Analysis of the yield milk effect on the economics of milk production

Analýza vlivu dojivosti na ekonomiku výroby mléka

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Abstract: Relations between the level of milk yield and the economic results of dairy cows breeding were analysed on the base of operational and economic data received from 135 agricultural enterprises. The analysis was aiming at the optimization of milk production expressed by means of the cost function. By evaluating the above-mentioned relations, there was recorded a tendency of the faster growth of milk yield compared to the costs for market milk for one feeding day of a dairy cow. On the base of the expense function, there was expressed the maximum profit for a litre of market milk, the maximum profit for a dairy cow per year and the interval of profitability of milk production in 2000.

Key words: dairy cows breeding, milk, milk yield, economics, costs, price, profit

Abstrakt: Na základě provozně-ekonomických podkladových údajů získaných od 135 zemědělských podniků byly analyzovány závislosti mezi úrovní dojivosti a ekonomickými výsledky chovu dojnic. Cílem analýzy byla optimalizace výroby mléka vyjádřená prostřednictvím nákladové funkce. Posouzením uvedených závislostí byla zaznamenána tendence rychlejšího růstu dojivosti oproti nákladům na tržní mléko na krmný den dojnice. Na základě nákladové funkce byl vyjádřen maximální zisk na litr tržního mléka, maximální objem zisku na dojnici za rok a interval ziskovosti výroby mléka v roce 2000.

Klíčová slova: chov dojnic, mléko, dojivost, ekonomika, náklady, cena, zisk

INTRODUCTION

The analysis was aiming at the evaluation of relationships between the level of milk yield and the economic results of dairy cows breeding and the optimization of milk production on the base of the expense function.

The economics of milk production can be influenced by two decisive ways:

– by a favourable growth of the milk purchase price

– by a proportional development, with regard to milk yield, of the individual expense items, respectively.

The analysis is, first of all, concentrated on the problems connected with the costs of milk production.

MATERIAL

Problems of the milk production economics are being monitored in the framework of the periodical research which has been carried out since 1994 by the Group for Animal Production Economics in the Research Institute of Animal Production in Prague-Uhříněves. A unified method was used to ensure the comparability of the results in single years. Research activity is concentrated on the casual analysis of the factors effecting milk production. The results of these detailed and in-depth analyses have been gradually published (see the survey of literature).

The following effects influencing the economics of milk production were mainly researched at dairy cows:

– effect of milk yield
– effect of the level of feeding
– effect of a change of the technological stabling system
– effect of the breeding herd structure
– effect of natural conditions.

The analysis of the effect of milk yield on the milk production economics in 2000 is stemming out of a collection of 135 agricultural enterprises engaged in dairy cows breeding. Costs, marketability and profitability of milk production in view to milk yield has been evaluated on the base of the gained operational and economic data. This collection represented 12.9% from the whole number of dairy cows bred in the Czech Republic and the share of 14.6% in the production of market milk. The cited shares give evidence of a high informative value of this collection.

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METHODS

The milk yield per one cow and year was a criterion for the research of the milk yield effect on the milk production economics. An agricultural enterprise was a statistical unit. The subtraction method was used in calculations. By-products were evaluated by fixed prices. One kilogram of a new-born calf was estimated for 50 Czech crowns (further only CZK), one tone of stable manure by 50 CZK and one litre of milk suckled by calves by 4 CZK. Expenses were differentiated for the produced and sold milk. The estimated calves and stable manure were detracted from the costs per one feeding day of a dairy cow when calculating the costs of the produced milk. Besides the estimated calves and stable manure, there was detracted also the value of milk fed to calves in the costs calcualtions for the sold milk. The sold (market) milk represents a final production product. That is why the bulk of the production of market milk for a dairy cow per year is decisive in the evaluation of the level of milk production. So it is necessary to consider the profit from the sale of market milk of an average stabled dairy cow per year to be a decisive indicator of milk production.

When evaluating the effect of different performance on the milk production economics, there are mentioned economic changes regarding changes of the market milk production for a dairy cow per year. The cost function was used to mark the relative changes of the economic indicators aiming at determinating the optimum state. A settlement of the actual values of the regression functions was used to derive the cost function. A polynom of the third level was actually used.

