and environmental features are apparent and can be described with couple of quite logic positive effects and consequences. It is rather difficult to exactly identify economic proceeds that must especially be seen in producer's final perception (net margin). Methodology of net margin calculation is complicated and sometimes not fully transparent. A new (proper) methodological approach has been conceived in the concept of ATMP (Agricultural Technology Management Program). The Program is meant to provide the art of work to the extension worker in formulating sound and exact technological advice based upon both the availability of technological information (particularly on machinery sets and agronomic requirements) and rapid economic (costs) calculations. The program demonstrates an attempt to put into practice the concept of "precision technology" based on precision machinery inputs, which reduces machinery input costs. Preceding field survey carried out in August–September 2003 supplied basic data for technologies design and economic calculations. Five different mechanized technologies were conceived as provided with various operations and inputs: (1) classic mechanized technology composed of all necessary soil preparation, seeding, cultivation and harvesting operations; (2) direct sowing as a form of the minimum tillage (no soil preparation operations); (3) classic mechanized technology with farmyard fertilizing, (4) classical mechanized technology with combined cultivation operations; (5) classical mechanized technology with green manure. All technologies have been designed using Czech currency. The economic appropriateness of the respective technologies has been judged according to the main parameters of the crop budget that were selected for export to the comparison table. The parameters included in the comparison table were displayed in chart form. This enabled a better comparison of different parameters of the technologies. The main economic indicators that have been considered are the gross and net margins and own market price per ton of the product.

Keywords: ATMP; precision technology; crop budget; comparison table; combined operation; corporate business plan

Current farming no matter where in the world has undergone many changes. All farm power experts agree that the most obvious benefits of mechanization, e.g. using new machines, are their substitution benefits, their ability to reduce costs of production by replacing single operations with combined ones and using labour as less as possible. Respect to the environment and rural employment are other factors that have to be considered. Thus, the process of more sophisticated farming systems introduction must be considered as changes of the whole system (Havrland & Kapila 2000).

The mechanization has become the most intensive input in the modern agriculture. However, even technologic stages like hand-tool and draught animal technologies are becoming more and more sophisticated and can be considered as a certain stage of mechanization. Best measure of benefit of a certain technology is the perception derived by producers (farmers) from their incremental investments in mechanization – that is, the extra output, net of input costs, which outweigh the cost of foregoing their use in any other way. The height of costs itself cannot be a measure of effectiveness despite of it seems like (William 1989).

Theoretical considerations on economic optimality of technologies

It is a rather complex issue to define what makes user's decisions "economically optimal". Underlying

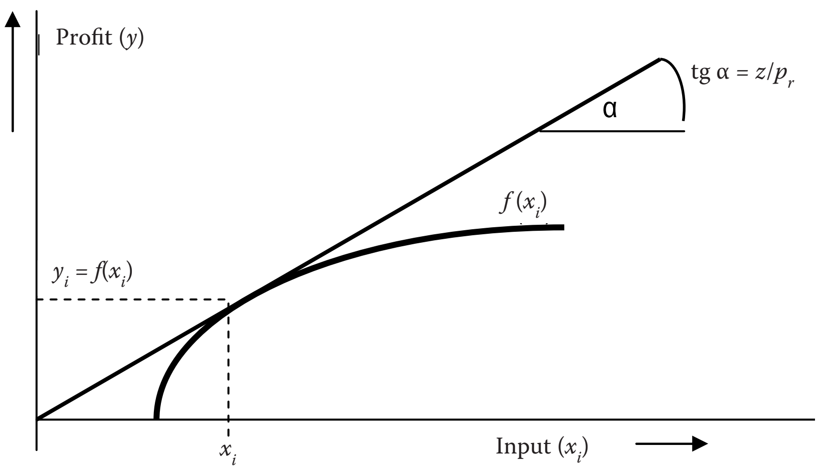

Figure 1. Economically optimal input application in a monoparametric (simple) model
Note: The above conclusion is constrained by the fact that, in the case of profit there is little known about functions $y = f(x)$ for most parameters

economic optimality must be some corresponding "economic objective" of the decision maker. Sometimes it is found useful to assume that a very simple model can be used to adequately frame and describe the economic objective of the user. In fact, the ATMP Programme, just apart of its practical use by farm machinery planners can serve as such a model embracing many independent variables as inputs and more dependent variables as outputs (Spugnoli & Vieri 1993).

A consistent choice from both groups and their testing is also possible by use of the Programme. In the following section theoretic considerations upon some system approaches are discussed (Chandra & Singh 1995).

Monoparametric system approach

In this model the machinery user (farmer, contractor) produces a simple output (net margin) that can be denoted by the variable y, by applying a number of inputs, such as machine purchase price, period of use, annual use, fuel consumption, etc. which are described by a vector of variables $x = (x_1, x_2, x_3 \ldots.. x_k)$. The net margin is assumed to share a fixed relationship with the application of inputs, where this relationship is described by a response function f which can be expressed as $y = f(x)$ (Cate *et al.* 1995).

Furthermore, it is assumed that the user observes p_u, the price per unit of output (hectare or other working output), and z a vector of prices per unit of each input $z = (z_1, z_2, z_3 \ldots.. z_k)$. Then, it is assumed that the user, knowing p_u, z and f, wishes to choose levels of inputs $(x_1, x_2, x_3 \ldots.. x_k)$ so that one maximizes profits which are defined as revenues (prices times quantity of output) minus costs (the sum of the products of input prices and quantity of inputs applied). The solution has been offered by Wetzstein *et al.* (1986).