RESULTS AND DISCUSSION

The characteristic features of the set of 135 agricultural enterprises can be seen in Table 1.

According to their level of milk yield, the whole set of enterprises was devided into 8 groups in the interval of milk yield of 500 litres per dairy cow per year. There was a certain shortage – a lower number of enterprises in the margin areas of the perfomance. Table 1 evidently shows a favourable development of the presented indicators with regard to the growth of milk yield. Together with the logical tendency of market milk (the share of non-market milk, mainly feeding milk, was about 350 to 450 litres per cow per year at all intervals of milk yield) there was a difference in the intensity of milk production.

The quality of milk which is reflected in the average purchase price of milk has not been shown significantly in the purchase price with regard to the conditions in the milk market in 2000.

It is also necessary to characterise the production conditions under which the enterprises were farming. The enterprises with the above-average milk yield were farming in a rather more favourable natural conditions, as it is seen from the official price for 1 m^2 of agricultural land. The main reason, however, of the differences in the production conditions lies in the technological equipment of stables, where the milk yield grew up with a higher share of free-box stabling (FBS). Milk yield, moreover, is affected by the higher share of the Holstein breed (H) in a stable of dairy cows.

Together with the growth of milk yield, there was seen the growth of the expenses for a feeding day of a dairy cow. Diagram 1 clearly shows the almost linear dependence between the costs of milk per 1 feeding day and the milk yield. The linear equation presented in Figure 1 shows that with every further increment (expressed in litres) of market milk per dairy cow per year, the costs have raised by 6.10 CZK. The following analysis gives an answear whether the growth of costs for feeding day of a dairy cow was proportional to the growth of milk yield.

The level of costs for 1 feeding day of a dairy cow and 1 litre of the produced and sold milk is obvious from the Table 2.

Table 1. Characteristic of a set of farm enterprises (2000)

Enterprises with milk yield of a.l.[1)]	Number of enterprises	Number of dairy cows for 100 ha of a.l.[1)]	Average milk yield for a dairy cow per year	Share maret milk of produced milk	Sale of milk for 1 ha of a.l.[1)]	Share of milk in Q	Realization price of one litre of milk[2)]	Production conditions		
								share of FBS	share of H breed	price for 1 m^2
l	n	n	l	%	l	%	CZK	%	%	CZK
under 4,500	10	23	4,117	92.2	877	38.3	7.45	35.0	11.7	3.15
4,501–5,000	22	22	4,752	91.7	965	38.4	7.65	56.0	16.6	4.10
5,001–5,500	31	24	5,233	92.5	1,160	34.9	7.66	42.6	25.5	4.54
5,501–6,000	27	22	5,768	94.0	1,183	37.9	7.71	69.1	49.7	4.81
6,001–6,500	18	27	6,213	94.1	1,590	55.1	7.80	77.3	42.8	5.35
6,501–7,000	14	37	6,679	94.5	2,357	61.8	7.73	83.6	58.4	5.67
7,001–7,500	9	25	7,265	95.3	1,696	65.9	7.77	79.4	73.8	5.58
over 7,501	4	23	8,557	94.3	1,856	98.8	7.81	98.1	95.5	6.28
Average	135	25	5,694	93.3	1,350	45.8	7.69	62.5	38.9	4.76