In fact, it is assumed that the user's objective is to solve the maximization task:

$$\max_{x1 \quad xk} \{ p_u \times f(x_1, x_2, x_3 \ldots.. x_k) - \text{sum } z_k \times x_k \}$$

The solution of the above equation can be illustrated graphically for the case of there being only one input (one variable), i.e. $k = 1$ and the input is then x_1. The result is typical for the economically optimal amount of input x_1 (the amount that solves the equation and so maximizes revenues minus costs. Logically, the slope of $f(x_1)$ equals the cost/profit ratio z/p_r. This economically optimal amount is labelled as x_1 in Figure 1.

Figure 1 shows a function $f(x_1)$ as a concave one. It is intuitively appealing that the function should be concave for the case when the input-to-profit ratio rises. It can be assessed that the majority of cases the ratio will be concave and would take a logarithmic shape. It means that the response on the increase of an input value would be not proportional but it will be attenuated at higher input values. As a consequence, a logical conclusion must be that the growth of input values must have limits (Chandra & Singh 1995).

However, the equation is multi-parametric and the solution in Figure 1 is not sufficient. The solution is than taking a polynomial shape.

Turning back to the Figure 2, the optimal decision (with minimum risk) of the machinery user is to use less input and have less profit, that is to move to a lower level of x_1 value, since there the response function $f(x_1)$ is more steeply sloped than it is at its higher level. Similarly, when the cost/profit ratio z/p_r falls, the optimal decision for the machinery user is to get more profit (move to a higher level of x_1 input), since there the response function is less steeply sloped than at $x_{1,i}$.

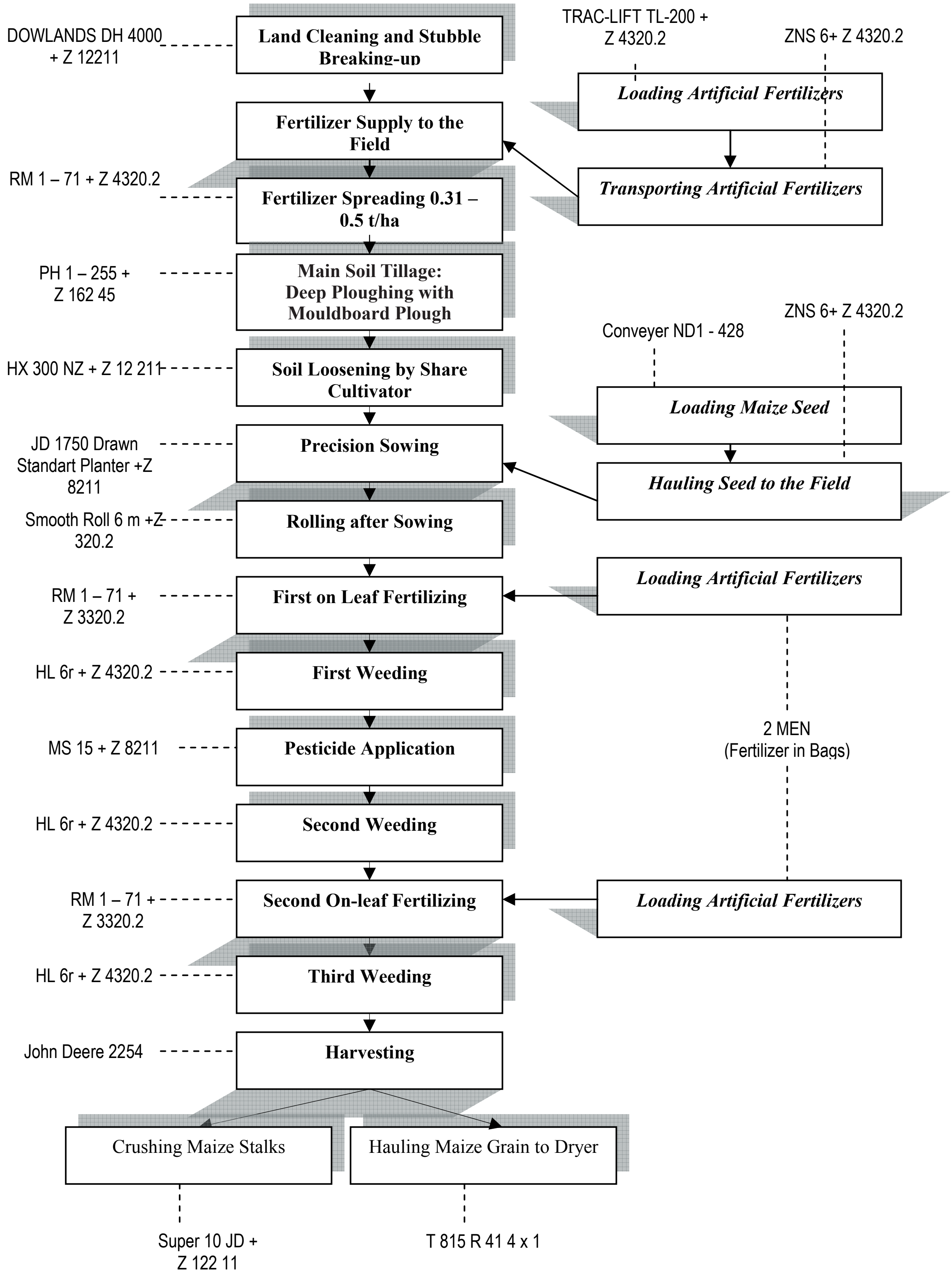

Figure 2. Classic mechanized technology

Economic optimality with more input parameters

The solution when using only one factor x_1 (input) is too simple for the analysis of profit strategy decisions. In general the final effect of many inputs on yield cannot be known with certainty until some point in time after the inputs are applied. This is because the levels of many factors of production that the manager (farmer, contractor, others) does not fully control (for instance variables depending on weather – time of machinery use, period of its use or cultural period; other set of variables can be market prices of both the inputs or outputs or so called legislative and banking parameters like depreciation and interest). The input impact cannot be assessed until after the user applies some of the inputs (Zijp 1991).

Thus, the uncontrolled factors may be said to be stochastic and the manager is said to be making decisions under uncertainty. The graphical illustration of this case must be a multidimensional. However, it is extremely difficult or even impossible to compute such functional relationships on basis of experimental data. Other difficulties are encountered when the results should be interpreted.

The task can be well solved by the method of multifactorial experiment at using a proper simulator that can enable modelling of the whole (very complex and dynamic) system. Method of planned experiment is one that can discover (compute) the "force" of individual parameters (Havrland *et al.* 2002).

One assumption that the economists very often make when trying to model such decision making dependent on uncontrolled factors of stochastic character (when managers operate under conditions of uncertainty) is that the manager's objective is to maximize expected profits "on average".

METHODOLOGY

General methodological lay-out

The methodology based upon the ATMP Programme use was set up so that economic assessment of five technologies through their crop budgets was possible. The comparison was conducted by simulating actual conditions in the agriculture. For this purpose five technologies have been modelled and further costs calculations, crop budget constructions and comparisons made. Equal maize-corn yield on the level of five tones has been considered in spite of the fact that the yield rate could vary in tune with the changing technologic parameters. (REM.: five tons of maize-corn is an average one under the Czech conditions.) Operations and machinery and material inputs were relevant to conception of individual technologies.

Size of the farm was considered about 600 ha and maize cropped area was set up on 200 ha. Tractors and machines were considered as usually available by farmers: Zetor tractors (four tractors and three different models of Zetor make tractors), mostly Czech made machines, combine harvester John Deere (JD 2254). Three operations (ploughing, harvesting and transport of maize-grain) were done by hired services – the farm could hardly have such heavy-duty machines.

ATMP technology processing mode starts with machinery sets provision for individual operations as identified hitherto. Machinery set main parameters have been exported into the Techsheet where material and labour inputs are added and expected yield defined. The Costing Sheet computes cost according to their conventional structure up to the final "operating cost". The following "crop budget" regroups revenues and structured costs adding overheads and taxes and produces main economic parameters. They are then exported into the comparison table offering transparent tabular and graphical comparison for farmer's management decision-making, which is strongly affected by his perception potential.

Technology assessment has been done according to crop (technology) budgets on basis of selected parameters considered as main economic indicators. Gross and net margins and farmer's own market price have been identified as the main criteria for the farmer's decision making.

The main objective is to find out the best (most appropriate and profitable) technology on basis of economic parameters and appraise the final result (net margin).

Technologies used

(1) Classic mechanized technology: composed of all necessary soil preparation, seeding, cultivation and harvesting operations (Figure 2).

(2) Direct sowing as a form of the minimum tillage (no soil preparation operations): represents a form of reduced machinery intervention in the field due to the absence of main tillage (ploughing) and seedbed preparation operations. Because of higher field weed infestation expected one more spraying operation was included into the technology algorithm. The seeding operation has become more costly because the precision seeding machine for direct seeding is more expensive. The rest of the technology has been kept unchanged as related to the technology No. 1.

(3) Classic mechanized technology with farmyard fertilizing: there is a tendency to declining from inorganic fertilizing practices organic farming by using farmyard manure. The farmyard manuring has replaced fertilizing with use of artificial compounds however it (its transport component) is far more expensive. The rest of the technology has been kept unchanged as related to the technology No. 1.