[1] agricultural land
[2] purchase price of milk including state supports

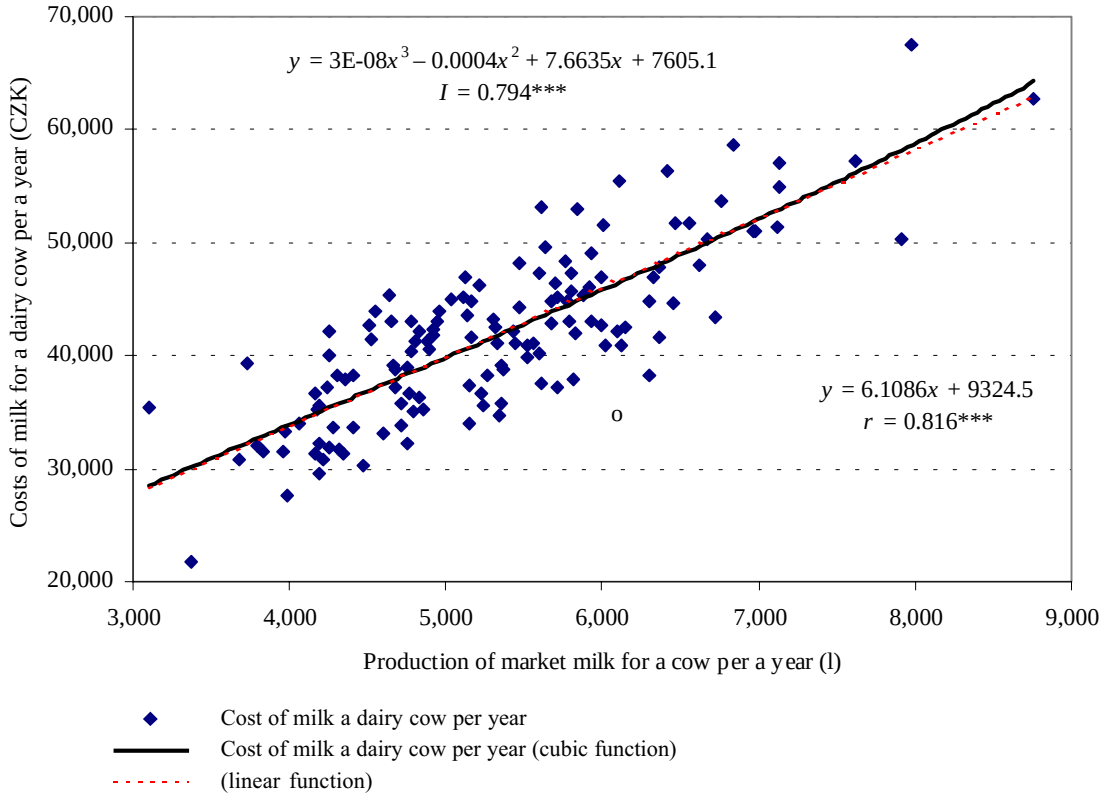

Figure 1. Relationship between the milk costs for a dairy cow per a year and milk yield in 2000

To compare the share of the costs of market milk in the total costs, the bellow table involves a deduction coefficient of the costs per feeding day per 1 dairy cow. This coefficient (ratio) together with the share of market milk of produced milk differs, to some extent, with regard to the milk yield, but not substantially, however. It is given by the total sum of estimations of by-products in the individual milk yield intervals. By the help of the conversion coefficient of the costs, there was lowered the level of the costs for a feeding day of a dairy cow and thus the costs for the market milk per 1 feeding day of a dairy cow were expressed (Table 3).

The dependence between the market milk yield and the individual calculation items, their aggregations, respectively, determines, together with the realization price of milk, the economics of dairy cows breeding. The econom-

Table 2. Deduction of the costs for milk per a feeding day and a litre of produced and sold milk[1] (2000)

Enterprises with milk yield	Market milk yield for 1 year	Costs for a feeding day total	Estimation of by-products for a feeding day				Coefficient of conversion[2]	Expenses for milk		
			calves	stable manure	non-market milk	total		market for a feeding day	for 1 litre of produced milk	for 1 litre of sold milk
l	l	CZK						CZK		
under 4,500	3,796	96.07	4.27	1.59	3.50	9.36	0.90	86.71	8.02	8.36
4,501–5,000	4,359	107.05	3.80	1.70	4.30	9.80	0.91	97.25	7.82	8.17
5,001–5,500	4,840	119.61	4.30	1.78	4.29	10.38	0.91	109.23	7.94	8.26
5,501–6,000	5,423	124.98	4.07	1.80	3.78	9.64	0.92	115.35	7.56	7.79
6,001–6,500	5,847	130.85	4.22	1.65	4.01	9.87	0.92	120.97	7.36	7.57
6,501–7,000	6,313	139.36	4.14	1.99	4.00	10.13	0.93	129.23	7.30	7.49
7,001–7,500	6,924	153.31	4.26	2.20	3.72	10.19	0.93	143.12	7.40	7.57
over 7,501	8,065	174.74	4.61	2.37	5.38	12.36	0.93	162.37	7.17	7.37
Average	5,322	124.32	4.15	1.81	4.06	10.01	0.92	114.31	7.61	7.86