Table 1. Main crop budget parameters comparison

Crop	MaizeMechCZ I	MaizeMechCZ II	MaizeMechCZ III	MaizeMechCZ IV	MaizeMechCZ V
Technology	mechanical power technology				
Main product yield expected (t/ha)	5.00	5.00	5.00	5.00	5.00
By-product yield expected (t/ha)	0.00	0.00	0.00	0.00	0.00
MP average market price (cur/t)	3300.00	3300.00	3300.00	3300.00	3300.00
BP average market price (cur/t)	0.00	0.00	0.00	0.00	0.00
MP own price (at farmer's gate) (cur/t)	2865.08	3024.03	3647.78	3283.57	3188.84
BP own price (at farmer's gate) (cur/t)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MP output value (cur/ha)	16 500.00	16 500.00	16 500.00	16 500.00	16 500.00
BP output value (cur/ha)	0.00	0.00	0.00	0.00	0.00
Total output value (cur/ha)	16 500.00	16 500.00	16 500.00	16 500.00	16 500.00
Total gross margin (cur/t)	1350.79	1047.28	668.18	1128.67	1067.64
Total net margin (cur/t)	417.19	233.65	–398.22	–4.27	71.17
% of total net margin (%)	13%	7%	–12%	0%	2%
Total production costs (cur/t)	2865.08	3024.03	3647.78	3283.57	3188.84
Total labour costs (cur/t)	17.73	42.33	50.45	20.70	39.99
Total machinery costs (cur/t)	1057.38	992.32	1251.82	1380.38	1120.42
Total hand-tool costs: (cur/t)	0.80	0.80	0.80	0.80	0.80
Total draught-animal costs (cur/t)					
Total hire costs (cur/t)	673.35	392.69	673.35	673.35	673.35
Total costs of seed & seedling (cur/t)	540.00	540.00	540.00	540.00	540.00
Total costs of manure and compost (cur/t)	0.00	0.00	360.00	0.00	0.00
Total costs of fertilizers (cur/t)	868.00	868.00	868.00	868.00	868.00
Total costs of chemicals (cur/t)	84.40	216.70	84.40	84.40	216.70
Total costs of fuel & lubricants, energy (cur/t)	228.37	200.58	297.70	230.39	248.67
Total costs of repair & maintenance (cur/t)	142.30	221.82	236.66	268.94	164.73
Total depreciation (cur/t)	156.22	287.77	241.91	336.63	189.43
Total overheads (cur/t)	237.52	161.75	220.17	214.20	250.50
Total hours of labour (h/t)	1.59	2.87	3.53	2.87	2.98

cur – currency

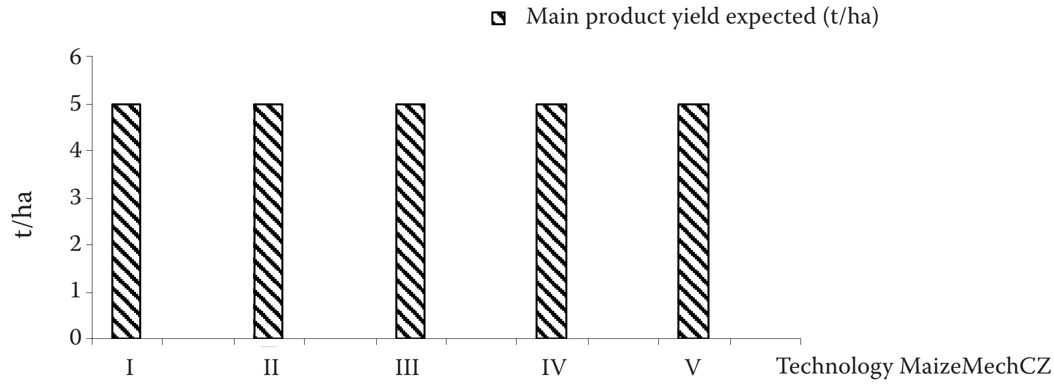

Figure 3. Product yield

(4) Classic mechanized technology with combined cultivation operations: an attempt to reduce number of inter-row operations by combining them. Two inter-row weeding operations have been combined with on-leaf application of artificial fertilizers. The rest of the technology has been kept unchanged as related to the technology No. 1.

(5) Classic mechanized technology with green matter fertilizing: green manuring has been included into the technology line as extra fertilizing and cost increasing factor. No extra yield increase has been considered and mere improvements in soil potential for next crops are focused (investments in the future).

RESULTS AND DISCUSSION

Parameters of all technologies (their Crop Budgets) considered as the most important were put into the comparison table (Table 1). The compared parameters have also been graphically illustrated in Figures 3–11. Parameters of all technologies have been statistically tested and discussed.

Assessment scheme

The assessment of all model technologies was carried out according to the crop budget parameters considered as the main economic characteristics of the technology. For an objective comparison comparable pre-requisites have had to be secured, for example the same starting and ending level of technologic operations. In the case of five selected technologies, they are starting by land clearing and ending by crushing maize stalks, which is a normal technologic pattern. On-farm maize-grain processing could not be included as it is not usual. However, it would make the farmer's margin growth, indeed. Number of operations within individual technologies varies according to their specificity and is subject to a considerable reduction for economic and environmental reasons. It can be considered as one of variables (Kavka 2000).

As to the main income parameters (crop yield and maize grain price) their influence was eliminated by keeping them the same in all technologies. It is not entirely correct for the above mentioned yield that

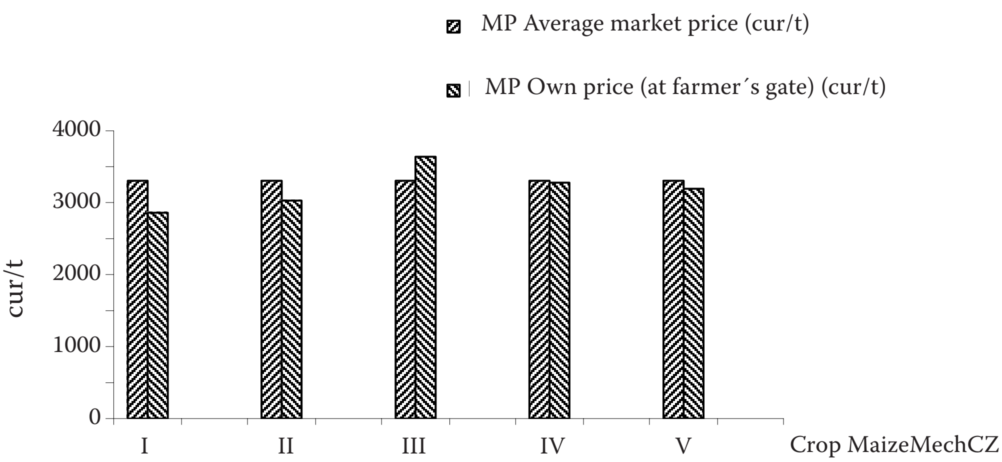

Figure 4. Market and own price

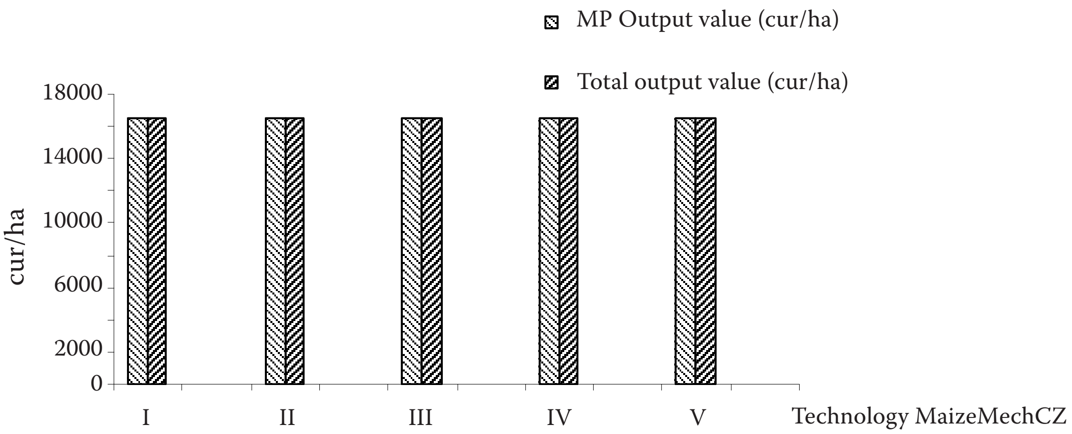

Figure 5. Output value

(probably) could be higher at technologies using farmyard manure (T3) and green fertilizing (T5). It is because the yield well describes the production intensity which has been neglected in the assessment scheme (Havrland 2001).

According to the Table 1, the most important output parameters are total gross margin (cur/t), total net margin (cur/t) and percentage of total net margin (%).

The own market price (along with the yield) demonstrates competitive potential of the modelled technology; it should be lower than the actual market price. Because no profit and VAT were added it was equal to the total production costs. The total output value characterizes potential of incomes per hectare from main product and by-product together. It is other important parameter along with total gross and total net margins per unit (t) and they are usually taken into account at the decision making process.

Total production costs (cur/t) is a very good criterion for measurement of technology productivity while total hours of labour (h/t) and total labour costs (cur/t) are good criteria for labour productivity assessment. However, all costs components (from total labour costs up to total overheads) as parts of the total production costs can be used for detailed economic analysis of the assessed technology, if necessary.

Assessment of technology net margin potential

The technology No. 1 in the comparison table (Table 1) is a classic mechanized technology using all operations including main tillage (deep plough-