[1] a deduction method was used to estimate 1 kg of calf at 50 CZK, one tone of stable manure to 50 CZK and a litre of non-sold milk to 4 CZK

[2] expenses for a feeding day of market milk

Table 3. Costs of market milk per 1 feeding day of a dairy cow (in Czech crowns) in 2000

Enterprises with milk yield of (l)	Operational expenses end insurance	Feed expenses			Breeding and veter. services and medicines	Deprreciation of fixed assets, repairs and energy	Amortization of dairy cows	Other costs	Costs for a feeding day total
		total	from this						
			own	bought					
3,796	16.82	31.51	23.04	8.48	3.82	9.62	7.29	17.65	86.71
4,359	17.27	33.17	23.22	9.95	5.42	12.49	7.90	21.01	97.25
4,840	18.64	41.28	25.58	15.70	6.24	15.27	7.45	20.35	109.23
5,423	17.13	42.14	24.50	17.64	5.82	14.90	8.50	26.85	115.35
5,847	14.52	49.78	30.35	19.43	6.09	15.21	9.17	26.21	120.97
6,313	17.12	53.28	37.65	15.63	6.84	15.77	8.86	27.37	129.23
6,924	17.04	57.22	35.15	22.07	6.92	17.13	13.17	31.66	143.12
8,065	14.22	71.34	38.61	32.73	8.10	19.61	13.49	35.62	162.37
5,322	17.06	43.72	27.70	16.02	5.99	14.62	8.66	24.26	114.31

ic expressions of the performance are accompanied by the effects of natural conditions which are characterized by the official price of land per 1 m^2 and the stabling technology. Enterprises with higher milk yield have a higher share of cows stabled in the free-box stables. The reason for the installation of this stabling system is lower labour demand of milk production which is expressed by the decline of labour costs for 1 feeding day. On the other hand, this system of stabling is accompanied by the higher costs for depreciation of fixed assets (DFA), for repairs and energy consumption. The enterprises with progressive technology, however, are evidently reaching a higher milk yield and milk quality by which a favourable economic expression in the conversion for a production unit is reached.

During the research work, it was substantial to analyse the changes of the variable costs in the growth of costs for 1 feeding day regarding the growth of milk yield. It was more convenient to analyse the set of enterprises without the marginal intervals of milk yield. The reason was a low number of the presented enterprises in the marginal intervals. It is possible to determine the basic costs as those reached in the enterprises with the minimum milk yield. For this reason, the group of enterprises with the milk yield of 4,359 litres of market milk was marked as the initial group.

Table 3 shows that some calculation items in the conversion for a feeding day have exclusively an intensification character. It concerns mainly the costs of feed as a picture of feed consumption at reaching higher milk yield. It is necessary to say that the classification of own feeds and purchased feeds is not identical with the classification of bulk feeds and concentrated feeds. The increase of the costs for own feeds is represented by a higher consumption of fodder cereals of own production in the enterprises that are reaching a higher level of milk yield.

The costs for feed for the feeding day of a dairy cow have been rising more quickly than milk yield in 2000. It is especially obvious regarding the purchased feeds. In order to ensure the fact that the intensification inputs would be economically efficient, i.e. to ensure the decline of the inputs, it was necessary to reach a lower speed of the growth at the other input items. Besides the feed costs, also the breeding and veterinary services can be involved into the calculating items of the intensification character. The higher level of breeding needs a more quality breeding work. The higher performance of dairy cows needs also a more costly veterinary care connected with the consumption of medicaments. It is obvious from the Table 3. The amortization of cows is a similar case. It is clear from the comparison of the data from Table 3 that these expenses per feeding day have admittedly raised, but more slowly than the performance.