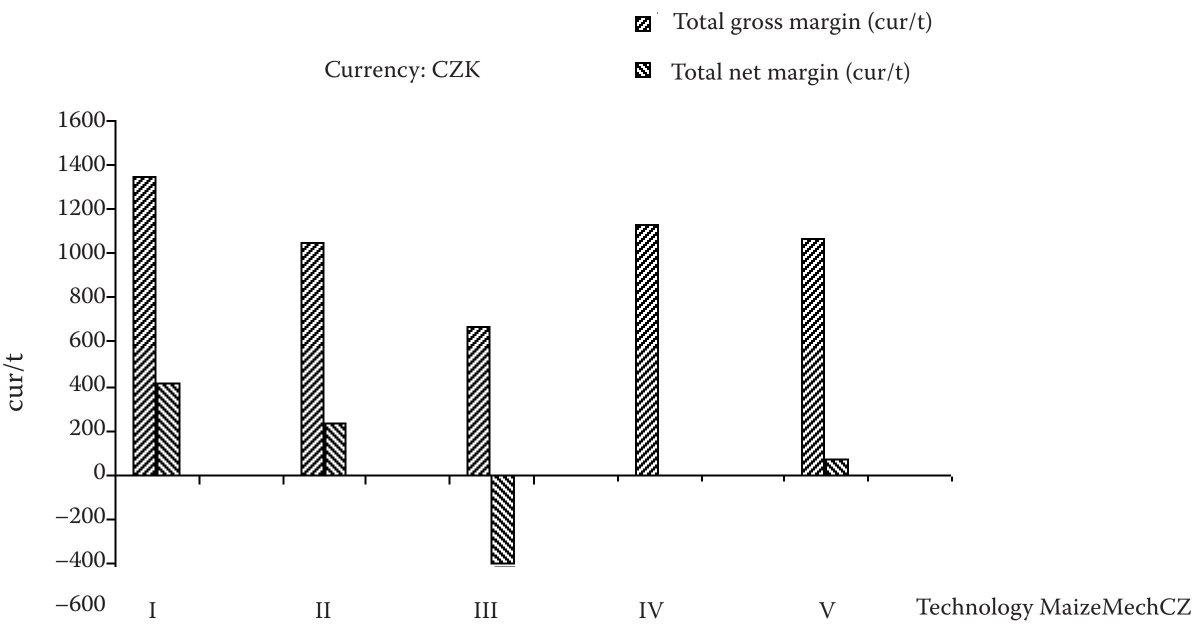

Figure 6. Gross and net margin

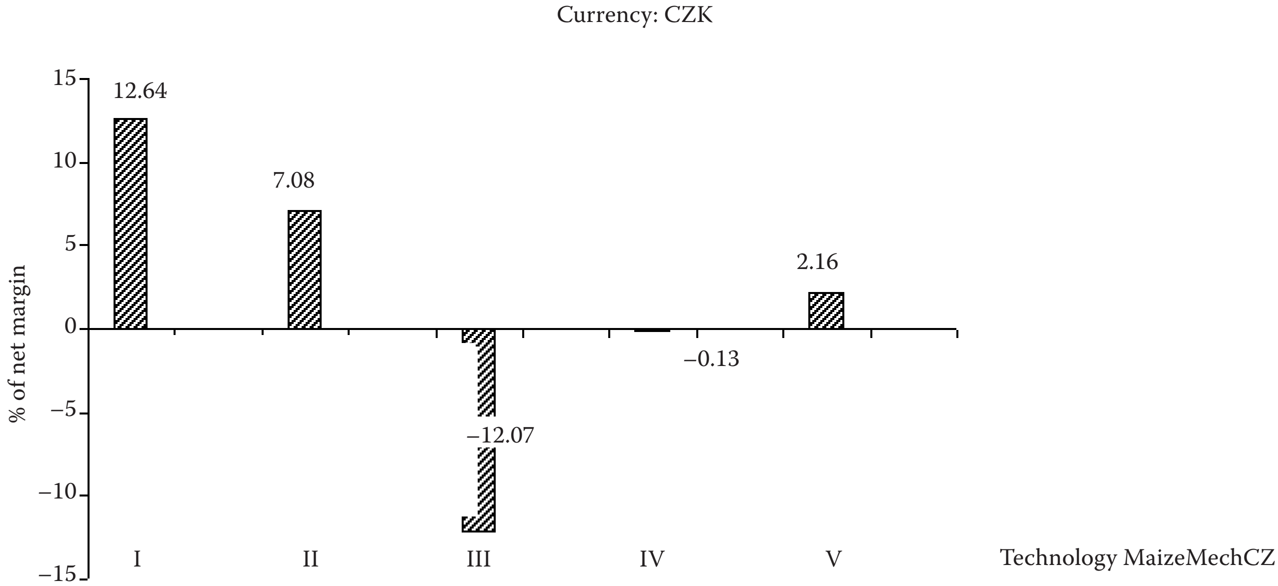

Figure 7. Percentage of total net margin

ing). The second one (No. 2) differs by the absence of soil preparation operations including ploughing. These operations are considered as a variable that impacts the net margin. In contrary to the expectations the net margin decreases by almost 50% which is mainly due to the use of expensive machinery set for combined seedbed preparation and seeding operations. Even the expensive operation as the deep ploughing did not disadvantage the first technology. The second technology can further be constrained by lower yield, which could push the net margin more down.

Use of farmyard manure (technology No. 3) is a set of very expensive operations and cannot be economically justified unless essential yield growth compensates higher costs. Under this circumstance the total net margin has decreased three times (when compared with the first technology) and become negative. It represents loss of 12%.

Combining the inter-row cultivation operations is also not economically justified. The net margin is still almost zero, thus being 13% under the profit level of the technology No. 1. Use of green manure (technology No. 5) improves a bit the result (2% of net margin) but it is still far behind the profitability of the technology No. 1.

Under the given cost and price circumstances, the used yield 5 t/ha, which can be considered as good one is not enough to cover the production costs at all. If the profit margin on 10% level and VAT on 19% level had been computed in, the economy of all technologies would have been negative. This is expressed by own market prices per ton that are much higher than average market prices. The increase of