The same situation was also in the case of the fixed-non-intensification "other" costs. Those are the overhead costs and direct costs connected with the operation of a dairy cow stable (in-house transport, rent etc.). The fixed costs should have been constant. In 2000, however, the situation was different owing to the influence of the methods. On one hand, there was dependence where with a higher intensity of a factor there is a higher share of overheads. Further, with raising milk yield, there was increasing even the food consumption, first of all the fodder cereals of own production. The raising feed consumption put higher claims to its transport and repairs. It can be further explained by the fact that the enterprises farming at a higher level spent a higher volume of financial means on the technological and common equipment and on rental items.

The gained results in the framework of the set are burdened with individual deviations which are caused by differences in the productive conditions under which the single enterprises produced milk in 2000. It results in the above mentioned dependence of the milk expenses per feeding day of dairy cows and milk yield (Figure 1). To settle the course of single economic items, there were used mathematical and statistical methods. By means of the regressive function, there were established tendencies of the purchase prices of milk (Figure 2). To settle the level of the course of single economic indicators, there was chosen a polynomic function of the third level (the cubic function). Its conclusiveness is characterized by the index of correlation (*I*). The regressive coefficients

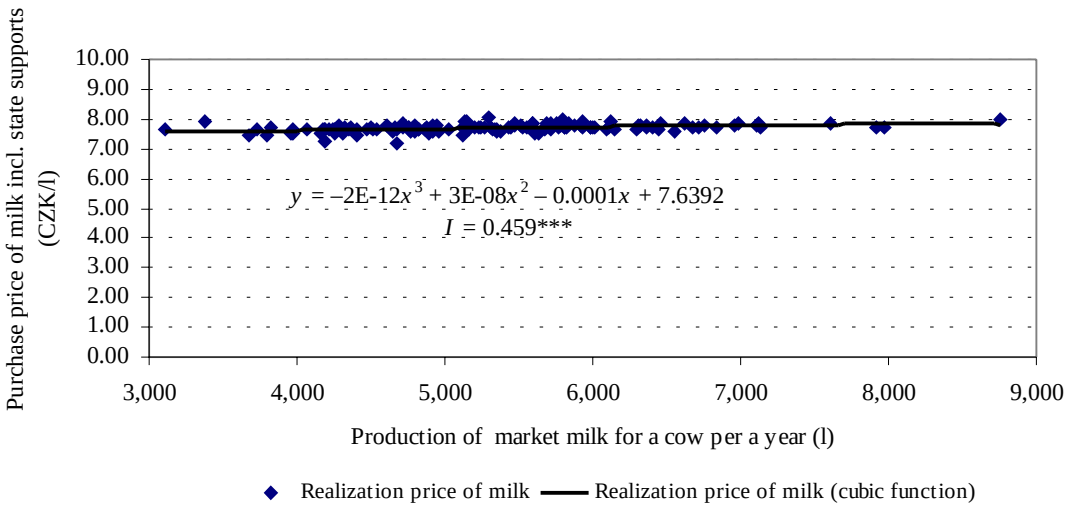

Figure 2. Relationship between the purchase price of milk including state supports and milk yield in 2000

of the course of single indicators with regard to milk yield are presented in Table 4.

On the base of the defined functional relations, there was calculated the course of the purchase milk price including state supports, the unit and limiting costs. The variable is represented by the production of market milk for a dairy cow per year (Table 5).

The qualitative differences between the purchase class of milk of the *Q* and *I* quality were annulated at the milk market in 2000 by the attitude of subscribers, respectively processors. Moreover, the milk processors comprehended the raised minimum guaranteed price as the market price. For these reasons, the purchase price was almost fixed in all intervals of milk production in 2000. On the other hand, the costs of one litre of market milk have lowered from 8.44 CZK at the milk yield of 4,000 litres to 7.33 CZK at the milk yield of 8,000 litres owing to the rising market milk yield. Thanks to the growth of the minimum guaranteed milk price to 7.50 CZK per a litre and state supports together with the proportional development of expenses with regard to milk yield, the individual cost items respectively, the limit of profitability was from

Table 4. The regressive coefficients of single indicators of milk yield, money conversion and expenses