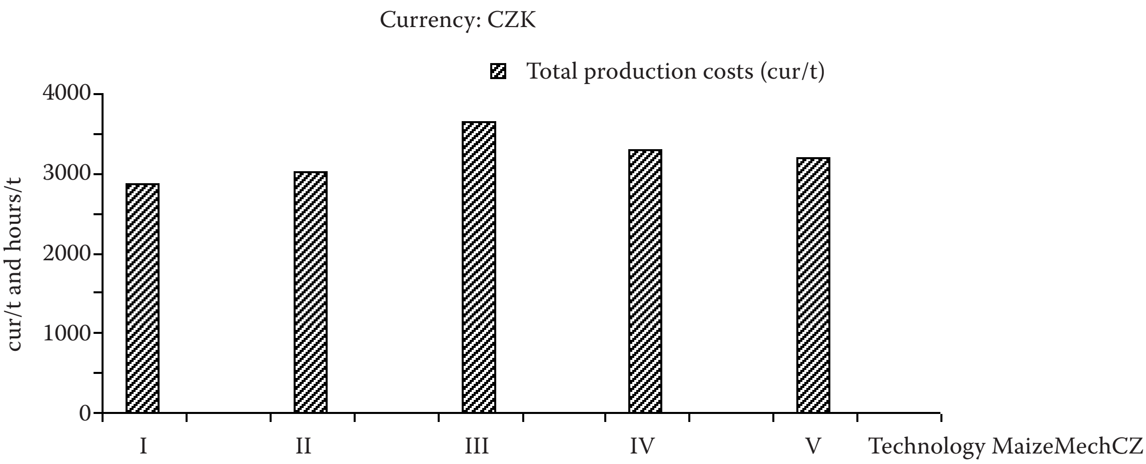

Figure 8. Costs/hours

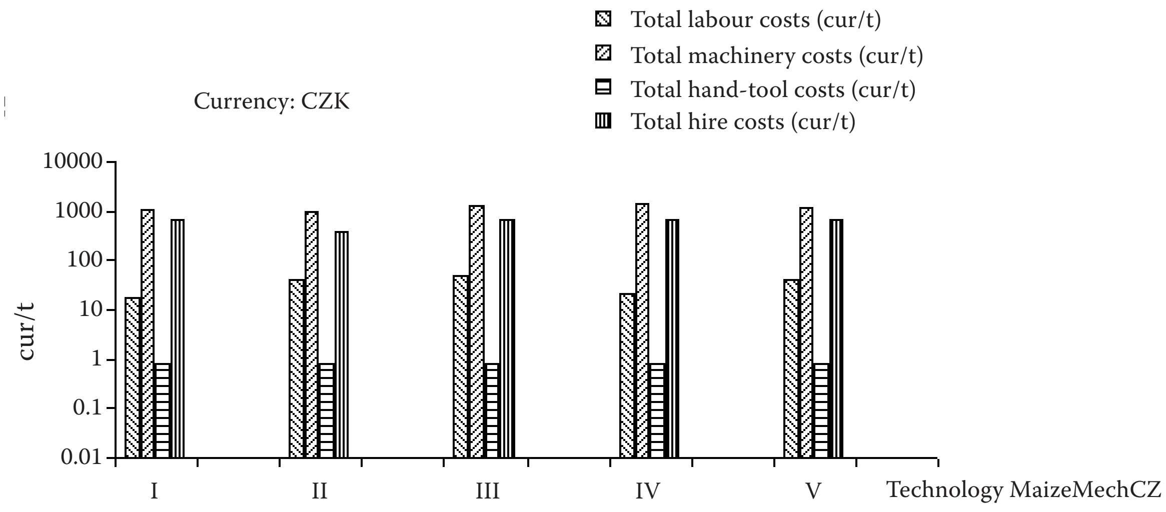

Figure 9. Costs

yields or higher maize grain prices would reverse the above result.

At absence of profit margin and VAT, the only total production costs are the main factor impacting the net margin.

The above conclusions coincide with the labour productivity expressed as total hours of labour per ton. The first and the most profitable technology has the least labour time consumed per ton (1.59 h/t) while the worst technology as to the net margin (No. 3) has showed the highest labour time consumed per ton (3.53 h/t). Slight differences in time consumed are among other technologies. The total labour costs follow the same scheme.

However, the total machinery costs differ from the above stereotypic scheme. From this point of view the lowest mechanization inputs have been found at the minimum tillage technology (No. 2) while the highest mechanization inputs are characteristic for the use of combined inter-row cultivation operations (No. 4) economic result of which was also not positive. Very high mechanization inputs have been discovered at the No. 3 as linked to the farmyard manure use.

On the other hand, the total costs of energy correspond to quite logical consideration. The lowest is at the absence of the main tillage and seedbed preparation (No. 2) while the highest is when application of farmyard manure is considered (No. 3). The green manure use also increased the energy consumption while the combined inter-row operations (No. 4) make it fall.

CONCLUSIONS AND RECOMMENDATIONS

– The ATMP Programme, just apart from its practical use by farm machinery planners can serve as a model embracing many independent variables as inputs and more dependent variables as outputs.