Indicator	*a*	*bx*	cx^2	dx^3	*I*	*Pr*
*y*1/*x*1	7.64	–0.0001	0.00000003	–0.000000000002	0.459	***
*y*2/*x*1	7,605.10	7.6635	–0.00040000	0.000000030000	0.799	***
*y*3/*x*1	–13,434.00	10.9560	–0.00190000	0.000000100000	0.201	**
*y*4/*x*1	728.37	2.6031	0.00000300	0.000000008000	0.794	***
*y*5/*x*1	45,858.00	–22.4970	0.00420000	–0.000000200000	0.410	***
*y*6/*x*1	–45,129.00	25.1000	–0.00420000	0.000000200000	0.480	***
*y*7/*x*1	–1,721.10	1.5489	–0.00020000	0.000000010000	0.337	***
*y*8/*x*1	–3,183.30	2.5748	–0.00020000	0.000000003000	0.320	***
*y*9/*x*1	8,213.60	–3.0866	0.00050000	–0.000000020000	0.349	***
*y*10/*x*1	17,002.00	–6.9328	0.00140000	–0.000000080000	0.430	***

* *Pr* > 0.10; ** *Pr* > 0.05; *** *Pr* > 0.01

where *x*1 – market milk yield for a cow and a day (l)
*y*1 – purchase price for one litre of milk including state subsides (in Czech crowns)
from *y*2 to *y*10 – costs of market milk for a dairy cow and a year (CZK)
*y*2 – costs of market milk for a dairy cow alltogether
out of which
*y*3 – working costs including insurance
*y*4 – feeds altogether out of which
*y*5 – own production and
*y*6 – bought
*y*7 – veterinary and breeding services and medicines
*y*8 – depreciation of fixed assets, repairs and maintenance, energy
*y*9 – amortization of dairy cows
*y*10 – other expenses (other direct expenses and running costs)

Table 5. The economics of the market milk production (the actual state from the year of 2000 was settled by the cubic function)

Market milk yield for a cow per a year	Realization price of 1 litre of milk[1]	Incomes per a dairy cow per a year	Costs of milk		Cost of 1 litre of market milk	Marginal costs of 1 litre of marketmilk[2]	Profit of a dairy cow per a year	Level of profitability of milk production
			for a cow per a year	for a feeding day				
(l)	CZK							%
3,000	7.56	22,666	27,806	75.97	9.27	6.07	–5,140	–18.5
4,000	7.59	30,365	33,779	92.29	8.44	5.90	–3,414	–10.1
5,000	7.64	38,196	39,673	108.40	7.93	5.91	–1,477	–3.7
6,000	7.69	46,123	45,666	124.77	7.61	6.10	457	1.0
7,000	7.72	54,062	51,940	141.91	7.42	6.47	2,123	4.1
8,000	7.74	61,882	58,673	160.31	7.33	7.02	3,209	5.5
9,000	7.71	69,401	66,047	180.46	7.34	7.75	3,354	5.1
10,000	7.64	76,392	74,240	202.84	7.42	8.66	2,152	2.9

[1] purchase price of milk including state supports
[2] marginal costs for one litre of market milk counted on the base of derivation of the expense function

5,000 to 6,000 litres of market milk for a dairy cow and a year. The precise limit of the profitability of the market milk production and the efficiency of additional investments to the production are seen from the cost function (Figure 3).

On the base of the operational and economic data of several agricultural enterprises, there was derived the optimisation of the market milk production in 2000 by the means of the cost function (Table 5). The course of the cost function can be characterised as progressive where the marginal costs of one litre of market milk were growing together with the raising production of market milk. The unit costs were, however, declining down to the level of the market milk yield of 8,410 litres of milk (9,014 litres of produced milk). At this level of the market milk yield, there was reached a maximum profit per one litre of milk in 2000 which is marked in Table 3 as Z_{max}. In spite of the fact that the costs of 1 litre of market milk were growing compared to the level of the market milk yield of 8,410 litres of milk for a dairy cow per year, the profit per 1 dairy cow and year was still growing up to the production of 8,934 litres of market milk (9,576 litres of produced milk). At this production of market milk, there was reached a maximum volume of the profit for a dairy cow per a year (Z_{max}) in 2000. It is obvious from the evaluation of the effectiveness of additional deposits that the expenses for a supplementary unit gain of the milk production was accompanied by the improvement of the economics up to the level of the production of 8,934 litres of market milk. The total increase of the costs was 32,268 CZK compared to the group with the market milk yield of 4,000 litres. From this cost increase, feed costs were 18,530 CZK (57.4%).

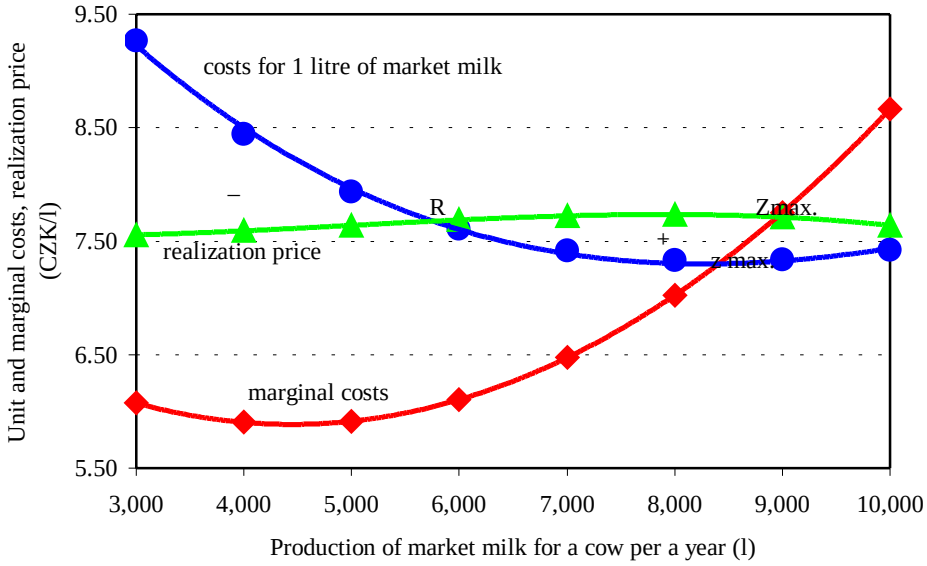

Figure 3. Development of the realization price, unit costs and marginal costs per a litre of sold milk with regard to milk yield in 2000 (CZK)

There was definitely seen an additional input of feed as an intensification factor of milk production, especially the influence of the purchased feed. Adequately, a lower speed of the growth was found at the other cost items.

Besides the maximum profit for a litre of market milk and the maximum volume of the profit for a dairy cow per one year, there was derived by means of the expense function also the limit of profitability of the market milk production. It is marked by the letter *R* in the figure. The production is profitable if the unit price is higher than the total unit expenses. This occurred in 2000 at the production level of 5,760 litres of market milk for a dairy cow per one year (6,174 litres of the produced milk). Profitability was reached up to the level of 10,694 litres of market milk production (11,462 litres of produced milk). This limit of the profitable interval has, however, overreached the actual level of the market milk yield.

CONCLUSION

On the base of the gained operational and economic data of the set of 135 agricultural enterprises engaged in dairy cow breeding which in 2000 represented the share of 12.9% from all dairy cows kept in the Czech Republic and the 14.6% share in the production of market milk, there were analysed dependences between the level of milk yield and the economic results of dairy cow breeding. A trend of a faster growth of milk yield was recorded compared with the costs per feeding day of a dairy cow by means of the evaluation of the above-mentioned dependences. Especially the expenses for the feed for one feeding day showed an intensification character because they were growing more quickly than milk yield. A proportionally lower speed of the growth was found at the other costs items.

On the base of the cost function, there was found a limit of the profitability of the milk production which represented 5,760 litres of market milk per dairy cow and year. This was thanks to the growth of the minimum guarranted milk price to 7.50 CZK in 2000 and state supports together with the proportional development of costs with regard to milk yield. It is logical that the second limit of the profitability interval which represented 10,694 litres of the milk market production (11,462 litres of produced milk) was just theoretical. The maximum profit for litre of market milk was reached in 2000 at the level of the market milk yield of 8,410 litres (at the milk yield of 9,014 litres). The maximum volume of the profit for a dairy cow and year was reached at the production of 8,934 litres of market milk (at the milk yield of 9,576 litres) in 2000.

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