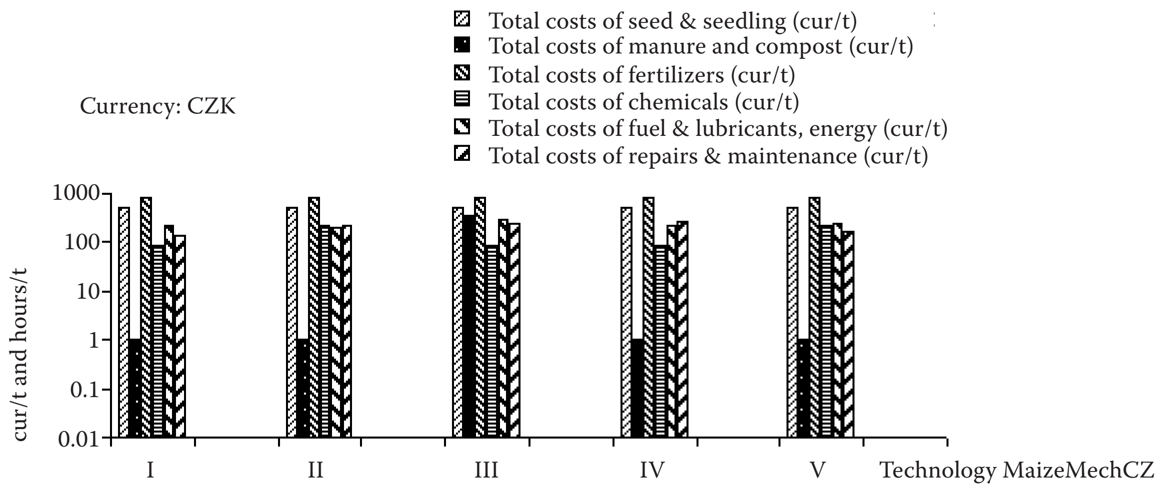

Figure 10. Costs – materials

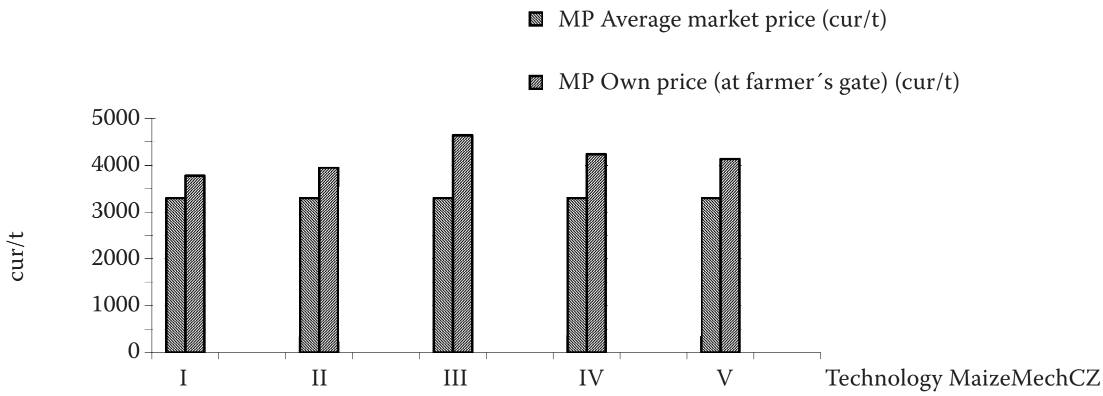

Figure 11. Market and own price

- The technology is a system of many inputs (independent variables) and outputs (dependent variables). The system can be solved as mono-parametric but this solution is not adequate. The multi-parametric solution is more complex but more correct. The task can be solved by the method of multi-factorial experiment.
- Five different mechanized technologies were conceived as provided with various operations and inputs: (1) classic mechanized technology composed of all necessary soil preparation, seeding, cultivation and harvesting operations; (2) direct sowing as a form of the minimum tillage (no soil preparation operations); (3) classic mechanized technology with farmyard fertilizing, (4) classic mechanized technology with combined cultivation operations; (5) classic mechanized technology with green matter fertilizing.
- The assessment of all model technologies was carried out according to the crop budget parameters considered as the main economic characteristics of the technology.
- The most important output parameters are total gross margin (cur/t), total net margin (cur/t) and percentage of total net margin (%).
- According to the comparison table, the absence of soil preparation operations (No. 1) or reduction of number of inter-row operations is not positive-reflected in the net margin. On the other hand, use of farmyard manure and green fertilizing is negative-reflected in the net margin due to increased operation costs.

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Abstrakt

Havrland B., Kavka M., Růžička M. (2006): **Vliv faktorů mechanizace pěstování kukuřice na zrno na čistý zisk**. Res. Agr. Eng., **52**: 69–79.

Tendence snížit počet mechanizačních operací pomocí jejich sdružení má technické, ekonomické a environmentální důsledky. Technické a environmentální aspekty jsou zjevné a mohou být popsány řadou zcela logických pozitivních efektů a konsekvencí. Je ale docela obtížné přesně identifikovat ekonomický přínos, který se musí odrazit v zisku podnikatele (v jeho čisté marži). Metodologie zjišťování čistého zisku je komplikovaná a často ne zcela transparentní. Nový metodologický přístup byl založen v konceptu ATMP (v Zemědělsko-technologickém manažerském programu). Program poskytuje služby poradcům při formulaci přesné technologické informace založené na technologické informaci (strojní soupravy a agrotechnické požadavky) a rychlých ekonomických (nákladových) propočtech. Tento program demonstruje pokus o zavedení pojmu „přesné technologie", založeném na přesných strojních vstupech, čímž jsou sníženy vstupní náklady. Předchozí terénní pozorování provedená v srpnu a září roku 2003 poskytla data pro konstrukci technologií a ekonomických výpočtů. Bylo zkoncipováno 5 různých strojních technologií s různými operacemi a vstupy: 1. klasická strojní technologie se všemi operacemi na přípravu půdy, setí, kultivaci a sklizeň; 2. technologie s přímým setím jako reprezentant minimálního zpracování půdy; 3. klasická strojní technologie s hnojením chlévskou mrvou; 4. klasická strojní technologie s kombinovanými operacemi pro meziřádkovou kultivaci; 5. klasická strojní technologie se zeleným hnojením. Ekonomické propočty byly uskutečněny v české měně. Ekonomická vhodnost použitých technologií byla stanovena na základě hlavních parametrů „rozpočtu plodiny", které byly přeneseny do srovnávací tabulky. Tyto parametry byly dále zobrazeny ve formě grafů. To umožnilo lepší srovnání různých parametrů v jednotlivých technologiích. Za nejdůležitější indikátory ekonomické vhodnosti technologií jsou považovány hrubý a čistý zisk (marže) a vlastní cena produktu, vytvořená na základě vlastních nákladů, zisku a DPH.

Klíčová slova: ATMP; přesná technologie; rozpočet plodiny; srovnávací tabulka; kombinovaná operace; celkový business plán

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